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**Department of Defense
Fiscal Year (FY) 2021 Budget Estimates**

February 2020



Air Force

Justification Book Volume 1 of 3

Research, Development, Test & Evaluation, Air Force

Vol-I

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Air Force • Budget Estimates FY 2021 • RDT&E Program

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Fiscal Year (FY) 2021 Budget Estimates RDT&E Descriptive Summaries Budget Activities February 2020

INTRODUCTION AND EXPLANATION OF CONTENTS

GENERAL

- This document has been prepared to provide information on the United States Air Force (USAF) Research, Development, Test and Evaluation (RDT&E) program elements and projects in the FY 2021 President's Budget (PB).
 - All exhibits in this document have been assembled in accordance with DoD 7000.14R, Financial Management Regulation, Volume 2B, Chapter 5.
 - Other comments on exhibit contents in this document:
 - Exhibits R-2/2a and R-3 provide narrative information for all RDT&E program elements and projects within the USAF FY 2021 RDT&E program with the exception of classified program elements. The format and contents of this document are in accordance to the guidelines and requirements of the Congressional committees in so far as possible.
 - The "Other Program Funding Summary portion of the R-2 includes, in addition to RDTE& funds, Procurement funds and quantities, Military Construction appropriation funds on specific development programs, Operations and Maintenance appropriation funds where they are essential to the development effort described, and where appropriate, Department of Energy (DOE) costs.

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- All exhibits contained in Volumes I, II, and III are unclassified. Classified exhibits are not included in the submission due to the level of security classification and necessity of special security clearances.

RDT&E, Air Force Overseas Contingency Operations (OCO)

- FY2021 OCO can be separated into the following categories:
 - OCO for Direct War Costs: Direct War costs are those combat or direct combat support costs that will not continue to be expended once combat operations end at major contingency locations.
 - OCO for Enduring Requirements: OCO for Enduring Requirements are enduring in-theater and in-CONUS costs that will likely remain after combat operations cease, and have previously been funded in OCO.
 - OCO for Base Requirements: OCO for Base Requirements is OCO funding for base budget requirements in support of the National Defense Strategy. The Budget requests these funds in OCO to comply with the base budget defense caps included in the Budget Control Act of 2011.

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Summary Recap of Budget Activities	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted (Base+Emerg+ OCO)
Basic Research	545,223	549,761			549,761
Applied Research	1,482,434	1,656,126			1,656,126
Advanced Technology Development	876,008	1,066,453			1,066,453
Advanced Component Development & Prototypes	6,386,187	8,244,911		44,335	8,289,246
System Development & Demonstration	5,377,043	6,690,641			6,690,641
Management Support	3,769,578	2,878,071			2,878,071
Operational Systems Development	22,982,541	24,480,992		83,913	24,564,905
Software & Digital Technology Pilot Programs					
Total Research, Development, Test & Evaluation	41,419,014	45,566,955		128,248	45,695,203

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Summary Recap of Budget Activities	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)
Basic Research	492,294				492,294
Applied Research	1,540,623				1,540,623
Advanced Technology Development	778,548				778,548
Advanced Component Development & Prototypes	9,049,227				9,049,227
System Development & Demonstration	6,359,375				6,359,375
Management Support	3,149,790				3,149,790
Operational Systems Development	26,199,822		5,304	5,304	26,205,126
Software & Digital Technology Pilot Programs	149,742				149,742
Total Research, Development, Test & Evaluation	47,719,421		5,304	5,304	47,724,725

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	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted (Base+Emerg+ OCO)
Summary Recap of FYDP Programs -----					
Strategic Forces	933,653	846,784			846,784
General Purpose Forces	3,020,691	3,748,342		5,200	3,753,542
Intelligence and Communications	1,530,574	1,340,238			1,340,238
Mobility Forces	894,433	936,221			936,221
Research and Development	13,189,310	14,528,474		26,450	14,554,924
Central Supply and Maintenance	93,964	37,505			37,505
Training Medical and Other	2,488	8,542			8,542
Administration and Associated Activities	117,431	90,730			90,730
Support of Other Nations	3,866	4,071			4,071
Space	4,800,166	6,240,052		17,885	6,257,937
Classified Programs	16,832,438	17,785,996		78,713	17,864,709
Total Research, Development, Test & Evaluation	41,419,014	45,566,955		128,248	45,695,203

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	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)
Summary Recap of FYDP Programs					
Strategic Forces	1,065,581				1,065,581
General Purpose Forces	4,019,405		5,304	5,304	4,024,709
Intelligence and Communications	1,090,263				1,090,263
Mobility Forces	1,048,447				1,048,447
Research and Development	14,101,988				14,101,988
Central Supply and Maintenance	95,633				95,633
Training Medical and Other	7,073				7,073
Administration and Associated Activities	78,515				78,515
Support of Other Nations	3,599				3,599
Space	6,798,195				6,798,195
Classified Programs	19,410,722				19,410,722
Total Research, Development, Test & Evaluation	47,719,421		5,304	5,304	47,724,725

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Basic Research	545,223	549,761			549,761
Applied Research	1,482,434	1,656,126			1,656,126
Advanced Technology Development	876,008	1,066,453			1,066,453
Advanced Component Development & Prototypes	6,386,187	8,244,911		44,335	8,289,246
System Development & Demonstration	5,377,043	6,690,641			6,690,641
Management Support	3,769,578	2,878,071			2,878,071
Operational Systems Development	22,982,541	24,480,992		83,913	24,564,905
Total Research, Development, Test & Evaluation	41,419,014	45,566,955		128,248	45,695,203
Summary Recap of FYDP Programs -----					
Strategic Forces	933,653	846,784			846,784
General Purpose Forces	3,020,691	3,748,342		5,200	3,753,542
Intelligence and Communications	1,530,574	1,340,238			1,340,238
Mobility Forces	894,433	936,221			936,221
Research and Development	13,189,310	14,528,474		26,450	14,554,924
Central Supply and Maintenance	93,964	37,505			37,505
Training Medical and Other	2,488	8,542			8,542
Administration and Associated Activities	117,431	90,730			90,730
Support of Other Nations	3,866	4,071			4,071

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Summary Recap of Budget Activities	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)
-----	-----	-----	-----	-----	-----
Basic Research	492,294				492,294
Applied Research	1,409,749				1,409,749
Advanced Technology Development	778,548				778,548
Advanced Component Development & Prototypes	7,737,916				7,737,916
System Development & Demonstration	2,615,359				2,615,359
Management Support	2,891,280				2,891,280
Operational Systems Development	21,466,680		5,304	5,304	21,471,984
Total Research, Development, Test & Evaluation	37,391,826		5,304	5,304	37,397,130
Summary Recap of FYDP Programs					

Strategic Forces	1,065,581				1,065,581
General Purpose Forces	4,019,405		5,304	5,304	4,024,709
Intelligence and Communications	1,090,263				1,090,263
Mobility Forces	1,048,447				1,048,447
Research and Development	14,101,988				14,101,988
Central Supply and Maintenance	95,633				95,633
Training Medical and Other	7,073				7,073
Administration and Associated Activities	78,515				78,515
Support of Other Nations	3,599				3,599

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Summary Recap of Budget Activities	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted (Base+Emerg+ OCO)
Space	4,800,166	6,240,052		17,885	6,257,937
Classified Programs	16,832,438	17,785,996		78,713	17,864,709
Total Research, Development, Test & Evaluation	41,419,014	45,566,955		128,248	45,695,203

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Summary Recap of Budget Activities	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)
Space	103,466				103,466
Classified Programs	15,777,856				15,777,856
Total Research, Development, Test & Evaluation	37,391,826		5,304	5,304	37,397,130

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Appropriation: 3600F Research, Development, Test & Eval, AF

Line No	Program Element Number	Item	Act	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020	
								Total Enacted S (Base+Emerg+ e OCO)	c
1	0601102F	Defense Research Sciences	01	374,047	356,107			356,107	U
2	0601103F	University Research Initiatives	01	159,073	178,859			178,859	U
3	0601108F	High Energy Laser Research Initiatives	01	12,103	14,795			14,795	U
		Basic Research		545,223	549,761			549,761	
4	0602020F	Future AF Capabilities Applied Research	02						U
5	0602102F	Materials	02	172,109	215,851			215,851	U
6	0602201F	Aerospace Vehicle Technologies	02	150,625	157,724			157,724	U
7	0602202F	Human Effectiveness Applied Research	02	109,598	134,795			134,795	U
8	0602203F	Aerospace Propulsion	02	202,638	226,775			226,775	U
9	0602204F	Aerospace Sensors	02	168,897	219,912			219,912	U
10	0602212F	Defense Laboratories R&D Projects (10 U.S.C, Sec 2358)	02	86,165					U
11	0602298F	Science and Technology Management - Major Headquarters Activities	02	8,288	7,968			7,968	U
12	0602602F	Conventional Munitions	02	100,573	142,772			142,772	U
13	0602605F	Directed Energy Technology	02	129,579	124,379			124,379	U
14	0602788F	Dominant Information Sciences and Methods	02	182,221	216,062			216,062	U
15	0602890F	High Energy Laser Research	02	40,400	48,221			48,221	U

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Line No	Program Element Number	Item	Act	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)	Se
1	0601102F	Defense Research Sciences	01	315,348				315,348	U
2	0601103F	University Research Initiatives	01	161,861				161,861	U
3	0601108F	High Energy Laser Research Initiatives	01	15,085				15,085	U
		Basic Research		492,294				492,294	
4	0602020F	Future AF Capabilities Applied Research	02	100,000				100,000	U
5	0602102F	Materials	02	140,781				140,781	U
6	0602201F	Aerospace Vehicle Technologies	02	349,225				349,225	U
7	0602202F	Human Effectiveness Applied Research	02	115,222				115,222	U
8	0602203F	Aerospace Propulsion	02						U
9	0602204F	Aerospace Sensors	02	211,301				211,301	U
10	0602212F	Defense Laboratories R&D Projects (10 U.S.C, Sec 2358)	02						U
11	0602298F	Science and Technology Management - Major Headquarters Activities	02	8,926				8,926	U
12	0602602F	Conventional Munitions	02	132,425				132,425	U
13	0602605F	Directed Energy Technology	02	128,113				128,113	U
14	0602788F	Dominant Information Sciences and Methods	02	178,668				178,668	U
15	0602890F	High Energy Laser Research	02	45,088				45,088	U

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Line No	Program Element Number	Item	Act	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted S (Base+Emerg+ e OCO)	c
16	1206601F	Space Technology	02	131,341	161,667			161,667	U
		Applied Research		1,482,434	1,656,126			1,656,126	
17	0603030F	AF Foundational Development/Demos	03						U
18	0603032F	Future AF Integrated Technology Demos	03						U
19	0603033F	Next Gen Platform Dev/Demo	03						U
20	0603034F	Persistent Knowledge, Awareness, & C2 Tech	03						U
21	0603035F	Next Gen Effects Dev/Demos	03						U
22	0603112F	Advanced Materials for Weapon Systems	03	44,099	60,086			60,086	U
23	0603199F	Sustainment Science and Technology (S&T)	03	13,353	16,249			16,249	U
24	0603203F	Advanced Aerospace Sensors	03	41,462	42,292			42,292	U
25	0603211F	Aerospace Technology Dev/Demo	03	115,406	127,949			127,949	U
26	0603216F	Aerospace Propulsion and Power Technology	03	140,247	170,973			170,973	U
27	0603270F	Electronic Combat Technology	03	53,704	48,408			48,408	U
28	0603401F	Advanced Spacecraft Technology	03	65,727	80,525			80,525	U
29	0603444F	Maui Space Surveillance System (MSSS)	03	10,268	11,878			11,878	U
30	0603456F	Human Effectiveness Advanced Technology Development	03	32,624	37,542			37,542	U
31	0603601F	Conventional Weapons Technology	03	191,704	225,817			225,817	U

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16	1206601F	Space Technology	02						U
		Applied Research		1,409,749				1,409,749	
17	0603030F	AF Foundational Development/Demos	03	103,280				103,280	U
18	0603032F	Future AF Integrated Technology Demos	03	157,619				157,619	U
19	0603033F	Next Gen Platform Dev/Demo	03	199,556				199,556	U
20	0603034F	Persistent Knowledge, Awareness, & C2 Tech	03	102,276				102,276	U
21	0603035F	Next Gen Effects Dev/Demos	03	215,817				215,817	U
22	0603112F	Advanced Materials for Weapon Systems	03						U
23	0603199F	Sustainment Science and Technology (S&T)	03						U
24	0603203F	Advanced Aerospace Sensors	03						U
25	0603211F	Aerospace Technology Dev/Demo	03						U
26	0603216F	Aerospace Propulsion and Power Technology	03						U
27	0603270F	Electronic Combat Technology	03						U
28	0603401F	Advanced Spacecraft Technology	03						U
29	0603444F	Maui Space Surveillance System (MSSS)	03						U
30	0603456F	Human Effectiveness Advanced Technology Development	03						U
31	0603601F	Conventional Weapons Technology	03						U

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32	0603605F	Advanced Weapons Technology	03	39,438	37,404			37,404	U
33	0603680F	Manufacturing Technology Program	03	62,187	130,916			130,916	U
34	0603788F	Battlespace Knowledge Development and Demonstration	03	58,369	56,414			56,414	U
35	0604445F	Wide Area Surveillance	03		20,000			20,000	U
36	0303467F	SENSR Spectrum Pipeline SRF	03	7,265					U
37	0303567F	Non-SENSR Spectrum Pipeline SRF	03	155					U
		Advanced Technology Development		876,008	1,066,453			1,066,453	
38	0603260F	Intelligence Advanced Development	04	5,568	5,672			5,672	U
39	0603742F	Combat Identification Technology	04	17,561	32,085			32,085	U
40	0603790F	NATO Research and Development	04	2,221	4,955			4,955	U
41	0603851F	Intercontinental Ballistic Missile - Dem/Val	04	24,994	30,969			30,969	U
42	0603859F	Pollution Prevention - Dem/Val	04	193	3,000			3,000	U
43	0604002F	Air Force Weather Services Research	04		772			772	U
44	0604003F	Advanced Battle Management System (ABMS)	04		8,000			8,000	U
45	0604004F	Advanced Engine Development	04	696,099	671,442			671,442	U
46	0604015F	Long Range Strike - Bomber	04	2,189,945	2,982,499			2,982,499	U
47	0604032F	Directed Energy Prototyping	04	48,316	44,000			44,000	U
48	0604033F	Hypersonics Prototyping	04	494,485	576,000			576,000	U

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Line No	Program Element Number	Item	Act	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)	Se
32	0603605F	Advanced Weapons Technology	03						U
33	0603680F	Manufacturing Technology Program	03						U
34	0603788F	Battlespace Knowledge Development and Demonstration	03						U
35	0604445F	Wide Area Surveillance	03						U
36	0303467F	SENSR Spectrum Pipeline SRF	03						U
37	0303567F	Non-SENSR Spectrum Pipeline SRF	03						U
		Advanced Technology Development		778,548				778,548	
38	0603260F	Intelligence Advanced Development	04	4,320				4,320	U
39	0603742F	Combat Identification Technology	04	26,396				26,396	U
40	0603790F	NATO Research and Development	04	3,647				3,647	U
41	0603851F	Intercontinental Ballistic Missile - Dem/Val	04	32,959				32,959	U
42	0603859F	Pollution Prevention - Dem/Val	04						U
43	0604002F	Air Force Weather Services Research	04	869				869	U
44	0604003F	Advanced Battle Management System (ABMS)	04	302,323				302,323	U
45	0604004F	Advanced Engine Development	04	636,495				636,495	U
46	0604015F	Long Range Strike - Bomber	04	2,848,410				2,848,410	U
47	0604032F	Directed Energy Prototyping	04	20,964				20,964	U
48	0604033F	Hypersonics Prototyping	04	381,862				381,862	U

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Line No	Program Element Number	Item	Act	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted S (Base+Emerg+ e OCO)	c
49	0604201F	PNT Resiliency, Mods, and Improvements	04	86,445	124,600			124,600	U
50	0604257F	Advanced Technology and Sensors	04	34,585	23,145			23,145	U
51	0604288F	National Airborne Ops Center (NAOC) Recap	04	7,168	12,669			12,669	U
52	0604317F	Technology Transfer	04	18,754	37,614			37,614	U
53	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	04	41,259	113,121			113,121	U
54	0604414F	Cyber Resiliency of Weapon Systems-ACS	04	57,671	56,325			56,325	U
55	0604776F	Deployment & Distribution Enterprise R&D	04	27,301	28,034			28,034	U
56	0604858F	Tech Transition Program	04	163,132	288,476		26,450	314,926	U
57	0605230F	Ground Based Strategic Deterrent	04	401,244	557,495			557,495	U
58	0207100F	Light Attack Armed Reconnaissance (LAAR) Squadrons	04		2,000			2,000	U
59	0207110F	Next Generation Air Dominance	04	413,938	905,000			905,000	U
60	0207455F	Three Dimensional Long-Range Radar (3DELRR)	04	24,716	23,190			23,190	U
61	0207522F	Airbase Air Defense Systems (ABADS)	04						U
62	0208099F	Unified Platform (UP)	04	28,327	10,000			10,000	U
63	0305236F	Common Data Link Executive Agent (CDL EA)	04	41,880	36,910			36,910	U

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Line No	Program Element Number	Item	Act	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)	Se
49	0604201F	PNT Resiliency, Mods, and Improvements	04						U
50	0604257F	Advanced Technology and Sensors	04	24,747				24,747	U
51	0604288F	National Airborne Ops Center (NAOC) Recap	04	76,417				76,417	U
52	0604317F	Technology Transfer	04	3,011				3,011	U
53	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	04	52,921				52,921	U
54	0604414F	Cyber Resiliency of Weapon Systems-ACS	04	69,783				69,783	U
55	0604776F	Deployment & Distribution Enterprise R&D	04	25,835				25,835	U
56	0604858F	Tech Transition Program	04	219,252				219,252	U
57	0605230F	Ground Based Strategic Deterrent	04	1,524,759				1,524,759	U
58	0207100F	Light Attack Armed Reconnaissance (LAAR) Squadrons	04						U
59	0207110F	Next Generation Air Dominance	04	1,044,089				1,044,089	U
60	0207455F	Three Dimensional Long-Range Radar (3DELRR)	04	19,356				19,356	U
61	0207522F	Airbase Air Defense Systems (ABADS)	04	8,737				8,737	U
62	0208099F	Unified Platform (UP)	04	5,990				5,990	U
63	0305236F	Common Data Link Executive Agent (CDL EA)	04	39,293				39,293	U

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64	0305251F	Cyberspace Operations Forces and Force Support	04		35,000			35,000	U
65	0305601F	Mission Partner Environments	04	9,694	8,550			8,550	U
66	0306250F	Cyber Operations Technology Development	04	237,393	202,364			202,364	U
67	0306415F	Enabled Cyber Activities	04	15,728	16,632			16,632	U
68	0401310F	C-32 Executive Transport Recapitalization	04						U
69	0901410F	Contracting Information Technology System	04	16,998	20,830			20,830	U
70	1203164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04	236,786	320,598			320,598	U
71	1203710F	EO/IR Weather Systems	04	7,786	125,964			125,964	U
72	1206422F	Weather System Follow-on	04	128,600	205,660			205,660	U
73	1206425F	Space Situation Awareness Systems	04	32,351	29,776			29,776	U
74	1206427F	Space Systems Prototype Transitions (SSPT)	04		142,045			142,045	U
75	1206434F	Midterm Polar MILSATCOM System	04	370,353					U
76	1206438F	Space Control Technology	04	68,604	58,231			58,231	U
77	1206730F	Space Security and Defense Program	04	45,542	56,385			56,385	U
78	1206760F	Protected Tactical Enterprise Service (PTES)	04	45,009	105,003			105,003	U
79	1206761F	Protected Tactical Service (PTS)	04	28,754	163,694			163,694	U
80	1206855F	Evolved Strategic SATCOM (ESS)	04	28,498	167,206			167,206	U

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64	0305251F	Cyberspace Operations Forces and Force Support	04						U
65	0305601F	Mission Partner Environments	04	11,430				11,430	U
66	0306250F	Cyber Operations Technology Development	04	259,823				259,823	U
67	0306415F	Enabled Cyber Activities	04	10,560				10,560	U
68	0401310F	C-32 Executive Transport Recapitalization	04	9,908				9,908	U
69	0901410F	Contracting Information Technology System	04	8,662				8,662	U
70	1203164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04						U
71	1203710F	EO/IR Weather Systems	04						U
72	1206422F	Weather System Follow-on	04						U
73	1206425F	Space Situation Awareness Systems	04						U
74	1206427F	Space Systems Prototype Transitions (SSPT)	04	8,787				8,787	U
75	1206434F	Midterm Polar MILSATCOM System	04						U
76	1206438F	Space Control Technology	04						U
77	1206730F	Space Security and Defense Program	04	56,311				56,311	U
78	1206760F	Protected Tactical Enterprise Service (PTES)	04						U
79	1206761F	Protected Tactical Service (PTS)	04						U
80	1206855F	Evolved Strategic SATCOM (ESS)	04						U

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								Total Enacted S (Base+Emerg+ e OCO)	c
81	1206857F	Space Rapid Capabilities Office	04	288,289	9,000		17,885	26,885	U
		Advanced Component Development & Prototypes		6,386,187	8,244,911		44,335	8,289,246	
82	0604200F	Future Advanced Weapon Analysis & Programs	05	262	5,000			5,000	U
83	0604201F	PNT Resiliency, Mods, and Improvements	05	45,363	142,782			142,782	U
84	0604222F	Nuclear Weapons Support	05	4,311	4,406			4,406	U
85	0604270F	Electronic Warfare Development	05	1,839	2,066			2,066	U
86	0604281F	Tactical Data Networks Enterprise	05	242,328	189,631			189,631	U
87	0604287F	Physical Security Equipment	05	13,893	9,700			9,700	U
88	0604329F	Small Diameter Bomb (SDB) - EMD	05	75,345	45,241			45,241	U
89	0604429F	Airborne Electronic Attack	05	5,948					U
90	0604602F	Armament/Ordnance Development	05	44,788	28,043			28,043	U
91	0604604F	Submunitions	05	2,989	3,045			3,045	U
92	0604617F	Agile Combat Support	05	22,739	26,944			26,944	U
93	0604618F	Joint Direct Attack Munition	05						U
94	0604706F	Life Support Systems	05	10,334	14,624			14,624	U
95	0604735F	Combat Training Ranges	05	42,383	52,365			52,365	U
96	0604800F	F-35 - EMD	05	67,999	7,628			7,628	U
97	0604932F	Long Range Standoff Weapon	05	646,800	712,539			712,539	U
98	0604933F	ICBM Fuze Modernization	05	124,457	161,199			161,199	U

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81	1206857F	Space Rapid Capabilities Office	04						U
		Advanced Component Development & Prototypes		7,737,916				7,737,916	
82	0604200F	Future Advanced Weapon Analysis & Programs	05	25,161				25,161	U
83	0604201F	PNT Resiliency, Mods, and Improvements	05	38,564				38,564	U
84	0604222F	Nuclear Weapons Support	05	35,033				35,033	U
85	0604270F	Electronic Warfare Development	05	2,098				2,098	U
86	0604281F	Tactical Data Networks Enterprise	05	131,909				131,909	U
87	0604287F	Physical Security Equipment	05	6,752				6,752	U
88	0604329F	Small Diameter Bomb (SDB) - EMD	05	17,280				17,280	U
89	0604429F	Airborne Electronic Attack	05						U
90	0604602F	Armament/Ordnance Development	05	23,076				23,076	U
91	0604604F	Submunitions	05	3,091				3,091	U
92	0604617F	Agile Combat Support	05	20,609				20,609	U
93	0604618F	Joint Direct Attack Munition	05	7,926				7,926	U
94	0604706F	Life Support Systems	05	23,660				23,660	U
95	0604735F	Combat Training Ranges	05	8,898				8,898	U
96	0604800F	F-35 - EMD	05	5,423				5,423	U
97	0604932F	Long Range Standoff Weapon	05	474,430				474,430	U
98	0604933F	ICBM Fuze Modernization	05	167,099				167,099	U

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99	0605030F	Joint Tactical Network Center (JTNC)	05		2,414			2,414	U
100	0605056F	Open Architecture Management	05		30,000			30,000	U
101	0605221F	KC-46	05	77,852	59,561			59,561	U
102	0605223F	Advanced Pilot Training	05	236,840	340,373			340,373	U
103	0605229F	Combat Rescue Helicopter	05	430,483	247,047			247,047	U
104	0605931F	B-2 Defensive Management System	05	244,638	250,100			250,100	U
105	0101125F	Nuclear Weapons Modernization	05	42,001	27,564			27,564	U
106	0207171F	F-15 EPAWSS	05	133,382	47,322			47,322	U
107	0207328F	Stand In Attack Weapon	05	14,542	162,840			162,840	U
108	0207701F	Full Combat Mission Training	05	978	9,797			9,797	U
109	0303267F	Auctioned Spectrum Relocation Fund	05	44,652					U
110	0305176F	Combat Survivor Evader Locator	05						U
111	0401221F	KC-46A Tanker Squadrons	05						U
112	0401310F	C-32 Executive Transport Recapitalization	05	5,989	9,930			9,930	U
113	0401319F	VC-25B	05	713,633	757,923			757,923	U
114	0701212F	Automated Test Systems	05	13,153	2,787			2,787	U
115	0804772F	Training Developments	05						U
116	0901299F	AF A1 Systems	05						U
117	1203176F	Combat Survivor Evader Locator	05	913	2,000			2,000	U

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99	0605030F	Joint Tactical Network Center (JTNC)	05						U
100	0605056F	Open Architecture Management	05	30,547				30,547	U
101	0605221F	KC-46	05						U
102	0605223F	Advanced Pilot Training	05	248,669				248,669	U
103	0605229F	Combat Rescue Helicopter	05	63,169				63,169	U
104	0605931F	B-2 Defensive Management System	05						U
105	0101125F	Nuclear Weapons Modernization	05	9,683				9,683	U
106	0207171F	F-15 EPAWSS	05	170,679				170,679	U
107	0207328F	Stand In Attack Weapon	05	160,438				160,438	U
108	0207701F	Full Combat Mission Training	05	9,422				9,422	U
109	0303267F	Auctioned Spectrum Relocation Fund	05						U
110	0305176F	Combat Survivor Evader Locator	05	973				973	U
111	0401221F	KC-46A Tanker Squadrons	05	106,262				106,262	U
112	0401310F	C-32 Executive Transport Recapitalization	05						U
113	0401319F	VC-25B	05	800,889				800,889	U
114	0701212F	Automated Test Systems	05	10,673				10,673	U
115	0804772F	Training Developments	05	4,479				4,479	U
116	0901299F	AF A1 Systems	05	8,467				8,467	U
117	1203176F	Combat Survivor Evader Locator	05						U

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118	1203269F	GPS III Follow-On (GPS IIIIF)	05	412,202	447,875			447,875	U
119	1203940F	Space Situation Awareness Operations	05	35,569	56,829			56,829	U
120	1206421F	Counterspace Systems	05	19,637	27,037			27,037	U
121	1206422F	Weather System Follow-on	05		2,237			2,237	U
122	1206425F	Space Situation Awareness Systems	05	139,172	362,894			362,894	U
123	1206426F	Space Fence	05	18,841					U
124	1206431F	Advanced EHF MILSATCOM (SPACE)	05	139,927	117,290			117,290	U
125	1206432F	Polar MILSATCOM (SPACE)	05	25,480	412,400			412,400	U
126	1206433F	Wideband Global SATCOM (SPACE)	05	3,833	1,920			1,920	U
127	1206441F	Space Based Infrared System (SBIRS) High EMD	05	58,765	1			1	U
128	1206442F	Next Generation OPIR	05	736,389	1,470,278			1,470,278	U
129	1206445F	Commercial SATCOM (COMSATCOM) Integration	05	47,869	5,000			5,000	U
130	1206853F	National Security Space Launch Program (SPACE) - EMD	05	428,525	432,009			432,009	U
		System Development & Demonstration		5,377,043	6,690,641			6,690,641	
131	0604256F	Threat Simulator Development	06	33,666	59,693			59,693	U
132	0604759F	Major T&E Investment	06	213,273	106,663			106,663	U
133	0605101F	RAND Project Air Force	06	33,308	35,258			35,258	U
134	0605502F	Small Business Innovation Research	06	795,378					U

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118	1203269F	GPS III Follow-On (GPS IIIIF)	05						U
119	1203940F	Space Situation Awareness Operations	05						U
120	1206421F	Counterspace Systems	05						U
121	1206422F	Weather System Follow-on	05						U
122	1206425F	Space Situation Awareness Systems	05						U
123	1206426F	Space Fence	05						U
124	1206431F	Advanced EHF MILSATCOM (SPACE)	05						U
125	1206432F	Polar MILSATCOM (SPACE)	05						U
126	1206433F	Wideband Global SATCOM (SPACE)	05						U
127	1206441F	Space Based Infrared System (SBIRS) High EMD	05						U
128	1206442F	Next Generation OPIR	05						U
129	1206445F	Commercial SATCOM (COMSATCOM) Integration	05						U
130	1206853F	National Security Space Launch Program (SPACE) - EMD	05						U
		System Development & Demonstration		2,615,359				2,615,359	
131	0604256F	Threat Simulator Development	06	57,725				57,725	U
132	0604759F	Major T&E Investment	06	208,680				208,680	U
133	0605101F	RAND Project Air Force	06	35,803				35,803	U
134	0605502F	Small Business Innovation Research	06						U

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135	0605712F	Initial Operational Test & Evaluation	06	17,383	13,793			13,793	U
136	0605807F	Test and Evaluation Support	06	692,784	717,895			717,895	U
137	0605826F	Acq Workforce- Global Power	06	229,904	255,667			255,667	U
138	0605827F	Acq Workforce- Global Vig & Combat Sys	06	243,647	249,992			249,992	U
139	0605828F	Acq Workforce- Global Reach	06	149,306	149,191			149,191	U
140	0605829F	Acq Workforce- Cyber, Network, & Bus Sys	06	227,337	235,360			235,360	U
141	0605830F	Acq Workforce- Global Battle Mgmt	06	157,258	160,196			160,196	U
142	0605831F	Acq Workforce- Capability Integration	06	237,297	228,255			228,255	U
143	0605832F	Acq Workforce- Advanced Prgm Technology	06	36,739	39,392			39,392	U
144	0605833F	Acq Workforce- Nuclear Systems	06	126,681	133,231			133,231	U
145	0605898F	Management HQ - R&D	06	11,024	5,590			5,590	U
146	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	06	187,216	88,445			88,445	U
147	0605978F	Facilities Sustainment - Test and Evaluation Support	06	28,888	29,424			29,424	U
148	0606017F	Requirements Analysis and Maturation	06	46,145	86,715			86,715	U
149	0606398F	Management HQ - T&E	06		5,013			5,013	U

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135	0605712F	Initial Operational Test & Evaluation	06	13,557				13,557	U
136	0605807F	Test and Evaluation Support	06	764,606				764,606	U
137	0605826F	Acq Workforce- Global Power	06						U
138	0605827F	Acq Workforce- Global Vig & Combat Sys	06						U
139	0605828F	Acq Workforce- Global Reach	06						U
140	0605829F	Acq Workforce- Cyber, Network, & Bus Sys	06						U
141	0605830F	Acq Workforce- Global Battle Mgmt	06						U
142	0605831F	Acq Workforce- Capability Integration	06	1,362,038				1,362,038	U
143	0605832F	Acq Workforce- Advanced Prgm Technology	06	40,768				40,768	U
144	0605833F	Acq Workforce- Nuclear Systems	06	179,646				179,646	U
145	0605898F	Management HQ - R&D	06	5,734				5,734	U
146	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	06	70,985				70,985	U
147	0605978F	Facilities Sustainment - Test and Evaluation Support	06	29,880				29,880	U
148	0606017F	Requirements Analysis and Maturation	06	63,381				63,381	U
149	0606398F	Management HQ - T&E	06	5,785				5,785	U

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150	0303255F	Command, Control, Communication, and Computers (C4) - STRATCOM	06						U
151	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	06	17,258	10,628			10,628	U
152	0702806F	Acquisition and Management Support	06	12,130	5,913			5,913	U
153	0804731F	General Skill Training	06	432	6,475			6,475	U
154	0909999F	Financing for Cancelled Account Adjustments	06	3,593					U
155	1001004F	International Activities	06	3,866	4,071			4,071	U
156	1206116F	Space Test and Training Range Development	06	22,408	14,942			14,942	U
157	1206392F	ACQ Workforce - Space & Missile Systems	06	180,512	167,810			167,810	U
158	1206398F	Space & Missile Systems Center - MHA	06	10,508	10,170			10,170	U
159	1206860F	Rocket Systems Launch Program (SPACE)	06	21,906	13,192			13,192	U
160	1206862F	Tactically Responsive Launch	06		19,000			19,000	U
161	1206864F	Space Test Program (STP)	06	29,731	26,097			26,097	U
		Management Support		3,769,578	2,878,071			2,878,071	
162	0604003F	Advanced Battle Management System (ABMS)	07	27,883	35,611			35,611	U
163	0604233F	Specialized Undergraduate Flight Training	07	10,974	2,584			2,584	U

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150	0303255F	Command, Control, Communication, and Computers (C4) - STRATCOM	06	24,564				24,564	U
151	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	06	9,883				9,883	U
152	0702806F	Acquisition and Management Support	06	13,384				13,384	U
153	0804731F	General Skill Training	06	1,262				1,262	U
154	0909999F	Financing for Cancelled Account Adjustments	06						U
155	1001004F	International Activities	06	3,599				3,599	U
156	1206116F	Space Test and Training Range Development	06						U
157	1206392F	ACQ Workforce - Space & Missile Systems	06						U
158	1206398F	Space & Missile Systems Center - MHA	06						U
159	1206860F	Rocket Systems Launch Program (SPACE)	06						U
160	1206862F	Tactically Responsive Launch	06						U
161	1206864F	Space Test Program (STP)	06						U
		Management Support		2,891,280				2,891,280	
162	0604003F	Advanced Battle Management System (ABMS)	07						U
163	0604233F	Specialized Undergraduate Flight Training	07	8,777				8,777	U

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Line No	Program Element Number	Item	Act	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted S (Base+Emerg+ e OCO)	c
164	0604776F	Deployment & Distribution Enterprise R&D	07	257	903			903	U
165	0604840F	F-35 C2D2	07		642,371			642,371	U
166	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	07	39,794	40,567			40,567	U
167	0605024F	Anti-Tamper Technology Executive Agency	07	32,182	47,193			47,193	U
168	0605117F	Foreign Materiel Acquisition and Exploitation	07	68,368	70,083			70,083	U
169	0605278F	HC/MC-130 Recap RDT&E	07	15,641	17,218			17,218	U
170	0606018F	NC3 Integration	07	18,633	25,917			25,917	U
171	0606942F	Assessments and Evaluations Cyber Vulnerabilities	07	84,908					U
172	0101113F	B-52 Squadrons	07	290,097	323,624			323,624	U
173	0101122F	Air-Launched Cruise Missile (ALCM)	07	5,741	10,217			10,217	U
174	0101126F	B-1B Squadrons	07	58,175	1,000			1,000	U
175	0101127F	B-2 Squadrons	07	101,827	93,076			93,076	U
176	0101213F	Minuteman Squadrons	07	185,640	104,219			104,219	U
177	0101316F	Worldwide Joint Strategic Communications	07	17,767	26,177			26,177	U
178	0101324F	Integrated Strategic Planning & Analysis Network	07	22,231	24,261			24,261	U
179	0101328F	ICBM Reentry Vehicles	07	13,747	65,671			65,671	U
181	0102110F	UH-1N Replacement Program	07	190,523	170,975			170,975	U

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164	0604776F	Deployment & Distribution Enterprise R&D	07	499				499	U
165	0604840F	F-35 C2D2	07	785,336				785,336	U
166	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	07	27,035				27,035	U
167	0605024F	Anti-Tamper Technology Executive Agency	07	50,508				50,508	U
168	0605117F	Foreign Materiel Acquisition and Exploitation	07	71,229				71,229	U
169	0605278F	HC/MC-130 Recap RDT&E	07	24,705				24,705	U
170	0606018F	NC3 Integration	07	26,356				26,356	U
171	0606942F	Assessments and Evaluations Cyber Vulnerabilities	07						U
172	0101113F	B-52 Squadrons	07	520,023				520,023	U
173	0101122F	Air-Launched Cruise Missile (ALCM)	07	1,433				1,433	U
174	0101126F	B-1B Squadrons	07	15,766				15,766	U
175	0101127F	B-2 Squadrons	07	187,399				187,399	U
176	0101213F	Minuteman Squadrons	07	116,569				116,569	U
177	0101316F	Worldwide Joint Strategic Communications	07	27,235				27,235	U
178	0101324F	Integrated Strategic Planning & Analysis Network	07	24,227				24,227	U
179	0101328F	ICBM Reentry Vehicles	07	112,753				112,753	U
181	0102110F	UH-1N Replacement Program	07	44,464				44,464	U

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								Total Enacted S (Base+Emerg+ e OCO)	c
182	0102326F	Region/Sector Operation Control Center Modernization Program	07	5,904					U
183	0102412F	North Warning System (NWS)	07						U
184	0205219F	MQ-9 UAV	07	105,088	127,296			127,296	U
185	0205671F	Joint Counter RCIED Electronic Warfare	07	4,000			4,000	4,000	U
186	0207131F	A-10 Squadrons	07	27,537	31,916			31,916	U
187	0207133F	F-16 Squadrons	07	182,190	193,013			193,013	U
188	0207134F	F-15E Squadrons	07	196,035	684,229			684,229	U
189	0207136F	Manned Destructive Suppression	07	13,609	15,521			15,521	U
190	0207138F	F-22A Squadrons	07	563,635	546,298			546,298	U
191	0207142F	F-35 Squadrons	07	490,319	99,943			99,943	U
192	0207146F	F-15EX	07						U
193	0207161F	Tactical AIM Missiles	07	29,042	10,314			10,314	U
194	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	50,728	55,384			55,384	U
195	0207227F	Combat Rescue - Pararescue	07	623	281			281	U
196	0207247F	AF TENCAP	07		21,365			21,365	U
197	0207249F	Precision Attack Systems Procurement	07	14,346	10,696			10,696	U
198	0207253F	Compass Call	07	43,466	31,888			31,888	U
199	0207268F	Aircraft Engine Component Improvement Program	07	116,808	112,505			112,505	U

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182	0102326F	Region/Sector Operation Control Center Modernization Program	07	5,929				5,929	U
183	0102412F	North Warning System (NWS)	07	100				100	U
184	0205219F	MQ-9 UAV	07	162,080				162,080	U
185	0205671F	Joint Counter RCIED Electronic Warfare	07			4,080	4,080	4,080	U
186	0207131F	A-10 Squadrons	07	24,535				24,535	U
187	0207133F	F-16 Squadrons	07	223,437				223,437	U
188	0207134F	F-15E Squadrons	07	298,908				298,908	U
189	0207136F	Manned Destructive Suppression	07	14,960				14,960	U
190	0207138F	F-22A Squadrons	07	665,038				665,038	U
191	0207142F	F-35 Squadrons	07	132,229				132,229	U
192	0207146F	F-15EX	07	159,761				159,761	U
193	0207161F	Tactical AIM Missiles	07	19,417				19,417	U
194	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	51,799				51,799	U
195	0207227F	Combat Rescue - Pararescue	07	669				669	U
196	0207247F	AF TENCAP	07	21,644				21,644	U
197	0207249F	Precision Attack Systems Procurement	07	9,261				9,261	U
198	0207253F	Compass Call	07	15,854				15,854	U
199	0207268F	Aircraft Engine Component Improvement Program	07	95,896				95,896	U

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200	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	07	40,933	78,498			78,498	U
201	0207410F	Air & Space Operations Center (AOC)	07	98,854	114,864			114,864	U
202	0207412F	Control and Reporting Center (CRC)	07	6,216	8,109			8,109	U
203	0207417F	Airborne Warning and Control System (AWACS)	07	108,795	67,996			67,996	U
204	0207418F	AFSPECWAR - TACP	07	2,562	2,462			2,462	U
206	0207431F	Combat Air Intelligence System Activities	07	10,316	13,668			13,668	U
207	0207438F	Theater Battle Management (TBM) C4I	07						U
208	0207444F	Tactical Air Control Party-Mod	07	6,135	4,117			4,117	U
209	0207448F	C2ISR Tactical Data Link	07	538					U
210	0207452F	DCAPES	07	14,649	19,910			19,910	U
211	0207521F	Air Force Calibration Programs	07						U
212	0207573F	National Technical Nuclear Forensics	07	1,723	1,788			1,788	U
213	0207590F	Seek Eagle	07	24,618	28,237			28,237	U
214	0207601F	USAF Modeling and Simulation	07	16,572	15,725			15,725	U
215	0207605F	Wargaming and Simulation Centers	07	5,916	4,316			4,316	U
216	0207610F	Battlefield Abn Comm Node (BACN)	07	42,349	26,946			26,946	U
217	0207697F	Distributed Training and Exercises	07	3,699	4,303			4,303	U

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200	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	07	70,792				70,792	U
201	0207410F	Air & Space Operations Center (AOC)	07	51,187				51,187	U
202	0207412F	Control and Reporting Center (CRC)	07	16,041				16,041	U
203	0207417F	Airborne Warning and Control System (AWACS)	07	138,303				138,303	U
204	0207418F	AFSPECWAR - TACP	07	4,223				4,223	U
206	0207431F	Combat Air Intelligence System Activities	07	16,564				16,564	U
207	0207438F	Theater Battle Management (TBM) C4I	07	7,858				7,858	U
208	0207444F	Tactical Air Control Party-Mod	07	12,906				12,906	U
209	0207448F	C2ISR Tactical Data Link	07						U
210	0207452F	DCAPES	07	14,816				14,816	U
211	0207521F	Air Force Calibration Programs	07	1,970				1,970	U
212	0207573F	National Technical Nuclear Forensics	07	396				396	U
213	0207590F	Seek Eagle	07	29,680				29,680	U
214	0207601F	USAF Modeling and Simulation	07	17,666				17,666	U
215	0207605F	Wargaming and Simulation Centers	07	6,353				6,353	U
216	0207610F	Battlefield Abn Comm Node (BACN)	07	6,827				6,827	U
217	0207697F	Distributed Training and Exercises	07	3,390				3,390	U

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								Total Enacted (Base+Emerg+ e OCO)	S c
218	0208006F	Mission Planning Systems	07	61,164	71,465			71,465	U
219	0208007F	Tactical Deception	07	6,687	7,446			7,446	U
220	0208064F	OPERATIONAL HQ - CYBER	07		7,602			7,602	U
221	0208087F	Distributed Cyber Warfare Operations	07	38,857	35,178			35,178	U
222	0208088F	AF Defensive Cyberspace Operations	07	36,953	38,609			38,609	U
223	0208097F	Joint Cyber Command and Control (JCC2)	07	12,553	11,603			11,603	U
224	0208099F	Unified Platform (UP)	07	26,093	84,702			84,702	U
228	0208288F	Intel Data Applications	07	1,200			1,200	1,200	U
229	0301017F	Global Sensor Integrated on Network (GSIN)	07	3,468					U
230	0301025F	GeoBase	07		2,723			2,723	U
231	0301112F	Nuclear Planning and Execution System (NPES)	07	28,623	44,190			44,190	U
238	0301401F	Air Force Space and Cyber Non-Traditional ISR for Battlespace Awareness	07	6,633	3,575			3,575	U
239	0302015F	E-4B National Airborne Operations Center (NAOC)	07	55,707	60,173			60,173	U
240	0303131F	Minimum Essential Emergency Communications Network (MEECN)	07	62,146	13,543			13,543	U
241	0303133F	High Frequency Radio Systems	07	49,912	15,881			15,881	U
242	0303140F	Information Systems Security Program	07	35,775	27,726			27,726	U

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218	0208006F	Mission Planning Systems	07	91,768				91,768	U
219	0208007F	Tactical Deception	07	2,370				2,370	U
220	0208064F	OPERATIONAL HQ - CYBER	07	5,527				5,527	U
221	0208087F	Distributed Cyber Warfare Operations	07	68,279				68,279	U
222	0208088F	AF Defensive Cyberspace Operations	07	15,165				15,165	U
223	0208097F	Joint Cyber Command and Control (JCC2)	07	38,480				38,480	U
224	0208099F	Unified Platform (UP)	07	84,645				84,645	U
228	0208288F	Intel Data Applications	07			1,224	1,224	1,224	U
229	0301017F	Global Sensor Integrated on Network (GSIN)	07						U
230	0301025F	GeoBase	07	2,767				2,767	U
231	0301112F	Nuclear Planning and Execution System (NPES)	07	32,759				32,759	U
238	0301401F	Air Force Space and Cyber Non-Traditional ISR for Battlespace Awareness	07	2,904				2,904	U
239	0302015F	E-4B National Airborne Operations Center (NAOC)	07	3,468				3,468	U
240	0303131F	Minimum Essential Emergency Communications Network (MEECN)	07	61,887				61,887	U
241	0303133F	High Frequency Radio Systems	07						U
242	0303140F	Information Systems Security Program	07	10,351				10,351	U

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243	0303142F	Global Force Management - Data Initiative	07	2,108	2,210			2,210	U
245	0304115F	Multi Domain Command and Control (MDC2)	07		100,880			100,880	U
246	0304260F	Airborne SIGINT Enterprise	07	109,838	85,157			85,157	U
247	0304310F	Commercial Economic Analysis	07	4,014	3,431			3,431	U
250	0305015F	C2 Air Operations Suite - C2 Info Services	07	8,324	9,313			9,313	U
251	0305020F	CCMD Intelligence Information Technology	07	1,586	1,121			1,121	U
252	0305022F	ISR Modernization & Automation Dvmt (IMAD)	07		19,000			19,000	U
253	0305099F	Global Air Traffic Management (GATM)	07	3,966	4,544			4,544	U
254	0305103F	Cyber Security Initiative	07						U
255	0305111F	Weather Service	07	33,563	35,461			35,461	U
256	0305114F	Air Traffic Control, Approach, and Landing System (ATCALs)	07	12,873	8,651			8,651	U
257	0305116F	Aerial Targets	07	6,527	7,448			7,448	U
260	0305128F	Security and Investigative Activities	07	403	425			425	U
261	0305145F	Arms Control Implementation	07	24,804	41,546			41,546	U
262	0305146F	Defense Joint Counterintelligence Activities	07	3,845	6,858			6,858	U
264	0305179F	Integrated Broadcast Service (IBS)	07		8,728			8,728	U

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243	0303142F	Global Force Management - Data Initiative	07	1,346				1,346	U
245	0304115F	Multi Domain Command and Control (MDC2)	07						U
246	0304260F	Airborne SIGINT Enterprise	07	128,110				128,110	U
247	0304310F	Commercial Economic Analysis	07	4,042				4,042	U
250	0305015F	C2 Air Operations Suite - C2 Info Services	07						U
251	0305020F	CCMD Intelligence Information Technology	07	1,649				1,649	U
252	0305022F	ISR Modernization & Automation Dvmt (IMAD)	07	19,265				19,265	U
253	0305099F	Global Air Traffic Management (GATM)	07	4,645				4,645	U
254	0305103F	Cyber Security Initiative	07	384				384	U
255	0305111F	Weather Service	07	23,640				23,640	U
256	0305114F	Air Traffic Control, Approach, and Landing System (ATCALs)	07	6,553				6,553	U
257	0305116F	Aerial Targets	07	449				449	U
260	0305128F	Security and Investigative Activities	07	432				432	U
261	0305145F	Arms Control Implementation	07						U
262	0305146F	Defense Joint Counterintelligence Activities	07	4,890				4,890	U
264	0305179F	Integrated Broadcast Service (IBS)	07	8,864				8,864	U

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265	0305202F	Dragon U-2	07	87,618	36,389			36,389	U
266	0305205F	Endurance Unmanned Aerial Vehicles	07	15,000	15,000			15,000	U
267	0305206F	Airborne Reconnaissance Systems	07	195,323	137,909			137,909	U
268	0305207F	Manned Reconnaissance Systems	07	14,223	11,787			11,787	U
269	0305208F	Distributed Common Ground/Surface Systems	07	52,421	25,009			25,009	U
270	0305220F	RQ-4 UAV	07	221,675	191,733			191,733	U
271	0305221F	Network-Centric Collaborative Targeting	07	14,256	10,757			10,757	U
272	0305238F	NATO AGS	07	51,527	32,567			32,567	U
273	0305240F	Support to DCGS Enterprise	07	26,579	37,774			37,774	U
274	0305600F	International Intelligence Technology and Architectures	07	11,564	13,515			13,515	U
275	0305881F	Rapid Cyber Acquisition	07	4,146	4,383			4,383	U
276	0305984F	Personnel Recovery Command & Ctrl (PRC2)	07	2,385	2,133			2,133	U
277	0307577F	Intelligence Mission Data (IMD)	07	5,717	8,614			8,614	U
278	0401115F	C-130 Airlift Squadron	07	58,408	101,425			101,425	U
279	0401119F	C-5 Airlift Squadrons (IF)	07	28,245	10,223			10,223	U
280	0401130F	C-17 Aircraft (IF)	07	43,288	21,101			21,101	U
281	0401132F	C-130J Program	07	9,924	8,640			8,640	U
282	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	07	4,182	5,424			5,424	U

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265	0305202F	Dragon U-2	07	18,660				18,660	U
266	0305205F	Endurance Unmanned Aerial Vehicles	07						U
267	0305206F	Airborne Reconnaissance Systems	07	121,512				121,512	U
268	0305207F	Manned Reconnaissance Systems	07	14,711				14,711	U
269	0305208F	Distributed Common Ground/Surface Systems	07	14,152				14,152	U
270	0305220F	RQ-4 UAV	07	134,589				134,589	U
271	0305221F	Network-Centric Collaborative Targeting	07	15,049				15,049	U
272	0305238F	NATO AGS	07	36,731				36,731	U
273	0305240F	Support to DCGS Enterprise	07	33,547				33,547	U
274	0305600F	International Intelligence Technology and Architectures	07	13,635				13,635	U
275	0305881F	Rapid Cyber Acquisition	07	4,262				4,262	U
276	0305984F	Personnel Recovery Command & Ctrl (PRC2)	07	2,207				2,207	U
277	0307577F	Intelligence Mission Data (IMD)	07	6,277				6,277	U
278	0401115F	C-130 Airlift Squadron	07	41,973				41,973	U
279	0401119F	C-5 Airlift Squadrons (IF)	07	32,560				32,560	U
280	0401130F	C-17 Aircraft (IF)	07	9,991				9,991	U
281	0401132F	C-130J Program	07	10,674				10,674	U
282	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	07	5,507				5,507	U

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Line No	Program Element Number	Item	Act	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted S (Base+Emerg+ e OCO)	c
283	0401218F	KC-135s	07	2,692					U
284	0401219F	KC-10s	07	5,084	20			20	U
285	0401314F	Operational Support Airlift	07	3,059					U
286	0401318F	CV-22	07	15,981	17,906			17,906	U
287	0401840F	AMC Command and Control System	07	1,626					U
288	0408011F	Special Tactics / Combat Control	07	2,322	3,629			3,629	U
289	0702207F	Depot Maintenance (Non-IF)	07	1,880	1,890			1,890	U
290	0708055F	Maintenance, Repair & Overhaul System	07	49,330	10,311			10,311	U
291	0708610F	Logistics Information Technology (LOGIT)	07	13,065	16,065			16,065	U
292	0708611F	Support Systems Development	07	4,406	539			539	U
293	0804743F	Other Flight Training	07	1,948	2,057			2,057	U
294	0808716F	Other Personnel Activities	07	108	10			10	U
295	0901202F	Joint Personnel Recovery Agency	07	1,947	2,060			2,060	U
296	0901218F	Civilian Compensation Program	07	2,849	3,809			3,809	U
297	0901220F	Personnel Administration	07	4,102	6,476			6,476	U
298	0901226F	Air Force Studies and Analysis Agency	07	1,364	1,443			1,443	U
299	0901538F	Financial Management Information Systems Development	07	86,578	9,323			9,323	U
300	0901554F	Defense Enterprise Acntng and Mgt Sys (DEAMS)	07		46,789			46,789	U

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283	0401218F	KC-135s	07	4,591				4,591	U
284	0401219F	KC-10s	07						U
285	0401314F	Operational Support Airlift	07						U
286	0401318F	CV-22	07	18,419				18,419	U
287	0401840F	AMC Command and Control System	07						U
288	0408011F	Special Tactics / Combat Control	07	7,673				7,673	U
289	0702207F	Depot Maintenance (Non-IF)	07						U
290	0708055F	Maintenance, Repair & Overhaul System	07	24,513				24,513	U
291	0708610F	Logistics Information Technology (LOGIT)	07	35,225				35,225	U
292	0708611F	Support Systems Development	07	11,838				11,838	U
293	0804743F	Other Flight Training	07	1,332				1,332	U
294	0808716F	Other Personnel Activities	07						U
295	0901202F	Joint Personnel Recovery Agency	07	2,092				2,092	U
296	0901218F	Civilian Compensation Program	07	3,869				3,869	U
297	0901220F	Personnel Administration	07	1,584				1,584	U
298	0901226F	Air Force Studies and Analysis Agency	07	1,197				1,197	U
299	0901538F	Financial Management Information Systems Development	07	7,006				7,006	U
300	0901554F	Defense Enterprise Acntng and Mgt Sys (DEAMS)	07	45,638				45,638	U

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Line No	Program Element Number	Item	Act	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted S (Base+Emerg+ e OCO)	c
301	1201017F	Global Sensor Integrated on Network (GSIN)	07		3,647			3,647	U
302	1201921F	Service Support to STRATCOM - Space Activities	07	28,636	988			988	U
303	1202140F	Service Support to SPACECOM Activities	07		11,863			11,863	U
304	1202247F	AF TENCAP	07	31,986					U
305	1203001F	Family of Advanced BLoS Terminals (FAB-T)	07	58,582	195,288			195,288	U
306	1203110F	Satellite Control Network (SPACE)	07	26,374	57,891			57,891	U
308	1203165F	NAVSTAR Global Positioning System (Space and Control Segments)	07	8,610					U
309	1203173F	Space and Missile Test and Evaluation Center	07	69,785	4,566			4,566	U
310	1203174F	Space Innovation, Integration and Rapid Technology Development	07	20,250	33,292			33,292	U
311	1203179F	Integrated Broadcast Service (IBS)	07	9,887					U
312	1203182F	Spacelift Range System (SPACE)	07	20,168	5,837			5,837	U
313	1203265F	GPS III Space Segment	07	136,998	42,440			42,440	U
314	1203400F	Space Superiority Intelligence	07	16,278	14,428			14,428	U
315	1203614F	JSpOC Mission System	07	43,108	85,762			85,762	U
316	1203620F	National Space Defense Center	07	53,305	2,653			2,653	U
317	1203873F	Ballistic Missile Defense Radars	07		15,881			15,881	U
318	1203906F	NCMC - TW/AA System	07						U

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Line No	Program Element Number	Item	Act	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)	Se
301	1201017F	Global Sensor Integrated on Network (GSIN)	07	1,889				1,889	U
302	1201921F	Service Support to STRATCOM - Space Activities	07	993				993	U
303	1202140F	Service Support to SPACECOM Activities	07	8,999				8,999	U
304	1202247F	AF TENCAP	07						U
305	1203001F	Family of Advanced BLoS Terminals (FAB-T)	07						U
306	1203110F	Satellite Control Network (SPACE)	07						U
308	1203165F	NAVSTAR Global Positioning System (Space and Control Segments)	07						U
309	1203173F	Space and Missile Test and Evaluation Center	07						U
310	1203174F	Space Innovation, Integration and Rapid Technology Development	07						U
311	1203179F	Integrated Broadcast Service (IBS)	07						U
312	1203182F	Spacelift Range System (SPACE)	07						U
313	1203265F	GPS III Space Segment	07						U
314	1203400F	Space Superiority Intelligence	07	16,810				16,810	U
315	1203614F	JSpOC Mission System	07						U
316	1203620F	National Space Defense Center	07	2,687				2,687	U
317	1203873F	Ballistic Missile Defense Radars	07						U
318	1203906F	NCCM - TW/AA System	07	6,990				6,990	U

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Line No	Element Number	Program Item	Act	FY 2019 (Base + OCO)	FY 2020 Base Enacted	FY 2020 Emergency	FY 2020 OCO Enacted	FY 2020 Total Enacted S (Base+Emerg+ e OCO) c
319	1203913F	NUDET Detection System (SPACE)	07	21,578	49,300			49,300 U
320	1203940F	Space Situation Awareness Operations	07	18,920	17,834			17,834 U
321	1206423F	Global Positioning System III - Operational Control Segment	07	491,601	445,302			445,302 U
322	1206770F	Enterprise Ground Services	07		118,870			118,870 U
9999	9999999999	Classified Programs		16,832,438	17,785,996		78,713	17,864,709 U
		Operational Systems Development		22,982,541	24,480,992		83,913	24,564,905
Total Research, Development, Test & Eval, AF				41,419,014	45,566,955		128,248	45,695,203

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Line No	Program Element Number	Item	Act	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)	See
319	1203913F	NUDET Detection System (SPACE)	07						U
320	1203940F	Space Situation Awareness Operations	07						U
321	1206423F	Global Positioning System III - Operational Control Segment	07						U
322	1206770F	Enterprise Ground Services	07						U
9999	9999999999	Classified Programs		15,777,856				15,777,856	U
		Operational Systems Development		21,466,680		5,304	5,304	21,471,984	
		Total Research, Development, Test & Eval, AF		37,391,826		5,304	5,304	37,397,130	

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Summary Recap of Budget Activities -----					
Applied Research					
Advanced Component Development & Prototypes					
System Development & Demonstration					
Management Support					
Operational System Development					
Software & Digital Technology Pilot Programs					
Total Research, Development, Test & Evaluation					
Summary Recap of FYDP Programs -----					
Space					
Classified Programs					
Total Research, Development, Test & Evaluation					

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	FY 2021 Base	FY 2021 OCO for Base Requirements	FY 2021 OCO for Direct War and Enduring Costs	FY 2021 Total OCO	FY 2021 Total (Base + OCO)
Summary Recap of Budget Activities -----					
Applied Research	130,874				130,874
Advanced Component Development & Prototypes	1,311,311				1,311,311
System Development & Demonstration	3,744,016				3,744,016
Management Support	258,510				258,510
Operational System Development	4,733,142				4,733,142
Software & Digital Technology Pilot Programs	149,742				149,742
Total Research, Development, Test & Evaluation	10,327,595				10,327,595
Summary Recap of FYDP Programs -----					
Space	6,694,729				6,694,729
Classified Programs	3,632,866				3,632,866
Total Research, Development, Test & Evaluation	10,327,595				10,327,595

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18	03	0603032F	Future AF Integrated Technology Demos.....	Volume 1 - 257
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21	03	0603035F	Next Gen Effects Dev/Demos.....	Volume 1 - 315
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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force / BA 1: Basic Research</i>	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	374.047	356.107	315.348	0.000	315.348	331.452	367.809	381.631	362.629	Continuing	Continuing
613001: <i>Physics and Electronics</i>	-	110.757	105.346	91.504	0.000	91.504	96.609	108.465	112.774	109.771	Continuing	Continuing
613002: <i>Aerospace, Chemical and Material Sciences</i>	-	115.888	109.915	96.084	0.000	96.084	101.264	113.213	117.619	113.427	Continuing	Continuing
613003: <i>Mathematics, Information and Life Sciences</i>	-	111.670	105.513	91.504	0.000	91.504	96.743	108.594	112.947	110.719	Continuing	Continuing
613004: <i>Education and Outreach</i>	-	35.732	35.333	36.256	0.000	36.256	36.836	37.537	38.291	28.712	Continuing	Continuing

A. Mission Description and Budget Item Justification

Defense Research Sciences consists of extramural research activities in academia and industry along with in-house investigations performed in the Air Force Research Laboratory (AFRL). This program supports fundamental broad-based scientific and engineering research in areas critical to Air Force weapon, sensor, and support systems. All research areas are subject to long-range planning and technical review by both Air Force and tri-Service scientific planning groups. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F, and 1206601SF.

This program is in Budget Activity 1, Basic Research because this budget activity includes scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 1: <i>Basic Research</i>	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	383.322	356.107	363.097	0.000	363.097
Current President's Budget	374.047	356.107	315.348	0.000	315.348
Total Adjustments	-9.275	0.000	-47.749	0.000	-47.749
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-9.820	0.000			
• Other Adjustments	0.545	0.000	-47.749	0.000	-47.749

Congressional Add Details (\$ in Millions, and Includes General Reductions)

	FY 2019	FY 2020
Project: 613001: <i>Physics and Electronics</i>		
Congressional Add: <i>Program Increase - Basic Research</i>	10.718	0.000
Congressional Add Subtotals for Project: 613001	10.718	0.000
Project: 613002: <i>Aerospace, Chemical and Material Sciences</i>		
Congressional Add: <i>Program Increase - Basic Research</i>	10.718	0.000
Congressional Add Subtotals for Project: 613002	10.718	0.000
Project: 613003: <i>Mathematics, Information and Life Sciences</i>		
Congressional Add: <i>Program Increase - Basic Research</i>	10.718	0.000
Congressional Add Subtotals for Project: 613003	10.718	0.000
Project: 613004: <i>Education and Outreach</i>		
Congressional Add: <i>Program Increase - Basic Research</i>	1.949	0.000
Congressional Add Subtotals for Project: 613004	1.949	0.000
Congressional Add Totals for all Projects	34.103	0.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 1: <i>Basic Research</i>	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	
<u>Change Summary Explanation</u> Decrease in FY 2021 of \$47.749 million is due to civilian pay reprice adjustments and reduced emphasis in Defense Research Sciences projects/efforts based on higher Department of Defense and Air Force priorities.		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 1					R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>				Project (Number/Name) 613001 / <i>Physics and Electronics</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
613001: <i>Physics and Electronics</i>	-	110.757	105.346	91.504	0.000	91.504	96.609	108.465	112.774	109.771	Continuing	Continuing

A. Mission Description and Budget Item Justification

Basic research in the Physics and Electronics Project seeks to enable revolutionary advances and expand the fundamental knowledge supporting technologies critical to the future of the Air Force. Research stresses high-risk, far-term, game-changing capability breakthroughs essential for future leaps in warfighter system performance, functionality, reliability, and survivability while simultaneously reducing component and system power, size, mass, and life cycle costs. Major areas being investigated in this project are complex electronics and fundamental quantum processes; plasma physics and high energy density non-equilibrium processes; and lasers and optics, electromagnetics, communication, and signal processing. While the following specific sub-areas are the focus of the project, there is interest in exploring novel ideas that may bridge these major efforts as well as those in the other projects within this program.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Complex Electronics and Fundamental Quantum Processes</p> <p>Description: Scientific focus areas are atomic and molecular physics, photonics, quantum electronic solids, gigahertz-terahertz electronics and material, semiconductor and electromagnetic materials, and optoelectronics.</p> <p>FY 2020 Plans: Explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, metamaterials, cathodes, dielectric and magnetic materials, memristive systems, new classes of high-temperature, superconductors, quantum dots, quantum wells and graphene. Includes generating and controlling quantum states, such as superposition and entanglement, in photonic systems, quantum dots and defects in solids, and ultracold atoms and molecules.</p> <p>FY 2021 Plans: Continue to explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, metamaterials, cathodes, dielectric and magnetic materials, memristive systems, new classes of high-temperature superconductors, quantum dots, quantum wells and graphene. Includes generating and controlling quantum states, such as superposition and entanglement, in photonic systems, quantum dots and defects in solids, and ultracold atoms and molecules.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.603 million. Funding decreased due civilian pay reprice adjustments and reduced emphasis in Electronics and Fundamental Quantum Processes research based on higher Department of Defense and Air Force priorities.</p>	39.024	42.639	37.036
<p>Title: Plasma Physics and High Energy Density Non-Equilibrium Processes</p> <p>Description: Scientific focus areas are plasma, electro-energetic physics and space sciences.</p>	21.371	21.964	19.078

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613001 / <i>Physics and Electronics</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> Explore a wide range of activities characterized by processes sufficiently energetic to require understanding and managing plasma phenomenology and the non-linear response of materials to high electric and magnetic fields. Includes space weather, plasma discharges, radio frequency propagation, radio frequency-plasma interaction, and high-power, beam-driven microwave devices.</p> <p><i>FY 2021 Plans:</i> Continue to explore a wide range of activities characterized by processes sufficiently energetic to require understanding and managing plasma phenomenology and the non-linear response of materials to high electric and magnetic fields. Includes space weather, plasma discharges, radio frequency propagation, radio frequency-plasma interaction, and high-power, beam-driven microwave devices.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$2.886 million. Funding decreased due civilian pay reprice adjustments and reduced emphasis in Plasma Physics and High Energy Density Non-Equilibrium Processes research based on higher Department of Defense and Air Force priorities.</p>			
<p><i>Title:</i> Lasers and Optics, Electromagnetics, Communication and Signal Processing</p> <p><i>Description:</i> Scientific focus areas are physical mathematics and applied analysis, novel computational methods, electromagnetics and wave propagation in complex media, ultra-fast dynamics, for revolutionary approaches to remote sensing and imaging physics, and surveillance and navigation.</p> <p><i>FY 2020 Plans:</i> Explore all aspects of producing and receiving electromagnetic and electro-optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Investigate aspects of the phenomenology of lasers including high energy lasers, non-linear optics, and ultra-short pulse laser science. Includes the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals.</p> <p><i>FY 2021 Plans:</i> Continue to explore all aspects of producing and receiving electromagnetic and electro-optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Continue to investigate aspects of the phenomenology of lasers including high energy lasers, non-linear optics, and ultra-short pulse laser science. Includes the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i></p>	39.644	40.743	35.390

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613001 / <i>Physics and Electronics</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$5.353 million. Funding decreased due to civilian pay reprice adjustments and reduced emphasis in Lasers and Optics, Electromagnetics, Communication and Signal Processing research based on higher Department of Defense and Air Force priorities.			
Accomplishments/Planned Programs Subtotals	100.039	105.346	91.504

	FY 2019	FY 2020
Congressional Add: Program Increase - Basic Research	10.718	0.000
FY 2019 Accomplishments: Conducted Congressionally directed effort.		
FY 2020 Plans: Not applicable		
Congressional Adds Subtotals	10.718	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 1					R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>				Project (Number/Name) 613002 / <i>Aerospace, Chemical and Material Sciences</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
613002: <i>Aerospace, Chemical and Material Sciences</i>	-	115.888	109.915	96.084	0.000	96.084	101.264	113.213	117.619	113.427	Continuing	Continuing

A. Mission Description and Budget Item Justification

Basic research in the Aerospace, Chemical, and Materials Sciences Project seeks to enable revolutionary advances and expand the fundamental knowledge supporting technologies critical to the future of the Air Force. Research stresses high-risk, far-term, game-changing capability breakthroughs essential for future leaps in warfighter system performance, functionality, reliability, and survivability while simultaneously reducing component and system power, size, mass, and life cycle costs. Research topics include: aero-structure interactions and control; energy, power, and propulsion; complex materials and structures; and cross-disciplinary research reflecting the highly integrated nature of future weapon systems.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Aero Structure Interactions and Control	29.170	32.397	28.320
Description: Scientific focus areas are high temperature aerospace materials, non-equilibrium aerothermodynamics and chemistry, unsteady, compressible flow turbulence, multiscale fluid-material interactions, and flow control.			
FY 2020 Plans: Investigate the characterization, modeling, and exploitation of interactions between the unsteady aerodynamic flow field and the dynamic air vehicle structure to enable enhanced performance in next generation Air Force systems. Explore the synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, high-performance structures, and thermodynamics.			
FY 2021 Plans: Continue to investigate the characterization, modeling, and exploitation of interactions between the unsteady aerodynamic flow field and the dynamic air vehicle structure to enable enhanced performance in next generation Air Force systems. Continue to explore the synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, high-performance structures, and thermodynamics.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.077 million. Funding decreased due to civilian pay reprice adjustments and reduced emphasis in Aero Structure Interactions and Control research based on higher Department of Defense and Air Force priorities.			
Title: Energy, Power, and Propulsion	34.269	34.953	30.555

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613002 / <i>Aerospace, Chemical and Material Sciences</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Scientific focus areas are thermal control, theoretical chemistry, molecular dynamics, space power and propulsion, and combustion and diagnostics.</p> <p>FY 2020 Plans: Exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hydrodynamics, structural dynamics, and multi-fidelity simulations. Investigate processes associated with the generation, storage, and utilization of energy, specifically for Air Force systems. This includes developing novel energetic materials as well as understanding optimizing and controlling combustion processes.</p> <p>FY 2021 Plans: Continue to exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hydrodynamics, structural dynamics, and multi-fidelity simulations. Continue to investigate processes associated with the generation, storage, and utilization of energy, specifically for Air Force systems including developing novel energetic materials as well as understanding optimizing and controlling combustion processes.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.398 million. Funding decreased due to civilian pay reprice adjustments and reduced emphasis in Energy, Power, and Propulsion research based on higher Department of Defense and Air Force priorities.</p>			
<p>Title: Complex Materials and Structures</p> <p>Description: Scientific focus areas are design, manufacturing, and dynamics and control of multifunctional materials and microsystems, multi-scale mechanics, diagnostics and prognosis, and physico-chemistry of novel organic materials.</p> <p>FY 2020 Plans: Investigate multifunctional materials and structures composed of different classes of materials, both organic and inorganic, that can adapt to environmental constraints or mission requirements. Explore complex materials, microsystems, and structures that incorporate hierarchical design and functionality from the nano-scale through the mesoscale, ultimately leading to controlled, well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility.</p> <p>FY 2021 Plans: Continue to investigate multifunctional materials and structures composed of different classes of materials, both organic and inorganic, that can adapt to environmental constraints or mission requirements. Continue to explore complex materials, microsystems, and structures that incorporate hierarchical design and functionality from the nano-scale through the mesoscale,</p>	41.731	42.565	37.209

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613002 / <i>Aerospace, Chemical and Material Sciences</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
ultimately leading to controlled, well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$5.356 million. Funding decreased due to civilian pay reprice adjustments and reduced emphasis in Complex Materials and Structures research based on higher Department of Defense and Air Force priorities.			
Accomplishments/Planned Programs Subtotals	105.170	109.915	96.084

	FY 2019	FY 2020
<i>Congressional Add:</i> Program Increase - Basic Research	10.718	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed effort.		
<i>FY 2020 Plans:</i> Not applicable		
Congressional Adds Subtotals	10.718	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 1					R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>					Project (Number/Name) 613003 / <i>Mathematics, Information and Life Sciences</i>		
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
613003: <i>Mathematics, Information and Life Sciences</i>	-	111.670	105.513	91.504	0.000	91.504	96.743	108.594	112.947	110.719	Continuing	Continuing

A. Mission Description and Budget Item Justification

Basic research in the Mathematics, Information Sciences, and Life Sciences seeks to expand fundamental knowledge and enable revolutionary advances and supporting technologies critical to the future of the Air Force. Major areas being investigated in this project are data fusion, machine learning and artificial intelligence, information and complex networks, cyber-security, autonomous decision making, dynamical systems, optimization and control, and natural materials and systems. While the following are specific sub-areas within this project, there is a continuing interest to explore novel ideas to bridge disciplines within this program.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Information and Complex Networks	23.883	26.898	23.327
Description: Scientific focus areas are information operations and security, data and information fusion, advanced computing, artificial intelligence and complex networks.			
FY 2020 Plans: Design and analyze techniques to enable reliable and secure exchange of information and predictable operation of networks and systems, including hardware and software interactions. This includes traditional aspects of information assurance, but with an emphasis on the underlying mathematics of secure-by-design architectures of networked communications and neural information processing. Analyze, optimize and design multi-scale networks with resilient features against noise and corruption from difficult environments and adversarial operations, using rigorous mathematical models of information exchange, physical operations, and human-machine interactions. Develop new computing approaches and algorithms for network-of-network information processing at the speed of warfare. Develop new mathematical approaches for predictive, multi-scale and multi-physics simulations of Air Force systems and systems-of-systems in realistic environments.			
FY 2021 Plans: Continue to design and analyze techniques to enable reliable and secure exchange of information and predictable operation of networks and systems, including hardware and software interactions, including traditional aspects of information assurance, but with an emphasis on the underlying mathematics of secure-by-design architectures of networked communications and neural information processing. Continue to analyze, optimize and design multi-scale networks with resilient features against noise and corruption from difficult environments and adversarial operations, using rigorous mathematical models of information exchange, physical operations, and human-machine interactions. Continue to develop new computing approaches and algorithms for			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613003 / <i>Mathematics, Information and Life Sciences</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
network-of-network information processing at the speed of warfare and new mathematical approaches for predictive, multi-scale and multi-physics simulations of Air Force systems and systems-of-systems in realistic environments. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$3.571 million. Funding decreased due to civilian pay reprice adjustments and reduced emphasis in Information and Complex Networks research based on higher Department of Defense and Air Force priorities.				
Title: Decision Making Description: Scientific focus areas are mathematical modeling of cognition and decision making, development and testing of advanced representations and processes for higher-level artificial intelligence, trust between humans and autonomous agents, mixed human-machine decision making, and computational social science for asymmetric threat detection and predictive large-scale influence. FY 2020 Plans: Investigate new mathematical laws, scientific principles, and robust algorithms that underlie intelligent, mixed human-machine decision-making to achieve accurate real-time integration of human expertise and knowledge into a machine-based battlespace network. Develop new mathematical models for information capture; object, scene and relation identification; and multi-level reasoning and meta-learning. Advance the critical knowledge base in modeling of individual and group cognitive processing and decision making, and construct advanced methodologies for predictive, verifiable simulations of large-scale socio-cultural and human-machine hybrid networks. FY 2021 Plans: Continue to investigate new mathematical laws, scientific principles, and robust algorithms that underlie intelligent, mixed human-machine decision-making to achieve accurate real-time integration of human expertise and knowledge into a machine-based battlespace network. Continue to develop new mathematical models for information capture; object, scene and relation identification; and multi-level reasoning and meta-learning. Continue to advance the critical knowledge base in modeling of individual and group cognitive processing and decision making, and construct advanced methodologies for predictive, verifiable simulations of large-scale socio-cultural and human-machine hybrid networks. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$2.785 million. Funding decreased due to civilian pay reprice adjustments and reduced emphasis in Information and Complex Networks research based on higher Department of Defense and Air Force priorities.		20.565	20.978	18.193
Title: Dynamical Systems, Optimization, and Control		27.180	27.725	24.044

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613003 / <i>Mathematics, Information and Life Sciences</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Scientific focus areas are computer models of dynamical data and communication networks, data-fusion, dynamics and control theory for multi-scale and complex networks, and mathematics of distributed optimization in uncertain, variable, continuous and discrete networked systems. Includes the development of advanced computing architectures for solving optimization and data-fusion problems in real time and by embedded processors in autonomous or semi-autonomous platforms.</p> <p>FY 2020 Plans: Develop new scientific concepts supported by rigorous analysis for advancing the science of autonomy and promoting the understanding necessary to analyze and design complex multi-scale systems as well as provide guaranteed levels of performance. Develop novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments.</p> <p>FY 2021 Plans: Continue to develop new scientific concepts supported by rigorous analysis for advancing the science of autonomy and promoting the understanding necessary to analyze and design complex multi-scale systems as well as provide guaranteed levels of performance. Continue to develop novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$3.681 million. Funding decreased due to civilian pay reprice adjustments and reduced emphasis in Dynamical Systems, Optimization, and Control research based on higher Department of Defense and Air Force priorities.</p>			
<p>Title: Natural Materials and Systems</p> <p>Description: Scientific focus areas are natural materials and nature inspired systems, human performance and biosystems, cognitive neuroscience and biophysics.</p> <p>FY 2020 Plans: Investigate multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems are built, assembled and organized, and functioning to accomplish their objectives. Develop fundamental understanding of bio-chemical mechanisms and control procedures for the production and manufacture of natural materials, and develop reverse-engineering approaches to optimize the bio-chemical functionality. Develop approaches to adapt, blend and mimic existing natural sensory systems and neural systems of varying complexity, to add existing capabilities to these organisms and design in-silico replicas with similar or advanced capabilities.</p> <p>FY 2021 Plans:</p>	29.324	29.912	25.940

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613003 / <i>Mathematics, Information and Life Sciences</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Continue to investigate multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems are built, assembled and organized, and functioning to accomplish their objectives. Continue to develop fundamental understanding of bio-chemical mechanisms and control procedures for the production and manufacture of natural materials, and develop reverse-engineering approaches to optimize the bio-chemical functionality. Continue to develop approaches to adapt, blend and mimic existing natural sensory systems and neural systems of varying complexity, to add existing capabilities to these organisms and design in-silico replicas with similar or advanced capabilities.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$3.972 million. Funding decreased due to civilian pay reprice adjustments and reduced emphasis in Natural Materials and Systems research based on higher Department of Defense and Air Force priorities.			
Accomplishments/Planned Programs Subtotals	100.952	105.513	91.504

	FY 2019	FY 2020
<i>Congressional Add:</i> Program Increase - Basic Research	10.718	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed effort.		
<i>FY 2020 Plans:</i> Not applicable		
Congressional Adds Subtotals	10.718	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 1					R-1 Program Element (Number/Name) PE 0601102F / Defense Research Sciences				Project (Number/Name) 613004 / Education and Outreach			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
613004: <i>Education and Outreach</i>	-	35.732	35.333	36.256	0.000	36.256	36.836	37.537	38.291	28.712	Continuing	Continuing

A. Mission Description and Budget Item Justification

The major efforts in the Science and Technology (S&T) Education and Outreach Project are to facilitate interactions between the international and domestic research communities and Air Force researchers, and to support and develop scientists and engineers with an awareness of Air Force basic research priorities. These professional interactions and collaborations benefit the Air Force by increasing awareness of Air Force basic research priorities in the research community as a whole, and attracting talented scientists and engineers to address Air Force needs. International interactions facilitate future interoperability of coalition systems and foster relationships with future coalition partners. This project also seeks to enhance interactions with Historically Black Colleges and Universities, Hispanic serving institutions, and other minority institutions.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Outreach to International S&T Community	11.355	12.441	12.766
Description: Foster international S&T cooperation by supporting direct interchanges with a broad range of key international researchers and communities. Identify and leverage international scientific advances when appropriate.			
FY 2020 Plans: Leverage international expertise and support international technology liaison missions to identify and maintain awareness of foreign science and technology developments. Explore current foreign investments and influence world-class scientific research on specific topics of Air Force interest. Pursue access to technical information on foreign research capabilities within our interests. Support international visits by scientists and high-level DoD science and technology delegations, and provide primary interface to coordinate international science and technology participation among DoD organizations.			
FY 2021 Plans: Continue to leverage international expertise and support international technology liaison missions to identify and maintain awareness of foreign science and technology developments. Continue to explore current foreign investments and influence world-class scientific research on specific topics of Air Force interest. Continue to pursue access to technical information on foreign research capabilities within our interests. Continue to support international visits by scientists and high-level DoD science and technology delegations, and provide primary interface to coordinate international science and technology participation among DoD organizations.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.325 million. Justification for the increase is described in the plans above.			
Title: Outreach to U.S. S&T Workforce	22.428	22.892	23.490

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613004 / <i>Education and Outreach</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Strengthen science, mathematics, and engineering research and infrastructure in the U.S., thereby strengthening current and future Air Force S&T capabilities.</p> <p>FY 2020 Plans: Identifying, recruiting, and increasing opportunities for new young investigators to participate in critical Air Force research. Support science, mathematics, and engineering research including Historically Black Colleges and Universities, Hispanic serving institutions, and other minority institutions. Support science activities that encourage elementary/middle/high school youths to develop an interest in and pursue higher education and employment in the science, mathematics, and engineering fields.</p> <p>FY 2021 Plans: Continue identifying, recruiting, and increasing opportunities for new young investigators to participate in critical Air Force research. Support science, mathematics, and engineering research including Historically Black Colleges and Universities, Hispanic serving institutions, and other minority institutions. Continue to support science activities that encourage elementary/middle/high school youths to develop an interest in and pursue higher education and employment in the science, mathematics, and engineering fields.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.598 million. Justification for the increase is described in the plans above.</p>			
Accomplishments/Planned Programs Subtotals	33.783	35.333	36.256

	FY 2019	FY 2020
Congressional Add: Program Increase - Basic Research	1.949	0.000
FY 2019 Accomplishments: Conducted Congressionally directed effort.		
FY 2020 Plans: Not applicable		
Congressional Adds Subtotals	1.949	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>	R-1 Program Element (Number/Name) PE 0601103F / <i>University Research Initiatives</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	159.073	178.859	161.861	0.000	161.861	165.083	168.248	171.615	150.000	Continuing	Continuing
615094: <i>University Research Initiatives</i>	-	159.073	178.859	161.861	0.000	161.861	165.083	168.248	171.615	150.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program supports defense-related basic research in a wide range of scientific and engineering disciplines relevant to maintaining U.S. military technology superiority. Research topics include, but are not limited to, transformational and high priority technologies such as nanotechnology, sensor networks, artificial intelligence and information fusion, smart materials and structures, quantum materials and processes for sensing, communication and computing, efficient energy and power conversion, and high-energy materials for propulsion and control. The program also enhances and promotes the education of U.S. scientists and engineers in disciplines critical to maintaining, advancing, and enabling future U.S. defense technologies. For example, the National Defense Science and Engineering Graduate (NDSEG) program awards fellowships to train U.S. citizens in science and engineering disciplines of military importance under a joint tri-Service and Office of the Assistant Secretary of Defense for Research and Engineering competitive scholarship program. Finally, this program assists universities in establishing superior instrumentation capabilities needed to improve the quality of defense-related research and education. A fundamental component of this program is the recognition that future technologies and technology exploitations require highly coordinated and concerted multi- and inter-disciplinary efforts. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F and 1206601SF.

This program is in Budget Activity 1, Basic Research because this budget activity includes scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 1: <i>Basic Research</i>	R-1 Program Element (Number/Name) PE 0601103F / <i>University Research Initiatives</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	164.991	158.859	161.914	0.000	161.914
Current President's Budget	159.073	178.859	161.861	0.000	161.861
Total Adjustments	-5.918	20.000	-0.053	0.000	-0.053
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	20.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-5.918	0.000			
• Other Adjustments	0.000	0.000	-0.053	0.000	-0.053

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 615094: *University Research Initiatives*

Congressional Add: *Program Increase - Basic Research*

Congressional Add Subtotals for Project: 615094

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	9.621	20.000
Congressional Add Subtotals for Project: 615094	9.621	20.000
Congressional Add Totals for all Projects	9.621	20.000

C. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Multidisciplinary University Research Initiative	78.906	86.552	88.286
Description: Promote fundamental, multi- and interdisciplinary science and engineering research projects involving multiple principle investigators.			
FY 2020 Plans: Fund competitive research grants at U.S. universities that focus on significantly expanding the basic knowledge of Air Force-relevant science and technology areas, not normally achievable in smaller funded, single investigator awards. Support and recognize superior academic researchers in the early stages of their careers through the Presidential Early Career Award for Scientists and Engineers program. Fund existing multi-year awards of multi-disciplinary programs.			
FY 2021 Plans: Continue funding competitive research grants at U.S. universities that focus on significantly expanding the basic knowledge of Air Force-relevant science and technology areas, not normally achievable in smaller funded, single investigator awards. Continue to			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 1: <i>Basic Research</i>		R-1 Program Element (Number/Name) PE 0601103F / <i>University Research Initiatives</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
support and recognize superior academic researchers in the early stages of their careers through the Presidential Early Career Award for Scientists and Engineers program. Continue funding of existing multi-year awards of multi-disciplinary programs. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.734 million. Funding increased due to added emphasis in multidisciplinary university research and the Presidential Early Career Award for Scientists and Engineers program.				
Title: Science and Engineering Education Description: Support post-graduate, graduate, and undergraduate education in science and engineering disciplines at U.S. universities. FY 2020 Plans: Award highly competitive National Defense Science and Engineering Graduate fellowships. Support competitive awards for graduate and undergraduate research experiences, including those established under the Awards to Stimulate and Support Undergraduate Research Experiences program. Fund awards initiated under prior year DoD programs. FY 2021 Plans: Continue to award highly competitive National Defense Science and Engineering Graduate fellowships. Continue to support competitive awards for graduate and undergraduate research experiences, including those established under the Awards to Stimulate and Support Undergraduate Research Experiences program. Continue funding for awards initiated under prior year DoD programs. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.000 million. Funding increased due to added emphasis in National Defense Science and Engineering Graduate and undergraduate research awards.		55.652	57.041	58.041
Title: Research Instrumentation Description: Enhance scientific and engineering research through advanced education infrastructure and instrumentation at U.S. universities. FY 2020 Plans: Award grants on a competitive basis under the Defense University Research Instrumentation Program to U.S. universities to acquire state-of-the-art, high technology instrumentation and infrastructure to enhance research and educational capabilities. FY 2021 Plans:		14.894	15.266	15.534

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 1: <i>Basic Research</i>	R-1 Program Element (Number/Name) PE 0601103F / <i>University Research Initiatives</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Continue to award grants on a competitive basis under the Defense University Research Instrumentation Program to U.S. universities to acquire state-of-the-art, high technology instrumentation and infrastructure to enhance research and educational capabilities.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$0.268 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	149.452	158.859	161.861

	FY 2019	FY 2020
<i>Congressional Add:</i> Program Increase - Basic Research	9.621	20.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed effort		
<i>FY 2020 Plans:</i> Conduct Congressionally directed effort		
Congressional Adds Subtotals	9.621	20.000

D. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>	R-1 Program Element (Number/Name) PE 0601108F / <i>High Energy Laser Research Initiatives</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	12.103	14.795	15.085	0.000	15.085	15.397	15.703	16.017	16.342	Continuing	Continuing
615097: <i>Joint Directed Energy Basic Research</i>	-	12.103	14.795	15.085	0.000	15.085	15.397	15.703	16.017	16.342	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program funds basic research aimed at developing fundamental scientific knowledge to support future Department of Defense Directed Energy Weapon systems through the Joint Directed Energy Transition Office. This program funds multi-disciplinary research institutes to conduct research on laser, laser beam control and high power microwave technologies. In addition, this program supports educational grants to stimulate student interest in directed energy and encourage graduate research in topics related to high energy lasers and high power microwaves. These educational grants are used for educational tools, scholarships, and summer intern employees in military laboratories. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In FY 2021, Project 615097 is renamed from High Energy Research Initiatives to Joint Directed Energy Basic Research. This project name change reflects the direction in the 2017 and 2018 National Defense Authorization Acts.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 1, Basic Research because this budget activity includes scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force				Date: February 2020		
Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research		R-1 Program Element (Number/Name) PE 0601108F I High Energy Laser Research Initiatives				
B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	
Previous President's Budget	13.016	14.795	15.090	0.000	15.090	
Current President's Budget	12.103	14.795	15.085	0.000	15.085	
Total Adjustments	-0.913	0.000	-0.005	0.000	-0.005	
• Congressional General Reductions	0.000	0.000				
• Congressional Directed Reductions	0.000	0.000				
• Congressional Rescissions	0.000	0.000				
• Congressional Adds	0.000	0.000				
• Congressional Directed Transfers	0.000	0.000				
• Reprogrammings	0.000	0.000				
• SBIR/STTR Transfer	-0.478	0.000				
• Other Adjustments	-0.435	0.000	-0.005	0.000	-0.005	
C. Accomplishments/Planned Programs (\$ in Millions)				FY 2019	FY 2020	FY 2021
Title: Directed Energy Sources and Devices				5.598	6.766	6.910
Description: Improve the fundamental understanding and modeling of high energy laser and high power microwave sources and devices.						
FY 2020 Plans: Continue investigations into innovative laser technologies, in diode-pumped lasers, fiber, and solid state laser technologies. Continue investigations into innovative microwave technologies, in microwave sources, antennas, and related microwave component technologies. Continue overseas efforts to leverage international technology advancements. Continue investigations into innovative high power laser and high power microwave technologies.						
FY 2021 Plans: Continue investigations into innovative laser technologies, in diode-pumped lasers, fiber, and solid state laser technologies. Continue investigations into innovative microwave technologies, in microwave sources, antennas, and related microwave component technologies. Continue overseas efforts to leverage international technology advancements. Continue investigations into innovative high power laser and high power microwave technologies.						
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.144 million. Justification for the increase described in the plans above.						
Title: Directed Energy Propagation Technologies				5.461	6.779	6.925

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>		R-1 Program Element (Number/Name) PE 0601108F / <i>High Energy Laser Research Initiatives</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Description: Improve the fundamental understanding and modeling of beam control technologies as they relate to high energy laser applications and high power microwaves. Conduct research in atmospheric characterization, metrology, control systems, algorithms, waveguides, antennas and beam control component technology.</p> <p>FY 2020 Plans: Continue research of innovative high energy laser and high power microwave beam control architectures. Continue to leverage international research developments and technology advancements.</p> <p>FY 2021 Plans: Continue research of innovative high energy laser and high power microwave beam control architectures. Continue to leverage international research developments and technology advancements.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.146 million. Justification for the increase is described in the plans above.</p>				
<p>Title: Directed Energy Education</p> <p>Description: Fund educational grants to stimulate student interest in directed energy.</p> <p>FY 2020 Plans: Continue to provide scholarships and internships to support college students studying in fields related to high energy lasers and high power microwaves. Continue to provide grants to the United States Service Academies to stimulate studies related to high energy lasers and high power microwaves among military cadets. Continue to fund publication of journals and support continuing education for professionals in the high energy laser and high power microwave fields.</p> <p>FY 2021 Plans: Continue to provide scholarships and internships to support college students studying in fields related to high energy lasers and high power microwaves. Continue to provide grants to the United States Service Academies to stimulate studies related to high energy lasers and high power microwaves among military cadets. Continue to fund publication of journals and support continuing education for professionals in the high energy laser and high power microwave fields.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>		1.044	1.250	1.250
Accomplishments/Planned Programs Subtotals		12.103	14.795	15.085
D. Other Program Funding Summary (\$ in Millions)				
N/A				

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>	R-1 Program Element (Number/Name) PE 0601108F / <i>High Energy Laser Research Initiatives</i>
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D. Other Program Funding Summary (\$ in Millions)

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>					R-1 Program Element (Number/Name) PE 0602020F / <i>Future AF Capabilities Applied Research</i>							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	0.000	0.000	100.000	0.000	100.000	100.000	100.000	100.000	100.000	Continuing	Continuing
620200: <i>Enterprise Transformational Appld Research</i>	-	0.000	0.000	100.000	0.000	100.000	100.000	100.000	100.000	100.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops cross-enterprise transformational applied research efforts to accelerate the "pipeline" of technology-enabled capability candidates focused on the five strategic capabilities outlined in the Air Force Science and Technology (S&T) Strategy approved by the Secretary of the Air Force in April 2019. The five strategic capabilities as outlined in the Strategy are as follows: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality. Air Force Research Laboratory (AFRL) will plan and manage these funds at the enterprise level to achieve the intent of the Strategy.

In FY 2021, the Air Force created PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, to consolidate the specific Future AF Capabilities Applied Research efforts/ activities from the following PEs and Projects: PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls and Pilot-Vehicle Interface; PE 0602202F, Human Effectiveness Applied Research, Project 625328, Human Dynamics Evaluation; PE 0602204F, Aerospace Sensors, Project 627622, RF Sensors and Countermeasures Tech; PE 0602602F, Conventional Munitions, Project 622068, Advanced Guidance Technology; and PE 0602788F, Dominant Information Sciences and Methods, Project 625315, C4I Dominance Technology, in order to better align with the Air Force Science and Technology Strategy, April 2019, and execute transformational Applied Research.

This Program Element creation and realignment of funding from the existing Air Force RDT&E Applied Research PEs are administrative realignments and not a new start.

These activities are managed by the Air Force Research Laboratory Chief Technologist located at Wright Patterson Air Force Base, Ohio, at the Enterprise level, and executed across the various AFRL Technology Directorate locations.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this program element would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602020F / <i>Future AF Capabilities Applied Research</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	100.000	0.000	100.000
Total Adjustments	0.000	0.000	100.000	0.000	100.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	100.000	0.000	100.000

Change Summary Explanation

Increase in FY 2021 of \$100.00 million is due to the realignment and consolidation of Future AF Capabilities Applied Research efforts/ activities from the following PEs and Projects: PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls and Pilot-Vehicle Interface; PE 0602202F, Human Effectiveness Applied Research, Project 625328, Human Dynamics Evolution; PE 0602204F Aerospace Sensors, Project 627622, RF Sensors and Countermeasures Tech; PE 0602602F, Conventional Munitions, Project 622068, Advanced Guidance Technology; and PE 0602788F, Dominant Information Sciences and Method, Project 625315, C4I Dominance Technology, to better align with the Air Force S&T strategy, April 2019, and provide Congress with increased transparency on transformational Air Force S&T activities.

C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
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Title: Transformational Capability Incubator	0.000	0.000	100.000
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Description: Integrates cross-enterprise transformational applied research efforts to accelerate the "pipeline" of technology-enabled capability candidates focused on the five strategic capabilities outlined in the Air Force Science and Technology Strategy approved by the Secretary of the Air Force in April 2019. The Air Force Research Laboratory will plan and manage these efforts and activities at the enterprise level to achieve the intent of the Strategy.

FY 2020 Plans:

In FY 2020, this work is performed under the Future AF Capabilities Applied Research efforts within the following Air Force Science and Technology PEs and Projects: PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls and Pilot-Vehicle Interface; PE 0602202F, Human Effectiveness Applied Research, Project 625328, Human Dynamics Evolution; PE 0602204F Aerospace Sensors, Project 627622, RF Sensors and Countermeasures Tech; PE 0602602F, Conventional Munitions,

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602020F / <i>Future AF Capabilities Applied Research</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Project 622068, Advanced Guidance Technology; and PE 0602788F, Dominant Information Sciences and Method, Project 625315, C4I Dominance Technology.</p> <p>FY 2021 Plans: Conduct structured horizon scanning and ideation activities to identify future candidate technologies for consideration and pursuit. Using the results of structured horizon scanning and ideation activities, will conduct modeling, simulation, and analysis to guide investment decisions, create technology roadmaps, and track technology maturation, opportunities, and gaps focused on identifying and incubating leap ahead technology solutions along the five strategic capabilities identified in the Air Force S&T Strategy. Engage the Air Force and other government research organizations, industry, and academia through a series of competitive, open opportunity calls to promote solution-oriented thinking, leverage new partnerships, and incubate leap ahead technology demonstrations with the goal of moving the Air Force from a current force challenged by increasingly sophisticated adversaries to a future force that dominates time, space and complexity in future conflict.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$100.000 million. Funding increased due to the realignment and consolidation of the Future AF Capabilities Applied Research efforts/activities to PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, to better align with the Air Force S&T Strategy, April 2019, and provide Congress with increased transparency on transformational Air Force S&T activities.</p>			
Accomplishments/Planned Programs Subtotals	0.000	0.000	100.000

D. Other Program Funding Summary (\$ in Millions)
N/A

Remarks

E. Acquisition Strategy
N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	172.109	215.851	140.781	0.000	140.781	132.522	127.914	130.928	133.385	Continuing	Continuing
624347: <i>Materials for Structures, Propulsion, and Subsystems</i>	-	83.861	103.844	53.433	0.000	53.433	48.230	46.714	47.852	48.761	Continuing	Continuing
624348: <i>Materials for Electronics, Optics, and Survivability</i>	-	35.561	56.507	37.740	0.000	37.740	35.982	34.191	34.991	35.600	Continuing	Continuing
624349: <i>Materials Technology for Sustainment</i>	-	52.687	55.500	49.608	0.000	49.608	48.310	47.009	48.085	49.024	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops advanced materials, processing, and inspection technologies to reduce life cycle costs and improve performance, sustainability, availability, affordability, supportability, reliability, and survivability of current and future Air Force systems and operations. The program has three projects that develop: structural, propulsion, and sub-systems materials and processes technologies; electronic, optical, and survivability materials and processes technologies; and sustainment materials, processes technologies, and advanced non-destructive inspection methodologies. Efforts in the program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	181.373	128.851	126.436	0.000	126.436
Current President's Budget	172.109	215.851	140.781	0.000	140.781
Total Adjustments	-9.264	87.000	14.345	0.000	14.345
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	87.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-2.854	0.000			
• Other Adjustments	-6.410	0.000	14.345	0.000	14.345

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 624347: *Materials for Structures, Propulsion, and Subsystems*

	FY 2019	FY 2020
Congressional Add: <i>Program increase - Certification of advanced composites</i>	14.764	15.000
Congressional Add: <i>Program Increase - Thermal Protection for Hypersonic Vehicles</i>	9.843	0.000
Congressional Add: <i>Program Increase - High Temperature Material Technologies for Turbine Engines</i>	4.921	0.000
Congressional Add: <i>Program Increase - High Performance Materials</i>	7.874	8.000
Congressional Add: <i>Program Increase - Turbine Airfoil Demonstration</i>	2.953	0.000
Congressional Add: <i>Program Increase - Additive Manufacturing</i>	0.000	20.000
Congressional Add: <i>Program Increase - Advanced aerospace composite structures</i>	0.000	8.000
Congressional Add: <i>Program Increase - Molybdenum silicon boron research</i>	0.000	3.000
Congressional Add Subtotals for Project: 624347	40.355	54.000

Project: 624348: *Materials for Electronics, Optics, and Survivability*

Congressional Add: <i>Program Increase - Biosensor Materials</i>	4.921	0.000
Congressional Add: <i>Program Increase - Minority leaders program</i>	0.000	8.500
Congressional Add: <i>Program Increase - Deployable passive cooling</i>	0.000	5.000
Congressional Add: <i>Program Increase - Human monitoring capabilities</i>	0.000	9.500

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>
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<u>Congressional Add Details (\$ in Millions, and Includes General Reductions)</u>	FY 2019	FY 2020
Congressional Add Subtotals for Project: 624348	4.921	23.000
Project: 624349: <i>Materials Technology for Sustainment</i>		
Congressional Add: <i>Program Increase - Coating Technologies</i>	9.843	10.000
Congressional Add Subtotals for Project: 624349	9.843	10.000
Congressional Add Totals for all Projects	55.119	87.000

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$6.410 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Increase in FY 2021 of \$14.345 million is due to the following:

- 1) Civilian pay repricing adjustments
- 2) Initiating Joint Service 1000 Molecules activities to support the sustainable transition of critical synthetic biology capabilities
- 3) Realignment of the Pervasive and Affordable Metals Technologies effort from PE 0603112F, Advanced Materials for Weapons Systems, Project 633946, Materials Transition, Pervasive and Affordable Metals Technologies, to PE 0602102F, Materials, Project 624347, Materials for Structures, Propulsion, and Subsystems.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>				Project (Number/Name) 624347 / <i>Materials for Structures, Propulsion, and Subsystems</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624347: <i>Materials for Structures, Propulsion, and Subsystems</i>	-	83.861	103.844	53.433	0.000	53.433	48.230	46.714	47.852	48.761	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops the materials and processing technology base for aircraft, spacecraft, launch systems, and missiles to improve affordability, maintainability, and performance of current and future Air Force systems. A family of affordable lightweight materials is being developed, including metals, polymers, ceramics, metallic and nonmetallic composites, and hybrid materials to provide upgraded capabilities for existing aircraft, missile, and propulsion systems to meet the future system requirements. The project develops high-temperature turbine engine materials that will enable engine designs to improve turbine engine thrust-to-weight ratio, specific fuel consumption and affordability. Advanced high temperature protection materials are being developed that are affordable, lightweight, dimensionally stable, thermally conductive, and/or ablation and erosion resistant to meet aerospace and missile requirements. Alternative or replacement materials are being developed to maintain the performance of aging operational systems. The project concurrently develops advanced processing methods to enable adaptive processing of aerospace materials.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Ceramics and Composites	25.669	29.552	28.319
Description: Develop ceramic, ceramic matrix composite, and hybrid materials technologies for performance and supportability improvement in propulsion systems and high temperature aerospace structures.			
FY 2020 Plans: Demonstrate and mature new advanced processing methods, coating technologies, and behavioral life prediction concepts for current and future higher capability polymer and ceramic matrix composites. Continue in-depth analyses and assessment of severe environment durability of advanced composite systems via mechanical testing. Continue developing and testing the new ceramic and polymer matrix composite materials and processes with higher temperature capability for next generation propulsion systems and aerospace structures. Continue to advance and integrate the computational material science infrastructure for composite materials to model, characterize, and accelerate the development and certification of advanced composite materials. Continue to verify and validate damage progression models on increasingly complex polymer matrix composite structural applications. Continue newer testing and assessment methods to development composite damage progression models for application in an engineering environment. Develop and refine modeling tools to link processing to performance of organic/polymer matrix composites and expand damage mechanics models to increasingly complex composite materials. Develop and validate the development and exploration of materials to meet evolving requirements for structural hardening.			
FY 2021 Plans: Continue to demonstrate and mature new advanced processing methods, coating technologies, and behavioral life prediction concepts for current and future higher capability polymer and ceramic matrix composites. Continue in-depth analyses and			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624347 / <i>Materials for Structures, Propulsion, and Subsystems</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>assessment of severe environment durability of advanced composite systems via mechanical testing. Continue validating, developing, and testing the new ceramic and polymer matrix composite materials and processes with higher temperature capability for next generation propulsion systems and aerospace structures. Continue to advance and integrate the computational material science infrastructure for composite materials in tools to model, characterize, and accelerate the development and certification of advanced composite materials. Continue to verify and validate damage progression models on increasingly complex polymer matrix composite structural applications. Continue developing newer testing and assessment methods on composite damage progression models for application in an engineering environment. Continue to develop and validate advanced materials to meet evolving requirements for structural hardening. Initiate development of Enhanced Physics-based Prognosis techniques and inspection methods for ceramics matrix composites.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.233 million. Funding decreased due to reduced emphasis on computational material science infrastructure and technologies.</p>			
<p>Title: Metals</p> <p>Description: Develop lightweight and high temperature metallics, life prediction, and metals processing technologies for increased affordability, durability, and reliability.</p> <p>FY 2020 Plans: Continue demonstration and implementation of advanced computation methods to support material development and characterization modeling. Continue to analyze relationships between microstructure, processing, properties, and performance of affordable metallic and high performance gradient metallic materials. Validate integrated material/manufacturing and component analysis for life management and development of affordable structural metals and low cost processes. Continue to advance reliable affordable metallic structural components through computational methods. Validate the value of integrated analytical tools in the optimization of design and certification of additively manufactured metallic components. Continue development and refine low cost processing methods and affordable metals for low cost, attritable propulsion systems. Initiate development of enhanced life management practices to incorporate effects of engineered residual stress. Continue research on application of advanced data science, artificial intelligence and machine learning on materials science problems.</p> <p>FY 2021 Plans: Continue to demonstrate and implement advanced computation methods to support faster material development and characterization modeling. Continue to analyze relationships between microstructure, processing, properties, and performance of affordable metallic and high performance gradient metallic materials. Continue to validate integrated material/manufacturing and component analysis for life management and development of affordable structural metals and low cost processes. Continue to advance reliable affordable metallic structural components through computational methods. Continue to validate the value of</p>	13.487	15.283	16.564

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624347 / <i>Materials for Structures, Propulsion, and Subsystems</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>integrated analytical tools in the optimization of design and certification of additively manufactured metallic components. Continue development of novel capabilities via metallic additive manufacturing to be used as an alternative process when applicable. Continue to develop and refine low cost processing methods and affordable metals for low cost, attritable propulsion systems. Continue development of enhanced life management practices to incorporate effects of engineered residual stress. Continue research on application of advanced data science, artificial intelligence and machine learning on materials science problems. Initiate research on engine lifing for sustainment.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.281 million. Funding increased due to civilian pay reprice adjustments.</p>				
<p>Title: Thermal Protection Materials</p> <p>Description: Develop and evaluate lightweight, active, adaptive, multifunctional, high temperature, and durable material systems for extreme environments and hypersonic applications.</p> <p>FY 2020 Plans: Mature processing methods for fabricating materials required for expendable hypersonic applications. Validate, develop and refine unique experimental techniques to assess mechanical properties and time-dependent behavior. Continue to validate and demonstrate material properties and performance to meet design needs for control surfaces, leading edges, aero shells, and apertures. Further the development of computational models to assess environmental degradation of materials in a hypersonic environment. Initiate development of materials to meet emerging requirements of systems for effective nuclear deterrence.</p> <p>FY 2021 Plans: Continue to mature processing methods for fabricating materials required for expendable hypersonic applications. Continue to validate, develop and refine unique experimental techniques to assess mechanical properties and time-dependent behavior. Continue to validate and demonstrate material properties and performance to meet design needs for control surfaces, leading edges, aero shells, and apertures. Further the development of computational models to assess environmental degradation of materials in a hypersonic environment. Continue the development of materials to meet emerging requirements of systems for effective nuclear deterrence.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.334 million. Funding increased due to civilian pay reprice adjustments.</p>		4.350	5.009	5.343
<p>Title: Pervasive and Affordable Metals Technologies</p> <p>Description: Develop and demonstrate affordable, novel high temperature powder processing materials/structures and additive metals technology concepts to enable future defense capabilities, air vehicle propulsion, and computational prediction models.</p>		0.000	0.000	3.207

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624347 / <i>Materials for Structures, Propulsion, and Subsystems</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> For FY 2020 and prior, this work is performed under the Pervasive and Affordable Metals Technologies effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633946, Materials Transition.</p> <p><i>FY 2021 Plans:</i> Continue to demonstrate affordable metallic turbine engine disks made through powder processing technologies through high temperature, aggressive environment testing. Continue to develop low cost, complex shape metallic component made through additive manufacturing for advanced weapon system component prototypes. Continue to develop computational methodologies that incorporate impact of surface residual stress on ability to extend life and lower life cycle cost of air vehicle propulsion system components.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$3.207 million. Funding increased due to the realignment of the Pervasive and Affordable Metals Technologies effort from PE 0603112F, Advanced Materials for Weapons Systems, Project 633946, Materials Transition, to this effort.</p>			
Accomplishments/Planned Programs Subtotals	43.506	49.844	53.433

	FY 2019	FY 2020
<p><i>Congressional Add:</i> Program increase - Certification of advanced composites</p> <p><i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts.</p> <p><i>FY 2020 Plans:</i> Conducted Congressionally directed efforts.</p>	14.764	15.000
<p><i>Congressional Add:</i> Program Increase - Thermal Protection for Hypersonic Vehicles</p> <p><i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts.</p> <p><i>FY 2020 Plans:</i> Not Applicable</p>	9.843	0.000
<p><i>Congressional Add:</i> Program Increase - High Temperature Material Technologies for Turbine Engines</p> <p><i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts.</p> <p><i>FY 2020 Plans:</i> Not Applicable</p>	4.921	0.000
<p><i>Congressional Add:</i> Program Increase - High Performance Materials</p>	7.874	8.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020	
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624347 / <i>Materials for Structures, Propulsion, and Subsystems</i>	
		FY 2019	FY 2020
FY 2019 Accomplishments: Conducted Congressionally directed efforts.			
FY 2020 Plans: Conducted Congressionally directed efforts.			
Congressional Add: Program Increase - Turbine Airfoil Demonstration		2.953	0.000
FY 2019 Accomplishments: Conducted Congressionally directed efforts.			
FY 2020 Plans: Not Applicable			
Congressional Add: Program Increase - Additive Manufacturing		0.000	20.000
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conducted Congressionally directed efforts.			
Congressional Add: Program Increase - Advanced aerospace composite structures		0.000	8.000
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Add: Program Increase - Molybdenum silicon boron research		0.000	3.000
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Adds Subtotals		40.355	54.000
C. Other Program Funding Summary (\$ in Millions)			
N/A			
Remarks			
D. Acquisition Strategy			
N/A.			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>				Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624348: <i>Materials for Electronics, Optics, and Survivability</i>	-	35.561	56.507	37.740	0.000	37.740	35.982	34.191	34.991	35.600	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops materials technologies for Intelligence, Surveillance, and Reconnaissance (ISR), situational awareness, and low-observable systems and subsystems for aircraft and missile applications, including sensor, microwave, and short, mid, and long-wave infrared (SWIR, MWIR, LWIR) detection and countermeasures devices used for targeting, electronic warfare, and active aircraft protection. Materials for protection of aircrews, sensors, and aircraft from laser, and high-power microwave directed energy threats are also developed. Electronic and optical materials are being developed to enable surveillance and situational awareness with faster operating speeds, greater tunability, higher power output, improved thermal management (including higher operating temperatures), greater sensitivity, and extended dynamic range. New materials are being developed to counter the most prominent laser threats and to respond to emerging and agile threat wavelengths without impairing mission effectiveness. The project develops nanostructured and biological materials for aircraft structures, munitions, air vehicle subsystems, and personnel. The project develops novel materials for electromagnetic interactions with matter for electromagnetic pulse, high power microwave, and lightning strike protection.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Infrared Detector and Electromagnetic Device Materials	10.111	11.090	11.354
Description: Develop infrared (IR) detector and Electro-magnetic device materials and processes technologies for performance, affordability, and operational capability of surveillance, tracking, targeting, and situational awareness systems.			
FY 2020 Plans: Continue advanced development, demonstration and validation of materials and processes for control and detection of electromagnetic radiation for Intelligence, Surveillance, Reconnaissance (ISR) technologies. Further the development, testing, and assessment of materials for use in high resolution imaging by electromagnetic radiation and demonstrate the results. Proceed with advanced demonstration of nanoscale materials, meta materials, and models for use in producing detectors. Continue to utilize all aspects of computational materials science to improve performance prediction and reliability models, as well as analyzing quantum materials for aerospace applications. Continue specific development and demonstration of short wave infrared detector materials and hyper-spectral long wave infrared materials. Verify and validate materials and processes for integration of radio frequency and optical signals as well as concepts for novel optical devices and components. Validate generated data and continue development of photonics for air vehicle applications, and demonstrate nanostructured materials for components to enable agile radio frequency capability.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Continue advanced development, demonstration and validation of materials and processes for control and detection of electromagnetic radiation for Intelligence, Surveillance, Reconnaissance (ISR) technologies. Further the development, testing, and assessment of materials for use in high resolution imaging by electromagnetic radiation and demonstrate the results. Continue advanced demonstration of nanoscale materials, metamaterials, and models for use in producing detectors. Continue to utilize all aspects of computational materials science to improve performance prediction and reliability models, as well as analyzing quantum materials for aerospace applications. Continue specific development and demonstration of short wave infrared detector materials and hyper-spectral long wave infrared materials. Continue to verify and validate materials and processes for integration of radio frequency and optical signals as well as concepts for novel optical devices and components. Continue to validate generated data and continue development of photonics for air vehicle applications, and demonstrate nanostructured materials for components to enable agile radio frequency capability. Initiate development of techniques using quantum materials and processes.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.264 million. Funding increased due to civilian pay reprice adjustments.</p>			
<p>Title: Directed Energy Hardened Materials</p> <p>Description: Develop and demonstrate technologies to enhance the safety, survivability, and mission effectiveness of aircrews, sensors, viewing systems, and related assets.</p> <p>FY 2020 Plans: Continue to analyze and validate the comprehensive generated data of materials and technologies to protect against directed energy threats. Develop and demonstrate advanced optical limiter materials for damage protection, enhanced hybrid materials for advanced applications, and continue to assess response of new materials for high-energy laser interactions. Continue developing the novel approaches for integration of multi-modal hardening into structures and devices. Continue to assess data and validate repeatability and utilize computational materials science to enhance multi-scale modeling for design of robust, reliable integrated protection. Initiate development of proven selected advanced materials technologies to protect against nuclear flash blindness.</p> <p>FY 2021 Plans: Continue to analyze and validate the comprehensive generated data of materials and technologies to protect against directed energy threats. Continue to develop and demonstrate advanced optical limiter materials for damage protection, enhanced hybrid materials for advanced applications, and continue to assess response of new materials for high-energy laser interactions. Continue developing the novel approaches for integration of multimodal hardening into structures and devices. Continue to assess data and validate repeatability and utilize computational materials science to enhance multi-scale modeling for design of robust,</p>	11.643	12.672	13.075

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
reliable integrated protection. Continue development of proven selected advanced materials technologies to protect against nuclear flash blindness. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.403 million. Funding increased due to civilian pay reprice adjustments.				
Title: Laser Source Materials Description: Develop materials to enable higher performance high power laser sources (quasi-Continuous Wave to Continuous Wave) with emphasis on laser output in the mid-InfraRed spectral region (2-5 microns). FY 2020 Plans: Continue to validate materials and process technologies to control and generate directed electromagnetic energy for survivability and other applications. Further demonstrate and model materials processes for controlling laser beam direction and focus with optical components, and materials for frequency conversion, high power optical isolators, mid-wave infrared laser sources and high power microwave sources for directed energy sources. FY 2021 Plans: Continue to validate materials and process technologies to control and generate directed electromagnetic energy for survivability and other applications. Further demonstrate and model materials processes for controlling laser beam direction and focus with optical components, and materials for frequency conversion, high power optical isolators, mid-wave infrared laser sources and high power microwave sources for directed energy sources. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.032 million. Funding increased due to civilian pay reprice adjustments.		1.226	1.344	1.376
Title: Nanostructured and Biological Materials Description: Develop enabling and foundational biotechnologies for guidance and control, rapid tagging, tracking, and identification of targets, and bio-integrated electronics and sensing for Air Force applications. FY 2020 Plans: Continue to validate and verify engineering, scientific and processing methods for nano and biological materials to address unique requirements for Air Force man-machine integration, and electronic components. Explore sustainability demand biotechnology to assess the impact of microbes and fungi on Air Force systems. Continue to study more robust and reliable materials and processes to optimize components for compact, flexible, stretchable multi-functional devices, and validate materials and process for functional additive manufacturing of electronic components. Demonstrate methods to assess reliability and field resiliency of		7.660	8.401	11.935

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
nano and bio materials and processes. Continue to support Flexible Hybrid Electronics Institute for Manufacturing Innovation and the NanoBio Manufacturing Consortium for collaborative teaming. FY 2021 Plans: Continue to validate and verify engineering, scientific and processing methods for nano and biological materials to address unique requirements for Air Force man-machine integration, and electronic components. Continue to explore biotechnology to assess the impact of microbes and fungi on Air Force systems. Continue to study more robust and reliable materials and processes to optimize components for compact, flexible, stretchable multi-functional devices, and validate materials and process for functional additive manufacturing of electronic components. Continue to demonstrate methods to assess reliability and field resiliency of nano and bio materials and processes. Continue to support the Flexible Hybrid Electronics Institutes for Manufacturing Innovation and the NanoBio Manufacturing Consortium for collaborative teaming. Initiate development of advanced materials for human-machine applications. Initiate Joint Service 1000 Molecules activities to support the sustainable transition of critical synthetic biology capabilities. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$3.534 million. Funding increased due to civilian pay reprice adjustments and emphasis on synthetic biology capabilities.			
Accomplishments/Planned Programs Subtotals	30.640	33.507	37.740

	FY 2019	FY 2020
Congressional Add: Program Increase - Biosensor Materials FY 2019 Accomplishments: Conducted Congressionally directed efforts. FY 2020 Plans: Not Applicable	4.921	0.000
Congressional Add: Program Increase - Minority leaders program FY 2019 Accomplishments: Not Applicable FY 2020 Plans: Conduct Congressionally directed efforts.	0.000	8.500
Congressional Add: Program Increase - Deployable passive cooling FY 2019 Accomplishments: Not Applicable FY 2020 Plans: Conduct Congressionally directed efforts.	0.000	5.000
Congressional Add: Program Increase - Human monitoring capabilities	0.000	9.500

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020	
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>	
		FY 2019	FY 2020
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Adds Subtotals		4.921	23.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>				Project (Number/Name) 624349 / <i>Materials Technology for Sustainment</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624349: <i>Materials Technology for Sustainment</i>	-	52.687	55.500	49.608	0.000	49.608	48.310	47.009	48.085	49.024	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops materials and processing technologies to support operational Air Force mission areas by providing the ability to inspect the quality of delivered systems, transitioning more reliable and maintainable materials, establishing a capability to detect and characterize performance threatening defects, characterizing materials processes and properties necessary for materials transition, and providing quick reaction support and failure analysis to the operational commands and repair centers. Repair techniques and nondestructive inspection/evaluation (NDI/E) methods are developed that are needed for metallic and non-metallic structures, coatings, corrosion control processes, and to support integration of composite structures for aerospace systems. Various NDI/E methods are essential to ensure optimum quality in the design and production of aircraft, propulsion, and missile systems. These NDI/E methods are also essential to monitor and detect the onset of any service initiated damage and/or deterioration due to aging of operational systems.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Material State Awareness	14.996	16.022	17.363
Description: Develop Materials State Awareness technologies to identify and characterize materials and/or damage regardless of scale for managing the health of aging structures, propulsion systems, and low-observable materials/structures, plus enabling advanced materials qualification.			
FY 2020 Plans: Continue to validate and demonstrate non-destructive evaluation modeling capabilities and use these competencies to drive improvements in capability to detect, characterize and quantify damage in realistic aerospace structures and engine components. Continue to analyze approaches to address the variability inherent in aerospace systems and materials and begin to quantify the impact of that variability on nondestructive inspection capability and reliability. Validate advanced sensing technologies to detect and characterize changes in material properties, damage evolution, and other factors that detrimentally affect aerospace systems. Continue development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Validate and continue development of advanced methods to monitor and evaluate material state awareness. Continue development of augmented reality technologies to improve the process of performing nondestructive evaluation tasks, acquiring and archiving data and reporting results.			
FY 2021 Plans: Continue to validate and demonstrate non-destructive evaluation modeling capabilities and use these competencies to drive improvements in capability to detect, characterize and quantify damage in realistic aerospace structures and engine components. Continue to analyze approaches to address the variability inherent in aerospace systems and materials and begin to quantify			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624349 / <i>Materials Technology for Sustainment</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>the impact of that variability on nondestructive inspection capability and reliability. Continue to validate advanced sensing technologies to detect and characterize changes in material properties, damage evolution, and other factors that detrimentally affect aerospace systems. Continue development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Continue to improve methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of special materials that enables/ensures more affordable coatings assessment. Validate tools to improve characterization and failure modes of specialty multilayer coatings. Continue to develop automation and robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.341 million. Funding increased due to civilian pay reprice adjustments.</p>				
<p>Title: Production and Repair Technologies</p> <p>Description: Develop support capabilities, information, and processes to resolve problems with materials in the production and repair of systems components and structures.</p> <p>FY 2020 Plans: Develop best practices to ensure repeatability of advanced materials and processes technology to repair and extend the life of Air Force systems. Further refine through demonstration the understanding of material durability and repair limits for emerging Air Force systems. Advance the analysis and development of improved lifecycle prediction test methods and techniques to understand effects of service environments, corrosion, residual stresses, and material processes on structural and functional materials. Continue to improve the service life of advanced materials, processes and designs for improved repair and maintainability and life cycle cost of outer-moldline coatings, access panel treatments, and multifunctional systems. Further advance specialty material affordability technologies and processes to reduce maintenance costs of specialty materials.</p> <p>FY 2021 Plans: Develop and communicate to the field best practices to ensure repeatability of advanced materials and processes technology to repair and extend the life of Air Force systems. Further refine through demonstration the understanding of material durability and repair limits for emerging Air Force systems. Continue to advance the analysis and development of improved lifecycle prediction test methods and techniques to understand effects of service environments, corrosion, residual stresses, and material processes on structural and functional materials. Continue to improve the service life of advanced materials, processes and designs for improved repair and maintainability and life cycle cost of outer-moldline coatings, access panel treatments, and multifunctional systems. Further advance specialty material affordability technologies and processes to reduce maintenance costs of specialty materials.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		11.139	11.625	12.898

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624349 / <i>Materials Technology for Sustainment</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$1.273 million. Funding increased due to civilian pay reprice adjustments.			
<p>Title: Failure Analysis Technologies</p> <p>Description: Develop support capabilities, information, and processes to resolve materials problems and provide electronic and structural failure analysis of components.</p> <p>FY 2020 Plans: Continue to perform and increase efficiency of quick response failure analyses and materials investigations. Further the development and investigate improved analysis techniques to determine and prevent root cause materials failure/degradation. Continue to develop and provide advanced materials and processing solutions to ensure warfighter system availability and safety of flight. Refine development of functional materials failure analysis capabilities. Continue to analyze and validate advanced electrostatic discharge protection technologies and procedures for emerging avionics subsystems. Transition advanced test and characterization methods for analyzing electrical and structural failures of emerging materials. Continue development and demonstrate new, more durable materials and protection for high power wiring technologies, and advanced materials.</p> <p>FY 2021 Plans: Continue to perform and increase efficiency of quick response failure analyses and materials investigations. Further the development and investigate improved analysis techniques to determine and prevent root cause materials failure/degradation. Continue to develop and provide advanced materials and processing solutions to ensure warfighter systems availability and safety of flight. Continue to refine development of functional materials failure analysis capabilities. Continue to analyze and validate advanced electrostatic discharge protection technologies and procedures for emerging avionics subsystems. Continue to transition advanced test and characterization methods for analyzing electrical and structural failures of emerging materials. Continue development of new, more durable materials and protection for high power wiring technologies, and advanced materials.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.494 million. Funding increased due to civilian pay reprice adjustments and additional emphasis on materials analysis research.</p>	16.709	17.853	19.347
Accomplishments/Planned Programs Subtotals	42.844	45.500	49.608

	FY 2019	FY 2020
<p>Congressional Add: Program Increase - Coating Technologies</p> <p>FY 2019 Accomplishments: Conducted Congressionally directed efforts.</p> <p>FY 2020 Plans: Conduct Congressionally directed efforts.</p>	9.843	10.000
Congressional Adds Subtotals	9.843	10.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624349 / <i>Materials Technology for Sustainment</i>

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force / BA 2: Applied Research	R-1 Program Element (Number/Name) PE 0602201F / Aerospace Vehicle Technologies
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	150.625	157.724	349.225	0.000	349.225	357.519	342.564	350.533	355.874	Continuing	Continuing
622401: Aeromechanics and Structures Technology	-	40.754	41.817	78.700	0.000	78.700	80.655	77.360	79.266	80.475	Continuing	Continuing
622403: Flight Controls and Pilot-Vehicle Interface	-	37.925	49.297	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
622404: Aeromechanics and Integration	-	29.036	28.595	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
622405: High Speed Systems Technology	-	42.910	38.015	53.578	0.000	53.578	55.932	53.583	54.771	55.598	Continuing	Continuing
622406: Aerospace Power & Flight Control Technology	-	0.000	0.000	72.653	0.000	72.653	76.366	72.548	74.338	75.467	Continuing	Continuing
623066: Turbine Engine Technology	-	0.000	0.000	73.887	0.000	73.887	73.705	70.860	72.425	73.523	Continuing	Continuing
624847: Rocket Propulsion Technology	-	0.000	0.000	62.855	0.000	62.855	63.217	60.717	62.075	63.025	Continuing	Continuing
625330: Aerospace Fuel Technology	-	0.000	0.000	7.552	0.000	7.552	7.644	7.496	7.658	7.786	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program investigates, develops, and analyzes aerospace vehicle technologies in the six primary areas of high speed systems, power and flight control technologies, rocket propulsion, turbine engine technologies, fuel sciences, and aeromechanics and structure systems. The effort has six projects, each focusing on a technology area critical to the Air Force. The High Speed Systems Technology project develops high speed/hypersonic aerospace vehicles as well as high-speed air breathing propulsion engines to include combined cycle, ramjet, and hypersonic scramjet technologies to enable revolutionary propulsion capability for the Air Force. The Power and Flight Control Technologies project develops technologies that enable maximum affordable capability from manned, remotely-piloted and autonomous aerospace vehicles while developing electrical and thermal control technologies for military applications that remove operational limitations and enable advanced vehicle designs and high-power mission systems. The Rocket Propulsion Technology project develops advances in rocket propulsion technologies for space access, space maneuver, missiles, the sustainment of strategic systems, and tactical rockets. The Turbine Engine Technology project develops and enables advanced engine architectures across small, medium, large thrust classes; to provide optimized performance, fuel efficiency, and integrated propulsion, power, and thermal capability, while enhancing affordability. Includes technology concepts for legacy and future, advanced turbine engines. The Aerospace Fuel Technology project evaluates hydrocarbon-based fuels for legacy and advanced turbine engines, scramjets, pulse detonation, and combined-cycle engines. The Aeromechanics and Structures project develops and exploits

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	
<p>new materials, fabrication processes, design techniques, and incorporating vehicle, inter-vehicle, and intra-vehicle control systems. Advanced aerodynamic vehicle configurations are developed and analyzed through simulations, experiments, and multi-disciplinary analyses.</p> <p>In FY 2021, the Aerospace Systems RDT&E Budget Activity 02 (BA02) efforts and activities under PE 0602203F, Aerospace Propulsion, and PE 0602201F, Aerospace Vehicle Technologies, are realigned and consolidated into PE 0602201F, Aerospace Vehicle Technologies, to increase the efficiency and effectiveness of internal Air Force Research Laboratory Aerospace Systems Technology Directorate operations to finalize the 2012 merger of the Air Vehicles Directorate and Propulsion Directorate; and to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force Science and Technology Strategy, April 2019.</p> <p>All transfers detailed below are administrative realignments for consolidation, and not new starts. This work will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located either in Wright Patterson Air Force Base, OH or Edwards Air Force Base, CA.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623048, Combustion & Mechanical Systems is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology.</p> <p>In FY 2021, the entirety of PE 0603216F, Aerospace Propulsion & Power Technology, Project 632480, Aerospace Fuels is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology.</p> <p>In FY 2021, the entirety of PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls & Pilot-Vehicle Interface is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622406, Aerospace Power & Flight Control Technology.</p> <p>In FY 2021, the entirety of Program Element 0602201F, Aerospace Vehicle Technologies, Project 622404, Aeromechanics & Integration, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622401, Aeromechanics & Structures Technology.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623012, Advanced Propulsion Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622405, High Speed Systems Technology.</p>		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>
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This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	160.461	147.724	150.700	0.000	150.700
Current President's Budget	150.625	157.724	349.225	0.000	349.225
Total Adjustments	-9.836	10.000	198.525	0.000	198.525
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	10.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-4.995	0.000			
• Other Adjustments	-4.841	0.000	198.525	0.000	198.525

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 622403: *Flight Controls and Pilot-Vehicle Interface*

Congressional Add: *Program increase - human machine teaming*

Congressional Add: *Program increase - flight controls and pilot-vehicle interfaces*

Congressional Add Subtotals for Project: 622403

Project: 622405: *High Speed Systems Technology*

Congressional Add: *Program increase - high speed systems technology*

Congressional Add: *Program increase - hypersonic vehicle structures*

Congressional Add: *Program increase - hypersonic wind tunnels*

Congressional Add Subtotals for Project: 622405

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	3.876	0.000
	4.844	0.000
	8.720	0.000
	5.813	0.000
	9.689	10.000
	4.844	0.000
	20.346	10.000
	29.066	10.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force Date: February 2020

Appropriation/Budget Activity
3600: *Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research*

R-1 Program Element (Number/Name)
PE 0602201F / *Aerospace Vehicle Technologies*

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$4.841 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Increase in FY 2021 of \$198.525 million is due to the following:

- 1) Civilian pay repricing adjustments
- 2) Realignment of the entirety of PE 0602203F, Aerospace Propulsion, to PE 0602201F, Aerospace Vehicle Technologies, to increase the efficiency and effectiveness of internal Aerospace Systems Technology Directorate operations to finalize the 2012 merger of the Air Vehicles Directorate and Propulsion Directorate.
- 3) Realignment of PE 0603216F, Aerospace Propulsion & Power Technology, Project 632480, Aerospace Fuels to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology to consolidate Aerospace RDT&E fuel research.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 622401 / <i>Aeromechanics and Structures Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622401: <i>Aeromechanics and Structures Technology</i>	-	40.754	41.817	78.700	0.000	78.700	80.655	77.360	79.266	80.475	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops advanced structures concepts to exploit new materials and fabrication processes and investigates new concepts and design techniques. New structural concepts include low cost design and fabrication techniques, incorporating subsystem hardware items and adaptive mechanisms into the aerospace structures and/or skin of the platform.

In FY 2021, Project 622401 is renamed from Structures to Aeromechanics and Structures Technology.

In FY 2021, the entirety of Project 622404, Aeromechanics & Integration is transferred to Project 622401, Aeromechanics & Structures Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Aircraft Service Life Technologies	21.250	15.109	16.887
Description: Develop an economic service life analysis capability comprised of analysis tools, methodologies, and structural health monitoring technologies.			
FY 2020 Plans: Complete methods for achieving lifing credit in advanced & enhanced metallic airframe components to extend structural life. Continue demonstration of Aircraft Digital Twin models and tools on legacy fleet aircraft. Complete development of impact damage analysis criteria and methods for advanced composite structures. Initiate lifing methods for durability and damage tolerance of aging composite structures on legacy fleet aircraft. Initiate development of digital maintenance models and virtual and augment reality maintenance tools.			
FY 2021 Plans: Complete demonstration of Aircraft Digital Twin models and tools on legacy fleet aircraft. Continue lifing methods for durability and damage tolerance of aging composite structures on legacy fleet aircraft. Complete development of digital maintenance models and virtual and augment reality maintenance tools.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622401 / <i>Aeromechanics and Structures Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$1.778 million. Funding increased due to additional emphasis in digital engineering and civilian pay repricing adjustments.				
<p>Title: Vehicle Design Technologies</p> <p>Description: Develop methodologies to reduce the cost and time involved from design to full-scale testing of structural concepts and aerospace systems.</p> <p>FY 2020 Plans: Continue the development of advanced high fidelity aircraft design analysis tools. Continue the development of integrating cost, mission effectiveness, and affordable manufacturing methods into aircraft design analysis tools (completing methods on low cost attritable aircraft concepts in FY 2020 and starting methods for other aircraft systems). Continue the development of control effector designs for supersonic tailless aircraft. Initiate new design techniques to quantify and trade risk impacts against performance in aircraft designs.</p> <p>FY 2021 Plans: Continue the development of advanced high fidelity aircraft design analysis tools. Continue the development of integrating cost, mission effectiveness, and affordable manufacturing methods into aircraft design analysis tools. Complete the development of control effector designs for supersonic tailless aircraft. Continue new design techniques to quantify and trade risk impacts against performance in aircraft designs. Initiate the development of new design methods that link vehicle system requirements to mission operation performance.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.617 million. Funding increased due to additional emphasis on the development of new vehicle design methods and civilian pay repricing adjustments.</p>		11.944	13.739	15.356
<p>Title: Structural Concepts</p> <p>Description: Develop design methods, processes, and lightweight, adaptive, and multifunctional structural concepts to capitalize on new materials, multi-role considerations, and technology integration into aircraft systems.</p> <p>FY 2020 Plans: Continue development and verification of low cost attritable airframe concepts and manufacturing methods (completing wing structure developments in FY 2020 and starting concepts for the fuselage and complete airframe). Complete development of lightweight aircraft structural concepts to support Air Superiority 2030 and Advanced Mobility requirements. Continue development of innovative structural design methods to dramatically reduce weight and complexity of aircraft structures. Continue development</p>		7.560	12.969	14.496

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622401 / <i>Aeromechanics and Structures Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>of fail-safe technologies for bonded unitized composite structures applicable to Mobility aircraft (completing durability requirements in FY 2020 and starting structural life component tests).</p> <p>FY 2021 Plans: Complete development and verification of low cost attritable airframe concepts and manufacturing methods. Continue development of innovative structural design methods to dramatically reduce weight and complexity of aircraft structures. Continue development of fail-safe technologies for bonded unitized composite structures applicable to Mobility aircraft. Initiate validation of impact damage analysis and methods for advanced fail-safe composite structures applicable to Mobility aircraft.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.527 million. Funding increased due to additional emphasis in low-cost aircraft design and manufacturing applicable to strike and mobility aircraft and civilian pay repricing adjustments.</p>				
<p>Title: Aerodynamic Systems Technologies</p> <p>Description: Develop aerodynamic assessment prediction methods centered on expanding the design capabilities of future air vehicles.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under Project 622404, Aeromechanics and Integration, Aerodynamics Systems Technologies effort.</p> <p>FY 2021 Plans: Continue development and assessment of low cost attritable unmanned air vehicle concepts. Initiate an assessment of design options to allow runway independence for low cost attritable unmanned air vehicle concepts. Continue design assessments of distributed propulsion concepts for next generation Mobility. Complete the development of a high fidelity aerodynamic analysis tool for the design of laser turrets applicable to Air Superiority 2030 requirements. Continue the assessment and development of incorporating active flow control techniques into advanced design to enable new aircraft configurations.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$7.161 million. Funding increased due to realignment of Aerodynamic Systems research from Project 622404, Aeromechanics and Integration, Aerodynamic Systems Technology effort, and civilian pay repricing adjustments.</p>		0.000	0.000	7.161
<p>Title: Next Generation Aerodynamic Technologies</p> <p>Description: Develop and assess technologies for the next generation of multi-role large aircraft.</p> <p>FY 2020 Plans:</p>		0.000	0.000	7.921

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622401 / <i>Aeromechanics and Structures Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>For FY 2020 and prior years, this work is performed under Project 622404, Aeromechanics and Integration, Next Generation Aerodynamic Technologies effort.</p> <p>FY 2021 Plans: Continue next generation tanker maturation and assess promising configurations in high and low speed wind tunnels. Complete wind tunnel tests of practical laminar flow treatments and coatings for highly swept wings applicable to Mobility applications. Continue the design of a small, pod-mounted tactical air refueling boom for future Mobility applications. Continue the development of advanced high fidelity aerodynamic analysis tools for aircraft conceptual design.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$7.921 million. Funding increased due to realignment of Next Generation Aerodynamic research from Project 622404, Aeromechanics and Integration, Next Generation Aerodynamic Technologies effort, and civilian pay repricing adjustments.</p>				
<p>Title: Aircraft Integration Technologies</p> <p>Description: Develop enabling technologies to allow efficient and effective integration of propulsion, weapons, and subsystems into current and future air vehicles.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under Project 622404, Aeromechanics and Integration, Aircraft Integration Technologies effort.</p> <p>FY 2021 Plans: Continue development of advanced kinetic and directed energy weapons integration technologies for Air Superiority 2030. Continue integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility and completing the full flow path demonstration design. Complete propulsion integrations component wind tunnels tests for Air Superiority 2030 requirements. Initiate design and analysis methods to allow rapid certification of stores separation for new small weapons on tactical aircraft.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$16.879 million. Funding increased due to realignment of Aircraft Integration research from Project 622404, Aeromechanics and Integration, Aircraft Integration Technologies effort, and civilian pay repricing adjustments.</p>		0.000	0.000	16.879
Accomplishments/Planned Programs Subtotals		40.754	41.817	78.700

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622401 / <i>Aeromechanics and Structures Technology</i>

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / Aerospace Vehicle Technologies				Project (Number/Name) 622403 / Flight Controls and Pilot-Vehicle Interface			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622403: <i>Flight Controls and Pilot-Vehicle Interface</i>	-	37.925	49.297	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops technologies that enable maximum affordable capability from manned, remotely-piloted, and autonomous aerospace vehicles. Advanced control technologies are developed for maximum vehicle performance throughout the flight envelope and simulated in virtual environments. Resulting technologies contribute significantly towards the development of reliable autonomous or remotely piloted air vehicles, hypersonic aircraft, and extended-life legacy aircraft.

In FY 2021, the entirety of Project 622403, Flight Controls & Pilot-Vehicle Interface is transferred to, Project 622406, Aerospace Power & Flight Control Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Advanced Flight Controls Technologies	6.693	6.790	0.000
Description: Develop technologies for advanced control-enabled capabilities, including flight controls, components, integrated vehicle management systems, and software and system certification techniques for both manned/unmanned and remotely piloted aircraft.			
FY 2020 Plans: Continue the development, demonstration, and assessment of advanced flight control mechanization technologies for trusted and certifiable operations under adverse and contested environments. Complete the development of survivable and health-adaptive control system architecture. Continue the development of trusted autonomy approach, integrating certification processes, and autonomy development.			
FY 2021 Plans: For FY 2021 and future years, this work will be performed under Project 622406, Aerospace Power & Flight Control Technology, Advanced Flight Controls Technologies effort.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$6.790 million. Funding decreased due to realignment of Advanced Flight Controls research to Project 622406, Aerospace Power & Flight Control Technology, Advanced Flight Controls Technologies effort.			
Title: Manned and Unmanned Teaming Technologies	17.391	17.644	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622403 / <i>Flight Controls and Pilot-Vehicle Interface</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Description: Develop technology for flight control systems that will permit safe interoperability between manned and remotely piloted aircraft and effective teaming in adverse and contested environments.</p> <p>FY 2020 Plans: Continue development, demonstration, and assessment of advanced control automation techniques. Continue the development of mixed initiative control techniques for teams of remotely piloted aircraft and/or manned-unmanned teams in contested, dynamic mission environments, as well as for the integration of unmanned systems into controlled airspace and airbase operations. Continue the development of robust, affordable Unmanned Air Systems (UAS) operations in a terminal airspace environment. Complete the development of autonomous behaviors for safe, loyal wingman. Initiate the development of autonomous behaviors for safe, effective manned-unmanned teams.</p> <p>FY 2021 Plans: For FY 2021 and future years, this work will be performed under Project 622406, Aerospace Power & Flight Control Technology, Manned and Unmanned Teaming Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$17.644 million. Funding decreased due to realignment of Manned and Unmanned Teaming research to Project 622406, Aerospace Power & Flight Control Technology, Manned and Unmanned Teaming Technologies effort.</p>				
<p>Title: Flight Controls Technologies Modeling and Simulation</p> <p>Description: Develop tools and methods for capitalizing on simulation-based research and development of future aerospace vehicles.</p> <p>FY 2020 Plans: Continue modeling and simulation efforts to evaluate emerging autonomous and robust flight control technologies and concepts, as well as assess mission-level performance of integrated aerospace systems. Complete analyses of automated unmanned air systems and manned-unmanned teams in controlled airspace and airbase operations. Continue analyses of manned-unmanned teams in adversarial mission environments. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Continue manned-unmanned teaming evaluations including rapid development of new capabilities. Complete development of autonomy for tactical aircraft operations.</p> <p>FY 2021 Plans:</p>		5.121	5.196	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622403 / <i>Flight Controls and Pilot-Vehicle Interface</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>For FY 2021 and future years, this work will be performed under Project 622406, Aerospace Power & Flight Control Technology, Flight Controls Technologies Modeling and Simulation effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.196 million. Funding decreased due to realignment of Flight Controls Technologies Modeling and Simulation research to Project 622406, Aerospace Power & Flight Control Technology, Flight Controls Technologies Modeling and Simulation effort.</p>				
<p>Title: Future AF Capabilities Applied Research</p> <p>Description: Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/unconventional weapons).</p> <p>The National Defense Strategy and Air Force Science and Technology (S&T) Strategy will inform investments over the FYDP.</p> <p>In FY 2019, this work was performed under multiple projects and efforts within the following Air Force S&T Programs: 0602102F, Materials; 0602201F, Aerospace Vehicle Technologies; 0602202F, Human Effectiveness Applied Research; 0602203F, Aerospace Propulsion; 0602204F, Aerospace Sensors; 1206601F, Space Technology; 0602602F, Conventional Munitions; 0602605F, Directed Energy Technology; and 0602788F, Dominant Information Science and Methods.</p> <p>FY 2020 Plans: Investigate and mature science and technology that enables future warfighting concepts to provide leap-ahead capabilities. The National Defense Strategy and Air Force S&T Strategy focus this science and technology toward, but not limited to, the following capabilities: 1) global persistent awareness; 2) resilient information sharing; 3) rapid, effective decision-making; 4) complexity, unpredictability, and mass; and 5) speed and reach of disruption and lethality.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$19.667 million. Funding decreased due to realignment and consolidation of Future AF Capabilities Applied Research effort to PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise</p>		0.000	19.667	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622403 / <i>Flight Controls and Pilot-Vehicle Interface</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Transformational Applied Research, Transformational Capability Incubator effort, to better align with the Air Force S&T Strategy SECAF April 2019 and provide Congress with increased transparency on transformational Air Force S&T activities.			
Accomplishments/Planned Programs Subtotals	29.205	49.297	0.000

	FY 2019	FY 2020
Congressional Add: Program increase - human machine teaming <i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts. <i>FY 2020 Plans:</i> Not Applicable	3.876	0.000
Congressional Add: Program increase - flight controls and pilot-vehicle interfaces <i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts. <i>FY 2020 Plans:</i> Not Applicable	4.844	0.000
Congressional Adds Subtotals	8.720	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 622404 / <i>Aeromechanics and Integration</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622404: <i>Aeromechanics and Integration</i>	-	29.036	28.595	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops aerodynamic configurations of a broad range of revolutionary, affordable aerospace vehicles. It matures and applies modeling and numerical simulation methods for fast and affordable aerodynamics prediction and integrates and demonstrates multi-disciplinary advances in airframe, propulsion, weapon, and air vehicle control integration.

In FY 2021, the entirety of Project 622404, Aeromechanics & Integration is be transferred to Project 622401, Aeromechanics & Structures Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Aerodynamic Systems Technologies</p> <p>Description: Develop aerodynamic assessment prediction methods centered on expanding the design capabilities of future air vehicles.</p> <p>FY 2020 Plans: Continue development and assessment of low cost attritable unmanned air vehicles concepts. Continue design assessments of distributed propulsion concepts for next generation Mobility. Continue the development of a high fidelity aerodynamic analysis tool for the design of laser turrets applicable to Air Superiority 2030 requirements (completing a sub-scale design in FY 2020 and starting a sub-scale build and full-scale turret design). Initiate the assessment and development of incorporating active flow control techniques into advanced design to enable new aircraft configurations.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in Project 622401, Aeromechanics and Structures Technology, Aerodynamic Systems Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$6.407 million. Funding decreased due to realignment of Aerodynamic Systems research to Project 624401, Aeromechanical and Structures Technology, Aerodynamic Systems Technology effort.</p>	7.680	6.407	0.000
<p>Title: Next Generation Aerodynamic Technologies</p> <p>Description: Develop and assess technologies for the next generation of multi-role large aircraft.</p>	9.256	7.087	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622404 / <i>Aeromechanics and Integration</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> Continue next generation tanker maturation and assess promising configurations in high and low speed wind tunnels. Continue wind tunnel tests of practical laminar flow treatments and coatings for highly swept wings applicable to Mobility applications. Initiate the design of a small, pod-mounted tactical air refueling boom for future Mobility applications. Initiate the development of advanced high fidelity aerodynamic analysis tools for aircraft conceptual design.</p> <p><i>FY 2021 Plans:</i> Starting in FY 2021, this work is performed in Project 622401, Aeromechanics and Structures Technology, Next Generation Aerodynamic Technologies effort.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$7.087 million. Funding decreased due to realignment of Next Generation research to Project 624401, Aeromechanical and Structures Technology, Next Generation Aerodynamic Technology effort.</p>			
<p><i>Title:</i> Aircraft Integration Technologies</p> <p><i>Description:</i> Develop enabling technologies to allow efficient and effective integration of propulsion, weapons, and subsystems into current and future air vehicles.</p> <p><i>FY 2020 Plans:</i> Continue development of advanced kinetic and directed energy weapons integration technologies for Air Superiority 2030. Continue integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility, completing the system requirements definition in FY 2020 and starting the full flow bath demonstration design. Continue propulsion integrations component wind tunnels tests for Air Superiority 2030 requirements.</p> <p><i>FY 2021 Plans:</i> Starting in FY 2021, this work is performed Project 622401, Aeromechanics and Structures Technology, Aircraft Integration Technologies effort.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$15.101 million. Funding decreased due to realignment of Aircraft Integration research to Project 624401, Aeromechanical and Structures Technology, Aircraft Integration Technologies effort.</p>	12.100	15.101	0.000
Accomplishments/Planned Programs Subtotals	29.036	28.595	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622404 / <i>Aeromechanics and Integration</i>

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy

Not Applicable.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 622405 / <i>High Speed Systems Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622405: <i>High Speed Systems Technology</i>	-	42.910	38.015	53.578	0.000	53.578	55.932	53.583	54.771	55.598	Continuing	Continuing

A. Mission Description and Budget Item Justification

This effort investigates, analyzes, and develops high speed/hypersonic aerospace vehicle technologies. Advanced high temperature structures concepts are explored and developed to exploit new materials, fabrication processes, and design techniques. Advanced aerodynamic vehicle configurations are developed and analyzed through simulations, experiments, and multi-disciplinary analyses. Advanced flight control technologies are developed and simulated for hypersonic vehicles. These technologies will enable future high speed weapons; intelligence, surveillance, and reconnaissance systems; and space access vehicles.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623012, Advanced Propulsion Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622405, High Speed Systems Technology. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Speed Systems Technology	13.117	16.286	15.092
Description: Develop design analysis methods and technologies for high speed systems in for extreme flight conditions.			
FY 2020 Plans: Continue maturation of innovative structural concepts for high speed/hypersonic air vehicles. Continue development of analytical methods for predicting structural response needed for design and evaluation of hot primary structure for hypersonic vehicles. Continue to assess the impact of path dependent structural behavior on the service life prediction for hot structures encountering extreme environments. Continue to develop and integrate model uncertainty methods into multi-disciplinary simulations and quantify its impact on the structural margin. Continue development of structural analysis methods and technology for hot structure concepts under extreme environment loading conditions. Continue the assessment of the aerospace community to quantify the structural margins for extreme environment hot structure through experimental validation of ground test articles. Continue development of structural life prediction methodology for extreme environment structures and thermal protection systems. Continue development on novel designs and demonstration of integrated hot structures for hypersonic reusable air platforms.			
FY 2021 Plans: Continue to mature critical technologies for high speed/ hypersonic flight with greater emphasis on longer range flight and heavier payloads. Continue maturation of innovative structural concepts, analytical methods, service life predictions, and thermal management techniques for structure. Continue development of design/analysis techniques/ tools and experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622405 / <i>High Speed Systems Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>capabilities. Continue investigation of aeromechanic technologies to reduce drag and enable robust stability and control at all flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed component technologies through experimental ground and flight testing. Continue assessment of engagement, mission, and campaign-levels of effectiveness for promising high speed systems and refine concept designs to incorporate needed capabilities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.194 million. Funding decreased due to a reduction in ground and flight testing.</p>				
<p>Title: Hypersonic Scramjet Technologies</p> <p>Description: Develop robust hydrocarbon fueled scramjet engine components and technologies to improve performance, operability, durability, and scalability for future platforms.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623012, Advanced Propulsion Technology, Hypersonic Scramjet Technologies effort.</p> <p>FY 2021 Plans: Continue to develop and demonstrate advanced engine components to improve scramjet operating margin, operating time, and to refine scramjet scaling laws for expendable and reusable applications. Continue to develop low internal drag flame stabilization devices and flight test engine components. Continue propulsion studies and design efforts required for the development and demonstration of an engine flight test that expands the flight environment of current high speed propulsion systems.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$27.617 million. Funding increased due to realignment of Hypersonic Scramjet research from PE 0602203F, Aerospace Propulsion, Project 623012, Advanced Propulsion Technology, Hypersonic Scramjet Technologies effort, and civilian pay repricing adjustments.</p>		0.000	0.000	27.617
<p>Title: High Speed Vehicle Aeromechanics and Integration</p> <p>Description: Develop new and improved components, concepts, and designs for sustained flight of high-speed/hypersonic expendable and re-useable vehicles. Conduct analyses of high speed/hypersonic vehicles to enable revolutionary capabilities.</p> <p>FY 2020 Plans: Continue to mature critical technologies for high speed/ hypersonic flight. Continue development of design/analysis techniques/ tools and experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary capabilities. Continue investigation of aeromechanic technologies to reduced drag and enable robust</p>		9.447	11.729	10.869

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622405 / <i>High Speed Systems Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>stability and control at low dynamic pressure flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed technologies through experimental testing. Continue assessment of mission level effectiveness and refinement of definition of preferred high speed weapon alternatives and limited life hypersonic intelligence, surveillance, and reconnaissance vehicles. Continue assessment of campaign level benefits of preferred high speed weapon alternatives.</p> <p>FY 2021 Plans: Continue to mature critical technologies for high speed/ hypersonic flight with greater emphasis on longer range flight and heavier payloads. Continue development of design/analysis techniques/ tools and experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary capabilities. Continue investigation of aeromechanic technologies to reduce drag and enable robust stability and control at all flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed component technologies through experimental ground and flight testing. Continue assessment of engagement, mission, and campaign levels of effectiveness for promising high speed systems and refine concept designs to incorporate needed capabilities. Continue assessment of campaign level benefits of preferred high speed weapon alternatives.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.860 million. Justification for the decrease is described in the plans above.</p>			
Accomplishments/Planned Programs Subtotals	22.564	28.015	53.578

	FY 2019	FY 2020
Congressional Add: Program increase - high speed systems technology	5.813	0.000
FY 2019 Accomplishments: Conducted Congressionally directed efforts		
FY 2020 Plans: Not Applicable		
Congressional Add: Program increase - hypersonic vehicle structures	9.689	10.000
FY 2019 Accomplishments: Conducted Congressionally directed efforts		
FY 2020 Plans: Conduct Congressionally directed efforts		
Congressional Add: Program increase - hypersonic wind tunnels	4.844	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020	
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622405 / <i>High Speed Systems Technology</i>	
		FY 2019	FY 2020
FY 2019 Accomplishments: Conducted Congressionally directed efforts.			
FY 2020 Plans: Not Applicable			
Congressional Adds Subtotals		20.346	10.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 622406 / <i>Aerospace Power & Flight Control Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622406: <i>Aerospace Power & Flight Control Technology</i>	-	0.000	0.000	72.653	0.000	72.653	76.366	72.548	74.338	75.467	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops integrated electrical and thermal management components, controls and systems for military aerospace applications. Power component technologies are developed to increase reliability, maintainability, commonality, affordability, and supportability of aircraft and flight line equipment. Research is conducted in energy storage and hybrid power system technologies to enable special purpose applications. Electrical power and thermal management technologies enable future military megawatt level power and thermal management needs. Controls and system integration technologies ensure the interoperability of aircraft, power, thermal, engine and other systems and subsystems. This project supports development of electrical power and thermal management components, controls and systems suitable for applications to legacy and future aircraft platforms including strike and mobility concepts. Lightweight power systems suitable for other aerospace applications are also developed. This project develops technologies that enable maximum affordable capability from manned, remotely-piloted and autonomous aerospace vehicles. Advanced control technologies are developed for maximum vehicle performance throughout the flight envelope and simulated in virtual environments. Resulting technologies contribute significantly towards the development of reliable autonomous or remotely piloted air vehicles, hypersonic aircraft, and extended-life legacy aircraft.

In FY 2021, Project 622406, Aerospace Power & Flight Control Technology, was created in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept. Efforts in this project were previously accomplished under PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls & Pilot-Vehicle Interface and PE 0602203F, Aerospace Propulsion, Project 623145, Aerospace Power Technology.

This is an administrative realignment to provide increased execution flexibility and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Power System Technologies	0.000	0.000	40.448
Description: Develop integrated system architecture, controls, and component technologies to provide for the large amounts of electrical power needed, and concurrent thermal mitigation required, by current and future manned and unmanned systems.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623145, Aerospace Power Technology, High Power System Technologies effort.			
FY 2021 Plans: Continue development of system and component electrical power, electro-mechanical, and thermal technologies for high-power applications. Continue development of hybrid approaches to power generation, storage, and application as well as thermal			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622406 / <i>Aerospace Power & Flight Control Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>management. Continue testing of subsystems hardware in conjunction with continued platform level tip-to-tail modeling and simulation energy optimization. Continue development of advanced, safe energy storage, power distribution, and management systems to include Silicon Carbide applications and batteries. Continue power and thermal development toward demonstration of tactical aircraft high-power payload capability, e.g. laser weapon system. Continue analysis and development of adaptive power and thermal control systems for high-power aircraft. Continue weapon system contractor support for platform integration of advanced power and thermal system architectures. Initiate medium-scale propulsion, power and thermal system studies and development.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$40.448 million. Funding increased due to realignment of High Power Systems research from PE 0602203F, Aerospace Propulsion, Project 623145, Aerospace Power Technology, High Power Systems Technologies effort, and civilian pay repricing adjustments.</p>			
<p>Title: Advanced Flight Control Technologies</p> <p>Description: Develop technologies for advanced control-enabled capabilities, including flight controls, components, integrated vehicle management systems and software and system certification techniques for both manned/unmanned and remotely piloted aircraft.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls & Pilot-Vehicle Interface, Advanced Flight Control Technologies effort.</p> <p>FY 2021 Plans: Complete the development, demonstration, and assessment of advanced flight control mechanization technologies for trusted and certifiable operations under adverse and contested environments. Continue the development of trusted autonomy approach, integrating certification processes and autonomy development. Initiate the development, demonstration, and assessment of autonomy capabilities under adverse and contested environments.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$7.380 million. Funding increased due to realignment of Advanced Flight Control research from Project 622403, Flight Controls & Pilot-Vehicle Interface, Advanced Flight Control Technologies effort, and civilian pay repricing adjustments.</p>	0.000	0.000	7.380
<p>Title: Manned and Unmanned Teaming Technologies</p> <p>Description: Develop technology for flight control systems that will permit safe interoperability between manned and remotely piloted aircraft and effective teaming in adverse and contested environments.</p>	0.000	0.000	19.178

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622406 / <i>Aerospace Power & Flight Control Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> For FY 2020 and prior years, this work is performed under PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls & Pilot-Vehicle Interface, Manned and Unmanned Teaming Technologies effort.</p> <p><i>FY 2021 Plans:</i> Continue development, demonstration, and assessment of advanced control automation techniques. Complete the development of mixed initiative control techniques for teams of remotely piloted aircraft and/or manned-unmanned teams in contested, dynamic mission environments, as well as for the integration of unmanned systems into controlled airspace and airbase operations. Complete the development of robust, affordable Unmanned Air Systems (UAS) operations in a terminal airspace environment. Continue the development of autonomous behaviors for safe, effective manned-unmanned teams. Initiate the development of tactical autonomy for manned-unmanned teams in contested, dynamic mission environments.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$19.178 million. Funding increased due to realignment of Manned and Unmanned Teaming Technologies research from Project 622403, Flight Controls & Pilot-Vehicle Interface, Manned and Unmanned Teaming Technologies effort, and civilian pay repricing adjustments.</p>			
<p><i>Title:</i> Flight Controls Technologies Modeling and Simulation</p> <p><i>Description:</i> Develop tools and methods for capitalizing on simulation-based research and development of future aerospace vehicles.</p> <p><i>FY 2020 Plans:</i> For FY 2020 and prior years, this work is performed under Project 622403, Flight Controls & Pilot-Vehicle Interface, Flight Controls Technologies Modeling and Simulation effort.</p> <p><i>FY 2021 Plans:</i> Continue modeling and simulation efforts to evaluate emerging autonomous and robust flight control technologies and concepts, as well as assess mission level performance of integrated aerospace systems. Continue analyses of manned-unmanned teams in adversarial mission environments. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Continue manned-unmanned teaming evaluations including rapid development of new capabilities. Initiate analyses of capability concepts for future advanced development programs.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i></p>	0.000	0.000	5.647

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622406 / <i>Aerospace Power & Flight Control Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$5.647 million. Funding increased due to realignment of Flight Controls Technologies Modeling and Simulation research from Project 622403, Flight Controls & Pilot-Vehicle Interface, Flight Controls Technologies Modeling and Simulation Technologies effort and civilian pay repricing adjustments.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	72.653

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
623066: <i>Turbine Engine Technology</i>	-	0.000	0.000	73.887	0.000	73.887	73.705	70.860	72.425	73.523	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops technology to increase turbine engine operational reliability, durability, mission flexibility, and performance, while reducing weight, fuel consumption, and cost of ownership. Analytical and experimental areas of emphasis are fans and compressors, high temperature combustors, turbines, internal flow systems, controls, augmentor and exhaust systems, integrated power and thermal management systems, engine inlet integration, mechanical systems, adaptive cycle technologies, and structural design. The project investigates advanced propulsion, power, and thermal management system for subsonic, supersonic, or hypersonic vision systems for the 2025-2035 timeframe to: Develop and demonstrate propulsion technologies for subsonic expendable and attritable air platforms; develop and validate targeted life component design, materials, and modeling tools for all engine classes; develop advanced turbine engine technologies to enable significantly increased range and dash speed; investigate durability, efficiency, and specific power with reduced cost of ownership for reusable engines; develop pervasive, hydrocarbon fueled pressure gain propulsion technologies that offer increased efficiency, reduced propulsion system volume/weight, and truly disruptive vehicle performance to the warfighter; evaluate lubricants, mechanical systems, and combustion concepts for advanced turbine engines, pressure gain propulsion, and combined cycle engines; analysis for an adaptive cycle engine architecture that provides both optimized performance and fuel efficiency for widely varying mission needs.

This project supports joint Department of Defense, agency, and industry efforts to focus turbine propulsion technology on national needs. The project plan is relevant across capability areas for global responsive air superiority, strike, tactical and global mobility, responsive space lift, and persistent intelligence, surveillance, and reconnaissance (ISR).

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology. In addition, the entirety of PE 0602203F, Aerospace Propulsion, Project 623048, Combustion & Mechanical Systems is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology. These transfers support internal Technology Directorate operations and realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Turbofan/Turbojet Engine Technologies	0.000	0.000	30.795
Description: Develop core turbofan/turbojet engine components (i.e., fans, nozzles, compressors, combustors, and turbines and mechanical systems) for fighters, bombers, sustained supersonic/hypersonic cruise vehicles, and transports.			
FY 2020 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Core Technologies and Bearing Technologies efforts.</p> <p>FY 2021 Plans: Complete development and validation of modeling and simulation tools for the design and analysis of advanced turbine components with improved durability for advanced engines including: planning for a conceptual design, fabrication, and testing of component technology rigs, including bearing testing; exploring new approaches for advanced engine technologies, including use of high-temperature materials, integrated propulsion, power and thermal technologies and responsive controls; finalizing the concepts for achieving the product goals for increased fuel efficiency, power and thermal management and propulsive capability. Continue development of improved aerodynamic design tools and analysis methods to extend engine operability and efficiency. Continue developing physics-based bearing life model based on bearing alloy fatigue & microstructural investigations, including bearing life factors for advanced bearing materials. Continue incorporating fatigue life, fault evolution, and parametric heat generation of advanced material systems into the models. Continue development of oil-free bearing technology for Unmanned Air Systems. Complete development of active thrust-balance/prognostic health management system for large man-rated and medium-scale propulsion. Initiate the development and demonstration of propulsion technologies for subsonic expendable and attritable air platforms, small and medium scale propulsion technologies, and evaluate lubricants, mechanical systems, bearing technology and combustion concepts for advanced turbine engines. Initiate the development of fundamental knowledge of bearing material rolling contact fatigue failure mechanisms and lubricant interactions through microstructural investigations and failure analysis.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$30.795 million. Funding increased due to realignment of Turbofan/Turbojet Engine Core research from PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Core Technologies effort, Bearing Technologies effort, and civilian pay repricing adjustments.</p>				
<p>Title: Turboshaft/Turboprop and Small Turbofan Engine Technologies</p> <p>Description: Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623066. Three efforts from PE 0602203F, Aerospace Propulsion are combined into a single effort in PE 0602201F, Aerospace Vehicle Technologies; Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies; Turbine Engine Technology, Missile and Remotely Piloted Aircraft Engine Technologies; and Turbine Engine Technology, Combustion Technologies efforts.</p> <p>FY 2021 Plans:</p>		0.000	0.000	11.621

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Continue to demonstrate advanced component designs in rig testing. Continue to utilize validation data to develop improved test protocol for small engine augmentor designs. Continue development and validation of modeling and simulation tools for the design and analysis of turbine components with mission-tailored aero-performance and highly efficient cooling geometries. Complete the development and validation of parameter, process, and performance modeling for components manufactured through additive technologies. Complete the development and validation of rules and tools to enable flexible design for targeted life applications. Continue the new innovative architectures, critical technologies, exploration of targeted life applications for small missile and remotely piloted aircraft applications; evaluate critical technologies that will increase range, performance, durability, electrical power and thermal capacity of these systems. Continue the exploration of new small engine technologies that can operate in high speed applications; Evaluate risk reduction technologies to increase usage time of systems. Complete development of computations, modeling and simulation, and research experimentation of advanced combustion concepts including pressure gain combustion components. Continue demonstrating advanced component designs and modeling tools in rig and engine testing. Continue to utilize validation data to develop improved test protocol for small engine designs. Continue development and validation of modeling and simulation tools for the design and analysis of engine components with new manufacturing processes. Continue the exploration of advanced integrated engine controls with potential for synergistic airframe system level benefits. Continue exploration of new small and medium size engine technologies for increased fuel efficiency, propulsive capability, power and thermal management, and reduced life cycle cost. Continue identification of new architectures and critical technologies for integrated power and thermal systems. Continue identification of requirements and develop models for simulation of highly integrated systems. Continue exploring interactions and effects of compressor and turbine components on the combustor and combustor materials to reduce engine weight and increase efficiency. Continue using advanced diagnostics tools to develop high-quality datasets for use by academia and industry for model development and verification. Continue the determination of necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon systems. Continue to support development of advanced computational fluid dynamics (CFD) models to reduce combustor and augmentor design costs. Continue development of computations, modeling and simulation, and research experimentation of advanced combustion concepts including pressure gain combustion components and system level architectures. Continue to explore advanced combustion and flameholding concepts working towards improved understanding at relevant operating conditions such as sub-atmospheric (less than 1 atmosphere) and high pressure (greater than 10 atmospheres); this includes initiating fundamental combustion modeling and fluid-dynamic phenomena on high speed systems and rocket propulsion and advanced turbine engine applications, identifying modeling and simulation concepts/approaches to address combustion chemistry and physics and light/matter interactions, for high speed systems exploring turbulent combustion modeling in advanced configurations, exploring advanced combustion including pressure gain propulsion as it relates to new applications and architectures. Initiate the development and demonstration of new tools and use of new designs and materials to improve efficiency, power under quiet operations. Initiate investigation to identify and assess disruptive propulsion/power</p>			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>concepts and evaluate concepts. Initiate development of new technologies for unmanned aircraft system propulsion/power systems for improved understanding at relevant operating conditions.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$11.621 million. Funding increased due to realignment of Turboshaft/Turboprop and Small Turbofan Engine research from PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies effort, Missile and Remotely Piloted Aircraft Engine Technologies effort, Combustion Technologies and civilian pay repricing adjustments.</p>				
<p>Title: Diagnostic Technologies</p> <p>Description: Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary propulsion technologies.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623048, Combustion and Mechanical Systems, Diagnostic Technologies effort.</p> <p>FY 2021 Plans: Complete the development and demonstration of diagnostic systems for high-bandwidth kilohertz to megahertz measurement of combustion chemistry and physics. Complete the development of diagnostic techniques to include 1) time-division-multiplexed hyperspectral absorption spectroscopy, 2) pulse-burst lasers, and 3) ultrashort-pulse (picosecond, femtosecond) lasers. Complete the application of the insights gained to engine test cells and fielded systems including development and deployment of fiber-coupled sensor systems based on hyperspectral absorption spectroscopy. Continue supporting computational fluid dynamics combustion modeling by providing, insights for interpreting experimental results using existing Modeling & Simulation methodologies and applying recently developed high-speed, spatially resolved laser diagnostics to our representative, single-element combustion experiments in order to demonstrate and deliver measurements of key combustion species and flow properties under high pressure conditions. Continue development of diagnostic tools/methods for robust measurement capability in engine test cells and full annular ground test environments including; reacting and non-reacting spray experiments for liquid fuel spray model development, employing Nonintrusive optical diagnostics will be used to obtain accurate, spatially/temporally resolved data. This provides the local flow field data required for comparisons to results of numerical simulations. Complete the development of portable measurement capability for engine testing. Complete the advancement of algorithms for tomographic reconstruction and spatiotemporal nonlinear data analysis to assess the rich data sets generated in the fundamental experiments and system testing described above. Initiate the development of improved numerical methods and turbulent combustion models to guide design and development of experimental components and systems utilizing existing Modeling & Simulation methodologies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		0.000	0.000	0.918

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$0.918 million. Funding increased due to realignment of Diagnostics research from PE 0602203F, Aerospace Propulsion, Project 623048, Combustion and Mechanical, Diagnostic Technologies effort; and civilian pay repricing adjustments.				
<p>Title: Revolutionary Propulsion Technology</p> <p>Description: Develop, test, and evaluate revolutionary propulsion concepts for gas turbine, pressure gain propulsion, and combined cycle engines for missiles, manned and unmanned systems.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies effort.</p> <p>FY 2021 Plans: Complete development of modeling and simulation tools, for advanced turbine engine concepts. Complete advanced modeling and simulation tools for the design and analysis of advanced propulsion technologies to enable lower cost/weight systems with improved aero-performance for increased range and endurance at altitude. Complete analysis of advanced propulsion engines, such as rotating detonation engines and advanced high-speed concepts. Continue identification of control technology elements applicable to integrated propulsion/power/thermal solutions. Continue evaluation of power and thermal modeling of advanced architectures into aircraft system level multidisciplinary analysis and optimization tools: explore new control methods for integrated propulsion, power and thermal management; continue evaluation of integration of advanced augmentors and ramburners; continue exploration of new expendable and attritable architectures. Initiate the development and evaluation of advanced, integrated propulsion technologies for supersonic expendable, attritable, and reusable strike & ISR systems. Initiate studies for exploration of advanced propulsion technologies. Explore and evaluate innovative architectures for affordable & efficient air-launched propulsion capability from Mach 3 to Mach 5+, and turbine based combined cycle propulsion capability to Mach 5+.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$15.375 million. Funding increased due to realignment of Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies research from PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies effort; and civilian pay repricing adjustments.</p>		0.000	0.000	15.375
<p>Title: Missile and Unmanned Aerial System (UAS) Engine Technologies</p> <p>Description: Develop limited life engine components for missile and Unmanned Aerial System (UAS) applications, including long-range subsonic, supersonic and hypersonic vehicles.</p>		0.000	0.000	12.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies effort.</p> <p><i>FY 2021 Plans:</i> Complete development of modeling and simulation tools for advanced missile and unmanned aerial system concepts. Complete advanced modeling and simulation tools for the design and analysis of new systems to enable lower cost/weight systems with improved aero-performance for increased range and endurance at altitude. Continue identification of control technology elements applicable to integrated propulsion/power/thermal solutions. Continue evaluation of power and thermal modeling of advanced architectures into aircraft system level multidisciplinary analysis and optimization tools: explore new control methods for integrated propulsion, power and thermal management; continue evaluation of integration of advanced augmentors and ramburners; continue exploration of new expendable and attritable architectures. Initiate the development and evaluation of advanced, integrated propulsion technologies for supersonic expendable, attritable, and reusable strike & ISR systems. Explore new engine concepts for missile and unmanned systems.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$15.375 million. Funding increased due to realignment of Missile and Unmanned Aerial System(UAS) Engine Technologies research from PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Missile and Unmanned Aerial System Engine Technologies effort; and civilian pay repricing adjustments.</p>			
<p><i>Title:</i> Lubricant Technologies</p> <p><i>Description:</i> Develop, test, and qualify advanced turbine engine lubricants. Generate and maintain military specifications for aviation engine lubricants.</p> <p><i>FY 2020 Plans:</i> For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623048, Combustion and Mechanical Systems, Lubricant Technologies effort.</p> <p><i>FY 2021 Plans:</i> Continue developing innovative fluids by; defining target requirements for new polyol ester oils, conducts Research & Development for new/enhanced turbine engine oils for legacy & emerging engines, qualifies new & updated engine oil products for legacy & emerging engines. Complete identification and development on in-line mechanical system health monitoring sensor technology. Continue the development of lubricant modeling through characterization of heat generation, lubrication system cooling effectiveness, failure progression of bearing materials under relevant engine conditions, and overall system performance of advanced bearing concepts for model validation. Continue supporting the warfighter on field-related mechanical system issues.</p>	0.000	0.000	3.178

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Initiate performance validation study of advanced bearing designs/materials, lubricant & lubrication system components via full-scale high-fidelity laboratory parametric testing at representative engine operating conditions. Initiate the generation of the fatigue life database & assess fatigue growth characteristics of state of the art baseline, emerging, & advanced engine rolling element bearing materials thru sub-scale experimental investigations.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$3.178 million. Funding increased due to realignment of Lubricant research from PE 0602203F, Aerospace Propulsion, Project 623048, Combustion and Mechanical, Lubricant Technologies effort; and civilian pay repricing adjustments.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	73.887

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624847: <i>Rocket Propulsion Technology</i>	-	0.000	0.000	62.855	0.000	62.855	63.217	60.717	62.075	63.025	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops rocket propulsion technologies for space access, space maneuver, the sustainment of strategic systems (including solid boost/missile propulsion, post boost control, aging and surveillance efforts), and tactical missiles. Analytical and experimental areas of emphasis are propellants, propellant management, combustion, rocket material applications, technology for sustainment of strategic systems, and innovative space propulsion concepts. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of these systems. Develop technologies to reduce the weight and cost of components using new materials and improved designs and manufacturing techniques. All efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire Department of Defense (DoD). Technologies under this project enable capabilities of interest to both DoD and National Aeronautics and Space Administration (NASA). Tasks include: modeling and simulation; proof of concept tests of critical components; advanced component development; and ground-based tests. Aging and surveillance tasks could reduce lifetime prediction uncertainties for individual motors by 50%, enabling motor replacement for cause. All thrusts are part of the Rocket Propulsion 21 (RP21) collaboration and are reviewed by a DoD level steering committee yearly for relevance to DoD missions and progress towards RP21 Goals.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Fuel Technologies	0.000	0.000	12.669
Description: Develop, characterize, and test advanced hydrocarbons, energetics, solid propellants, and monopropellants to increase space launch payload capability and refine new synthesis methods.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Fuel Technologies effort.			
FY 2021 Plans: Continue to develop solid rocket propellant binder systems for use across operationally relevant conditions. Continue to devise, synthesize, scale-up, and characterize novel energetic ingredients for monopropellants, fuels, and oxidizers, for use across the span of space and missile applications including tactical, strategic, and in-space thrust and attitude control. Continue knowledge transfer for making green monopropellants to United States industrial base. Continue to formulate, scale-up, and evaluate			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>formulations of solid and liquid rocket propellants. Continue to identify, evaluate, and adapt 21st century material processing techniques and equipment to enable more rapid and agile development for more precise products. Continue research in high-temperature resins, insulators, and composite case fabrication techniques to enable high performance rocket motor cases.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$12.669 million. Funding increased due to realignment of Fuel Technology research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Fuel Technologies effort, and civilian pay repricing adjustments.</p>				
<p>Title: Liquid Engine Combustion Technologies</p> <p>Description: Develop advanced liquid engine combustion technology for improved performance, while preserving chamber lifetime and reliability needs for engine uses in heavy lift space vehicles.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Liquid Engine Combustion Technologies effort.</p> <p>FY 2021 Plans: Continue evaluation of methane multi-injector designs in hot-fire conditions. Continue hot fire tests in combustion stability rig. Continue combustion stability modeling critical for future hydrocarbon fueled liquid rocket engines. Complete the delivery of combustion stability codes with nearly complete set of validation data to rocket community, enabling more robust and stable engine designs. Continue developing understanding of hydrocarbon fuel production, expanding testing into methane fuels and other cryogenic cooling. Continue the employment of new fuel and material operating limitations, manufacturing processes, and launch goals in cycle analysis to identify trade space for future engines. Continue to develop and evaluate advanced material solutions for high temperature components in rocket propulsion. Continue installation of new test facility that will fill the current capability gap and allow for fast, low-cost testing of multi-injector designs and stability strategies at conditions relevant to the demands of both Department of Defense and industry for next-generation engines (including use of liquid oxygen and higher pressures and thrust). Continue development and payoff determination of rotating detonation rocket engine technologies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$11.282 million. Funding increased due to realignment of Liquid Engine Combustion research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Liquid Engine Combustion Technologies effort, and civilian pay repricing adjustments.</p>		0.000	0.000	11.282
<p>Title: Advanced Liquid Engine Technologies</p>		0.000	0.000	4.994

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Develop advanced liquid engine technologies for improved performance, while increasing life and reliability needs for engine uses in expendable and reusable launch vehicles.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Advanced Liquid Engine Technologies effort.</p> <p>FY 2021 Plans: Complete exploring engine concepts for next generation, beyond 2035, launch vehicles and concepts to effect cost reductions. Continue sub-scale risk mitigation and technology maturation activities to incorporate into next generation engine concepts. Continue modular component integration and interaction research activities supporting next generation engine concepts.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$4.994 million. Funding increased due to realignment of Advanced Liquid Engine research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Advanced Liquid Engine Technologies effort, and civilian pay repricing adjustments.</p>			
<p>Title: On-Orbit Propulsion Technologies</p> <p>Description: Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for station-keeping, repositioning, and orbit transfer for satellites and satellite constellations.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, On-Orbit Propulsion Technologies effort.</p> <p>FY 2021 Plans: Continue advanced chemical propellants scale-up research focusing on transition of numerical tools and experimental methodologies for advanced monopropellants to spacecraft industry. Continue to support the maturation of advanced diagnostics for both chemical and electric propulsion thruster plumes with potential for integrated state-of-health application. Continue to expand the validation and verification programs (both experimental and flight) to quantify accuracy of modeling and simulation tools developed to support thruster-spacecraft integration. Continue transition and support of thruster/ plume modeling framework to spacecraft industry, with addition of advanced Electric Propulsion thruster models, to industry partners. Expanding exploration of advanced integrated electric propulsion and chemical thruster concepts and assess new spacecraft propulsion requirements.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	0.000	0.000	7.696

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$7.696 million. Funding increased due to realignment of On-orbit propulsion research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, On-orbit Propulsion Technologies effort, and civilian pay repricing adjustments.				
Title: Ballistic and Tactical Propulsion Technologies		0.000	0.000	26.214
Description: Develop missile propulsion technologies and aging & surveillance technologies for ballistic and tactical missiles.				
FY 2020 Plans: For Fiscal Year 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Space Access and Strike Applications and Ballistic Missile Technologies efforts.				
FY 2021 Plans: Continue to apply next generation of chemical and mechanical aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, to user needs and unique challenges. Continue development of advanced sensor, non-destructive evaluation, modeling and supporting technology development efforts to detect and explain phenomena further improve data acquisition and reduce uncertainty in tactical, hypersonic, and ballistic missile solid rocket motor service life predictions. Continue long-term validation of tools through long-term aging and testing of sub-scale motors. Continue to develop advanced tactical propulsion and concepts. Continue propellant development efforts including long-life and other novel propellant systems. Continue development, evaluation, verification, and validation of next generation of updated, physics-based modeling, simulation, and analysis tools for rapid and agile missile propulsion design, analysis, and production to include designs for 21st century material processing techniques and equipment. Continue to develop advanced component technologies for missile propulsion applications for strategic and strike systems helping to ensure their long-term sustainment.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$26.214 million. Funding increased due to realignment of Space Access and Strike Applications and Ballistic Missile Technologies research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Space Access and Strike Applications and Ballistic Missile technologies effort, and civilian pay repricing adjustments.				
Accomplishments/Planned Programs Subtotals		0.000	0.000	62.855
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625330: <i>Aerospace Fuel Technology</i>	-	0.000	0.000	7.552	0.000	7.552	7.644	7.496	7.658	7.786	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project evaluates hydrocarbon-based fuels for legacy and advanced turbine engines, scramjets, pressure gain propulsion and combined cycle engines. This project also considers fuel related concepts that can increase turbine engine operational reliability, durability, mission flexibility, energy efficiency, and performance while reducing weight, fuel consumption, and cost of ownership. Applications include missiles, aircraft, sustained high-speed vehicles, and responsive space launch. Analytical and experimental areas of emphasis include evaluations of fuel properties and characteristics of alternative fuels developed from unconventional sources (such as coal, natural gas, biomass, and combinations thereof), unique/alternate fuels and components used in integrated thermal and energy management systems including high heat sink fuel capability, fuels logistics and associated vulnerabilities, and combustion diagnostics and engine emissions measurements.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology. In addition, the entirety of Project 632480, Aerospace Fuels in PE 0603216F, Propulsion & Power Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology. These transfers realign and consolidation Aerospace Fuel research and realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Integrated Thermal and Energy Management	0.000	0.000	1.606
Description: Develop and demonstrate advanced components and conduct performance assessments of advanced aircraft integrated thermal and energy management systems for engines and aircraft.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Integrated Thermal and Energy Management effort.			
FY 2021 Plans: Continue the evaluation of advanced additives, catalysts, and fuel composition approaches to minimize endothermic fuel coking for hypersonic applications; Evaluate the impact of additively-manufactured parts and selected proposed industry "hot fuel" conditions by FY 2024. Continue model development for integrated thermal and energy management to include designs and evaluation of vehicle fuel systems, prototype sensors to monitor the fuel chemistry that produces coke deposits and characterization of system-level impacts from thermally-stressed fuel. These products will enable the hypersonics community to develop next generation systems that require hot fuels for thermal management. Initiate the development of fuel models			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>for system design and evaluation. Initiate the development of online sensors for monitoring chemistry that causes deposits. Characterize system-level impacts of emerging aviation technologies. Initiate new and continue existing studies using fuel as a thermal management fluid to meet AF requirements, including impact on combustor performance and emissions.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.606 million. Funding increased due to realignment of Integrated Thermal and Energy Management research from PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Integrated Thermal and Energy Management effort, and civilian pay repricing adjustments.</p>			
<p>Title: Advanced Fuels</p> <p>Description: Develop endothermic hydrocarbon fuels and catalysts for hypersonic applications. Evaluate heat sink of endothermic fuels under relevant conditions. Evaluate stability and performance of high-energy-density fuels. Develop nano-energetic approaches to high-altitude ignition and fuel energy density improvement.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 625330. Three efforts from PE 0602203F, Aerospace Propulsion, are combined into a single effort in PE 0602203F Aerospace Fuel Technology. The three efforts are: Combustion Emissions and Performance; Fuel-Related Thermal Management; Aerospace Fuel Technology, Gas Turbine Combustion, Emissions, and Performance; and Alternative Jet Fuels efforts.</p> <p>FY 2021 Plans: Continue aviation fuels combustion tests to identify fuel composition performance impacts. Continue investigation of fuel heat sink approaches for thermal management of advanced engines, and other systems evaluating integrated power and thermal management approaches. Continue investigation of heat exchangers including additive manufactured units and its reaction to fuels. Continue developing integrated test rigs to tests these approaches and assess efficiency of these approaches. Continue evaluating advanced high-mach fuel concepts. Evaluate fuel reaction models that enable high temperature systems for evaluating endothermic fuels. Continue development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions. Initiate study of fuel temperature limitations and use data to validate models, including the development and utilization of the analytical methods and knowledge discovery tools necessary to understand fundamental fuel composition and its impact across the operational domain to ensure readiness across the operational domain for the AF. Complete alternative fuel specification for commercial jet fuels with Federal Aviation Agency.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$3.452 million. Funding increased due to realignment of Advanced Fuels research from PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Combustion Emissions and</p>	0.000	0.000	3.452

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
Performance effort, Fuel-Related Thermal Management effort, Gas Turbine Combustion, Emissions, and Performance effort, Alternative Jet Fuels effort and civilian pay repricing adjustments.				
<p>Title: Fuel Logistics & Sustainment</p> <p>Description: Study and evaluate low-cost approaches to reduce fuel logistics footprint to reduce cost. Study fuel logistics vulnerabilities and develop detection and mitigation technologies. Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Air Force</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Fuel Logistics effort and PE 0603216F, Aerospace Propulsion & Power Technology, Project 632480, Aerospace Fuels, Fuel Logistics effort.</p> <p>FY 2021 Plans: Continue supporting fuel sustainment issues as needed, to understand problems and work to find solutions. Continue determining fuel temperature limits and other fuel technology approaches (additives, deoxygenation) for full-life fuel systems for advanced applications. Identify new approaches to be able to capture fuel stability limiters to minimize logistics vulnerabilities, work on bio-detection and mitigation to support logistics readiness, coordinate and collaborate with Army and Navy in identification and development of fuel sensing technologies. Continue the development of fuel composition in-situ sensors to ensure thermal stability throughout platform mission. Continue the development of fuel sensors and mitigation products to detect and mitigate fuel bio-contamination. Continue development of compositional analysis that can be verified across services and leverages a database of specification and extended compositional information to advance data visualization and analytics. Continue to analyze to develop fuels, fuel blends and catalyst formulations that provide endothermic cooling capacity for hypersonic applications. Initiate and expand study of fuel models for next generation vehicles.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$2.494 million. Funding increased due to realignment of Fuel Logistics research from PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Fuel Logistics effort, and PE 0603216F, Aerospace Propulsion & Power Technology, Project 632480, Aerospace Fuels, Fuel Logistics effort, and civilian pay repricing adjustments.</p>		0.000	0.000	2.494
Accomplishments/Planned Programs Subtotals		0.000	0.000	7.552
C. Other Program Funding Summary (\$ in Millions)				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	0.000	109.598	134.795	115.222	0.000	115.222	119.441	115.417	118.210	120.454	Continuing	Continuing
621123: <i>Learning and Operational Readiness</i>	0.000	20.665	22.495	22.606	0.000	22.606	23.079	21.785	22.094	22.315	Continuing	Continuing
625328: <i>Human Dynamics Evaluation</i>	0.000	28.820	51.449	27.941	0.000	27.941	28.549	27.268	27.877	28.307	Continuing	Continuing
625329: <i>Sensory Evaluation and Decision Science</i>	0.000	28.972	33.726	37.547	0.000	37.547	38.862	38.308	38.914	39.873	Continuing	Continuing
627757: <i>Bioeffects</i>	0.000	31.141	27.125	27.128	0.000	27.128	28.951	28.056	29.325	29.959	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program conducts applied research in the area of airmen training, airmen system interfaces, bioeffects, and understanding and shaping adversarial behavior. The Learning and Operational Readiness project conducts research to increase the agility of training for readiness while advancing learning and performance assessment science and practice. The Human Dynamics Evaluation project conducts research to discover, demonstrate, and transition capabilities which optimize and safe-guard Airman physical and cognitive performance allowing for the maximum potential of the multi-domain Airman. The Sensory Evaluation and Decision Science project conducts research to discover, demonstrate, and transition communication enhancements, and decision analytics to generate maximally effective warfighting teams resulting from the integration of Airmen and increasingly intelligent machines. The Bioeffects project conducts novel and operational exposure bioeffects research, exposure effects analysis and national/international exposure standards for the Air Force to enable, sustain, and enhance Airman performance and protection during deployment and application of advanced chemicals/materiel in air superiority platforms and warfighting directed energy systems.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	119.018	131.795	131.809	0.000	131.809
Current President's Budget	109.598	134.795	115.222	0.000	115.222
Total Adjustments	-9.420	3.000	-16.587	0.000	-16.587
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	3.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-2.439	0.000			
• Other Adjustments	-6.981	0.000	-16.587	0.000	-16.587

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 625328: *Human Dynamics Evaluation*

Congressional Add: *Program Increase - Warfighter physiology program*

Congressional Add: *Program Increase - Hypoxia research*

Congressional Add Subtotals for Project: 625328

Project: 625329: *Sensory Evaluation and Decision Science*

Congressional Add: *Program increase - Advanced technology development*

Congressional Add Subtotals for Project: 625329

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	1.469	0.000
	4.811	0.000
	6.280	0.000
	0.000	3.000
	0.000	3.000
	6.280	3.000

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$6.981 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Decrease in FY 2021 is due to the realignment and consolidation of the Future AF Capabilities Applied Research efforts/activities to PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, to better align with the Air Force S&T Strategy SECAF April 2019 and provide Congress with increased transparency on transformational Air Force S&T activities.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>				Project (Number/Name) 621123 / <i>Learning and Operational Readiness</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
621123: <i>Learning and Operational Readiness</i>	0.000	20.665	22.495	22.606	0.000	22.606	23.079	21.785	22.094	22.315	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project advances research to measure, accelerate, and expand the cognitive skills necessary to improve airmen training and mission performance. These discoveries will provide Airmen the knowledge, skills, and experiences to dominate the decision environment. Research is conducted in two focus areas: personalized learning and cognitive modeling. Personalized learning focuses on scientific discovery and exploratory application of adaptive personalization technologies to provide more effective learning which will increase mission readiness. Cognitive modeling leverages computational methods to understand the human mind and/or facilitate the development of models capable of operating as intelligent teammates, adversaries, or coaches, and cognitive performance prediction systems.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Personalized Learning	13.000	13.705	14.309
Description: Research enhances distributed mission operations (DMO) and live virtual constructive (LVC) environments and identifies technology requirements for training in live and immersive environments. Continuous learning strategies improve mission training, command and control (C2), intelligence, surveillance and reconnaissance (ISR), and cyber missions.			
In FY 2021, this effort is renamed from Continuous Learning to Personalized Learning.			
FY 2020 Plans: Initiate validation of objective performance metrics in operationally relevant testbeds. Mature personalized learning technologies. Begin training scenario development and simulated mission rehearsals with focus on contested and degraded operational environments. Execute integrated multi-domain training evaluations to assess modeling and simulation capabilities and limitations. Begin studies to evaluate an optimized mix of live, synthetic, and blended training technologies and architecture standards to determine standards for proficiency based training and readiness assessments.			
FY 2021 Plans: Continue to mature emerging technologies for the Readiness Product Line by advancing proficiency-based training through persistent, high resolution human and system measurement and secure multi-classification-level training integration. Balance the applied research portfolio with exploratory research in novel methods for adaptive, multi-objective instruction and interactive task learning, as well as the development of quantitative measures to estimate uncertainty in proficiency measurement and prediction.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.604 million. Funding increased due to civilian pay reprice adjustments.			
Title: Cognitive Modeling	7.665	8.790	8.297

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 621123 / <i>Learning and Operational Readiness</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Research explores application of mathematical and computational modeling to understand the human mind and factors that will enhance or degrade cognitive performance. Simulations of training in mission-relevant environments (e.g., flight simulators, multi-domain operations) will optimize learning strategies during training to increase/accelerate mission readiness.</p> <p>FY 2020 Plans: Initiate research to extend fatigue models to unmanned aerial vehicles (UAV) and special operations. Begin research to generalize model-based mission planning capabilities to multi-domain command & control (C2) operational planning. Demonstrate multiscale models for real-time cognitive load estimation and prediction in operationally relevant environments. Demonstrate predictive models of toxin-induced cognitive and performance decrements in a laboratory environment. Mature trainable agent research to integrate machine learning to acquire knowledge from operational data. Transition retention-based scheduling system for training.</p> <p>FY 2021 Plans: Continuing research and development toward the maturation of emerging technologies for Readiness and Sensing & Assessment production lines. Initiating maturation of models of physiology with computational cognitive models to predict cognitive performance under low-oxygen and chemical exposure conditions. Continue maturation of framework for rapidly developing high-fidelity representations of human cognitive behavior and performance. Continue research and development of high-cognitive-fidelity models capable of broader social interactions within Air Force relevant environments.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.493 million. Funding decreased due to civilian pay reprice adjustments.</p>			
Accomplishments/Planned Programs Subtotals	20.665	22.495	22.606

<p>C. Other Program Funding Summary (\$ in Millions) N/A</p> <p>Remarks None</p> <p>D. Acquisition Strategy N/A</p>
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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>				Project (Number/Name) 625328 / <i>Human Dynamics Evaluation</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625328: <i>Human Dynamics Evaluation</i>	0.000	28.820	51.449	27.941	0.000	27.941	28.549	27.268	27.877	28.307	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops technologies to sense, assess, and augment Airman physical and cognitive performance by conducting biological/bioengineering research focused in the areas of 1) cognitive science, 2) systems biology and performance, and 3) molecular sensing and physiology. Cognitive sciences develops and validates assessments of current and predicted cognitive states combined with personalized cognitive performance enhancement techniques and incorporation of technologies to augment these states. Systems biology and performance integrates the full spectrum of biosciences to discover the underlying mechanisms of airman performance. Molecular sensing and physiology will utilize real-time non-invasive physiological and environmental monitoring to assess the biological state of the airman for the purposes of maintaining and enhancing airman performance. Project also conducts research to predict physiological impacts of extreme, dynamic aerospace environments on aircrew safety, and performance.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Future AF Capabilities Applied Research	0.000	19.666	0.000
<p>Description: Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/unconventional weapons).</p> <p>The National Defense Strategy and Air Force Science and Technology (S&T) Strategy will inform investments over the FYDP.</p> <p>In FY 2019, this work was performed under multiple projects and efforts within the following Air Force S&T Programs: 0602102F, Materials; 0602201F, Aerospace Vehicle Technologies; 0602202F, Human Effectiveness Applied Research; 0602203F, Aerospace Propulsion; 0602204F, Aerospace Sensors; 1206601F, Space Technology; 0602602F, Conventional Munitions; 0602605F, Directed Energy Technology; and 0602788F, Dominant Information Science and Methods.</p> <p>FY 2020 Plans: Investigate and mature science and technology that enables future warfighting concepts to provide leap-ahead capabilities. The National Defense Strategy and Air Force S&T Strategy focus this science and technology toward, but not limited to, the following</p>			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625328 / <i>Human Dynamics Evaluation</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
capabilities: 1) global persistent awareness; 2) resilient information sharing; 3) rapid, effective decision-making; 4) complexity, unpredictability, and mass; and 5) speed and reach of disruption and lethality.				
<p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$19.666 million. Funding decreased due to realignment and consolidation of Future AF Capabilities Applied Research effort to PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort, to better align with the Air Force S&T Strategy SECAF April 2019 and provide Congress with increased transparency on transformational Air Force S&T activities.</p>				
<p>Title: Human Analyst Augmentation</p> <p>Description: Conduct research to enhance human components of intelligence, surveillance and reconnaissance (ISR). Develop ability to improve human analytic efficiency and effectiveness with fewer personnel and in increasingly complex mission space. Develop the ability to improve human cognitive performance of the ISR weapon system through improved data exploitation and intelligence content synthesis. Conduct research to optimize multi-domain ISR airman performance.</p> <p>FY 2020 Plans: Develop fundamental design principles and theories in human-machine teaming, human performance, psychological processes, and physiological indicators focused on system analytics and multi-domain integrated concepts. Design and envision capabilities to improve analytic insight and reasoning, and integrated multi-domain planning and execution. Integrate threat detection, characterization, and tracking algorithms into human-machine teaming systems to improve decision making for multi-domain operational planners. Develop robust and dynamic synthetic intelligence mission data to stimulate, evaluate, and validate software tools for multi-domain operational planners.</p> <p>FY 2021 Plans: In FY 2021, Human Analyst Augmentation work will be performed under the System Analytics effort and the Collaborative Interfaces and Teaming effort in Project 625329, Sensory Evaluation and Decision Science.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$9.691 million. Funding decreased due to realignment of Human Analyst Augmentation research to the System Analytics effort under Project 625329, Sensory Evaluation and Decision Science.</p>		9.377	9.691	0.000
<p>Title: Human Trust and Interaction</p>		8.306	8.784	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625328 / <i>Human Dynamics Evaluation</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Conduct research in cross-cultural communication and automated speech translation tools for Air Force missions. Conduct research to address important aspects of trust in airman-machine teams including investigating how an airman knows an autonomous or semiautonomous system is safe to use and whether the system, data, conclusions, and decision recommendations can be trusted.</p> <p>FY 2020 Plans: Advance and mature human machine teaming trust and transparency standards to semi-autonomous and autonomous applications. Investigate extending translation and natural language processing research to multimedia information extraction.</p> <p>FY 2021 Plans: In FY 2021, Human Trust and Interaction work will be transferred to the System Analytics effort in Project 625329, Sensory Evaluation and Decision Science.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$8.784 million. Funding decreased due to the realignment of Human Trust and Interaction research to the System Analytics effort under Project 625329, Sensory Evaluation and Decision Science.</p>			
<p>Title: Molecular Sensing and Physiology</p> <p>Description: Provides advanced science and technology solutions for the characterization and exploitation of novel molecular biosignatures attributed to physiological stress and utilizing these biosignatures to sense and assess the physiological state of airmen within their associated operational environments. Goal of this research is to sustain and/or augment airmen performance and alert the airmen and their commanders when they are trending toward sub-optimal performance so that intervention strategies can be implemented to restore mission effectiveness.</p> <p>In FY 2021, the effort is renamed from Human Signatures to Molecular Sensing and Physiology.</p> <p>FY 2020 Plans: Develop methodologies for air quality and physiological monitoring of personnel using machine learning techniques. Continue to develop algorithms to characterize human detections from air based sensors. Research and develop sensors that detect volatile organic compounds and novel biomarkers to determine Airman readiness.</p> <p>FY 2021 Plans:</p>	4.857	6.091	6.675

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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625328 / <i>Human Dynamics Evaluation</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Research biological recognition elements (BRE) for biosignature detection. Investigate new biosignatures in non-invasive biofluids. Develop reliable, wearable sensors for near real-time detection in non-invasive physiological fluids and sensors for hydration monitoring in Air Force environments. Evaluate and down select sensors for an aircrew fatigue management system.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.584 million. Funding increased due to civilian pay reprice adjustments.</p>				
<p>Title: Systems Biology and Performance</p> <p>Description: Investigates the underlying molecular-biological mechanisms contributing to airman physiological and cognitive performance optimization. Provide airman protection from performance degradation and/or enhance performance capability under demanding training and mission activities through molecular bioscience research.</p> <p>In FY 2019 and prior, this work is performed under the Molecular Bioeffects effort in Project 627757, Bioeffects.</p> <p>In FY 2021, the effort is renamed from Molecular Bioeffects to Systems Biology and Performance.</p> <p>FY 2020 Plans: Study the unknown physiological events occurring in pilots using omics technology (i.e., genomics, proteomics, and metabolomics) to predict Airman physical and cognitive states in that operational environment. Refine the development of an Air Force specific in vitro screen to enable rapid and accurate assessment of potentially toxic chemicals and materials including nanoparticles. Identify a potential safe and effective fatigue counter measures to improve Airmen performance in physically or mentally intensive operational environment. Conduct studies to predict how networks that form the whole of living organisms will change over time and under varying operationally relevant conditions.</p> <p>FY 2021 Plans: Apply biotechnology to investigate methods for engineering the microbiome for enhancing airman performance. Explore synthetic biology techniques to enable performance modification and resiliency. Develop mathematical models to predict system biology system biology performance. Develop advanced organ and tissue human models for mechanistic assessments.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.052 million. Funding decreased due to civilian pay reprice adjustments.</p>		0.000	7.217	7.165
<p>Title: Cognitive Neuroscience</p> <p>Description: Conduct research to develop and validate assessments of current and predicted cognitive states, enabling the development of personalized cognitive performance enhancements (e.g., neuromodulation, nutrition, physiological training, recovery approaches), supported by a foundational understanding of neurological mechanisms.</p>		0.000	0.000	6.902

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625328 / <i>Human Dynamics Evaluation</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> For FY 2020 and prior, Cognitive Neuroscience work is performed under the Applied Neuroscience effort in Project 625329, Sensory Evaluation and Decision Science.</p> <p><i>FY 2021 Plans:</i> Refine neuromodulation animal models for use in predicting human cognitive performance to include molecular predictors. Integrate inclusion of stress models on cognitive performance. Validate transcranial Direct Current Stimulation (tDCS) in operational environments and contexts. Expand Signature Tracking for Optimized Nutrition and Training (STRONG) Laboratory research to outside units for assessing program effectiveness. Complete a flexible domain package of cognitive workload assessment. Continue to develop algorithms for faster, predictable decision making capabilities. Initiate exploration of brain-machine interface research to enhance human state assessment, decision making, and trust. Explore use of bioinformatics to predict changes in cognitive neuroscience. Deliver enhanced lumbar spinal injury criteria and advance spinal injury prediction. Continue development of Multi-Axis Neck Injury Criteria (MANIC) model neck injury criteria transfer functions. Continue development of 5th and 95th percentile computational human ejection models to include expanded aircrew populations. Conduct current trainer aircraft on-board oxygen generation system (OBOGS) test & evaluations. Begin other fighter and new trainer aircraft OBOGS test & evaluation. Finalize and integrate innovative single/dual-breathing machine simulator development.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$6.902 million. Funding increased due to realignment of Cognitive Neuroscience research from the Applied Neuroscience effort in Project 625329, Sensory Evaluation and Decision Science, to this effort.</p>			
<p><i>Title:</i> Aircrew Biodynamics and Protection</p> <p><i>Description:</i> Conduct research to predict physiological impacts of extreme, dynamic aerospace environments (e.g., aircrew ejection, high altitude, high-G flight) on aircrew safety and performance. Research and develop novel innovative protective and safety devices related to aircraft ejection systems and flight safety equipment. Assess existing Air Force and Department of Defense safety standards and criteria for neck/spinal injury. Research performance of on-board oxygen generation systems (OBOGS) and implications on human physiology for current and next-generation aircraft.</p> <p><i>FY 2020 Plans:</i> For FY 2020 and prior years, Aircrew Biodynamics and Protection work is performed under the Applied Neuroscience effort in Project 625329, Sensory Evaluation and Decision Science.</p> <p><i>FY 2021 Plans:</i> Deliver enhanced lumbar spinal injury criteria and advance spinal injury prediction. Continue development of Multi-Axis Neck Injury Criteria model neck injury criteria transfer functions. Continue development of 5th and 95th percentile computational human</p>	0.000	0.000	7.199

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625328 / <i>Human Dynamics Evaluation</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
ejection models to include expanded aircrew populations. Conduct current trainer aircraft OBOGS test & evaluations. Begin other fighter and new trainer aircraft OBOGS test & evaluation. Finalize and integrate innovative single/dual-breathing machine simulator development.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$7.199 million. Funding increased due to realignment of Aircrew Biodynamics and Protection research from Project 625329, Sensory Evaluation and Decision Science, Applied Neuroscience effort, to this effort.			
Accomplishments/Planned Programs Subtotals	22.540	51.449	27.941

	FY 2019	FY 2020
<i>Congressional Add:</i> Program Increase - Warfighter physiology program	1.469	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts		
<i>FY 2020 Plans:</i> Not Applicable		
<i>Congressional Add:</i> Program Increase - Hypoxia research	4.811	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts		
<i>FY 2020 Plans:</i> Not Applicable		
Congressional Adds Subtotals	6.280	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>				Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625329: <i>Sensory Evaluation and Decision Science</i>	0.000	28.972	33.726	37.547	0.000	37.547	38.862	38.308	38.914	39.873	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts the discovery, development, and transition advanced interface technology, decision aiding tools, and situationally-adaptive augmentation methods to seamlessly integrate Airmen and intelligent machines into maximally collaborative warfighting teams. Advanced technologies will enhance how Airmen fight, via improved team interactions and adaptive information throughput. Airman-Machine interaction design is critical for achieving mission success and maintaining meaningful human control in highly complex, uncertain, and rapidly evolving environments.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Applied Neuroscience	14.108	14.211	0.000
Description: Develop technologies to enhance Airman performance and Airman-machine collaboration in high-stress decision-making environments. Conduct research to predict physiological impacts of extreme, dynamic environments.			
FY 2020 Plans: Validate sensing and assessment technologies/capabilities for sustained and enhanced Airman performance. Support the development of non-invasive off-body sensors for sensing biological and physiological indices of human performance. Continue to explore the utility of non-invasive peripheral nerve stimulation and other neuromodulation techniques to enhance cognitive performance. Identify the biological and physiological markers that predict enhanced cognitive performance in multiple field environments and under various stressors such as fatigue, high exertion, and oxygen deprived environments. Conduct bioinformatics studies on longitudinal data sets to inform cognitive performance augmentation strategies and refine customer decision tools. Research the novel biological and physical effects and safety implications of current and next-generation ejection seats and intense kinetic-energy scenarios involving human safety, to include the modeling & simulation of these effects on the human. Research the breathing and oxygenation systems for aircraft, investigate potential molecular and physiological sensing tools and techniques to ensure warfighter air quality safety and performance.			
FY 2021 Plans: In FY 2021, Applied Neuroscience work will performed under the Cognitive Neuroscience effort and the Aircrew Biodynamics and Protection effort in Project 625328, Human Dynamics Evaluation.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$14.211 million. Funding decreased due to the realignment of Applied Neuroscience research to the Cognitive Neuroscience effort and the Aircrew Biodynamics and Protection effort under Project 625328, Human Dynamics Evaluation.				
<p>Title: Collaborative Interfaces and Teaming</p> <p>Description: Research new Human-Machine Teaming (HMT) technologies and concepts (e.g., information portrayal, control devices, decision aiding algorithms and adaptive agents) for effective human-machine interaction and teamwork.</p> <p>In FY 2021, this effort is renamed from Human Role in Semiautonomous Systems to Collaborative Interfaces and Teaming.</p> <p>FY 2020 Plans: Examine novel HMT concepts and metrics in moderate-fidelity laboratory environments characterized by high-consequence, high-uncertainty missions. Examine the impact of novel HMT concepts, interfaces and agents on workload, shared situation awareness, performance, and trust using realistic laboratory environments which parallel operational challenges derived from Air Force operations, specifically focused on Multi-Domain Command & Control (MDC2).</p> <p>FY 2021 Plans: Execute the following: research on swift trust development and effective teaming methods between human operators in an MDC2 context; research on trust in software code; experiments to test visualizations and displays using HMT simulations, research and experimentation focused on HMT and collaborative interface design among mixed human-human and human-machine teams; research on intelligent agent development and testing; conduct research focused on development of software architectures and platforms to enable HMT for pilot-vehicle interfaces, Unmanned Aerial System (UAS) teaming, and Air Battle Management.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increase compared to FY 2020 by \$4.240 million. Funding increased due to realignment of HMT research from the Human Analyst Augmentation effort under Project 625328, Human Dynamics Evaluation, to this effort.</p>		5.924	6.019	10.259
<p>Title: Battlespace Visualization</p> <p>Description: Research the visualization, interaction and understanding of complex information to enhance warfighter decision making.</p> <p>FY 2020 Plans: Select and evaluate analytic strategies with machine learning techniques to achieve next-generation, automated, data exploitation capability, and develop visual interfaces to enhance task performance and decision making. Develop and evaluate integration and tailoring of Explainable Artificial Intelligence (XAI) analytic methods with analytic visual interfaces. Continue data analytics research focused on human visualization of complex data. Test and modify multi-domain operator system interfaces for integrated</p>		6.568	7.244	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>defensive and offensive operations. Transition model of predicted visibility of objects viewed by humans under both unaided and aided conditions and develop multi-modal model integration. Test and evaluate visualizations of events and their influence on objectives and courses of action for C2 environments across the air, space and cyberspace domains. Conduct multi-sensory research and develop concepts for seamlessly integrating multiple interaction modes, such as visual, auditory, vestibular, and tactile, into integrated work aids.</p> <p>FY 2021 Plans: In FY 2021, Battlespace Visualization work will be performed under the Multisensory Perceptions and Communication effort within this Project.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$7.224 million. Funding decreased due to realignment of Battlespace Visualization research to the Multisensory Perceptions and Communication effort within Project 625329, Sensory Evaluation and Decision Science.</p>				
<p>Title: Battlespace Acoustics</p> <p>Description: Conducts research on advanced auditory and communication technologies that mitigate effects of noise and enhance performance in operational environments.</p> <p>FY 2020 Plans: Conduct research on single sensor perception and multisensory interactions, focusing on multisensory integration and facilitation, as well as multisensory conflict for issues such as spatial disorientation. Determine optimal approaches for information presentation and communication management, incorporating both performance and preference metrics for enhanced decision making. Conduct research on speech identification and production, and develop interfaces and techniques to support effective human-human and human-machine communication. Evaluate emerging hearing enhancement and protection technologies to provide design guidelines for capabilities supporting future operations. Continue to enhance and refine models of acoustic detection for special operations aviation.</p> <p>FY 2021 Plans: In FY 2021, Battlespace Acoustics work will be performed under the the Multisensory Perceptions and Communication effort within this Project.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		2.372	3.252	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$3.252 million. Funding decreased due to realignment of Battlespace Acoustics research to the Multisensory Perceptions and Communication effort under Project 625329, Sensory Evaluation and Decision Science.				
<p>Title: Multisensory Perceptions and Communication</p> <p>Description: Multisensory Perception and Communication focuses on identifying and exploiting the underlying sensory and cognitive mechanisms mediating human perception and communication in order to inform the development of multimodal interfaces and speech/language technologies. Research will examine sensory processing, multisensory integration, and human communication processes in simple and complex environments to identify the barriers to effective information transmission and inform the development of technologies to overcome, or exploit, those barriers in order to enhance Airmen performance.</p> <p>FY 2020 Plans: For FY 2020 and prior years, Multisensory Perceptions and Communication work is performed under Battlefield Visualization effort and Battlefield Acoustics effort within this Project.</p> <p>FY 2021 Plans: Initiate research examining impact of communication interruption on task performance and develop a prototype real-time system; Plan study examining relative contribution of vocabulary and language rhythms and sounds on human interruption strategies; Initiate new behavioral/neurophysiological studies of multisensory perception and multimodal display research; Initiate program on multimodal contribution to automatic speech recognition and machine translation; Initiate lab experiments on perceptual jamming; Continue experiments on speech perception in complex environments; Plan new research in spatial attention monitoring; Measure and model acoustic signatures for aircraft and operational environments.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2020 increased compared to FY 2019 by \$14.121 million. Funding increased due to consolidation of Battlefield research from the Battlefield Visualization effort and Battlefield Acoustics effort within Project 625329, Sensory Evaluation and Decision Science, to this effort.</p>		0.000	0.000	14.121
<p>Title: System Analytics</p> <p>Description: System Analytics studies the macro-cognition of the Airman using computational tools to accomplish mission objectives, encompassing interactions between operators, analytics, and environment. The goal of this research area is to describe, assess, and design for effective integration of analytics into mission systems.</p> <p>FY 2020 Plans:</p>		0.000	0.000	13.167

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
For FY 2020 and prior years, System Analytics work is performed under the Human Analyst Augmentation effort and the Human Trust and Interaction effort in Project 625328, Human Dynamics Evaluation.			
<i>FY 2021 Plans:</i> Leverage ongoing research investments to: develop analytics that bring structure, meaning, and context to mission data in order to build representations to support warfighter mission systems; assess the benefits and costs of integrated data analytics by quantifying how analytics alter thinking and reasoning in order to promote effective decision making. Key research lines include assessment of analytics for full motion video, data visualization for dynamic wide area monitoring, and development of analytics to improve analytic insight and reasoning during exploitation of multiple data sources.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$13.167 million. Funding increased due to realignment of the System Analytics research from the Human Analyst Augmentation effort and the Human Trust and Interaction effort under Project 625328, Human Dynamics Evaluation, to this effort.			
Accomplishments/Planned Programs Subtotals	28.972	30.726	37.547

	FY 2019	FY 2020
<i>Congressional Add:</i> Program increase - Advanced technology development	0.000	3.000
<i>FY 2019 Accomplishments:</i> Not applicable		
<i>FY 2020 Plans:</i> Conduct Congressionally directed efforts		
Congressional Adds Subtotals	0.000	3.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 627757 / <i>Bioeffects</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
627757: <i>Bioeffects</i>	0.000	31.141	27.125	27.128	0.000	27.128	28.951	28.056	29.325	29.959	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts applied research on the effects of human exposure to electromagnetic (EM) energy (direct current (DC) to radio frequency (RF) to optical), scalable directed energy weapons, and non-lethal weapons. This research addresses fundamental physical principles, as well as the biophysical interaction between directed energy and the individual or groups of individuals. Research is divided into two core focus areas: novel directed energy bioeffects and mechanisms and directed energy modeling, simulation, and analysis. The research enhances combat survivability and systems effectiveness through technologies that enable deployed forces to counter optical threats and exploit optical systems for offensive applications. In addition, basic biological investigations into the mechanisms associated with high peak power and high average power RF exposure allow for the exploitation of directed energy systems for offensive capabilities while protecting the warfighter from adversarial use of RF technologies. The novel directed energy bioeffects mechanisms research examines the physical, physiological, and neural interactions of EM with tissues to understand dose-response effects as well as reveal the means to cause or prevent a specific effect. The directed energy modeling, simulation, and analysis research is focused on new software components that represent and optimize concepts of directed energy system employment from the Airman standpoint. These components are matured for future transition and application for engagement-to-mission level simulations in which directed energy weapons are employed.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Optical Radiation Bioeffects</p> <p>Description: Conduct laboratory experiments and field research on laser bioeffects, enabling military exploitation of laser technology while providing countermeasures for optical hazards/threats.</p> <p>FY 2020 Plans: Initiate validation and verification experiments for 3-dimensional tissue models of laser exposures. Complete studies of alternate laser wavelength bioeffects for use in high-energy lasers and the assessment of relative hazards. Transition model for probabilistic evaluation of risks from laser exposures on Air Force and Department of Defense laser ranges. Advance dose-response models to include severe retinal and skin optical radiation exposures. Develop metrics for the influence of optical distortion in evaluating developing eye protection technology. Mature models for combining separate images of same retinal or skin area into one image with higher fidelity of injury.</p> <p>FY 2021 Plans: In FY 2021, Optical Radiation Bioeffects work will be transferred to the Novel Directed Energy Bioeffects and Mechanisms effort and the Directed Energy Bioeffects Modeling, Simulation and Analysis effort under Project 627757, Bioeffects.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	13.347	15.316	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 627757 / <i>Bioeffects</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$15.316 million. Funding decreased due to realignment of this research to the Novel Directed Energy Bioeffects and Mechanisms effort and the Directed Energy Bioeffects Modeling, Simulation and Analysis effort under Project 627757, Bioeffects.				
<p>Title: Radio Frequency Bioeffects</p> <p>Description: Conduct laboratory experiments and field research to enable safe exploitation of directed energy technologies for communication, target identification, and weapons development.</p> <p>FY 2020 Plans: Conduct in vivo measurement of high average power exposures and high peak power microwave exposures to identify and baseline novel bioeffects. Build thermo-acoustic dosimetry techniques for in vivo assessment of high power sources including radio frequency (RF) acoustics. Determine acute and chronic bioeffects from emerging sources such as particle beam. Expand in vivo molecular signature of RF exposure to assess acute and chronic bioeffects of RF to inform exposure scenarios.</p> <p>FY 2021 Plans: In FY 2021, Radio Frequency Bioeffects work will be transferred to the Novel Directed Energy Bioeffects and Mechanisms effort and the Directed Energy Bioeffects Modeling, Simulation and Analysis effort under Project 627757, Bioeffects.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$11.809 million. Funding decreased due to the realignment of this research to the Novel Directed Energy Bioeffects and Mechanisms effort and the Directed Energy Bioeffects Modeling, Simulation and Analysis effort under Project 627757, Bioeffects.</p>		9.973	11.809	0.000
<p>Title: Novel Directed Energy Bioeffects and Mechanisms</p> <p>Description: Conduct laboratory experiments to provide fundamental knowledge of mechanisms of interaction of directed energy (DE) with molecules, cells, tissues, organs, and whole organisms in support of military DE systems. Conduct laboratory experiments to understand the mechanistic and behavioral effects of novel weapon incidents to the Airman and to understand the effects of protection strategies on Airman performance.</p> <p>FY 2020 Plans: For FY 2020 and prior years, Novel Directed Energy Bioeffects and Mechanisms work is performed under the Optical Radiation Bioeffects effort and the Radio Frequency Bioeffects effort under Project 627757, Bioeffects.</p> <p>FY 2021 Plans: Complete bioeffects studies of potential future use laser wavelengths for use in high-energy lasers and the assessment of relative hazards. Develop metrics for the influence of optical distortion in evaluating developing eye protection technology. Conduct</p>		0.000	0.000	9.818

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 627757 / <i>Bioeffects</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>studies to understand use of laser eye protection on Airman performance. Conduct in vivo measurement of high average power exposures and high peak power microwave exposures to identify and baseline novel bioeffects. Build thermo-acoustic dosimetry techniques for in vivo assessment of high power sources including radio frequency (RF) thermal elastic expansion. Determine acute and chronic bioeffects from emerging sources. Expand in vivo molecular signature of RF exposure to assess acute and chronic bioeffects of RF to inform exposure scenarios.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$9.818 million. Funding increased due to realignment of Novel Directed Energy Bioeffects and Mechanism activities from the Optical Radiation Bioeffects effort and the Radio Frequency Bioeffects effort under Project 627757, Bioeffects.</p>				
<p>Title: Directed Energy Bioeffects Modeling, Simulation and Analysis</p> <p>Description: Conduct physics-level modeling and simulations to represent and optimize directed energy bioeffects to include direct, scalable, and collateral effects.</p> <p>FY 2020 Plans: For FY 2020 and prior years, Directed Energy Bioeffects Modeling, Simulation and Analysis work is performed under the Optical Radiation Bioeffects effort and the Radio Frequency Bioeffects effort under Project 627757, Bioeffects.</p> <p>FY 2021 Plans: Initiate validation and verification experiments for 3-dimensional tissue models of laser exposures. Transition model for probabilistic evaluation of risks from laser exposures on Air Force and Department of Defense laser ranges. Advance dose-response models to include severe retinal and skin optical radiation and radio frequency exposures. Mature models for combining separate images of same retinal or skin area into one image with higher fidelity of injury.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$17.310 million. Funding increased due to the realignment of Directed Energy Bioeffects Modeling and Simulation activities from the Optical Radiation Bioeffects effort and the Radio Frequency Bioeffects effort under Project 627757, Bioeffects.</p>		0.000	0.000	17.310
<p>Title: Molecular Bioeffects</p> <p>Description: Protect airman from toxic chemicals and materials and enhance performance capability under demanding training and mission activities through molecular bioscience research. Investigate the underlying molecular-biological mechanisms contributing to airman physical and cognitive performance optimization.</p> <p>FY 2020 Plans:</p>		7.821	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 627757 / <i>Bioeffects</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Starting in FY 2020, this work will be performed under the Systems Biology and Performance effort (formerly known as the Molecular Bioeffects effort) under Project 625328, Human Dynamics Evaluation. <i>FY 2021 Plans:</i> Not Applicable <i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> Not Applicable			
Accomplishments/Planned Programs Subtotals	31.141	27.125	27.128

C. Other Program Funding Summary (\$ in Millions)
N/A

Remarks

D. Acquisition Strategy
N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	202.638	226.775	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
623012: <i>Advanced Propulsion Technology</i>	-	24.875	29.802	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
623048: <i>Combustion and Mechanical Systems</i>	-	9.920	11.134	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
623066: <i>Turbine Engine Technology</i>	-	48.640	56.582	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
623145: <i>Aerospace Power Technology</i>	-	47.873	44.213	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
624847: <i>Rocket Propulsion Technology</i>	-	67.114	80.302	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
625330: <i>Aerospace Fuel Technology</i>	-	4.216	4.742	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This effort develops propulsion and power technologies to achieve enabling and revolutionary aerospace technology capabilities. The effort has six projects, each focusing on a technology area critical to the Air Force. The Advanced Propulsion Technology project develops high-speed air breathing propulsion engines to include combined cycle, ramjet, and hypersonic scramjet technologies to enable revolutionary propulsion capability for the Air Force. The Combustion and Mechanical Systems project develops engine mechanical system technologies: bearings, seals, drives, and lubricants as well as combustion components, concepts, and technologies for legacy and advanced turbine engines. The Turbine Engine Technology project develops enabling capabilities to enhance performance and affordability of existing weapon systems and develops component technologies for ultra high pressure ratio, substantially improved durability, and adaptive cycle engine architecture to provide optimized performance, fuel efficiency, and life for widely varying mission needs. The Aerospace Power Technology project develops electrical power and thermal control technologies for military applications that remove operational limitations and enable advanced vehicle designs and high-power mission systems. The Rocket Propulsion Technology project develops advances in rocket propulsion technologies for space access, space maneuver, missiles, the sustainment of strategic systems, and tactical rockets. The Aerospace Fuel Technology project evaluates hydrocarbon-based fuels for legacy and advanced turbine engines, scramjets, pulse detonation, and combined-cycle engines. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

In FY 2021, the Aerospace Systems RDT&E Budget Activity 02 (BA02) efforts and activities under PE 0602203F, Aerospace Propulsion, and PE 0602201F, Aerospace Vehicle Technologies, are realigned and consolidated into PE 0602201F, Aerospace Vehicle Technologies, to increase the efficiency and effectiveness of internal

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	
<p>Air Force Research Laboratory Aerospace Systems Technology Directorate operations to finalize the 2012 merger of the Air Vehicles Directorate and Propulsion Directorate; and to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force Science and Technology Strategy, April 2019.</p> <p>All transfers detailed below are administrative realignments for consolidation, and not new starts. This work will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located either in Wright Patterson Air Force Base, OH or Edwards Air Force Base, CA.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623048, Combustion & Mechanical Systems is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 624847 , Rocket Propulsion Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology.</p> <p>In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623012, Advanced Propulsion Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622405, High Speed Systems Technology.</p> <p>This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.</p> <p>This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.</p>		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	218.419	198.775	196.753	0.000	196.753
Current President's Budget	202.638	226.775	0.000	0.000	0.000
Total Adjustments	-15.781	28.000	-196.753	0.000	-196.753
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	28.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-0.283	0.000			
• SBIR/STTR Transfer	-7.168	0.000			
• Other Adjustments	-8.330	0.000	-196.753	0.000	-196.753

Congressional Add Details (\$ in Millions, and Includes General Reductions)

	FY 2019	FY 2020
Project: 623066: Turbine Engine Technology		
Congressional Add: <i>Program increase - advanced turbine technologies</i>	0.000	2.000
Congressional Add Subtotals for Project: 623066	0.000	2.000
Project: 623145: Aerospace Power Technology		
Congressional Add: <i>Program increase - thermal management technologies</i>	5.813	7.000
Congressional Add: <i>Program increase - next generation heat exchangers</i>	6.298	0.000
Congressional Add Subtotals for Project: 623145	12.111	7.000
Project: 624847: Rocket Propulsion Technology		
Congressional Add: <i>Program increase - centers of excellence</i>	4.844	0.000
Congressional Add: <i>Program increase - next generation hall thrusters</i>	9.689	14.000
Congressional Add: <i>Program increase - next generation liquid propulsion</i>	0.000	5.000
Congressional Add Subtotals for Project: 624847	14.533	19.000
Congressional Add Totals for all Projects	26.644	28.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force Date: February 2020

Appropriation/Budget Activity
3600: *Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research*

R-1 Program Element (Number/Name)
PE 0602203F / *Aerospace Propulsion*

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$8.330 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Decrease in FY 2021 of \$196.753 million is due realignment of the entirety of PE 0602203F, Aerospace Propulsion, to PE 0602201F, Aerospace Vehicle Technologies, to increase the efficiency and effectiveness of internal Aerospace Systems Technology Directorate operations to finalize the 2012 merger of the Air Vehicles Directorate and Propulsion Directorate.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / Aerospace Propulsion				Project (Number/Name) 623012 / Advanced Propulsion Technology			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
623012: <i>Advanced Propulsion Technology</i>	-	24.875	29.802	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops combined/advanced cycle air breathing high-speed (up to Mach 5) and hypersonic (Mach 5 to 7) propulsion technologies to provide revolutionary propulsion options for the Air Force. These new engine technologies will enable future high-speed/hypersonic weapons and aircraft concepts. The primary focus is on hydrocarbon-fueled engines capable of operating over a broad range of flight Mach numbers. Efforts include modeling, simulations, and proof of concept demonstrations of critical components; advanced component development; and ground-based demonstrations.

In FY 2021, the entirety of Project 620312, Advanced Propulsion Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622405, High Speed Systems Technology in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Hypersonic Scramjet Technologies	24.875	29.802	0.000
Description: Develop robust hydrocarbon fueled scramjet engine components and technologies to improve performance, operability, durability, and scalability for future platforms.			
FY 2020 Plans: Continue to develop and demonstrate advanced engine components to improve scramjet operating margin and to refine scramjet scaling laws for reusable applications. Continue to develop low internal drag flame stabilization devices and flight test engine components. Initiate propulsion studies and design efforts required for the development and demonstration of an engine flight test in FY 2022 that expands the flight environment of current high speed propulsion systems.			
FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 622405, High Speed Systems Technology, Hypersonic Scramjet Technologies effort.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$29.802 million. Funding decreased due to realignment of Hypersonic Scramjet research to PE 0602201F, Aerospace Vehicle Technologies, Project 622405, High speed Systems Technology, Hypersonic Scramjet Technologies effort.			
Accomplishments/Planned Programs Subtotals	24.875	29.802	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force Date: February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623012 / <i>Advanced Propulsion Technology</i>
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C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 623048 / <i>Combustion and Mechanical Systems</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
623048: <i>Combustion and Mechanical Systems</i>	-	9.920	11.134	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project evaluates lubricants, mechanical systems, and combustion concepts for advanced turbine engines, pulse detonation engines, and combined cycle engines. This project also develops technologies to increase turbine engine operational reliability, durability, mission flexibility, maintainability, and performance while reducing weight, fuel consumption, and cost of ownership. Applications include: missiles, aircraft, and re-usable high-speed vehicles. Analytical and experimental areas of emphasis include: lubricants, bearings, mechanical systems diagnostics, mechanical systems prognostics, rotor dynamics, oil-less engine technology, optical diagnostics, fundamental combustion, detonations, combustors, and afterburners. Lubricants for these engines must be thermally stable, cost-effective, and operate over a broad range of conditions. Advanced combustion concepts must be cost-effective, durable, and reduce pollutant emissions. A portion of this project supports adaptive cycle technologies. Adaptive cycle technologies develops component technology for an adaptive cycle engine architecture that provides both optimized performance and fuel efficiency for widely varying mission needs.

In FY 2021, the entirety of Project 623048, Combustion & Mechanical Systems is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Combustion Technologies	4.130	4.600	0.000
Description: Develop, test, and evaluate revolutionary combustion and propulsion concepts for gas turbine, pulse detonation, and combined cycle engines for missiles, manned and unmanned systems.			
FY 2020 Plans:			
Continue to explore interactions and effects of compressor and turbine components on the combustor and combustor materials to reduce engine weight and increase efficiency. Continue using advanced diagnostics to obtain high-quality datasets that can be made available to and used by academia and industry for model development and verification. Continue the determination of necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon systems. Continue to support development of advanced computational fluid dynamics (CFD) models to reduce combustor and augmentor design costs. Continue development of computations, modeling and simulation, and research experimentation of advanced combustion concepts including pressure gain combustion components and system level architectures. Continue to explore advanced combustion and flameholding concepts working towards improved understanding at relevant operating conditions such as sub-atmospheric (less than 1 atmosphere) and high pressure (greater than 10 atmospheres); this includes initiating fundamental combustion modeling and fluid-dynamic phenomena on high speed systems			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623048 / <i>Combustion and Mechanical Systems</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>and rocket propulsion and advanced turbine engine applications, identifying modeling and simulation concepts/approaches to address combustion chemistry and physics and light/matter interactions, for high speed systems exploring turbulent combustion modeling in advanced configurations, exploring advanced combustion including pressure gain propulsion as it relates to new applications and architectures.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.600 million. Funding decreased due to realignment of Combustion research to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies effort.</p>				
<p>Title: Diagnostic Technologies</p> <p>Description: Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary propulsion technologies.</p> <p>FY 2020 Plans: Continue development and demonstration of diagnostic systems for high-bandwidth kilohertz to megahertz (kHz-MHz) measurements of combustion chemistry and physics: expand the diagnostic-technologies portfolio beyond current efforts to detonation devices and pressure-gain combustion (e.g., rotating-detonation engines), hypersonic/scramjet propulsion, and munitions; increase focus on high-pressure combustion, such as that associated with rocket systems, including propulsion at near-critical and supercritical conditions. Continue the development of diagnostic techniques to include 1) time-division-multiplexed hyperspectral absorption spectroscopy, 2) pulse-burst lasers, and 3) ultrashort-pulse (picosecond, femtosecond) lasers. Continue application of the insights gained to engine test cells and fielded systems including development and deployment of fiber-coupled sensor systems based on hyperspectral absorption spectroscopy. Continue to provide sufficient data to support computational fluid dynamics (CFD) combustion model development, including development and application of fast laser systems and various atomic tracers for high-speed, planar visualization of mixing as applied in gas-turbine and hypersonic/scramjet propulsion systems. Continue development of diagnostic tools/methods for robust measurement capability in engine test cells and full annular ground test environments. Continue development of portable measurement capability for engine testing. Initiate advanced algorithms for tomographic reconstruction and spatiotemporal nonlinear data analysis to assess the rich data sets generated in the fundamental experiments and system testing described above.</p> <p>FY 2021 Plans:</p>		0.657	0.790	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623048 / <i>Combustion and Mechanical Systems</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Diagnostic Technologies effort. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.790 million. Funding decreased due to realignment of Diagnostic Technology research to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Diagnostic Technologies effort.				
Title: Lubricant Technologies Description: Develop, test, and qualify advanced turbine engine lubricants. Generate and maintain military specifications for aviation engine lubricants. FY 2020 Plans: Continue developing innovative fluids (i.e., ionic fluids/additives) as potential high temperature lubricants for high-Mach and future high performance engines. Complete demonstration of Enhanced Ester (EE) oils in rig testing and design studies of turbine engines. Complete transitioning EE oil to F-35 and F-22 fleet. Continue identification and development on in-line mechanical system health monitoring sensor technology. Continue the implementation of new lubricant traction models into updated bearing design codes. Refine bearing design codes to include advanced traction, rheological, and heat generation models: develop advanced algorithms for mechanical system health monitoring and condition based maintenance, apply high-temperature lubricant technologies to magneto and electro-rheological fluids for smart dampers and engine vibration control. Continue supporting the warfighter on field-related mechanical system issues. FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Lubricant Technologies effort. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$2.734 million. Funding decreased due to realignment of Lubricant research to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Lubricant Technologies effort.		2.534	2.734	0.000
Title: Bearing Technologies Description: Develop and test advanced bearing material technology and bearing concepts for small, intermediate, and large-scale turbine engine applications. FY 2020 Plans:		2.599	3.010	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623048 / <i>Combustion and Mechanical Systems</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Continue developing physics-based bearing life model based on bearing alloy fatigue & microstructural investigations, including bearing life factors for advanced bearing materials. Include fatigue life, fault evolution, and parametric heat generation of advanced material systems into the models. Continue development of oil-free bearing technologies for small & medium scale unmanned aircraft system, expendable and low-cost engines. Continue the integration of new bearing modeling simulation tools into full-engine design models. Continue development of active thrust-balance/prognostic health management system for large man-rated and medium-scale propulsion: demonstrate algorithms for active bearing thrust modulation for optimum performance and life in large turbine engines, demonstrate smart damper capabilities for control of turbine engine vibration, initiate investigation into the potential of additive manufacturing to develop robust, high-performance bearing compartment seals.</p> <p><i>FY 2021 Plans:</i> Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Technologies effort.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$3.010 million. Funding decreased due to realignment of Bearing research to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Technologies effort.</p>			
Accomplishments/Planned Programs Subtotals	9.920	11.134	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
623066: <i>Turbine Engine Technology</i>	-	48.640	56.582	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops technology to increase turbine engine operational reliability, durability, mission flexibility, and performance, while reducing weight, fuel consumption, and cost of ownership. Analytical and experimental areas of emphasis are fans and compressors, high temperature combustors, turbines, internal flow systems, controls, augmentor and exhaust systems, integrated power and thermal management systems, engine inlet integration, mechanical systems, adaptive cycle technologies, and structural design. This project develops component technology for an adaptive cycle engine architecture that provides both optimized performance and fuel efficiency for widely varying mission needs. This project supports joint Department of Defense, agency, and industry efforts to focus turbine propulsion technology on national needs. The project plan is relevant across capability areas for global responsive strike, tactical and global mobility, responsive space lift, and persistent intelligence, surveillance, and reconnaissance (ISR).

In FY 2021, the entirety of Project 623066, Turbine Engine Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Turbofan/Turbojet Engine Core Technologies	21.785	22.772	0.000
Description: Develop core turbofan/turbojet engine components (i.e., compressors, combustors, and turbines) for fighters, bombers, sustained supersonic/hypersonic cruise vehicles, and transports.			
FY 2020 Plans: Continue development and validation of modeling and simulation tools for the design and analysis of advanced turbine components with improved durability for adaptive cycle engines: develop and validate new architectures, critical technologies and new designs of adaptive core technologies; formulate a plan for detailed design, fabrication, and testing of component technology rigs for adaptive cores; conduct key technology rig tests to validate or determine new modeling cycles and designs; explore new approaches for variable core technologies, including use of high-temperature materials, integrated propulsion, power and thermal technologies and responsive controls. Continue development of improved compressor aerodynamic design tools and analysis methods to extend engine operability and efficiency.			
FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Technologies effort.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>FY 2021 decreased compared to FY 2020 by \$23.772 million. Funding decreased due to realignment of Turbofan/Turbojet Engine Core research to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Technologies effort.</p> <p>Title: Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies</p> <p>Description: Develop turbofan/turbojet engine components (i.e., fans, nozzles, etc.) used in engines for fighters, bombers, sustained supersonic strike and hypersonic cruise vehicles, and transports.</p> <p>FY 2020 Plans: Continue development of modeling and simulation tools, including methods to predict behavior of serpentine inlets and nozzles. Continue to develop and validate modeling and simulation tools for the design and analysis of advanced low pressure turbine components to enable lower cost/weight systems with improved aero-performance for increased range and endurance at altitude. Continue to identify control technology elements applicable to integrated propulsion/power/thermal solutions. Initiate integration of power and thermal modeling of advanced architectures into aircraft system level multidisciplinary analysis and optimization tools: explore new control methods for integrated propulsion, power and thermal management, initiate evaluation of integration of advanced augmentors and ramburners, initiate exploration of new expendable and attritable architectures.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Revolutionary Propulsion Technology effort and Missile and Unmanned Aerial System (UAS) Engine Technology effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$23.936 million. Funding decreased due to realignment of Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration research to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Revolutionary Propulsion Technology effort and Missile and Unmanned Aerial System (UAS) Engine Technologies effort.</p>	21.848	22.936	0.000
<p>Title: Missile and Remotely Piloted Aircraft Engine Technologies</p> <p>Description: Develop limited life engine components for missile and remotely piloted aircraft (RPA) applications, including long-range supersonic and hypersonic vehicles.</p> <p>FY 2020 Plans: Continue to demonstrate advanced component designs in rig testing. Continue to utilize validation data to develop improved test protocol for small engine augmentor designs. Continue development and validation of modeling and simulation tools for the design and analysis of turbine components with mission-tailored aero-performance and highly efficient cooling geometries. Continue to develop and validate parameter, process, and performance modeling for components manufactured through additive technologies. Continue to develop and validate rules and tools to enable flexible design for targeted life applications. Initiate</p>	4.098	5.529	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>exploration of new innovative architectures and critical technologies for small missile and remotely piloted aircraft applications; evaluate critical technologies that will increase range, performance, durability, electrical power and thermal capacity on these systems. Initiate exploration of new small engine technologies that can operate in high speed applications. Initiate rig testing to validate targeted life models.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.529 million. Funding decreased due to realignment of Missile and Remotely Piloted Aircraft Engine research to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies effort.</p>				
<p>Title: Turboshaft/Turboprop and Small Turbofan Engine Technologies</p> <p>Description: Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports.</p> <p>FY 2020 Plans: Continue development and validation of modeling and simulation tools to achieve very high levels of loading for advanced low pressure turbine components. Continue the exploration of advanced integrated engine controls with potential for synergistic airframe system level benefits. Initiate exploration of new small and medium size engine technologies for increased fuel efficiency, propulsive capability, power and thermal management, and reduced life cycle cost. Initiate identification of new architectures and critical technologies for integrated power and thermal systems. Initiate identification of requirements and develop models for simulation of highly integrated systems.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$3.345 million. Funding decreased due to realignment of Turboshaft/Turboprop and Small Turbofan Engine research to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies effort.</p>		0.909	3.345	0.000
Accomplishments/Planned Programs Subtotals		48.640	54.582	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>
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	FY 2019	FY 2020
Congressional Add: Program increase - advanced turbine technologies	0.000	2.000
FY 2019 Accomplishments: Not Applicable		
FY 2020 Plans: Conduct Congressionally directed efforts		
Congressional Adds Subtotals	0.000	2.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 623145 / <i>Aerospace Power Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
623145: <i>Aerospace Power Technology</i>	-	47.873	44.213	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops integrated electrical and thermal management components, controls and systems for military aerospace applications. Power component technologies are developed to increase reliability, maintainability, commonality, affordability, and supportability of aircraft and flight line equipment. Research is conducted in energy storage and hybrid power system technologies to enable special purpose applications. Electrical power and thermal management technologies enable future military megawatt level power and thermal management needs. Controls and system integration technologies ensure the interoperability of aircraft, power, thermal, engine and other systems and subsystems. This project supports development of electrical power and thermal management components, controls and systems suitable for applications to legacy and future aircraft platforms including strike and mobility concepts. Lightweight power systems suitable for other aerospace applications are also developed.

In FY 2021, the entirety of Project 623145, Aerospace Power Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622406, Aerospace Power & Flight Control Technology in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Power System Technologies	35.762	37.213	0.000
Description: Develop integrated system architecture, controls, and component technologies to provide for the large amounts of electrical power needed, and concurrent thermal mitigation required, by current and future manned and unmanned systems.			
FY 2020 Plans: Continue development of system and component electrical power, electro-mechanical, and thermal technologies for high-power applications. Continue development of hybrid approaches to power generation, storage, and application as well as thermal management. Continue testing of subsystems hardware in conjunction with continued platform level tip-to-tail modeling and simulation energy optimization. Continue development of advanced, safe energy storage, power distribution, and management systems to include Silicon Carbide applications and batteries. Continue power and thermal development toward demonstration of tactical aircraft high-power payload capability, e.g. laser weapon system. Continue analysis and development of adaptive power and thermal control systems for high-power aircraft. Complete the development of advanced power options for small unmanned aircraft. Continue weapon system contractor support for platform integration of advanced power and thermal system architectures.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623145 / <i>Aerospace Power Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 622406, Aerospace Power & Flight Control Technology, High Power System Technologies effort.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$37.213 million. Funding decreased due to realignment of High Power Systems research to PE 0602201F, Aerospace Vehicle Technologies, Project 622406, Aerospace Power & Flight Control Technology, High Power System Technologies effort.			
Accomplishments/Planned Programs Subtotals	35.762	37.213	0.000

	FY 2019	FY 2020
<i>Congressional Add:</i> Program increase - thermal management technologies	5.813	7.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts		
<i>FY 2020 Plans:</i> Conduct Congressionally directed efforts		
<i>Congressional Add:</i> Program increase - next generation heat exchangers	6.298	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts		
<i>FY 2020 Plans:</i> Not Applicable		
Congressional Adds Subtotals	12.111	7.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624847: <i>Rocket Propulsion Technology</i>	-	67.114	80.302	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops rocket propulsion technologies for space access, space maneuver, the sustainment of strategic systems (including solid boost/missile propulsion, post boost control, aging and surveillance efforts), and tactical missiles. Analytical and experimental areas of emphasis are propellants, propellant management, combustion, rocket material applications, technology for sustainment of strategic systems, and innovative space propulsion concepts. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of these systems. Develop technologies to reduce the weight and cost of components using new materials and improved designs and manufacturing techniques. All efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire Department of Defense (DoD). Technologies under this project enable capabilities of interest to both DoD and National Aeronautics and Space Administration (NASA). Tasks include: modeling and simulation; proof of concept tests of critical components; advanced component development; and ground-based tests. Aging and surveillance tasks could reduce lifetime prediction uncertainties for individual motors by 50%, enabling motor replacement for cause. All thrusts are part of the Rocket Propulsion 21 (RP21) collaboration and are reviewed by a DoD level steering committee yearly for relevance to DoD missions and progress towards RP21 Goals.

In FY 2021, the entirety of Project 624847, Rocket Propulsion Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technologies in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Fuel Technologies	9.895	10.421	0.000
Description: Develop, characterize, and test advanced hydrocarbons, energetics, solid propellants, and monopropellants to increase space launch payload capability and refine new synthesis methods.			
FY 2020 Plans:			
Continue developing solid rocket propellant binder systems for intended use across a variety operationally relevant conditions. Continue to conceive, synthesize, scale-up, and characterize novel energetic ingredients, including both fuels and oxidizers, for use across the span of space and missile applications from strategic and tactical boost through in-space thrust and attitude control. Continue transferring knowledge for making green mono-propellants to the United States industrial base. Continue to formulate, scale-up, and evaluate formulations of solid and liquid rocket propellants. Continue to identify, evaluate, and adapt 21st century material processing equipment to enable more rapid and agile development and more precise products. Complete support for NASA's Green Propellant Infusion mission to demonstrate a non-toxic ionic liquid based propulsion system in space. Continue			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>research in high-temperature resins, insulators, and composite case fabrication techniques to enable high mass-fraction rocket motor cases. Continue high-performance bi-propellant synthesis and formulation.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Tech, Fuel Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$10.421 million. Funding decreased due to realignment of Fuel Technology research to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Fuel Technologies effort.</p>				
<p>Title: Liquid Engine Combustion Technologies</p> <p>Description: Develop advanced liquid engine combustion technology for improved performance, while preserving chamber lifetime and reliability needs for engine uses in heavy lift space vehicles.</p> <p>FY 2020 Plans: Continue evaluation of methane multi-injector designs in hot-fire conditions. Continue hot fire tests in combustion stability rig. Continue combustion stability modeling critical for future hydrocarbon fueled liquid rocket engines. Continue the delivery of combustion stability codes with nearly-complete set of validation data to rocket community, enabling more robust and stable engine designs. Continue developing understanding of hydrocarbon fuel production, expanding testing into methane fuels and other cryogenic cooling. Continue the employment of new fuel and material operating limitations, manufacturing processes, and launch goals in cycle analysis to identify trade space for future engines. Continue to evaluate and develop advanced material solutions for high temperature components in rocket engines. Continue installation of new test facility that will fill the current capability gap and allow for fast, low-cost testing of multi-injector designs and stability strategies at conditions relevant to the demands of both Department of Defense and industry for next-generation engines (including use of liquid oxygen and higher pressures and thrust). Initiate development of rotating detonation rocket engine technologies.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Liquid Engine Combustion Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$8.541 million. Funding decreased due to realignment of Liquid Engine Combustion research to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Liquid Engine Combustion Technologies effort.</p>		7.887	8.541	0.000
<p>Title: Advanced Liquid Engine Technologies</p>		11.568	11.590	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Develop advanced liquid engine technologies for improved performance, while increasing life and reliability needs for engine uses in expendable and reusable launch vehicles.</p> <p>FY 2020 Plans: Complete exploring engine concepts for next generation, beyond 2035, launch vehicles and concepts to effect cost reductions. Continue sub-scale risk mitigation and technology maturation activities to incorporate into next generation engine concepts. Initiate modular component integration and interaction research activities supporting next generation engine concepts.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Advanced Liquid Engine Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$11.590 million. Funding decreased due to realignment of Advanced Liquid Engine research to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Advanced Liquid Engine Technologies effort.</p>			
<p>Title: On-Orbit Propulsion Technologies</p> <p>Description: Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for station-keeping, repositioning, and orbit transfer for satellites and satellite constellations.</p> <p>FY 2020 Plans: Continue scale-up research of advanced chemical propellants with particular focus on transition of numerical tools and experimental methodologies for advanced mono-propellants to spacecraft industry. Continue to support the maturation of advanced plume diagnostics for both chemical and electric propulsion thrusters with potential for integrated state-of-health application. Continue to expand the validation and verification programs (both experimental and flight) to quantify accuracy of modeling and simulation tools developed to support thruster-spacecraft integration. Continue transition and support of thruster/plume modeling framework to spacecraft industry, with addition of advanced electric propulsion thruster models, to industry partners. Continue to explore advanced electric propulsion and chemical thruster concepts and assess new spacecraft propulsion requirements</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, On-Orbit Propulsion Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	12.710	16.553	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$16.553 million. Funding decreased due to realignment of On-Orbit Propulsion research to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, On-Orbit Propulsion Technologies effort.				
<p>Title: Space Access and Strike Applications</p> <p>Description: Develop missile propulsion and boost technologies for space access and strike applications.</p> <p>FY 2020 Plans: Continue to develop advanced tactical propulsion. Complete development of technology options for post-boost systems exploring cost reductions, performance improvements, and potential for commonality among Air Force, Navy, and Missile Defense Agency. Continue propellant development efforts including long-life propellants. Continue development and evaluation of next generation of updated, physics-based modeling, simulation, and analysis tools for missile propulsion components and applications. Continue to develop advanced component technologies for missile propulsion applications for strategic and strike systems helping to ensure their long-term sustainment.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Ballistic and Tactical Propulsion Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.614 million. Funding decreased due to realignment of Space Access and Strike Applications research to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Space Access and Strike Applications effort.</p>		5.785	5.614	0.000
<p>Title: Ballistic Missile Technologies</p> <p>Description: Develop missile propulsion technologies and aging and surveillance technologies for ballistic missiles.</p> <p>FY 2020 Plans: Continue to apply next generation of chemical and aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, to user needs and unique problems. Continue development of advanced sensor, non-destructive evaluation, modeling and supporting technology development efforts to detect and explain phenomena further improve data acquisition and reduce uncertainty in ballistic and tactical missile solid rocket motor life predictions. Continue long-term validation of tools through long-term aging of sub-scale motors. Continue to monitor and periodically test sub-scale motors to validate the sensor and analytical analysis of each motor.</p> <p>FY 2021 Plans:</p>		4.736	8.583	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / Aerospace Propulsion	Project (Number/Name) 624847 / Rocket Propulsion Technology
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Ballistic and Tactical Propulsion Technologies effort.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$8.583 million. Funding decreased due to realignment of Ballistic Missile research to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, Ballistic Missile Technologies effort.			
Accomplishments/Planned Programs Subtotals	52.581	61.302	0.000

	FY 2019	FY 2020
<i>Congressional Add:</i> Program increase - centers of excellence	4.844	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts		
<i>FY 2020 Plans:</i> Not Applicable		
<i>Congressional Add:</i> Program increase - next generation hall thrusters	9.689	14.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts		
<i>FY 2020 Plans:</i> Not Applicable		
<i>Congressional Add:</i> Program increase - next generation liquid propulsion	0.000	5.000
<i>FY 2019 Accomplishments:</i> Not Applicable		
<i>FY 2020 Plans:</i> Conduct Congressionally directed effort		
Congressional Adds Subtotals	14.533	19.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625330: <i>Aerospace Fuel Technology</i>	-	4.216	4.742	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project evaluates hydrocarbon-based fuels for legacy and advanced turbine engines, scramjets, pulse detonation and combined cycle engines. This project also considers fuel related concepts that can increase turbine engine operational reliability, durability, mission flexibility, energy efficiency, and performance while reducing weight, fuel consumption, and cost of ownership. Applications include missiles, aircraft, sustained high-speed vehicles, and responsive space launch. Analytical and experimental areas of emphasis include evaluations of fuel properties and characteristics of alternative fuels developed from unconventional sources (such as coal, natural gas, biomass, and combinations thereof), unique/alternate fuels and components used in integrated thermal and energy management systems including high heat sink fuel capability, fuels logistics and associated vulnerabilities, and combustion diagnostics and engine emissions measurements.

In FY 2021, the entirety of Project 625330, Aerospace Fuel Technology was transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Alternative Fuels	0.093	0.093	0.000
Description: Conduct evaluations and perform technical assessments of alternative hydrocarbon fuels derived from coal, natural gas, and biomass for use in legacy and advanced aerospace systems.			
FY 2020 Plans: Continue evaluation of fully-synthetic jet fuels produced from alcohol, triglyceride and other feedstocks including: conducting full characterization of fuel composition and relate these to potential performance impacts. Continue leveraging ongoing collaborative efforts in fuels characterization with Navy, Army, Federal Aviation Administration, and National Aeronautics and Space Administration to leverage and complement on-going research.			
FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Advanced Fuels effort.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.093 million. Funding decreased due to realignment of Alternative Fuels research to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Advanced Fuels effort.			
Title: Integrated Thermal and Energy Management	1.313	1.496	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Description: Develop and demonstrate advanced components and conduct performance assessments of advanced aircraft integrated thermal and energy management systems for engines and aircraft.</p> <p>FY 2020 Plans: Continue the evaluation of advanced additives, catalysts, and fuel composition approaches to minimize endothermic fuel coking for Hypersonic applications. Initiate work in model development and simulation tools for Integrated Thermal and Energy Management assessment of efficient technologies and architectures.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Integrated Thermal and Energy Management effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.496 million. Funding decreased due to realignment of Integrated Thermal and Energy Management research to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Integrated Thermal and Energy Management effort.</p>				
<p>Title: Fuel Logistics</p> <p>Description: Study and evaluate low-cost approaches to reduce fuel logistics footprint to reduce cost. Study fuel logistics vulnerabilities and develop detection and mitigation technologies.</p> <p>FY 2020 Plans: Continue the development of fuel temperature limits for full-life fuel systems as part of integrated power and thermal management systems: identify sensing approaches to be able to capture fuel stability limiters to minimize logistics vulnerabilities, work on bio detection and mitigation to support logistics readiness, coordinate and collaborate with Army and Navy in identification and development of sensing technologies.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Fuel Logistics and Sustainment effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.496 million. Funding decreased due to realignment of Fuel Logistics research to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Fuel Logistics and Sustainment effort.</p>		1.313	1.496	0.000
<p>Title: Combustion Emissions and Performance</p>		1.497	1.657	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Develop and test advanced emissions diagnostic techniques for airbreathing propulsion systems. Conduct evaluations of the combustion and emissions characteristics of aviation fuels.</p> <p>FY 2020 Plans: Initiate aviation fuels combustion tests to identify fuel composition performance impacts. Initiate Lean Blow test, cold start testing and emissions tests and analysis to work on model developments to be able to establish composition to performance correlations.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Advanced Fuels effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.657 million. Funding decreased due to realignment of Combustion Emissions and Performance research to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Advanced Fuels effort.</p>			
Accomplishments/Planned Programs Subtotals	4.216	4.742	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	168.897	219.912	211.301	0.000	211.301	205.495	200.423	205.424	208.882	Continuing	Continuing
622002: <i>Electronic Component Technology</i>	-	43.018	52.667	50.752	0.000	50.752	49.009	47.906	49.227	50.435	Continuing	Continuing
622003: <i>EO Sensors & Countermeasures Tech</i>	-	28.416	30.934	34.638	0.000	34.638	33.716	32.449	33.143	33.260	Continuing	Continuing
622005: <i>Cyber Technology</i>	-	6.109	9.387	10.625	0.000	10.625	8.445	8.808	9.539	9.836	Continuing	Continuing
624920: <i>Electronic Warfare Technology</i>	-	0.000	34.795	44.749	0.000	44.749	45.296	44.589	45.242	45.937	Continuing	Continuing
626095: <i>Sensor Fusion Technology</i>	-	31.826	32.063	35.716	0.000	35.716	34.875	33.462	34.154	35.052	Continuing	Continuing
627622: <i>RF Sensors and Countermeasures Tech</i>	-	59.528	60.066	34.821	0.000	34.821	34.154	33.209	34.119	34.362	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops the technology base for Air Force aerospace sensors and electronic combat. Advances in aerospace sensors are required to increase combat effectiveness by providing anytime, anywhere surveillance, reconnaissance, precision targeting, and electronic warfare (EW) capabilities. To achieve this progress, this program pursues simultaneous advances in: 1) generating, controlling, receiving, and processing electronic and photonic signals for radio frequency (RF) sensor aerospace applications; 2) electro-optical (EO) and infrared (IR) aerospace sensor technologies for a variety of offensive and defensive uses; 3) radio frequency antennas and associated electronics for airborne and space surveillance, together with active and passive electro-optical/infrared sensors; 4) technologies to manage and fuse on-board sensor information for timely, comprehensive situational awareness; 5) technology for affordable, trusted, and reliable, all-weather surveillance, reconnaissance, and precision strike radio frequency sensors and electronic combat systems; and 6) technologies that aid in the development of agile and resilient mission systems. This program has been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	171.307	202.912	209.631	0.000	209.631
Current President's Budget	168.897	219.912	211.301	0.000	211.301
Total Adjustments	-2.410	17.000	1.670	0.000	1.670
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	17.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-2.410	0.000			
• Other Adjustments	0.000	0.000	1.670	0.000	1.670

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 622002: *Electronic Component Technology*

Congressional Add: *Program increase - exploitation detection*

Congressional Add Subtotals for Project: 622002

FY 2019	FY 2020
0.000	9.000
0.000	9.000

Project: 627622: *RF Sensors and Countermeasures Tech*

Congressional Add: *Program increase - Air Force Minority Leaders Program*

Congressional Add: *Program increase - RF spectrum situational awareness*

Congressional Add Subtotals for Project: 627622

Congressional Add Totals for all Projects

4.930	0.000
0.000	8.000
4.930	8.000
4.930	17.000

Change Summary Explanation

Increase in FY 2021 of \$1.670 million is due to civilian pay reprice adjustments.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>				Project (Number/Name) 622002 / <i>Electronic Component Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622002: <i>Electronic Component Technology</i>	-	43.018	52.667	50.752	0.000	50.752	49.009	47.906	49.227	50.435	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project focuses on electronics and optoelectronics technologies that generate, control, receive, and process electromagnetic spectrum for aerospace sensor and electronic warfare (EW) applications. The enabling technologies developed under this project will be used for intelligence, surveillance, reconnaissance, electronic warfare, battlespace access, and precision engagement capabilities. The technologies developed include exploratory electronic and optoelectronic devices, components, microsystems and subsystems.

This project also assesses designs, develops, fabricates, and demonstrates the associated technologies for integrating combinations of these component technologies. The project demonstrates significantly smaller size, lower weight, lower cost, lower power dissipation, higher reliability, trustworthiness and improved performance. The device and subsystem technology developments under this project are military unique; they are based on Air Force and other Department of Defense weapon systems requirements in the areas of radar, communications, electronic warfare, positioning, navigation, timing, and smart weapons.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Sensor Subsystems	9.910	8.425	9.730
Description: Develop, analyze, demonstrate, and perform engineering trade studies for technologies for compact, affordable, multi-function subsystems for aerospace sensors.			
FY 2020 Plans: Complete wideband multifunction array technology development. Continue development of direction finding subsystem prototypes for attritable systems. Continue research for highly miniaturized and power-efficient on-board sensor processing. Initiate low cost electro-optical/infrared sensor subsystem development.			
FY 2021 Plans: Complete development of direction finding subsystem prototypes for attritable systems. Complete research for highly miniaturized and power-efficient on-board sensor processing. Continue low cost electro-optical/infrared sensor subsystem development. Initiate research into autonomous low size, weight and power sensor processing. Initiate research into digital at every element technology for multifunction microwave and millimeter wave arrays.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.305 million. Funding increased due to initiating digital at every element technology for multifunction microwave and millimeter wave arrays and civilian pay reprice adjustments.			
Title: Electronic Devices	7.615	7.467	8.751

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020	
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622002 / <i>Electronic Component Technology</i>	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020
<p>Description: Assess, research, develop, demonstrate and transition revolutionary and evolutionary electronic devices and their associate technologies.</p> <p>FY 2020 Plans: Complete commercialization of Air Force foundry process to industry. Complete millimeter-wave gallium nitride transistor development. Continue wide-bandgap device technology development for power generation and management. Initiate advanced wide band-gap model development for multi-use applications. Initiate novel wide-band gap switch integration with millimeter-wave transistor development.</p> <p>FY 2021 Plans: Complete wide-bandgap device technology proof of concept for power generation and management. Continue advanced wide band-gap model development for multi-use applications. Continue novel wide-band gap switch integration with millimeter-wave transistor development. Initiate development of integrated chip-level radio frequency devices and power conversion modeling and wide bandgap device and power conversion integration technologies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.284 million. Funding increased due to additional emphasis on development of integrated chip-level radio frequency devices, power conversion modeling wide bandgap device, power conversion integration technologies, and civilian reprice adjustments.</p>			
<p>Title: Electro-Optical/Infrared (EO/IR) Components</p> <p>Description: Research, develop, demonstrate and transition electro-optical/infrared (EO/IR) components for next generation intelligence, surveillance, reconnaissance (ISR) and countermeasures.</p> <p>FY 2020 Plans: Complete neutron/radiation detector demonstration. Complete wavelength conversion demonstration. Complete preliminary narrow line width laser demonstration. Continue to explore and evaluate innovative materials and devices for tunability, increased bandwidth and multi-wavelength operation. Continue compact, tunable, laser source prototype. Initiate advanced avalanche photo-diode based focal plane array development.</p> <p>FY 2021 Plans: Complete initial evaluation of innovative materials and devices for tunability, increased bandwidth and multi-wavelength operation. Complete compact, tunable, laser source prototype. Continue advanced avalanche photo-diode based focal plane array development. Initiate photonic and quantum substructure technology development. Initiate research into non-linear devices for tunability and power scaling.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		9.148	8.725
		10.246	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622002 / <i>Electronic Component Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$1.521 million. Funding increased due to additional emphasis on research into non-linear devices for tunability, power scaling, and civilian pay reprice adjustments.				
<p>Title: Trusted Electronics for Intelligence, Surveillance, Reconnaissance and Avionics Mission Systems</p> <p>Description: Investigate and develop designs of trusted electronic and optoelectronic systems when integrating commercially available solutions with emerging government-off-the-shelf advanced technologies. Areas of development include: multi-function radio frequency and electro-optical subsystems, advanced electronic and optoelectronic materials, on-board sensor processing, high-frequency power modules, electro-optical/infrared sources, electro-optical/infrared detectors, beam control and waveguides, and trusted and reliable electronics.</p> <p>In FY 2021, this effort is renamed from Trusted Electronics for Intelligence, Surveillance, Reconnaissance and Avionics Systems to Trusted Electronics for Intelligence, Surveillance, Reconnaissance and Avionics Mission Systems.</p> <p>FY 2020 Plans: Continue investigations and demonstration of trust in design and trust in fabrication. Advance modeling and simulation capability to improve predictive capability of mission assurance for highly integrated microsystems, devices, and materials. Continue development of prototype trustworthiness assessment capability. Continue reliability assessments of advanced heterogeneously integrated microsystems. Investigate application of trust into sensors and sensor systems to deter reverse engineering and exploitation of critical hardware and software technology and impede unwanted technology transfer, alteration of system capability, and prevent the development of countermeasures to our systems.</p> <p>FY 2021 Plans: Complete initial investigations of trust in design and trust in fabrication. Continue studies of modeling and simulation capability to improve predictive capability of mission assurance for highly integrated microsystems, devices, and materials. Continue development of prototype trustworthiness assessment capability. Continue reliability assessments of advanced heterogeneously integrated microsystems. Continue investigations of trust technologies and techniques in sensors and sensor systems to deter reverse engineering and exploitation of critical hardware and software technology and impede unwanted technology transfer, alteration of system capability, and prevent the development of countermeasures to our systems. Initiate the development of processes and techniques for trust through design. Initiate investigations of security verification techniques and methodologies for integrated circuit designs.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.535 million. Funding increased due to additional emphasis on development of processes and techniques for trust through design and civilian pay reprice adjustments.</p>		9.674	12.157	13.692
Title: Advanced Highly Integrated Microsystems for Intelligence, Surveillance, Reconnaissance and Electronic Warfare		6.671	6.893	8.333

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622002 / <i>Electronic Component Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
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Description: Develop, mature, and demonstrate critical electronic technologies to enable revolutionary electronic warfare subsystems.

FY 2020 Plans:

Complete initial demonstration of integrated wideband and adaptable transceiver microsystem. Initiate development of photonically enabled electronic intelligence subsystem. Initiate development of photonic antenna remoting concept. Initiate development of integrated and adaptable transceiver microsystems. Continue development of military relevant heterogeneous integration technologies. Continue development of additive techniques for advanced electronic subsystems.

FY 2021 Plans:

Complete assessment of military relevant heterogeneous integration technologies. Complete development of additive techniques for advanced electronic subsystems. Initiate development of next generation reconfigurable transceiver prototype. Continue development of photonically enabled electronic intelligence subsystem. Continue development of photonic antenna remoting concept. Continue development of integrated and adaptable transceiver microsystems. Initiate development of microsystem integration solutions that integrate advanced components and thermal management technologies for cost, size, weight and power constrained microwave and millimeter wave applications.

FY 2020 to FY 2021 Increase/Decrease Statement:

FY 2021 increased compared to FY 2020 by \$1.440 million. Funding increased due to additional emphasis on development of microsystem integration solutions that integrate advanced components and thermal management technologies for cost, size, weight and power constrained microwave and millimeter wave applications.

Accomplishments/Planned Programs Subtotals	43.018	43.667	50.752
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	FY 2019	FY 2020
Congressional Add: Program increase - exploitation detection	0.000	9.000
FY 2019 Accomplishments: Not applicable		
FY 2020 Plans: Conduct Congressional directed efforts		
Congressional Adds Subtotals	0.000	9.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622002 / <i>Electronic Component Technology</i>
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D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>				Project (Number/Name) 622003 / <i>EO Sensors & Countermeasures Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622003: <i>EO Sensors & Countermeasures Tech</i>	-	28.416	30.934	34.638	0.000	34.638	33.716	32.449	33.143	33.260	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project determines the technical feasibility of advanced electro-optical aerospace sensor technologies for a variety of offensive and defensive uses. The sensor technologies under development range from the ultraviolet through the infrared portion of the spectrum. Related efforts include improvements in avionics integration, digital processing, analysis tools, and sensor architectures. One of the project's goals is to improve electro-optical and related technologies for the detection, tracking, and identification of non-cooperative and difficult targets, such as those obscured by camouflage or acquired at great range. This project also develops the passive and active imaging sensors and algorithms needed to enable precision targeting in severe weather. These technologies are critical to future aerospace surveillance and targeting. Other project goals include advanced electro-optical threat warning and countermeasures.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Passive Electro-Optical/Infrared Sensing in Contested Environments	13.472	15.126	16.452
Description: Develop innovative passive optical sensing technology to support surveillance and reconnaissance in contested environments. Develop high performance focal planes, aperture technologies, sensing architectures, and imaging techniques capable of long range target detection and characterization for intelligence, surveillance, reconnaissance and air-to-air sensing.			
FY 2020 Plans: Continue infrared search and track simulation and modeling to support detection and tracking algorithm development and sensor performance assessment. Complete design and development of focal plane array and the associated read-out integrated circuit. Continue evaluation of compact hyperspectral imaging sensor performance through low altitude flight testing on a surrogate platform. Conduct a flight test of a breadboard active hyperspectral imaging system on a lab-class aircraft. Evaluate a novel atmospheric characterization technique through continued data collections coincident with truth sensors. Perform studies to leverage dual-band sensor concepts for improved turbulence mitigation to improve the useful range beyond the current state of the art. Initiate studies into improving standoff high-resolution imaging by leveraging new machine learning algorithms.			
FY 2021 Plans: Conduct a flight test evaluation of the staring infrared search and track system against military relevant targets. Start development of a low-cost, low volume, real-time hyperspectral sensor and processor for attritable platforms including advanced machine learning algorithms to improve performance, speed and computational efficiency of hyperspectral detection. Complete analysis of active hyperspectral imaging demonstrations in preparation for transition. Initiate development of low-earth orbit sensing systems for critical Air Force needs.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622003 / <i>EO Sensors & Countermeasures Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$1.326 million. Funding increased due to additional emphasis of developing low-earth orbit sensing systems and civilian pay reprice adjustments.				
Title: Laser Radar Sensing in Contested Environments		14.944	15.808	18.186
Description: Develop innovative laser sensing technology for non-cooperative identification of airborne and ground-based targets in contested environments. Develop optical spectrum transmitters, detectors and agile aperture technologies capable of sensing multiple target characteristics for robust non-cooperative target identification and future infrared countermeasure systems.				
FY 2020 Plans: Flight test near real time image formation algorithms for new 3-dimension sensing mode using focal planes built the previous year. Continue development of image formation algorithms for synthetic aperture lidar with advanced waveforms. Continue development of advanced focal planes for coherent lidar sensing; including completing design and build of integrated dewar cooler assembly. Develop approach for real-time determination of volumetric turbulence using a holographic sensor. 3-dimension shape sensing efforts will focus on real-time delivery of processed products with an emphasis on overcoming high sensor data rates. Enhance existing aided target recognition algorithms with a focus on segmenting target from its background. Continue to enhance state of the art lidar simulations to support requirements definition, engagement modeling, enhanced processing development, and synthetic data generation for aided target recognition efforts. Investigate use of photon counting arrays for coherent sensing. Investigate the use of polarization gratings as a low cost, low size weight and power method of steering lidar system.				
FY 2021 Plans: Continue development of data processing algorithms for 3-dimension sensing and synthetic aperture lidar (laser radar). Continue to advance the state of the art in coherent lidar (digital holography) and non-mechanical beam steering for low-cost sensing applications. Continue development of Aided Target Recognition algorithms for 3-dimension laser radar. Investigate use of data from flight collection of the vibration sensor to advance aided target recognition algorithms using artificial intelligence and machine learning. Continue to make improvements on lidar modeling to include engagement level models for evaluating mission effectiveness of various laser radar systems.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$2.378 million. Funding increased due to additional emphasis on synthetic aperture lidar, vibration sensing, and 3-dimension sensing research and civilian pay reprice adjustments.				
Accomplishments/Planned Programs Subtotals		28.416	30.934	34.638
C. Other Program Funding Summary (\$ in Millions)				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / Aerospace Sensors	Project (Number/Name) 622003 / EO Sensors & Countermeasures Tech

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>				Project (Number/Name) 622005 / <i>Cyber Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622005: <i>Cyber Technology</i>	-	6.109	9.387	10.625	0.000	10.625	8.445	8.808	9.539	9.836	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project focuses on technologies for enabling agile and resilient Air Force mission systems. This project improves our understanding of cyber vulnerabilities of mission systems by investigating the fundamental nature of those vulnerabilities including: how they come about, how they can be discovered, how they can be quantified and categorized, how they can be exploited, and how they can be removed or mitigated to secure the system. This project develops adaptable and resilient hardware/software for real-time avionics cyber-attack pattern recognition and develop a protection system with the capability for autonomous learning, adaptation, and self-protection. This project investigates open architecture concepts and technologies to deliver capability flexibility to Air Force mission systems. These technologies are matured via integrated capability demonstrations.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Vulnerability Mitigation	2.661	4.096	4.709
Description: Apply knowledge from computer vulnerability discovery and computer security to investigate capabilities for identifying and mitigating vulnerabilities in United States mission systems resulting from software and/or hardware deficiencies. Develop automated and cost effective processes, techniques and technologies to assist in the identification of potential vulnerabilities.			
FY 2020 Plans: Continue development of automated tools for performing cyber test and assessment of weapon systems. As more mature capabilities are transitioned, assess community capability gaps and develop/enhance tools as needed. Continue research and development of vulnerability mitigation technologies for legacy platforms and to support the maturation of next generation avionics architectures. Baseline technologies and capabilities will be available this year and will need continued investigation into their secure use. Increase focus on cyber test/assessment/situational-awareness of next-generation architectures. Investigate cyber assessment methodologies and open system architecture standards and approaches to reduce susceptibility of legacy and next-generation avionics architectures.			
FY 2021 Plans: Complete assessing Test, Maintenance, and Acquisition community capability gaps of transitioned automated test tools. Start last round of new tools and technique refinements as required. Continue to work with other Services to demonstrate cyber resiliency capabilities on air, ground and sea platforms. Continue development of next generation mission systems architecture to design in agile and resilient capabilities. Perform initial flight demonstration of integrated Open Mission Systems architecture with next generation mission systems architecture.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622005 / <i>Cyber Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$0.613 million due to civilian pay reprice adjustments.				
Title: Agile Mission Systems Protections		3.448	5.291	5.916
<p>Description: Develop avionics protection tools and capabilities to enable manned and unmanned aircraft, avionics, and related support equipment to automatically adapt to and withstand cyber attacks. Research and develop tools, methodologies and architecture guidelines that enable the design of avionics systems with sense, learn and adapt capabilities.</p> <p>In FY 2021, this effort is renamed from Adaptive Cyber Protections to Agile Mission Systems Protections.</p> <p>FY 2020 Plans: Mature malware detection, diagnostics, and attack inferencing capabilities for avionics and mission systems. Research and develop real-time response mechanisms for cyber-attacks. Perform research and development in software, firmware and hardware diversity to enable resilient cyber defense systems. Research and develop real-time instruction-level malware detection capabilities to enable early warning and response to cyber threats. Develop automated test generation tools to expose malware embedded within mission critical software and firmware. Investigate evolutionary/co-evolutionary algorithms as a means to develop test samples for the above detection algorithms and to investigate adaptive countermeasures to malware and cyber-attacks. Research and develop cyber resilient immune systems for avionics and mission systems. Investigate cyber protection methodologies and open system architecture standards and approaches to improve cyber resiliency of legacy and next-generation avionics architectures.</p> <p>FY 2021 Plans: Demonstrate initial capabilities for malware detection, diagnostics, and attack inferencing for mission systems. Continue research and develop real-time response mechanisms for cyber-attacks and software, firmware, and hardware diversity techniques to enable resilient cyber defense systems. Demonstrate automated test generation tools that expose malware embedded within mission critical software and firmware. Continue to investigate protection methodologies and open system architecture standards and approaches to improve agility and resiliency of legacy and next-generation mission systems architectures.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.625 million due to civilian pay reprice adjustments.</p>				
Accomplishments/Planned Programs Subtotals		6.109	9.387	10.625
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622005 / <i>Cyber Technology</i>
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D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>				Project (Number/Name) 624920 / <i>Electronic Warfare Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624920: <i>Electronic Warfare Technology</i>	-	0.000	34.795	44.749	0.000	44.749	45.296	44.589	45.242	45.937	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and assesses affordable, reliable, all weather radio frequency countermeasure concepts for aerospace applications covering the range of radio frequency sensors including communications, navigation, intelligence, surveillance and reconnaissance (ISR), and radar, both active and passive, across the air, land, sea, space and cyber domains. It develops and evaluates technology for electronic warfare, integrated radar and electronic warfare systems, and electro-optical/infrared seeker defeat. This project develops the radio frequency warning and countermeasure technology for advanced electronic warfare and information operations applications. The project also explores technologies to maintain a military advantage in positioning, navigation and timing integrity, accuracy, and resiliency as well as on aircraft mission assurance - the protection of airborne platforms, manned and unmanned, in contested environments. The ultimate goal of the project is to ensure unrestricted access to the airspace and the electromagnetic spectrum in contested and congested environments.

Project 624920, Electronic Warfare, was new for FY 2020. In FY 2019 and prior, these electronic warfare activities were reported under PE 0602204F, Aerospace Sensors, Project 627622, RF Sensors and Countermeasures Tech, and PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities, and Project 63691X, EO/IR Warning & Countermeasures Tech.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Positioning, Navigation and Timing in Contested/Denied Environments	0.000	9.663	13.276
Description: Develop resilient position, navigation and timing sensors. Explore position, navigation and timing solutions to enable novel distributed radio frequency sensing and countermeasure techniques. Develop technology base to provide solutions addressing navigation and timing threats.			
FY 2020 Plans: Expand research on navigation sensor integration, modeling, and simulation to incorporate open architecture attributes. Continue alternative navigation, bandwidth efficient communications for navigation, and timing technologies research. Continue exploring technologies to support precise time and time transfer with airborne platforms to enable coherent sensing (intelligence, surveillance, reconnaissance) and effects (electronic warfare). Start development of trust techniques to enable military use of global navigation satellite systems. Continue modeling and simulation studies to address the multispectrum threat to satellite navigation systems.			
FY 2021 Plans: Continue research on navigation sensor integration, modeling, and simulation to incorporate open architecture attributes. Continue alternative navigation, bandwidth efficient communications for navigation, and timing technologies research. Continue exploring technologies to support precise time and time transfer with airborne platforms to enable coherent sensing (intelligence,			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 624920 / <i>Electronic Warfare Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>surveillance, reconnaissance) and effects (electromagnetic warfare). Begin to develop the requirements for a prototype communications receiver to provide a connected solution for time, frequency, velocity and position data transfer. Continue development of trust techniques to enable military use of global navigational satellite systems. Continue modeling and simulation studies to address the multi-spectrum threats to satellite navigation systems.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$3.613 million. Funding increased due to realignment of Position, Navigation and Timing for Contested/Denied Environments research from PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities, Position, Navigation and Timing for Contested/Denied Environments effort, to this effort.</p>			
<p>Title: Radio Frequency Electronic Warfare Technologies</p> <p>Description: This project develops the radio frequency warning and countermeasure technology for advanced electronic warfare and information operations applications. This project develops techniques and technologies to detect and counter the communications links and sensors of threat integrated air defense systems and hostile command and control networks.</p> <p>FY 2020 Plans: Continue research to demonstrate electronic warfare technologies that can reason about threat capabilities and intentions and the electromagnetic environment to synthesize an optimized response in a time frame to support aircraft survivability against adaptive and agile threats. Continue to extend research to address dynamic planning for collaborative autonomous electronic warfare systems. Continue the demonstration of robust modeling, simulation, and assessment capability to study the efficiency versus effectiveness of electronic support and electronic attack capabilities, including distributed electronic warfare assets and cognitive/autonomous technologies, against complex threat emitters in integrated air defense systems and in complex electromagnetic spectrum background environments. Continue research into effective management of electronic warfare assets in operational environments focusing on a multi-ship strike package employment. Start incorporation of electro-optical and radio frequency integrated engagement model development to meet multispectrum threats.</p> <p>FY 2021 Plans: Continue research to demonstrate electronic warfare technologies that can reason about threat capabilities and intentions and the electromagnetic environment to synthesize an optimized response in a time frame to support aircraft survivability against adaptive and agile threats. Conduct technology maturation demonstrations to showcase improved performance. Continue the demonstration of robust modeling, simulation, and assessment capability to study the efficiency versus effectiveness of electronic support and electronic attack capabilities, including distributed electronic warfare assets and cognitive/autonomous technologies, against complex threat emitters in integrated air defense systems and in complex electromagnetic spectrum background environments. Start experimentation with low cost and miniaturized electronic attack assets. Conduct demonstration of distributed</p>	0.000	17.631	23.378

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 624920 / <i>Electronic Warfare Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
and robust techniques that are delivered through digital at the aperture jammers. Continue incorporation of electro-optical and radio frequency integrated engagement model development to meet multispectrum threats.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$5.747 million. Funding increased due to realignment of Radio Frequency Electronic Warfare research from PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities, Radio Frequency Electronic Warfare effort, to this effort.				
Title: Electro-Optical/Infrared Threat Warning and Countermeasures Technologies		0.000	7.501	8.095
Description: Develop electro-optical/infrared sensor countermeasure technologies. Explore novel concepts to enable electro-optical/infrared threat seeker exploitation and surrogate modeling. Conduct fundamental research in countermeasures to defeat electro-optical/infrared threat seekers. Conduct fundamental research on integrated electro-optical/infrared threat warning systems.				
FY 2020 Plans: Continue threat characterization and countermeasures development of new threats to include new jam codes and countermeasure techniques. Continue development of low-cost missile warning capabilities. Investigate long-range missile and laser warning technology concepts. Start incorporation of electro-optical and radio frequency integrated engagement model development to meet multispectrum threats.				
FY 2021 Plans: Continue threat characterization and countermeasures techniques development against new infrared guided threats. Evaluate advanced threat surrogates during infrared countermeasure testing at several test ranges. Begin laboratory and field testing of new low-cost missile warning sensor and evaluate upgrades to Large Aircraft Infrared Counter-Measure program missile warning and countermeasures sensors. Continue to investigate long-range missile and laser warning technology concepts. Continue development of electro-optical and radio frequency integrated engagement models into the Advanced Framework for Simulation, Integration and Modeling environment to meet multispectrum threats. Start test of novel countermeasure techniques against advanced threats.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.594 million due to civilian pay reprice adjustments.				
Accomplishments/Planned Programs Subtotals		0.000	34.795	44.749
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 624920 / <i>Electronic Warfare Technology</i>
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D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / Aerospace Sensors				Project (Number/Name) 626095 / Sensor Fusion Technology			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
626095: <i>Sensor Fusion Technology</i>	-	31.826	32.063	35.716	0.000	35.716	34.875	33.462	34.154	35.052	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops foundational technologies required for closed-loop autonomous sensing employing multiple information domains, diverse sensor phenomena, and multiple platform types to provide intelligence, surveillance, and reconnaissance; target recognition; situational awareness and battlespace visualization; fire control; and battle damage assessment capabilities against a wide variety of targets engaged in multitudes of behaviors in a broad range of operational environments. This project conducts exploratory investigations to determine technology feasibility and estimate operational capability constraints associated with missions in future contested and highly contested operating environments, using cooperative and non-cooperative sensing sources. This project develops techniques to automate multi-sensor exploitation and information processing that leverage the data fusion, adaptive signal processing, and artificial intelligence / machine learning research communities. This project develops concepts and algorithms for efficient parallel processing, distributed processing, and high-performance computing in sensor data processing and synthetic data generation.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Target Signature Modeling</p> <p>Description: Develop, evaluate, and demonstrate target signature models to support sensor exploitation algorithm development and testing for reconnaissance and strike mission applications.</p> <p>FY 2020 Plans: Starting in FY 2020, this work is performed under the Multi-Domain Sensing Effect and Analysis effort within Project 626095, Sensor Fusion Technology in this PE.</p> <p>FY 2021 Plans: Not applicable</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>	4.383	0.000	0.000
<p>Title: Sensor Exploitation Technologies</p> <p>Description: Develop technical methods required for algorithm performance models, performance driven sensing, layered sensing and other sensing and exploitation technologies impacted by automated exploitation capabilities.</p> <p>FY 2020 Plans:</p>	6.745	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 626095 / <i>Sensor Fusion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
Starting in FY 2020, this work is performed under the Multi-Domain Sensing Effect and Analysis and Synthesis for Understanding efforts within Project 626095, Sensor Fusion Technology in this PE. FY 2021 Plans: Not applicable FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable				
Title: Sensor Management for Automatic Target Recognition Description: Develop multi-platform and multi-sensor control strategies to create advantages for survival, autonomous sensing, and autonomous exploitation in contested environments. Incorporate sensing platform kinematics and external operating conditions into analyses of effective multi-sensor control and multiple intelligence data fusion capabilities. Assess advantages of multi-sensor closed loop control techniques for platform survival, command and control, intelligence, surveillance and reconnaissance, and strike missions. Enhance existing automatic target recognition sensor management, and sensor fusion technologies by application of multi-sensor data and distributed data processing. FY 2020 Plans: Starting in FY 2020, this work is performed under the Multisource Knowledge Representation and Management effort within Project 626095, Sensor Fusion Technology in this PE. FY 2021 Plans: Not applicable FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable		16.254	0.000	0.000
Title: Distributed Sensing for Automatic Target Recognition Description: Develop techniques and metrics for adaptive, penetrating, distributed radio frequency exploitation in contested environments. FY 2020 Plans: Starting in FY 2020, this work is performed under the Synthesis for Understanding and the Multisource Knowledge Representation and Management efforts within Project 626095, Sensor Fusion Technology in this PE. FY 2021 Plans: Not applicable FY 2020 to FY 2021 Increase/Decrease Statement:		4.444	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 626095 / <i>Sensor Fusion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
Not applicable				
<p>Title: Synthesis for Understanding</p> <p>Description: Continue to develop novel techniques for behavioral and physical knowledge generation from multiple sensors, intelligence sources, domains (Air, Space, Cyber) and sources to include algorithm development, assessment, and experiments across multiple distributed, homogeneous and heterogeneous sensors. This effort will focus on technology areas of data association, entity detect/track/identification, information fusion, training with limited data, and data/performance modeling. The application of machine learning techniques to address technical challenges in contested environments is a particular emphasis.</p> <p>FY 2020 Plans: Develop capabilities for space-time alignment of multiple hard (physics-based) and soft (human-based) information sources. Model information uncertainty for multiple information sources (hard and soft). Apply deep and machine learning techniques to the detection/tracking/identification of stationary and moving entities, and for pattern of life understanding. Develop decision/feature-level fusion capabilities for physics-based information from multiple sensors/intelligence sources. Investigate fusion of hard and soft information sources for military-relevant applications. Design and evaluate training techniques, for example, blended measured-synthetic training, for deep and machine learning classifiers given limited measured data.</p> <p>FY 2021 Plans: Continue to develop capabilities for space-time alignment of multiple domain information sources. Continue to apply deep and machine learning techniques to the detection/tracking/identification of stationary and moving objects and systems, and for pattern of life understanding in a broader set of operating conditions. Start advance development in decision/feature-level fusion capabilities that will be applied to new multi-sensor exploitation for autonomy efforts. Continue to investigate fusion of hard and soft information sources for military relevant applications. Continue to design and evaluate neural network training techniques, to include blended measured-synthetic training, for deep and machine learning classifiers.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.997 million due to civilian pay reprice adjustments.</p>		0.000	13.380	14.377
<p>Title: Multi-Domain Sensing Effects and Analysis</p> <p>Description: This effort will focus on two primary areas: (1) Multi domain sensing and effects mission analysis and (2) performance understanding and assessments. It will develop methodologies and modeling, simulation, and analysis tools to enable multi domain analysis and technology development, informing other efforts and projects across the directorate. Investments in modeling, simulation and analysis will represent current and next generation sensing platforms to include air, space, and cyber as well as the fusion of information amongst these three domains.</p> <p>FY 2020 Plans:</p>		0.000	6.535	8.206

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 626095 / <i>Sensor Fusion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Key applied research investments will be made in the following: 1) leverage academic partnerships with respect to specific Air Force applications in modeling, simulation and analysis, 2) design and build next generation correct fidelity performance models, 3) develop one or more challenge problems to support Air Force technology investment understanding, 4) perform in-the-field data collections to verify and validate performance using measured sensor data.</p> <p>FY 2021 Plans: Continue to leverage academic partnerships with respect to specific Air Force applications in modeling, simulation and analysis. Continue to design and build next generation correct fidelity performance models. Continue to develop operational vignettes to support Air Force technology investment understanding. Continue to support in-the-field data collections to verify and validate performance using measured sensor data. Start research efforts for effectively collecting, tagging, curating, and retrieving data for advanced sensing development. Start the development of representative scenarios for autonomy development.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.671 million. Funding increased due to additional emphasis on collecting, tagging, curating, and retrieving data for advanced sensing development.</p>				
<p>Title: Multisource Knowledge Representation and Management</p> <p>Description: Develop, evaluate, and demonstrate models for sensing and for adversary behavior that support anticipatory asset tasking, characterization of latencies and related uncertainties, and joint inference and control. Develop multisource sensing techniques providing environment characterization consistent with the needs of automated and autonomous systems.</p> <p>FY 2020 Plans: Continue to develop mission performance metrics for distributed sensing capabilities in which families of suitable solutions exist. Improve representational and computational efficiency of graph-based information fusion methods. Develop foundational algorithms for sensing management incorporating environment analysis, target tracking and recognition, and operationally representative external factors.</p> <p>FY 2021 Plans: Continue development of mission resource management techniques for distributed sensing capabilities. Start the development of improving representational and computational efficiency of ground base and on-board reasoning and re-planning methods. Continue development of foundational management algorithms for situation awareness incorporating environment analysis, target detection, tracking and recognition, and operationally representative contingencies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.985 million due to civilian pay reprice adjustments.</p>		0.000	12.148	13.133
Accomplishments/Planned Programs Subtotals		31.826	32.063	35.716

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force Date: February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 626095 / <i>Sensor Fusion Technology</i>
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C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>				Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
627622: <i>RF Sensors and Countermeasures Tech</i>	-	59.528	60.066	34.821	0.000	34.821	34.154	33.209	34.119	34.362	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and assesses affordable, reliable all weather radio frequency sensing and countermeasure concepts for aerospace applications covering the range of radio frequency sensors including communications, navigation, intelligence, surveillance and reconnaissance (ISR), and radar, both active and passive, across the air, land, sea, space and cyber domains. This project also develops and evaluates technology for intelligence, surveillance and reconnaissance sensors, fire control radars, electronic warfare, integrated radar and electronic warfare systems, and offensive information operations systems. It emphasizes the detection and tracking of surface and airborne targets with radio frequency signatures that are difficult to detect due to reduced radar cross sections, concealment and camouflage measures, severe clutter, or heavy jamming. Techniques exploited include the use of multiple radio frequency phenomenologies, multi-dimensional adaptive processing, advanced waveforms and knowledge-aided processing techniques. This project also develops concepts to counter threats to our aerospace systems. It develops and evaluates technology for electronic warfare, integrated radar and electronic warfare systems, and electro-optical/infrared seeker defeat. This project develops the radio frequency warning and countermeasure technology for advanced electronic warfare and information operations applications. The project also explores technologies to maintain a military advantage in positioning, navigation and timing integrity, accuracy, and resiliency.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Hybrid Sensor Technologies	12.687	0.000	0.000
Description: Develop hybrid sensor solutions to be responsive to needs and detect difficult targets. Develop resilient position, navigation and timing sensors. Explore position, navigation and timing solutions to enable novel distributed radio frequency sensing and countermeasure techniques. Develop technology base to provide solutions addressing threats that exploit multiple sensor phenomenologies.			
FY 2020 Plans: Starting in FY 2020, this work is performed under Project 624920, Electronic Warfare Technology, Positioning, Navigation and Timing in Contested/Denied Environments effort within this PE.			
FY 2021 Plans: Not applicable			
FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable			
Title: Radio Frequency Sensor Technologies	7.973	9.127	9.946

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Conduct applied research and development for the advancement of passive and active radio frequency sensors; including phenomenology, modeling and simulation, algorithm development, and experimentation. Plan, execute, and maintain state-of-the-art radio frequency sensor research and development facilities. Conduct research on sensing, learning, and adapting to enable the countering of emerging adaptive, agile radio frequency threats.</p> <p>FY 2020 Plans: Analyze passive radar illumination selection manager collected data from the ground-based static testing to establish an experimental technical baseline for a future airborne experiment.</p> <p>FY 2021 Plans: Complete analysis of ground-based data from passive illumination selection manager and initiate algorithm improvements. Start analysis of bistatic high resolution radar data in conjunction with advanced automated target recognition algorithms to demonstrate improved timeliness for combat identification of complex targets from bistatic radar systems. Initiate system integration and ground testing of low cost bistatic radar system for attritable/expendable platforms. Initiate integration of low cost data collection and signal processing backend to provide real-time processing for future airborne demonstration.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.819 million due to civilian on pay reprice adjustments.</p>			
<p>Title: Multi-Band/Multi-Beam Technologies</p> <p>Description: Develop multi-band and multi-beam forming technologies. Address technologies for antenna array operations in dynamic sensor networks.</p> <p>FY 2020 Plans: Continue to employ adaptive, reconfigurable and tunable detection methods and techniques as effective optional countermeasures to developing multi-mission, unmanned sensing blue force platforms such as the Low Cost Attritable Aircraft Technology effort.</p> <p>FY 2021 Plans: Continue to employ adaptive, additively manufactured phased array demonstration by laboratory testing and performance validation of single subarray panel. Start fabricating and integrating multiple subarray panels designed for a Low Cost Attritable Aircraft Technology experimental platform. Start advanced mode development for multi-beam digital arrays, implementing more complex modes and advanced waveforms. Start integration of advanced digital signal processing techniques to demonstrate mode-switching and multi-function capability.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	11.160	12.705	13.498

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$0.793 million due to civilian pay reprice adjustments.			
<p>Title: Sensor Resource Management</p> <p>Description: Develop technology to enable optimization of sensor resources in contested environments on own-ship and multi-ship in manned, unmanned and manned/unmanned teaming concepts.</p> <p>FY 2020 Plans: Utilize delivered sensor resource management tools to integrate data collected from the Defense Advanced Research Projects Agency System of Systems Integration Technology and Experimentation gauntlets and begin engineering study for multi-ship/multi-spectral sensor resource manager.</p> <p>FY 2021 Plans: Continue development of sensor resource management within Defense Advanced Research Projects Agency Arrays at Commercial Timescales architecture, extending beyond basic array control to real-time implementation including latency effects on mission execution. Initiate implementation of sensor resource management concepts for passive multi-mode radar, providing coordination of system resources between electronic support, illumination selection manager and passive radar subsystems. Continue development of multi-ship sensor resource management techniques for optimizing distributed and multi-spectral sensing resources.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.810 million due to civilian pay reprice adjustments.</p>	9.256	10.567	11.377
<p>Title: Radio Frequency Countermeasure Technologies</p> <p>Description: This project develops the radio frequency warning and countermeasure technology for advanced electronic warfare and information operations applications. Specifically, it develops techniques and technologies to detect and counter the communications links and sensors of threat integrated air defense systems and hostile command and control networks.</p> <p>FY 2020 Plans: Starting in FY 2020, this work is performed under Project 624920, Electronic Warfare Technology, Radio Frequency Electronic Warfare Technologies effort within this PE.</p> <p>FY 2021 Plans: Not applicable</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	13.522	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
Not applicable				
<p>Title: Future AF Capabilities Applied Research</p> <p>Description: Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/unconventional weapons).</p> <p>The National Defense Strategy and Air Force Science and Technology (S&T) Strategy will inform investments over the FYDP.</p> <p>In FY 2019, this work was performed under multiple projects and efforts within the following Air Force S&T Programs: 0602102F, Materials; 0602201F, Aerospace Vehicle Technologies; 0602202F, Human Effectiveness Applied Research; 0602203F, Aerospace Propulsion; 0602204F, Aerospace Sensors; 1206601F, Space Technology; 0602602F, Conventional Munitions; 0602605F, Directed Energy Technology; and 0602788F, Dominant Information Science and Methods.</p> <p>FY 2020 Plans: Investigate and mature science and technology that enables future warfighting concepts to provide leap-ahead capabilities. The National Defense Strategy and Air Force S&T Strategy focus this science and technology toward, but not limited to, the following capabilities: 1) global persistent awareness; 2) resilient information sharing; 3) rapid, effective decision-making; 4) complexity, unpredictability, and mass; and 5) speed and reach of disruption and lethality.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$19.667 million. Funding decreased due to realignment and consolidation of Future AF Capabilities Applied Research effort to PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort, to better align with the Air Force S&T Strategy SECAF April 2019 and provide Congress with increased transparency on transformational Air Force S&T activities.</p>		0.000	19.667	0.000
Accomplishments/Planned Programs Subtotals		54.598	52.066	34.821
		FY 2019	FY 2020	
Congressional Add: Program increase - Air Force Minority Leaders Program		4.930	0.000	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>

	FY 2019	FY 2020
FY 2019 Accomplishments: Conducted Congressionally directed efforts		
FY 2020 Plans: Not applicable		
Congressional Add: Program increase - RF spectrum situational awareness	0.000	8.000
FY 2019 Accomplishments: Not applicable		
FY 2020 Plans: Conduct Congressional directed efforts		
Congressional Adds Subtotals	4.930	8.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602212F / <i>Defense Laboratories R&D Projects (10 U.S.C, Sec 2358)</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	86.165	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
622030: <i>Defense Lab R&D Projects</i>	-	86.165	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

Implementation of 10 U.S.C. Section 2363, amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B), to fund: innovative basic and applied research conducted at the defense laboratory and supports military missions; development programs supporting the transition of technologies developed by the defense laboratory into operational use; workforce development activities improving the capacity of the defense laboratory to recruit and retain personnel with necessary scientific and engineering expertise that support military missions; and the repair or minor military construction of the laboratory infrastructure and equipment.

The Air Force is dependent on technological advances in response to emerging threats and to maintain a competitive advantage. Air Force has a comprehensive and deliberative planning process to identify and fund research that is expected to have the greatest benefit to the Air Force and the warfighter. 10 U.S.C. Section 2363 provides the Commander of the Air Force Research Laboratory (AFRL), in consultation with the Air Force Science and Technology (S&T) Executive, a degree of flexibility to rapidly exploit scientific breakthroughs or respond to emerging threats, to include developing a skilled workforce and necessary infrastructure. This flexibility increases the rate of innovation and accelerates the development and fielding of needed military capabilities to address current and future problems.

The Air Force has established PE 0602212F, where the 10 U.S.C. Section 2363 funds are internally reprogrammed to this program element in the year of execution after receipt of the appropriation. This allows increased transparency to Congress on 10 U.S.C. Section 2363 funding and additional execution flexibility for 10 U.S.C. Section 2363 activities to cross all technology areas.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research	R-1 Program Element (Number/Name) PE 0602212F I Defense Laboratories R&D Projects (10 U.S.C, Sec 2358)
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	86.165	0.000	0.000	0.000	0.000
Total Adjustments	86.165	0.000	0.000	0.000	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	86.165	0.000	0.000	0.000	0.000

Change Summary Explanation

Increase in FY 2019 in Other Adjustments is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2358, as amended by 10 U.S.C. 2805(d)(1)(B) and 10 U.S.C. Section 2363.

C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Title: Defense Laboratories R&D Projects - Air Force Research Laboratory</p> <p>Description: Implementation of 10 U.S.C. Section 2363, amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B), to fund: innovative basic and applied research conducted at the Air Force Research Laboratory (AFRL) and supports military missions; development programs supporting the transition of technologies developed by AFRL into operational use; workforce development activities improving the capacity of AFRL to recruit and retain personnel with necessary scientific and engineering expertise that support military missions; and the repair or minor military construction of the laboratory infrastructure and equipment.</p> <p>FY 2020 Plans: The budget for this program is implemented after an appropriation is passed as directed in provisions of 10 U.S.C. Section 2363.</p> <p>FY 2021 Plans: Not applicable</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>	86.165	0.000	0.000
Accomplishments/Planned Programs Subtotals	86.165	0.000	0.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force Date: February 2020

Appropriation/Budget Activity
3600: *Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research*

R-1 Program Element (Number/Name)
PE 0602212F / *Defense Laboratories R&D Projects (10 U.S.C, Sec 2358)*

D. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

E. Acquisition Strategy

Not Applicable

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602298F / <i>Science and Technology Management - Major Headquarters Activities</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	8.288	7.968	8.926	0.000	8.926	8.526	8.567	8.744	8.928	Continuing	Continuing
622520: <i>Science and Technology Management - Major HQ</i>	-	8.288	7.968	8.926	0.000	8.926	8.526	8.567	8.744	8.928	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force Research Laboratory (AFRL) is a global technical enterprise, boasting some of the best and brightest leaders in the world. It provides revolutionary, relevant, and responsive science and technology (S&T) to the Warfighter. AFRL's mission is to lead the discovery, development, and integration of affordable warfighting technologies for the global air, space, and cyberspace force.

This program element includes necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, and 1206601SF.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	8.288	7.968	8.101	0.000	8.101
Current President's Budget	8.288	7.968	8.926	0.000	8.926
Total Adjustments	0.000	0.000	0.825	0.000	0.825
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	0.825	0.000	0.825

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602298F / <i>Science and Technology Management - Major Headquarters Activities</i>					Project (Number/Name) 622520 / <i>Science and Technology Management - Major HQ</i>		
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622520: <i>Science and Technology Management - Major HQ</i>	-	8.288	7.968	8.926	0.000	8.926	8.526	8.567	8.744	8.928	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force Research Laboratory (AFRL) is a global technical enterprise, boasting some of the best and brightest leaders in the world. It provides revolutionary, relevant, and responsive science and technology (S&T) to the Warfighter. AFRL's mission is to lead the discovery, development, and integration of affordable warfighting technologies for the global air, space, and cyberspace force.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: AFRL - Major Headquarters Activities	8.288	7.968	8.926
Description: Provide professional government civilian workforce in support of all AFRL programs and activities.			
FY 2020 Plans: Continue to provide professional government civilian workforce in support of all AFRL programs and activities.			
FY 2021 Plans: Continue to provide professional government civilian workforce in support of all AFRL programs and activities.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.958 million. Funding increased due to civilian pay reprice adjustments.			
Accomplishments/Planned Programs Subtotals	8.288	7.968	8.926

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	100.573	142.772	132.425	0.000	132.425	147.652	134.767	137.765	139.838	Continuing	Continuing
622068: <i>Advanced Guidance Technology</i>	-	51.260	80.641	73.248	0.000	73.248	79.701	66.496	67.970	69.021	Continuing	Continuing
622502: <i>Ordnance Technology</i>	-	49.313	62.131	59.177	0.000	59.177	67.951	68.271	69.795	70.817	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program investigates, develops, and establishes the technical feasibility and military utility of guidance and ordnance technologies for conventional air-launched munitions. The effort supports core technical competencies of fuze technology; energetic materials; damage mechanisms; munitions aerodynamics, guidance, navigation, and control; terminal seeker sciences; and munition systems effects. Technologies to be developed include blast, fragmentation, penetrating and low-collateral damage war-heads, hard-target fuzing, precise terminal guidance, and high-performance and insensitive explosives.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	112.841	142.772	150.085	0.000	150.085
Current President's Budget	100.573	142.772	132.425	0.000	132.425
Total Adjustments	-12.268	0.000	-17.660	0.000	-17.660
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.409	0.000			
• Other Adjustments	-10.859	0.000	-17.660	0.000	-17.660

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force Date: February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>
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Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$10.859 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Decrease in FY 2021 is due to the realignment and consolidation of the Future AF Capabilities Applied Research efforts/activities to PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, to better align with the Air Force S&T Strategy SECAF April 2019 and provide Congress with increased transparency on transformational Air Force S&T activities.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>				Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622068: <i>Advanced Guidance Technology</i>	-	51.260	80.641	73.248	0.000	73.248	79.701	66.496	67.970	69.021	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project investigates, develops, and evaluates conventional munitions guidance technologies to establish technical feasibility and military utility of innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation. Project payoffs include adverse-weather, Global Positioning System (GPS)-degraded and Global Positioning System-denied, networked, and autonomous precision munition guidance capability; increased number of kills per sortie; increased aerospace vehicle survivability; improved weapon reliability and affordability; and improved weapon survivability and effectiveness.

B. Accomplishments/Planned Programs (\$ in Millions)

<p>Title: Seeker Technologies</p> <p>Description: Develops seeker technologies for air-delivered munitions to provide high-confidence target discrimination and classification, precise target location, and robust terminal tracking.</p> <p>FY 2020 Plans: Continue to emphasize technology development of multi-function sensors, rapid data compression for targeting, bio-inspired information processing and data fusion, and low-power computation. Continue to develop technologies that simplify, increase flexibility and reduce the cost of advanced seeker concepts to include biologically inspired low-cost concepts. Continue to develop algorithmic and mathematical approaches to integrate weapons into the kill chain to enable distributive, flexible seeker imaging targeting with or without an operator-in-the-loop. Continue development and testing of innovative air-to-air engagements for fifth generation aircraft and beyond with emphasis on radome and aperture materials that improve optical performance, as well as provide increased protection from operational environments including directed energy and rain. Continue to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker subsystems. Continue to explore specific techniques for seeker cost reduction with performance improvement; novel technical approaches such as sparse and compressive sensing will be investigated. Continue to conduct research on integrated processing techniques to enable networked systems to include early collaborative global positioning system denied navigation and miniature self-defense seeker design. Continue to develop open seeker architecture software-in-the-loop integration laboratory. Continue to investigate the technical challenges of cooperative radio frequency functions including coherent on-transmit/on-receive operation. Continue to refine the software development kit for Open Seeker Architecture to enable rapid technology insertion into software-defined, multi-function seekers.</p>	FY 2019	FY 2020	FY 2021
	6.805	9.416	9.463

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Continue to refine and further development of tools for evaluation of deep-learning networks to evaluate feasibility for weapon seekers. Continue analysis of Open Seeker Architecture cyber vulnerabilities and formulate software resilient techniques. Continue data collection experiments to support cooperative radio frequency systems.</p> <p>FY 2021 Plans: Continue to emphasize technology development of multi-function sensors, rapid data compression for targeting, bio-inspired information processing and data fusion, and low-power computation. Continue to develop technologies that simplify, increase flexibility, and reduce the cost of advanced seeker concepts. Continue to develop algorithmic approaches integrating weapons into the kill chain to enable distributive, flexible seeker targeting with or without an operator in the loop. Continue development and testing of innovative engagements for fifth generation aircraft and beyond. Continue materials research efforts on radomes and apertures, to improve transmission and optical performance while increasing protection from operational environments including directed energy and rain. Continue to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker subsystems. Continue to explore specific techniques for seeker cost reduction with performance improvement such as sparse sensing and compressive sensing. Continue research on integrated processing techniques to enable networked systems. Continue multi-function radio frequency technique development to enable coherent multi-weapon operation. Further development of Open Seeker Architecture with extended view to integrate into weapon mission computer to enable cooperative weapon operation. Continue integration of the Open Seeker architecture into the Weapon Open System Architecture and evaluate the impact with respect to cyber vulnerability. Continue to develop and demonstrate coherent collaborative radio frequency seeker operation.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.047 million. Funding increased due to added emphasis in autonomy and machine learning with legacy weapons research in support of cooperative / collaborative weapon technologies.</p>				
<p>Title: Aerodynamics, Navigation, and Control Technologies</p> <p>Description: Develops weapon aerodynamic control, navigation, and networking technologies for air-delivered munitions to provide precise, agile flight, networked effects, and immunity to countermeasures.</p> <p>FY 2020 Plans: Complete and transition the hypersonic flight performance aero-structural-thermal computational tools and prototype concept development tools to the program office. Complete the integration of algorithms to support distributed, multi-strategy weapon concept-of-operations to defeat enemy defenses. Continue execution of Position, Navigation and Timing acceleration research to integrate emitter geo-location and Electronic Intelligence into M-Code compliant anti-jam Global Position System chip set. Continue development of weapon platform interfaces to include concepts for double increased weapons load-out. Continue ground testing of advanced guidance laws and actuators to enable innovative air-to-air engagements and hyper-agility including hit-to-kill. Continue experiments demonstrating precision navigation using celestial aiding for long-range flights at high and low</p>		24.391	29.367	40.364

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>altitudes. Continue small, air-to-air, self-defense munitions research efforts. Continue cooperative/collaborative small cruise missile swarm flight demonstration to locate and overwhelm targets. Continue flight test of a multi-vehicle mapping (without Global Positioning System) and saturation approach of the entrance of a hardened-deeply-buried facility or tunnel target. Continue ground tests of rocket motor component technologies to evaluate their ability to increase weapon range and reduce size/weight. Continue development of defensive cyber algorithms for autopilot and navigation functions, including swarm. Continue execution of Joint Capability Technology Demonstration program with system program office and Combatant Command user for Global Position System-denied navigation suite for cruise missiles. Continue efforts to identify cyber vulnerabilities in software define radios used on weapons by testing meshing radios. Continue munition cyber-hardening demonstration coordinated with Cyber Command and extend to an integrated systems test environment. Continue intramural Air Force study of high fidelity models for store separation from aircraft using advanced dispense technologies. Initiate trade study of low-cost navigation grade Inertial Measurement Units, build weapon Size-Weight-And-Power celestial aiding sensor for upcoming high-altitude hypersonic test, use tactical software defined radio to flight test network aiding using meshing waveform. Initiate scaled flight demonstrations of advanced guidance laws for self-defense and multi-shot air-to-air missiles.</p> <p>FY 2021 Plans: Continue execution of Global Positioning System denied navigation demonstration programs. Initiate cooperative weapon swarming playbooks, demonstrating autonomous and collaborative behaviors, with various legacy weapon systems. Continue experiments demonstrating precision navigation, emphasizing cruise missile, form-factored optics and tracker for celestial aided navigation at supersonic cruise missile speeds and trajectory. Continue flight testing of articulating head missile at supersonic speeds at full scale. Continue flight demonstration on heterogeneous capability integrating kinetic swarm plays with electronic attack swarm plays. Continue flight demonstration of network aided navigation autonomy playbook. Continue flight demonstration of high-speed, high-performance weaponized quadrotor in a complex environment. Continue to use machine learning of a visual servo; learn servo commands from drone pilots using front looking camera.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$10.997 million. Funding increased due to added emphasis in autonomy and machine learning with legacy weapons research in support of cooperative / collaborative weapon technologies.</p>				
<p>Title: Guidance Technologies</p> <p>Description: Develops guidance subsystem integration and evaluation technologies to provide open and closed-loop ground testing, flight test risk reduction, and digital simulation of novel concepts.</p> <p>FY 2020 Plans: Complete transition of reconfigurable Radio Frequency Target Simulator to prime contractors to support hypersonic weapon development. Complete and refine the Modeling and Simulation capability with multi-level security enabling cross-domain, distributed Modeling and Simulation activities. Continue flight demonstration of critical behaviors for Distributed, Cooperative,</p>		20.064	22.192	23.421

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Collaborative strategies and other advanced guidance capabilities. Continue to improve constructive and virtual analysis tools for design, development, and analysis of advanced cruise missile concepts in representative environments and provide design, performance, and trade space analysis for hypersonic and air-to-air weapon concepts to the program offices. Continue to improve simulation technologies that evaluate innovative air-to-air and air-to-surface engagements to include guidance and control evaluation. Continue to develop a real-time radar/millimeter wave signature generation capability for testing algorithms in real-time software and hardware-in-the-loop environments to include additional targets and improved terrain resolution to multi-spectral signature generation capability for testing algorithms in real-time software and hardware-in-the-loop environments. Continue to develop simulation technologies that evaluate cooperative, flexible munition target engagements. Continue to transition refined engineering models to Air Force mission level simulation for analysis. Continue to improve capabilities of our reconfigurable radio-frequency hardware-in-the-loop chamber to handle faster and more complex scenes to include demonstrating real-time fluid thermal structural interaction effects during hardware-in-the-loop simulation of hypersonic weapons. Continue to develop new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems to include demonstrating increased scene complexity and closed-loop real-time interface and high-density Infrared Light Emitting Diode array with improved performance. Continue development of "help desk" high-fidelity modeling and scene generation modules for the extended modeling and simulation community using Air Force Simulation. Continue constructive and virtual analysis on numerous weapon concepts to provide design, performance, and trade space analysis to the program offices. Initiate refurbishment of main Kinetic Hardware-In-the-Loop System facility. Initiate distributed connectivity capability between multiple Air Force facilities for cross-domain, distributed, multi-level security modeling and simulation activities.</p> <p>FY 2021 Plans: Continue low-cost cruise missile demonstration of critical behaviors for distributed, cooperative, collaborative strategies and other advanced guidance capabilities. Further improve constructive and virtual analysis tools for design, development, and analysis of advanced low cost cruise missile concepts in representative environments. Continue engagement level analysis on hypersonic and air-to-air weapon concepts providing design, performance, and trade space analysis to the program offices. Continue to improve simulation technologies evaluating innovative air-to-air and air-to-surface engagements to include guidance and control evaluation. Continue to add additional targets and improved terrain resolution to radar/millimeter wave/infrared/ultraviolet signature generation capability for testing algorithms in real-time software and hardware in-the-loop environments. Continue development of hypersonic hardware-in-the-loop simulation technology, including thermal environment, aerodynamic control uncertainty, seeker modeling, and navigation sensor effectiveness. Initiate simulator upgrades to accommodate resolution requirements for navigation quality synthetic aperture radar target and background modeling. Continue development of infrared light emitting diode infrared target simulator technology to create higher framerate and higher resolution target simulator technology. Continue providing multi-security level, cross-domain distributed modeling and simulation support for munition research and development using distributed connectivity between multiple Eglin Air Force Base facilities. Continue development of 6-degrees of freedom and scene generation modules for the extended modeling and simulation community using Air Force</p>			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Simulator. Initiate hardware-in-the-loop activities in support of international cooperative research efforts. Complete hardware-in-the-loop facility expansion by adding optics lab for infrared target simulator development.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.229 million. Funding increased due to additional emphasis in modeling and simulation activities.</p>			
<p>Title: Future AF Capabilities Applied Research</p> <p>Description: Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/unconventional weapons).</p> <p>The National Defense Strategy and Air Force Science and Technology (S&T) Strategy will inform investments over the FYDP.</p> <p>In FY 2019, this work was performed under multiple projects and efforts within the following Air Force S&T Programs: 0602102F, Materials; 0602201F, Aerospace Vehicle Technologies; 0602202F, Human Effectiveness Applied Research; 0602203F, Aerospace Propulsion; 0602204F, Aerospace Sensors; 1206601F, Space Technology; 0602602F, Conventional Munitions; 0602605F, Directed Energy Technology; and 0602788F, Dominant Information Science and Methods.</p> <p>FY 2020 Plans: Investigate and mature science and technology that enables future warfighting concepts to provide leap-ahead capabilities. The National Defense Strategy and Air Force S&T Strategy focus this science and technology toward, but not limited to, the following capabilities: 1) global persistent awareness; 2) resilient information sharing; 3) rapid, effective decision-making; 4) complexity, unpredictability, and mass; and 5) speed and reach of disruption and lethality.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 due to realignment and consolidation of Future AF Capabilities Applied Research efforts to PE 0602020F, Future Air Force Capabilities Applied Research, Project 620200, Enterprise Transformational Applied</p>	0.000	19.666	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Research, Transformational Capability Incubator effort, to better align with the Air Force S&T Strategy SECAF April 2019 and provide Congress with increased transparency on transformational Air Force S&T activities.			
Accomplishments/Planned Programs Subtotals	51.260	80.641	73.248

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>				Project (Number/Name) 622502 / <i>Ordnance Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622502: <i>Ordnance Technology</i>	-	49.313	62.131	59.177	0.000	59.177	67.951	68.271	69.795	70.817	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project investigates, develops, and evaluates conventional ordnance technologies to establish technical feasibility and military utility for advanced explosives, fuzes, warheads, sub-munitions, and weapon airframes, carriage, and dispensing. The project also assesses the lethality and effectiveness of current and planned conventional weapons technology programs and assesses target vulnerability. The payoffs include improved storage capability and transportation safety of fully assembled weapons, improved warhead and fuze effectiveness, improved sub-munitions dispensing, low-cost airframe/subsystem components and structures, and reduced aerospace vehicle and weapon drag.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Energetic Materials Technology	2.667	3.509	3.833
Description: Investigates and develops energetic materials and technology that safely and securely optimize survivability, cost, and weapon lethality for air-delivered munitions.			
FY 2020 Plans: Continue to mature and develop selected energetic materials to increase energy density over that of traditional explosives while enhancing damage mechanisms and lethality for mass and volume-constrained applications. Continue to build and implement experimental techniques/capabilities to quantify dynamic and mechanical properties as well as survivability of energetic materials in extreme temperature and vibrational environments. Continue to develop theoretical and virtual formulation and processing techniques for energetic materials and provide the second release of the tool/software to the energetics community. Continue to develop tools and analysis techniques to further understanding of energy partitioning in order to optimize lethality against a broad spectrum of targets. Continue to formulate and test liner technologies to improve Insensitive Munitions performance. Continue to mature additive manufacturing techniques to increase the design space for kinetic weapon lethality. Initiate formulation of novel explosive fill to satisfy severe environmental constraints. Initiate development of large scale nano-energetic material fabrication.			
FY 2021 Plans: Continue to advance and develop selected energetic materials to increase energy density over traditional explosives while enhancing damage mechanisms and lethality for mass and volume-constrained applications. Continue to build and implement experimental techniques/capabilities to quantify dynamic and mechanical properties as well as survivability of energetic materials in extreme temperature and vibrational environments. Continue to develop tools and analysis techniques to further understanding of energy partitioning in order to optimize lethality against a broad spectrum of targets. Continue to formulate and test liner technologies to improve Insensitive Munitions performance. Continue to mature additive manufacturing techniques to increase			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622502 / <i>Ordnance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
the design space for kinetic weapon lethality. Continue formulation of novel explosive fill to satisfy severe environmental constraints. Continue development of large scale nano-energetic material fabrication.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.324 million. Justification for the increase is described in the plans above.				
Title: Fuze Technologies		3.578	5.303	4.777
Description: Investigate and develop fuzing technology for air-delivered weapons to ensure reliable and optimal function to maximize weapon lethality for all engagement scenarios.				
FY 2020 Plans: Continue to develop testing capabilities for munitions penetration scenarios and increase Modeling and Simulation capabilities to reduce research and development costs and timelines. Continue to develop and demonstrate alternative packaging technology for survivable fuze electronic components. Continue to investigate the reliability and survivability of electronic components to predict and measure fuze performance during monition penetration at high-impact speeds. Continue research to facilitate tailored lethal effects and enable optimum fuzing solutions across the spectrum of weapon and target interactions. Continue research for distributed and multi-point fuzing concepts. Continue implementing additive manufacturing techniques to increase fuze reliability. Initiate fuze explosive interfaces analysis for robust definition of explosive train reliability and performance. Initiate fuze endgame, active imaging for target detection and aim point selection.				
FY 2021 Plans: Continue to develop testing capabilities for munitions penetration scenarios and increase Modeling and Simulation capabilities to reduce research and development costs and timelines. Continue to develop and demonstrate alternative packaging technology for survivable fuze electronic components. Continue to investigate the reliability and survivability of electronic components to predict and measure fuze performance during monition penetration at high-impact speeds. Continue research to facilitate tailored lethal effects and enable optimum fuzing solutions across the spectrum of weapon and target interactions. Continue research for distributed and multi-point fuzing concepts. Continue implementing additive manufacturing techniques to increase fuze reliability. Continue fuze explosive interfaces analysis for robust definition of explosive train reliability and performance. Continue fuze endgame, active imaging for target detection and aim point selection.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.526 million. Justification for the decrease is described in the plans above.				
Title: Warhead Technologies		8.580	12.158	7.791
Description: Investigate and develop innovative warhead kill mechanisms for air-delivered weapons that maximize weapon lethality for all engagement scenarios.				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622502 / <i>Ordnance Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> Continue to mature small, multi-output warhead technologies for soft-surface targets, to include limited penetration capability of hardened structures. Continue to evolve test capabilities to enhance quantification of the mechanical response under high rate, high-pressure loading conditions for use in high fidelity Modeling and Simulation tools, to include materials used in additive manufacturing processes. Continue to develop additive manufacturing techniques and produce optimized sub-scale articles for test. Continue to demonstrate technologies for effective and survivable high-speed penetration into hard targets. Continue to develop air-to-air missile warhead concepts for the air targets in near-peer engagement scenarios. Continue to research and develop cumulative damage mechanisms that take advantage of distributed blast, as well as shock wave and reactive particle interactions. Continue integration of warhead research with related activities planned for the advanced/integrated ordnance subsystems research capability. Initiate a characterization of Low-Density and High-Density Reactive Materials for use in multi-mission roles. Initiate the development of topological optimization in support of additive manufacturing. Initiate studies of composite based warheads for penetrator/perforator applications.</p> <p><i>FY 2021 Plans:</i> Continue to mature small, multi-output warhead technologies for soft-surface targets, to include limited penetration capability of hardened structures. Continue to evolve test capabilities to enhance quantification of the mechanical response under high-rate, high-pressure loading conditions for use in high-fidelity Modeling and Simulation tools, to include materials used in additive manufacturing processes. Continue to develop additive manufacturing techniques and produce optimized sub-scale articles for test. Continue to demonstrate technologies for effective and survivable high-speed penetration into hard targets. Continue to develop warhead concepts for the air targets in near-peer engagement scenarios. Continue to research and develop cumulative damage mechanisms taking advantage of distributed blast, as well as shock wave and reactive particle interactions. Continue integration of warhead research with related activities planned for the advanced/integrated ordnance subsystems research capability. Continue the development of topological optimization in support of additive manufacturing. Continue studies of composite based warheads for penetrator/perforator applications.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$4.367 million. Funding decreased due to reduced emphasis in a portion of research in near-peer engagement scenarios with extreme conditions.</p>			
<p><i>Title:</i> Ordnance Technologies</p> <p><i>Description:</i> Investigate and develop ordnance sub-system (energetics, fuzes and war-heads) and integrated system concepts using both high-fidelity and fast-running engineering level Modeling and Simulation tools.</p> <p><i>FY 2020 Plans:</i> Continue to develop validated mesoscale Modeling and Simulation tools for computational physics sciences. Continue to mature engineering-level simulation architecture capability to enable weapon sub-system and system-level technology assessments.</p>	34.488	41.161	42.776

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622502 / <i>Ordnance Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Continue to implement cost-effective and rapid transition war-head technologies for inventory penetrator weapons. Continue to conduct Modeling and Simulation that explores the ordnance technology trade space for low-cost, long-range munition concepts. Continue to develop predictive techniques for munition effectiveness tools used in concept development and assessment as well as studies involving analysis of alternatives. Continue to develop test capability and data collection for Modeling and Simulation tools to characterize lethality, survivability and performance of sub-systems and integrated ordnance systems. Initiate the development of ordnance test and evaluation capabilities that include thermal and vibration management for hypersonic and high-speed flight.</p> <p><i>FY 2021 Plans:</i> Continue to develop validated mesoscale Modeling and Simulation tools for computational physics sciences. Continue to develop engineering-level simulation architecture capability to enable weapon sub-system and system-level technology assessments. Continue to implement cost-effective and rapid transition war-head technologies for inventory penetrators. Continue to Modeling and Simulation efforts exploring the ordnance technology trade space for low-cost, long-range munition concepts. Continue to develop predictive techniques for munition effectiveness tools used in concept development and assessment as well as studies involving analysis of alternatives. Continue to develop test capability and data collection for Modeling and Simulation tools to characterize lethality, survivability, and performance of sub-systems and integrated ordnance systems. Continue the development of ordnance test and evaluation capabilities that include thermal and vibration management for hypersonic and high-speed flight.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$1.615 million. Funding increased due to the additional emphasis in modeling and simulation activities.</p>			
Accomplishments/Planned Programs Subtotals	49.313	62.131	59.177

C. Other Program Funding Summary (\$ in Millions)
N/A

Remarks

D. Acquisition Strategy
Not Applicable.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	129.579	124.379	128.113	0.000	128.113	129.514	124.873	127.831	130.111	Continuing	Continuing
624866: <i>Lasers & Imaging Technology</i>	-	98.961	92.359	96.826	0.000	96.826	93.172	88.826	90.934	91.547	Continuing	Continuing
624867: <i>Advanced Weapons & Survivability Technology</i>	-	30.618	32.020	31.287	0.000	31.287	36.342	36.047	36.897	38.564	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program covers research in Directed Energy (DE) technologies, primarily High Energy Lasers (HEL); including devices, subcomponents, and novel materials; optical beam control; laser system integration; target laser lethality/vulnerability assessments; ground-based optical Space Situational Awareness (SSA); and high power microwaves (HPM). Laser research includes moderate to high power laser devices that are applicable to a wide range of applications, optical technologies to propagate laser beams through the atmosphere, and integration of these technologies into demonstration packages. Space Situational Awareness research uses the Starfire Optical Range (SOR) and the Maui Space Surveillance System (MSSS) to develop and implement technologies to identify visual characteristics such as status and health of orbiting space objects. In high power microwaves this research examines technologies for applications such as counter-electronics and non-lethal weapons. This program conducts research into other novel Directed Energy applications; conducts Directed Energy vulnerability/lethality assessments; develops protection technologies versus Directed Energy; conducts research into other advanced non-conventional/innovative weapons; develops and uses tools to compare solutions to determine the most effective and efficient Directed Energy technologies to meet Air Force needs; coordinates efforts through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	141.800	124.379	124.693	0.000	124.693
Current President's Budget	129.579	124.379	128.113	0.000	128.113
Total Adjustments	-12.221	0.000	3.420	0.000	3.420
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-2.648	0.000			
• Other Adjustments	-9.573	0.000	3.420	0.000	3.420

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$9.573 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Increase in FY 2021 of \$3.420 million is due to civilian pay reprice adjustments.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>				Project (Number/Name) 624866 / <i>Lasers & Imaging Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624866: <i>Lasers & Imaging Technology</i>	-	98.961	92.359	96.826	0.000	96.826	93.172	88.826	90.934	91.547	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project explores the technical feasibility of moderate to high power lasers, including beam control, for applications such as aircraft protection, force protection, and precision engagement from Air Force platforms. This project investigates the effects of laser weapons on a wide range of systems and components as well as producing, modifying, validating and applying Directed Energy and non-Directed Energy concept development and assessment tools to determine which technology solutions to pursue. Additionally, this project conducts research supporting ground-based optical space situational awareness.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Energy Laser Technologies and Directed Energy Assessments	75.499	65.641	70.117
<p>Description: Develop and demonstrate High Energy Laser device technologies for Air Force applications. Develop and demonstrate laser beam control technologies including atmospheric propagation and pointing and tracking. Perform laser system level modeling and simulation validated by laser effects and vulnerability testing. Develop tools and perform assessments which allow comparisons among concepts and tradeoffs between Directed Energy and non-Directed Energy solutions. Integrate optical beam control technologies with laser device technologies and demonstrate the combined technologies. Develop and use modeling, testing and diagnostic technologies to better understand the vulnerability of adversary weapon systems to High Energy Lasers.</p> <p>FY 2020 Plans: Continue to develop beam control technologies including aero-effects mitigation techniques based on supersonic data from laboratory and flight tests. Continue to power scale monolithic fiber amplifiers using advanced fibers. Continue with effects testing to establish system requirements and validate models. Complete integration of beam control subsystems into pod for FY 2020 pod-mounted low power ground and airborne laser demonstration. Begin ground demonstration of Phase I low power laser podded system. Complete development of moderate power system into a pod for Phase 2 moderate power aircraft self-protect demonstration vs representative targets in FY 2021. Complete prototype module for fully packaged ultra-compact fiber amplifier laser. Continue to transition the functionality of the Integrated Weapons Environment for Analysis engagement level model into the Advanced Framework for Simulation model for engagement and mission level analysis for internal and external users and utilize the Advanced Framework for Simulation model as the weapons server in an advanced framework to support Air Force-wide modeling, simulation, and analysis. Continue to assess directed energy weapon and/or synergistic directed energy weapon/kinetic energy weapon capabilities to help users plan weapon investments. Continue to model and characterize foreign high energy laser threats, and provide information to develop mitigation techniques to protect blue assets.</p> <p>FY 2021 Plans:</p>			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>	Project (Number/Name) 624866 / <i>Lasers & Imaging Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Continue to develop beam control technologies including aero-effects mitigation techniques based on transonic and supersonic data from laboratory and flight tests. Continue to power scale monolithic fiber amplifiers using advanced fibers. Continue with laser effects testing to establish system requirements and validate models. Complete System Requirements Review/Concept Design Review (SRR/CoDR) for 150 kW compact laser system. Continue to transition the functionality of the Integrated Weapons Environment for Analysis engagement level model into the Advanced Framework for Simulation model for engagement and mission level analysis for internal and external users. Transition the models to the Department of Defense and Industry Modeling, Simulation and Analysis community. Utilize the Advanced Framework for Simulation model as the weapons server in an advanced framework to support Air Force-wide modeling, simulation, and analysis. Continue to assess directed energy weapon and/or synergistic directed energy weapon/kinetic energy weapon capabilities to help users plan weapon investments. Continue to model and characterize foreign high energy laser threats, and provide information to develop mitigation techniques to protect blue assets.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$4.476 million. Funding increased due to additional emphasis on the development of the 150 kW compact laser system and civilian pay reprice adjustment.</p>			
<p>Title: Optical Space Situational Awareness and Satellite Vulnerability</p> <p>Description: Develop advanced, long-range, electro-optical technologies that enable ground-based optical Space Situational Awareness (SSA) and quantum-based optical communications. Develop and use technologies to understand the vulnerability of blue satellite systems and components to lasers. Operate the Starfire Optical Range (SOR) to conduct research meeting internal and customer requirements.</p> <p>FY 2020 Plans: Continue fielding the dynamic telescope subsystem that searches the geosynchronous satellite belt visible from the mid-Pacific multiple-times per night, enabling a periodic comprehensive census of dim objects in the geobelt. Continue to mature daylight detection of geosynchronous satellites thus allowing custody through daytime hours when satellites cannot normally be detected by our ground-based optical systems. Continue to mature component technologies for 24/7 real-time optical imaging of near-earth and geosynchronous objects enabling characterization on tactical timelines. Continue investigation through modeling and simulation the susceptibility of satellite components to laser threats to inform practical designs for protection equipment and for tactically rapid course-of-action decision-making enabling protection methods. Continue development of laser-enabled space situational awareness (SSA) research focused on full-dark imaging using laser illumination. Investigate laser-enabled options for both ranging to and imaging of geosynchronous satellites from apertures smaller than 3 meters. Continue development of long-range secure optical communications technologies leveraging quantum science for free space lasercom channels. Continue project to apply machine-learning to automatically identify geosynchronous-orbit objects more accurately and rapidly than current "hard-wired" algorithms can. Continue to maintain Starfire Optical Range (SOR) facility and experimental equipment in a mission-ready state.</p>	23.462	26.718	26.709

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>	Project (Number/Name) 624866 / <i>Lasers & Imaging Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>In FY 2020, the work under the Optical Space Situational Awareness and the Satellite Vulnerability effort in PE 06036505F, Project 633151, High Power Solid State Laser Technology transferred to this effort to consolidate Optical Space Situational Awareness and Satellite Vulnerability research efforts.</p> <p><i>FY 2021 Plans:</i> Continue fielding the dynamic telescope subsystem that searches the geosynchronous satellite belt visible from the mid-Pacific multiple-times per night, enabling a periodic comprehensive census of dim objects in the geobelt. Continue to mature daylight detection of geosynchronous satellites thus allowing custody through daytime hours when satellites cannot normally be detected by our ground-based optical systems. Continue to mature component technologies for 24/7 real-time optical imaging of near-earth and geosynchronous objects enabling characterization on tactical timelines. Continue investigation through modeling and simulation the susceptibility of satellite components to laser threats to inform practical designs for protection equipment and for tactically rapid course-of-action decision-making enabling protection methods. Continue development of laser-enabled space situational awareness (SSA) research focused on full-dark imaging using laser illumination. Investigate laser-enabled options for both ranging to and imaging of geosynchronous satellites from apertures smaller than 3 meters. Continue development of long-range secure optical communications technologies leveraging quantum science for free space lasercom channels. Continue project to apply machine-learning to automatically identify geosynchronous-orbit objects more accurately and rapidly than current "hard-wired" algorithms can. Continue to maintain the Starfire Optical Range (SOR) and Maui Space Surveillance Site (MSSS) facilities and experimental equipment in a mission-ready state. Continue research on laser-ranging to objects in geosynchronous orbit using active sensing techniques. Starting in FY 2021, work in Program Element 0603605F, Project 633151, High Power Solid State Laser Technology, Optical Space Situational Awareness and Satellite Vulnerability efforts will be performed under in Program Element 0602605F, Directed Energy Technology, Project 624866, Lasers & Imaging Technology, Optical Space Situational Awareness and Satellite Vulnerability effort to consolidate Optical Space Situational Awareness and Satellite Vulnerability research efforts.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$0.009 million. Justification for the decrease is described in the plans above.</p>			
Accomplishments/Planned Programs Subtotals	98.961	92.359	96.826

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>				Project (Number/Name) 624867 / <i>Advanced Weapons & Survivability Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624867: <i>Advanced Weapons & Survivability Technology</i>	-	30.618	32.020	31.287	0.000	31.287	36.342	36.047	36.897	38.564	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project explores the use of High Power Microwave and other unconventional/innovative weapon concepts to support applications such as nonlethal counter-personnel and electronic warfare including disruption, degradation, and damage of electronic infrastructure on Air Force platforms. This research includes weapon technology that can provide covert effects and/or no collateral or human damage. The project also investigates the effects of potential adversary High Power Microwave weapons and how to mitigate those effects on US assets, as well as producing and applying Directed Energy and non-Directed Energy concept development and assessment tools to determine which technology solutions to pursue. This project includes but is not limited to high power microwaves, plasmas, particle beams and millimeter waves.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Power Microwave and Unconventional Weapon Technologies	11.176	9.316	7.555
Description: Investigate technologies for High Power Microwave and unconventional weapon components. Investigate High Power Microwave and other unconventional weapon concepts using innovative technologies. Investigate advanced technologies that support force protection tactical applications, including non-kinetic/non-lethal counter-electronics applications.			
FY 2020 Plans: Assess the military utility of an ultra-short pulsed laser system. Conduct effects testing on electronics based on the target classes for the joint high power microwave program with the Navy. Develop and test high power microwave components for ground and aerial high power microwave demonstrators. Develop and test smaller, higher power, source technology for the joint Air Force-Navy high power microwave demonstration.			
FY 2021 Plans: Define measures of effectiveness and performance of an ultra-short pulsed laser system. Continue effects testing on electronics based on the target classes for the joint high power microwave program with the Navy. Continue to develop and test high power microwave components for ground and aerial high power microwave demonstrators. Continue to develop and test smaller, higher power, source technology for the next generation Air Force high power microwave demonstration. Continue to support the modeling, simulation, and analysis (MS&A) tools that have been transitioned to the broader modeling, simulation, and analysis community.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>	Project (Number/Name) 624867 / <i>Advanced Weapons & Survivability Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$1.761 million. Funding decreased due to schedule rephasing of the Joint High Power Microwave program with the Navy based on higher Air Force priorities.				
Title: High Power Microwave Effects and Mitigation Research		19.442	22.704	23.732
Description: Assess the effects/lethality of High Power Microwave technologies. Develop and apply sophisticated models to enhance the development of High Power Microwave and related technology. Develop tools and perform assessments which allow comparisons among Directed Energy concepts and tradeoffs between Directed Energy and non-Directed Energy solutions. Investigate technologies to counter the effects of High Power Microwaves.				
FY 2020 Plans: Transition software applications that are hosted in the directed energy High Performance Computing Software Applications Institute for a broad spectrum directed energy sources. Conduct end-to-end modeling and weapon utility assessments to incorporate high power microwave weapon technology into various platforms for multiple target prosecutions. Conduct synergistic weapon concept assessments that merge kinetic energy and non-kinetic weapon investments. Continue to support the modeling, simulation, and analysis tools that have been transitioned to the broader modeling, simulation, and analysis community.				
FY 2021 Plans: Validate and update software applications that are hosted in the directed energy High Performance Computing Software Applications Institute for a broad spectrum directed energy sources. Develop a data base of high power sources. Assess military utility of high power microwave weapon technology that is integrated into various platforms for multiple target engagements using end-to-end modeling. Assess synergistic weapon concepts that merge kinetic energy and non-kinetic weapon capabilities into one weapon system. Validate and update the modeling, simulation, and analysis tools that have been transitioned to the broader modeling, simulation, and analysis community.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.028 million. Funding increased due to development of a data base of high power sources and additional emphasis on modeling and simulation to ground future Air Force directed energy requirements for the warfighter.				
Accomplishments/Planned Programs Subtotals		30.618	32.020	31.287
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>	Project (Number/Name) 624867 / <i>Advanced Weapons & Survivability Technology</i>

D. Acquisition Strategy

Not Applicable

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research	R-1 Program Element (Number/Name) PE 0602788F I Dominant Information Sciences and Methods
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	182.221	216.062	178.668	0.000	178.668	174.121	167.838	171.504	175.011	Continuing	Continuing
625315: C4I Dominance Technology	-	31.804	134.355	91.558	0.000	91.558	90.307	87.117	89.032	90.697	Continuing	Continuing
625316: Info Mgt and Computational Tech	-	11.890	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.890
625317: Information Decision Making Tech	-	16.443	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	16.443
625318: Operational Awareness Tech	-	21.969	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	21.969
625319: Cyberspace Dominance Technology	-	79.410	60.281	63.926	0.000	63.926	60.832	57.840	59.109	60.468	Continuing	Continuing
620MMS: Research Site Support	-	20.705	21.426	23.184	0.000	23.184	22.982	22.881	23.363	23.846	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops enterprise-centric information technology for the Air Force. Advances in enterprise-centric information technologies are required to increase warfighter readiness and effectiveness by providing the right information, at the right time, in the right format, anytime, anywhere in the world. The Connectivity and Protection Tech project provides the technologies for multi-level, secure, seamless networks; advanced communications processors; anti-jam and low probability of intercept techniques, as well as technologies that deter any adversary from attacking computer systems while allowing access to, presence on, manipulation of, and operational effects on adversary computer systems. This project also develops the technology base for the next generation of ultra-wide-bandwidth, multi-channeled, air- and space-based communications networks. The Information Management and Computational Tech project provides advances in information management and dissemination technologies to ensure the delivery of high-quality, timely, secure information to the warfighter, and develop technologies to produce both advanced on demand computational processing and computer architectures with greater capacity and sophistication for addressing dynamic mission objectives under constraints imposed by Air Force systems. The Information Decision Making Tech project develops the technology to support the commander and staff's ability to command all viable options to achieve desired effects across the full spectrum of operations. The Operational Awareness Tech project develops technologies that improve their capability to generate, process, manage, fuse, exploit, interpret, and disseminate timely and accurate information. The Research Site Support project provides the Rome Research Site infrastructure at Rome, New York and provides for the continued operations of all Rome Research Site properties, buildings, and services necessary for the research mission. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>
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In FY 2020, Project 625316, Info Mgt and Computational Tech, Project 625317, Information Decision Making Tech, and Project 625318, Operational Awareness Tech efforts transferred to Project 625315, C4I Dominance Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0622041F, 0602605F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	185.276	181.562	184.766	0.000	184.766
Current President's Budget	182.221	216.062	178.668	0.000	178.668
Total Adjustments	-3.055	34.500	-6.098	0.000	-6.098
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	34.500			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-3.055	0.000			
• Other Adjustments	0.000	0.000	-6.098	0.000	-6.098

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 625315: *C4I Dominance Technology*

Congressional Add: *Program Increase- Artificial Intelligence/Machine Learning Accelerator*

Congressional Add: *Program Increase- Combat Cloud Technology*

Congressional Add: *Program Increase- Quantum Communications*

Congressional Add: *Program Increase- Quantum Cryptography*

Congressional Add: *Program Increase*

Congressional Add: *Program Increase- Quantum Information Science Innovation Center*

Congressional Add Subtotals for Project: 625315

	FY 2019	FY 2020
Congressional Add: <i>Program Increase- Artificial Intelligence/Machine Learning Accelerator</i>	0.000	8.000
Congressional Add: <i>Program Increase- Combat Cloud Technology</i>	0.000	2.500
Congressional Add: <i>Program Increase- Quantum Communications</i>	0.000	4.000
Congressional Add: <i>Program Increase- Quantum Cryptography</i>	0.000	7.000
Congressional Add: <i>Program Increase</i>	0.000	5.000
Congressional Add: <i>Program Increase- Quantum Information Science Innovation Center</i>	0.000	8.000
Congressional Add Subtotals for Project: 625315	0.000	34.500

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>
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Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2019	FY 2020
Project: 625316: <i>Info Mgt and Computational Tech</i>		
Congressional Add: <i>Program Increase - Quantum Computing CoE</i>	7.376	0.000
Congressional Add Subtotals for Project: 625316	7.376	0.000
Project: 625319: <i>Cyberspace Dominance Technology</i>		
Congressional Add: <i>Program Increase - Cyber Testbed for Unidentified C-UAS</i>	5.409	0.000
Congressional Add: <i>Program Increase</i>	9.835	0.000
Congressional Add Subtotals for Project: 625319	15.244	0.000
Congressional Add Totals for all Projects	22.620	34.500

Change Summary Explanation

Decrease in FY 2021 due to realignment and consolidation of Future Air Force Capabilities Applied Research efforts/activities to PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Appld Research to better align with Air Force Science and Technology Strategy, SECAF April 2019, and to provide Congress with increased transparency on transformational Air Force Science and Technology activities.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>C4I Dominance Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625315: <i>C4I Dominance Technology</i>	-	31.804	134.355	91.558	0.000	91.558	90.307	87.117	89.032	90.697	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force requires advanced technologies which support the Air Force five core missions and enable the Air Force to achieve Global Vigilance, Global Reach, and Global Power in support of national security objectives. The technologies developed under this project enable the National Defense Strategy and Air Force future operating concepts which require operational agility (the ability to rapidly generate—and shift among—multiple solutions for a given challenge), creating combinations of air, space, and cyberspace capabilities to achieve desired effects in the battlespace.

This project provides the technologies for secure, self-configuring, self-healing, seamless networks; advanced communications processors; anti-jam and low probability of intercept communications techniques; agile and dynamic policy-based network management capabilities; and modular, programmable, low-cost software radios. In addition, it develops both the technology base for ultra-wide bandwidth and multi-channeled communications networks (both air and space based) on and between platforms.

This project provides the technologies which enable the ability to globally share, discover, and access information across organizational, functional, and coalition boundaries and between and among domains, the timely delivery of information to tactical assets, the tailoring and prioritization of information based on mission needs and importance, and the scaling, robustness, and collaboration features required of the Air Force net-centric information management environment.

This project advances technologies enabling the effective execution of military objectives that will vastly improve the ability to support the commander and staff's ability to command all viable options to achieve desired effects across the full spectrum of operations (air, space, and cyberspace) at all levels of war (strategic, operational, and tactical) and during all phases of conflict. This project provides technologies for anticipatory decision support; course of action development, planning, scheduling, and assessment; and the real-time effective portrayal of complex data sets.

This project improves and automates the capability to generate, process, manage, fuse, exploit, interpret, and disseminate timely and accurate information. This project provides not only a network-centric, collaborative intelligence analysis capability that enables the fusion of multi-intelligence and sensor sources to provide timely situational awareness, understanding, and anticipation of the threats in the battlespace, but also the advanced, novel exploitation technologies needed to intercept, collect, locate, and process both covert and overt raw data from intelligence and sensor sources.

In FY 2020, Project 625316, Info Mgt and Computational Tech, Project 625317, Information Decision Making Tech, and Project 625318, Operational Awareness Tech efforts transferred to Project 625315, C4I Dominance Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>C4I Dominance Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Title: Advanced Connectivity Technologies</p> <p>Description: Develop improved, survivable, higher bandwidth communications, networking, and signal processing technologies to provide secure, adaptive, covert, anti-jam, and assured global battlespace connectivity tailored to anti-access and area-denial environments and contested operations.</p> <p>FY 2020 Plans: Starting in FY 2020, this work is performed within this Project, under the Assured Communications & Networks, the Nuclear C3 Modernization, and the Quantum Information Science efforts.</p> <p>FY 2021 Plans: Not Applicable.</p>	31.804	0.000	0.000
<p>Title: Assured Communications & Networks</p> <p>Description: Develop communications, networking, and signal processing technologies with improved survivability and capacity to provide secure, adaptive, covert, anti-jam, and assured global battlespace connectivity tailored to anti-access and area-denial environments and contested operations.</p> <p>For FY 2019 and prior years, the Advanced Connectivity Technologies activities were performed within this Project, under the Advanced Connectivity Technologies effort.</p> <p>For FY 2019 and prior years, the Dissemination Technologies activities were performed within Project 625316, Info Mgt and Computational Tech, under the Dissemination Technologies effort.</p> <p>FY 2020 Plans: Continue the research and development of technologies for robust, adaptive, and mission aware airborne networks. Continue the investigation of high frequency pathways (for example, the V and W band of the electromagnetic spectrum) to support aerial and space-based beyond line of sight communications. Continue the research and development of dynamic map-to-mission for secure message exchange operations continuity and agile info management. Continue development of a waveform testbed and flight test a new multi-waveform radio. Continue research and development to measure propagation at millimeter wave frequencies to validate previously developed models and enable future definition of military satellite communications systems. Continue ionospheric research, propagation modeling and simulation.</p> <p>FY 2021 Plans: Continue the research and development of technologies for robust, adaptive, and mission aware airborne networks. Continue the investigation of high frequency pathways (for example, the V and W band of the electromagnetic spectrum) to support aerial and</p>	0.000	23.680	24.598

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>C4I Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>space-based beyond line of sight communications. Continue the research and development of dynamic map-to-mission for secure message exchange operations continuity and agile info management. Continue development of a waveform testbed and flight test a new multi-waveform radio. Continue research and development to measure propagation at millimeter wave frequencies to validate previously developed models and enable future definition of military satellite communications systems. Continue ionospheric research, propagation modeling and simulation. Develop an ultra-wide band protocol stack to enable future ultra wide-band communications. Develop a directional radio prototype, with optimized user discovery and network interference control interface.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.918 million. Justification for the increase is described in the plans above.</p>				
<p>Title: Data to Decisions</p> <p>Description: Investigate and develop technologies for decision quality information dissemination services via publish, subscribe, and query across the Global Information Grid to enterprise and tactical assets and coalition partners.</p> <p>For FY 2019 and prior years, the Multi-Source Fusion Technologies and the Exploitation Technologies activities were performed within Project 625318, Operational Awareness Tech, under the Multi-Source Fusion Technologies effort and the Exploitation Technologies effort.</p> <p>FY 2020 Plans: Continue the research and development of data analytics and strategic indications and warnings technologies (including large data alignment, indexing and search on textual data, large-scale and disparate data sources, both structured and unstructured data, and employment of various ontologies and machine learning techniques). Continue to advance research and development for cloud-based data and information sharing environment for optimized processing and automated association capability. Continue to focus signals intelligence characterization on audio and other electronic signals. Continue research and development in exploitation technologies using audio processing for language modeling and deep learning techniques. Continue research on enhanced emitter feature extraction capabilities and development of automated electronics intelligence analysis toolsets.</p> <p>FY 2021 Plans: Continue the research and development of data analytics and strategic indications and warnings technologies (including large data alignment, indexing and search on textual data, large-scale and disparate data sources, both structured and unstructured data, and employment of various ontologies and machine learning techniques). Continue to advance research and development for cloud-based data and information sharing environment for optimized processing and automated association capability. Continue to focus signals intelligence characterization on audio and other electronic signals. Continue research and development in exploitation technologies using audio processing for language modeling and deep learning techniques. Continue research on</p>		0.000	13.272	14.271

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>C4I Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
enhanced emitter feature extraction capabilities and development of automated electronics intelligence analysis toolsets. Develop network dynamics algorithms. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.999 million. Funding increased due to work initiated in network dynamics algorithms.				
Title: Processing Technologies Description: Develop automatic and dynamically reconfigurable, scalable, affordable distributed peta-flop processing technologies for real-time global information systems. FY 2020 Plans: For FY 2020 and prior years, the work is performed in this PE within Project 625319 Cyberspace Dominance Technology under the Processing Technologies effort. FY 2021 Plans: Develop the application of novel neuromorphic systems for robust machine learning. Continue to advance research and development of the neuromorphic processor and validate capabilities for dynamic learning on mobile and power-constrained platforms. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$6.509 million. Funding increased due to realignment of advanced neuromorphic processing research for advanced processing capability on low-power platforms from Processing Technologies effort, Project 625319 Cyberspace Dominance Technology.		0.000	0.000	6.509
Title: Multi-Domain Command & Control (MDC2) Description: Develop advanced monitoring, planning, and assessment technologies enabling aerospace commanders to develop effects-based campaigns. Investigate, analyze, and develop technologies for planning, execution, and automatic rapid reconfiguration of distributed intelligent and integrated command and control information systems to achieve the commander's intent throughout varying crisis levels. For FY 2019 and prior years, the Command and Control System Technologies activities were performed within Project 625317, Information Decision Making Tech, under Command and Control System Technologies effort. For FY 2019 and prior years, the Next Generation Command Technologies activities were performed within Project 625318, Operational Awareness Tech, under Next Generation Command Technologies effort.		0.000	17.954	18.863

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>C4I Dominance Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> Continue to leverage prior efforts in developing plan assessment services and conduct quantitative evaluations of cyber assets to cyber operators, enabling them to present viable cyber options to commanders for multi-domain (air, space, cyberspace, land, sea, undersea) integrated plans. Continue the development of command and control system technologies in the area of multi-domain command and control. Continue research for applying machine learning techniques to enhance and optimize space operations.</p> <p><i>FY 2021 Plans:</i> Continue research for applying machine learning techniques to enhance and optimize space operations. Develop a system for distributed command and control, enabling cyber operators viable options for decision making in the multi-domain arena. Leverage prior efforts in developing a series of experiments in the area of multi-domain command and control.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$0.909 million. Justification for the increase is described in the plans above.</p>			
<p><i>Title:</i> Artificial Intelligence/Autonomy/Machine Learning</p> <p><i>Description:</i> Perform research and development (R&D) to harness the speed and scale of computers and machines to address problems of complexity.</p> <p>For FY 2019 and prior years, the Campaign Planning Technologies activities were performed within Project 625317, Information Decision Making Tech, under the Campaign Planning Technologies effort.</p> <p><i>FY 2020 Plans:</i> Continue to research combat planning and tactical assessment software services. Continue research for identifying and implementing state-of-the-art learning models. Develop algorithms for data-efficient learning and integrate with a machine learning framework.</p> <p><i>FY 2021 Plans:</i> Research and develop machine learning approaches for supporting and performing operations in complex adversarial environments. Conduct research to understand operations needs of machine learning algorithms and systems with the multi-domain command and control connect. Demonstrate analytical and simulation framework for large-scale swarms that considers potential constraints on communications, on-board processing, sensors, and flight systems.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$0.960 million. Justification for the increase is described in the plans above.</p>	0.000	14.808	15.768
<p><i>Title:</i> Nuclear C3 Modernization</p>	0.000	3.893	4.027

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>C4I Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Description: Perform research and development (R&D) to advance existing nuclear capable forces to ensure command, control, and connectivity for the President without constraints.</p> <p>For FY 2019 and prior years, the Advanced Connectivity Technologies activities were performed within this Project, under the Advanced Connectivity Technologies effort.</p> <p>FY 2020 Plans: Continue high-frequency mesh networking algorithm development, further very low frequency software-defined radio development. Continue to enhance/modernize propagation tools and the High Frequency Laboratory, and, will initiate trans-auroal and trans-equatorial long haul communication.</p> <p>FY 2021 Plans: Develop advanced, airborne high-frequency antenna/ionospheric structure. Test advanced waveforms. Develop, verify, and validate software-defined radio prototypes.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.134 million. Justification for the increase is described in the plans above.</p>				
<p>Title: Quantum Information Science</p> <p>Description: Perform research and development (R&D) that will utilize quantum physics for the storage, transmission, manipulation, computing, or measurement of information in ways that offer advantages to classical capabilities.</p> <p>For FY 2019 and prior years, the Advanced Connectivity Technologies activities were performed within this Project, under the Advanced Connectivity Technologies effort.</p> <p>FY 2020 Plans: Continue research and development in the area of supreme and quantum computing information sciences to establish the memory-based network nodes, to further evolve and adapt the photon-based interconnects, and to develop an integration scheme to interface a quantum network. Continue testing the ability to teleport quantum information between network nodes, and to establish two-way quantum communication between two memory nodes. Conduct an analysis of conventional/quantum channel interface for long-distance communication.</p> <p>FY 2021 Plans: Continue research and development in the area of supreme and quantum computing information sciences. Demonstrate entangling gates within a trapped ion based network node and perform remote entangling operations between independent</p>		0.000	6.581	7.522

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>C4I Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
network nodes. Conduct performance of interface using trapped ion, superconducting, and photon-based qubit. Develop compact memory-and photon-based network components to be used in future field demonstrations.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.941 million. Justification for this increase is described in the plans above.				
Title: Future AF Capabilities Applied Research		0.000	19.667	0.000
Description: Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/unconventional weapons). The National Defense Strategy and Air Force Science and Technology 2030 Strategy will inform investments over the FYDP. In FY 2019, this work was performed under multiple projects and efforts within the following Air Force S&T Programs: 0602102F, Materials; 0602201F, Aerospace Vehicle Technologies; 0602202F, Human Effectiveness Applied Research; 0602203F, Aerospace Propulsion; 0602204F, Aerospace Sensors; 1206601F, Space Technology; 0602602F, Conventional Munitions; 0602605F, Directed Energy Technology; and 0602788F, Dominant Information Science and Methods.				
FY 2020 Plans: Investigate and mature science and technology that enables future warfighting concepts to provide leap-ahead capabilities. The National Defense Strategy and Air Force S&T Strategy focus this science and technology toward, but not limited to, the following capabilities: 1) global persistent awareness; 2) resilient information sharing; 3) rapid, effective decision-making; 4) complexity, unpredictability, and mass; and 5) speed and reach of disruption and lethality.				
FY 2021 Plans: Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$19.667 million. Funding decreased due to realignment and consolidation of Future AF Capabilities Applied Research effort to PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>C4I Dominance Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Transformational Applied Research, Transformational Capability Incubator effort, to better align with the Air Force S&T Strategy SECAF April 2019 and provide Congress with increased transparency on transformational Air Force S&T activities.			
Accomplishments/Planned Programs Subtotals	31.804	99.855	91.558

	FY 2019	FY 2020
Congressional Add: Program Increase- Artificial Intelligence/Machine Learning Accelerator <i>FY 2019 Accomplishments:</i> Not applicable <i>FY 2020 Plans:</i> Conduct congressionally directed efforts.	0.000	8.000
Congressional Add: Program Increase- Combat Cloud Technology <i>FY 2019 Accomplishments:</i> Not applicable <i>FY 2020 Plans:</i> Conduct congressionally directed efforts.	0.000	2.500
Congressional Add: Program Increase- Quantum Communications <i>FY 2019 Accomplishments:</i> Not applicable <i>FY 2020 Plans:</i> Conduct congressionally directed efforts.	0.000	4.000
Congressional Add: Program Increase- Quantum Cryptography <i>FY 2019 Accomplishments:</i> Not applicable <i>FY 2020 Plans:</i> Conduct congressionally directed efforts.	0.000	7.000
Congressional Add: Program Increase <i>FY 2019 Accomplishments:</i> Not applicable <i>FY 2020 Plans:</i> Conduct congressionally directed efforts.	0.000	5.000
Congressional Add: Program Increase- Quantum Information Science Innovation Center <i>FY 2019 Accomplishments:</i> Not applicable <i>FY 2020 Plans:</i> Conduct congressionally directed efforts.	0.000	8.000
Congressional Adds Subtotals	0.000	34.500

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>C4I Dominance Technology</i>

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>				Project (Number/Name) 625316 / <i>Info Mgt and Computational Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625316: <i>Info Mgt and Computational Tech</i>	-	11.890	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.890

A. Mission Description and Budget Item Justification

The Air Force requires the capability to maximize the value, sharing, management, and use of its information and information assets in achieving its mission objectives as the importance of information grows in the current net-centric environment. Technology development in this project must be capable of taking advantage of future net-centric environments including new structured and ad hoc processes in response to rapidly changing warfare challenges. Advances in robust information management focus on quality of service and flow of information within the enterprise, information transformation and brokering, secure information sharing across and among domains, and collaboration of workflow within the enterprise. Technologies addressed in this project include the ability to globally share, discover, and access information across organizational, functional, and coalition boundaries and between and among domains, the timely delivery of information to tactical assets, the tailoring and prioritization of information based on mission needs and importance, and the scaling, robustness, and collaboration features required of the Air Force net-centric information management environment.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on the capability to maximize the value, sharing, management, and use of information and information assets in support of multi-domain command and control.

In FY 2020, Project 625316, Info Mgt and Computational Tech efforts transferred to Project 625315, C4I Dominance Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Dissemination Technologies	4.514	0.000	0.000
Description: Investigate and develop technologies for decision quality information dissemination services via publish, subscribe, and query across the Global Information Grid to enterprise and tactical assets and coalition partners.			
FY 2020 Plans: Starting in FY 2020, the work is performed in this PE, within Project 625315, C4I Dominance Technology under the Assured Communications & Networks effort.			
FY 2021 Plans: Not Applicable			
Accomplishments/Planned Programs Subtotals	4.514	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625316 / <i>Info Mgt and Computational Tech</i>

	FY 2019	FY 2020
Congressional Add: Program Increase - Quantum Computing CoE	7.376	0.000
FY 2019 Accomplishments: Conducted Congressionally directed efforts in the area of Quantum Computing.		
FY 2020 Plans: Not Applicable		
Congressional Adds Subtotals	7.376	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625317 / <i>Information Decision Making Tech</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
<i>625317: Information Decision Making Tech</i>	-	16.443	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	16.443

A. Mission Description and Budget Item Justification

The Air Force requires advances in technologies enabling the effective execution of military objectives that will vastly improve the ability to support the commander and staff's ability to command all viable options to achieve desired effects across the full spectrum of operations (air, space, and cyberspace) at all levels of war (strategic, operational, and tactical) and during all phases of conflict. Technology development in this project includes anticipatory decision support; course of action development, planning, scheduling, and assessment; and the real-time effective portrayal of complex data sets.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on the capability to maximize the value, sharing, management, and use of information and information assets in support of multi-domain command and control.

In FY 2020, Project 625317, Information Decision Making Tech efforts transferred to Project 625315, C4I Dominance Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Campaign Planning Technologies</p> <p>Description: Develop advanced monitoring, planning, and assessment technologies enabling aerospace commanders to develop effects-based campaigns.</p> <p>FY 2020 Plans: Starting in FY 2020, the work is performed within this PE, in Project 625315, C4I Dominance Technology, under the Artificial Intelligence/Autonomy/Machine Learning effort.</p> <p>FY 2021 Plans: Not Applicable</p>	9.612	0.000	0.000
<p>Title: Command and Control System Technologies</p> <p>Description: Investigate, analyze, and develop technologies for planning, execution, and automatic rapid reconfiguration of distributed intelligent and integrated command and control information systems to achieve the commander's intent throughout varying crisis levels.</p>	6.831	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625317 / <i>Information Decision Making Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> Starting in FY 2020, the work is performed within this PE, in Project 625315, C4I Dominance Technology, under the Multi-Domain Command and Control effort.</p> <p><i>FY 2021 Plans:</i> Not Applicable</p>			
Accomplishments/Planned Programs Subtotals	16.443	0.000	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>				Project (Number/Name) 625318 / <i>Operational Awareness Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625318: <i>Operational Awareness Tech</i>	-	21.969	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	21.969

A. Mission Description and Budget Item Justification

The Air Force requires technologies that improve and automate the capability to generate, process, manage, fuse, exploit, interpret, and disseminate timely and accurate information. This project provides not only a network-centric, collaborative intelligence analysis capability that enables the fusion of multi-intelligence and sensor sources to provide timely situational awareness, understanding, and anticipation of the threats in the battlespace, but also the advanced, novel exploitation technologies needed to intercept, collect, locate, and process both covert and overt raw data from intelligence and sensor sources. It leads the research, discovery, and development of technology that enables the fusion of multi-intelligence sources to provide accurate object tracking and identification, situational awareness, understanding, and anticipation of the threats in the battlespace (air, ground, space, and cyber). It also leads in the development of advanced exploitation technologies to maximize the intelligence gained from our adversaries in the areas of spectral detection and geolocation, signal recognition and analysis, and the data tagging, tracking, and tracing via the insertion of secure, imperceptible signal embedding for future fusion and understanding of the information.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, the Air Force requires dynamic and elastic intelligence, surveillance, and reconnaissance forces and capabilities to provide actionable intelligence to commanders and to increase understanding of the environment and an adversary's capabilities and intentions.

In FY 2020, Project 625318, Operational Awareness Tech efforts transferred to Project 625315, C4I Dominance Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Multi-Source Fusion Technologies	9.748	0.000	0.000
Description: Develop higher-level fusion and the enabling text information/knowledge base technologies to achieve situational awareness and understanding at all command levels for dynamic planning, assessment, and execution processes.			
FY 2020 Plans: Starting in FY 2020, the work is performed within this PE, under Project 625315, C4I Dominance Technology, in the Data to Decisions effort.			
FY 2021 Plans: Not Applicable			
Title: Exploitation Technologies	10.970	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625318 / <i>Operational Awareness Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Description: Develop digital information exploitation technologies for electronic communications and special signals intelligence, imagery, and measurement signatures to increase accuracy, correlation, and timeliness of the information.</p> <p>FY 2020 Plans: Starting in FY 2020, the work is performed within this PE, under Project 625315, C4I Dominance Technology, in the Data to Decisions effort.</p> <p>FY 2021 Plans: Not Applicable</p>				
<p>Title: Next Generation Command Technologies</p> <p>Description: Develop modeling and simulation technologies for the next generation of planning, assessment, and execution environments.</p> <p>FY 2020 Plans: Starting in FY 2020, the work is performed within this PE, under Project 625315, C4I Dominance Technology, in the Multi-Domain Command & Control effort.</p> <p>FY 2021 Plans: Not Applicable</p>		1.251	0.000	0.000
Accomplishments/Planned Programs Subtotals		21.969	0.000	0.000
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>				Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625319: <i>Cyberspace Dominance Technology</i>	-	79.410	60.281	63.926	0.000	63.926	60.832	57.840	59.109	60.468	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force requires technologies to deliver a full range of options in cyberspace on par with air and space dominance in each of the areas of cyber-attack, cyber defense, and cyber support to achieve the strategic capability of cyber dominance. The Air Force requires the development of superior, intelligent, on-demand computing to enable information superiority to include advances in secure information sharing across domains and boundaries as well as technologies that successfully deter any adversary from attacking computer systems anytime, anywhere by ensuring the Air Force's ability to: access, maintain presence on, and deliver effects to adversary systems; detect, defend, and respond to attacks on friendly computer systems and provide forensic analysis concerning those attack attempts; and provide cyber situational awareness to Air Force Commanders. In addition, the Air Force requires technology development that produces computing architectures with greater capacity and sophistication for addressing constrained, dynamic mission objectives; game-changing computing power to the warfighter, disruptive computing power at the tactical edge and for federated grid services; and interactive and real-time computing improving the usability of high-performance computing to the Air Force. It includes technologies in computational sciences and engineering, computer architectures and software intensive systems.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Cyber Defense Technologies	18.768	20.531	21.432
Description: Develop cyber defense and supporting technologies to detect, defend, and respond to attacks on computer systems as well as provide forensic concerning attacks.			
FY 2020 Plans: Continue research in the area of autonomous integrated cyber operations. Continue applied research in the area of biologically resilient cyber technologies. Continue research into mission-specific block-chain capabilities, and the alignment of cyber resilient services and dynamic management tailored towards unmanned aerial systems.			
FY 2021 Plans: Continue research in the area of autonomous integrated cyber operations. Continue applied research in the area of biologically resilient cyber technologies. Continue research into mission-specific block-chain capabilities, and the alignment of cyber resilient services and dynamic management tailored towards unmanned aerial systems. Develop radical architectural and infrastructural changes from computational diversity, to deliver a quantifiable improvement to cybersecurity.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.901 million. Justification for the increase is described in the plans above.			
Title: Cyber Offense Technologies	17.175	17.037	20.121

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Description: Develop offensive cyber operations technologies to access, maintain presence on, and deliver effects to adversary systems.</p> <p>FY 2020 Plans: Advance research and development of new, leading-edge technologies that are game changing and employ dominant power for cyber offensive operations. Continue increased activity in capabilities for multi-function, non-kinetic cyber effects against adversarial systems. Continue to demonstrate ground-based and airborne delivery of disrupt, deny, degrade, destroy, or deceive effects that are both cyber and physical/kinetic.</p> <p>FY 2021 Plans: Continue to advance research and development of new, leading-edge technologies that are game changing and employ dominant power for cyber offensive operations. Continue increased activity in capabilities for multi-function, non-kinetic cyber effects against adversarial systems. Continue to demonstrate ground-based and airborne delivery of disrupt, deny, degrade, destroy, or deceive effects that are both cyber and physical/kinetic. Initiate implementation of automated extension of attack model.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$3.084 million. Funding increased due to implementation of automated extension of attack model and additional research and development of techniques to detect, track, and defeat the exploitation of cyber vulnerabilities, both physical and kinetic.</p>				
<p>Title: Advanced Architectural Technologies</p> <p>Description: Develop the architectural mechanisms that form the basis for predictable software and high assurance systems.</p> <p>FY 2020 Plans: Sustain research and validation of a cyber hardened (robust, secure) processor for embedded weapon systems. Maintain applied research to create trusted and resilient embedded systems that are capable of identifying, localizing, and automatically repairing previously unknown and/or unintended vulnerabilities. Continue development of software using evolutionary approaches to make embedded systems tolerant to unexpected and unforeseen situations.</p> <p>FY 2021 Plans: Continue to sustain research and validation of a cyber-hardened (robust, secure) processor for embedded weapon systems. Continue to maintain applied research to create trusted and resilient embedded systems that are capable of identifying, localizing, and automatically repairing previously unknown and/or unintended vulnerabilities. Continue development of software using evolutionary approaches to make embedded systems tolerant to unexpected and unforeseen situations.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		10.105	7.689	8.624

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$0.935 million. Justification for the increase is described in the plans above.				
<p>Title: Processing Technologies</p> <p>Description: Develop automatic and dynamically reconfigurable, scalable, affordable distributed peta-flop processing technologies for real-time global information systems.</p> <p>FY 2020 Plans: Extend research the application of novel neuromorphic systems for robust machine learning. Advance research and development of the neuromorphic processor and validate capabilities for dynamic learning on mobile and power-constrained platforms.</p> <p>FY 2021 Plans: Starting in FY 2021, the non-cyber work will be performed within this PE, under Project 625315, C4I Dominance Technology, in the Processing Technologies effort.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.715 million. Funding decreased due to completion of cyber component and remaining non-cyber technology transferred to Project 625315, C4I Dominance Technology, in the Processing Technologies effort.</p>		8.938	4.715	0.000
<p>Title: Survivability Technologies</p> <p>Description: Develop methods and technologies for controlled operation of information systems during attacks and fault conditions, minimizing vulnerabilities of cyber attacks, and guaranteeing the accuracy and correctness of data and codes.</p> <p>FY 2020 Plans: Maintain research concepts and capabilities for cyber survivability techniques and algorithms for counter-unmanned aerial systems. Sustain development of a counter-unmanned aerial systems open architecture to enable interoperability. Extend evolution of autonomous machine learning functions. Pursue validation and demonstration of automated workflows into defensive cyber operations systems.</p> <p>FY 2021 Plans: Continue to investigate research concepts and capabilities for cyber survivability techniques and algorithms for counter-unmanned aerial systems. Continue development of a counter-unmanned aerial systems open architecture to enable interoperability. Continue with evolution of autonomous machine learning functions. Continue the validation and demonstration of automated workflows into defensive cyber operations systems.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		2.072	3.011	3.989

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$0.978 million. Justification for the increase is described in the plans above.				
<p>Title: Cross-Domain Technologies</p> <p>Description: Develop secure cross-domain discovery services for access to services outside the existing domain. Develop the tools to allow collaboration of workflows required by the Air Force net-centric information management system.</p> <p>FY 2020 Plans: Advance research and development in for cross-domain solution technologies by developing content filtering, with an emphasis on improving support for rapid inclusion of new data types with minimal requirements for lengthy data type threat assessments and minimal custom coding. Sustain research and development for machine to machine interfaces. Extend development of cross-domain solution command and control capabilities to manage cross-domain solution risks based upon changes in mission and threat for diversified platforms via hardware abstraction, containerization/separation of the operation system (mobile, desktop, server).</p> <p>FY 2021 Plans: Continue the research and development in cross-domain solution technologies by developing content filtering, with an emphasis on improving support for rapid inclusion of new data types with minimal requirements for lengthy data type threat assessments and minimal custom coding. Continue research and development for machine to machine interfaces. Continue to extend the development of cross-domain solution command and control capabilities to manage cross-domain solution risks based upon changes in mission and threat for diversified platforms via hardware abstraction, containerization/separation of the operation system (mobile, desktop, server).</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.068 million. Justification for the increase is described in the plans above.</p>		6.462	5.944	6.012
<p>Title: Cyber Technologies for Spectrum Warfare</p> <p>Description: Develop technologies combining electronic warfare, signals intelligence, communications, and cyber technologies that provide synergistic access, exploitation and effects across air and cyber domains in congested and contested environments.</p> <p>FY 2020 Plans: Continue to advance research in systems to perform blind data discovery associated with the Internet of Things. Pursue identification of items of interest associated with the Internet of Things. Initiate research for specific items of interest within the Internet of Things.</p> <p>FY 2021 Plans:</p>		0.646	1.354	3.748

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Continue to advance research in systems to perform blind data discovery associated with the Internet of Things. Continue with identification of items of interest associated with the Internet of Things. Continue research for specific items of interest within the Internet of Things.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$2.394 million. Funding increased due to additional applied research and development to address emerging threats and additional signals of interest.			
Accomplishments/Planned Programs Subtotals	64.166	60.281	63.926

	FY 2019	FY 2020
<i>Congressional Add:</i> Program Increase - Cyber Testbed for Unidentified C-UAS	5.409	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts.		
<i>FY 2020 Plans:</i> Not Applicable		
<i>Congressional Add:</i> Program Increase	9.835	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts.		
<i>FY 2020 Plans:</i> Not Applicable		
Congressional Adds Subtotals	15.244	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>				Project (Number/Name) 62OMMS / <i>Research Site Support</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
62OMMS: <i>Research Site Support</i>	-	20.705	21.426	23.184	0.000	23.184	22.982	22.881	23.363	23.846	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force Research Laboratory Information Directorate leads the discovery, development and implementation of information science and technology to drive transformation within the Air Force and across the Department of Defense. The focus of the work is to provide the warfighter with the required technology-based capabilities to defend the Nation by unleashing the power of innovative information science and technology to anticipate, find, fix, track, target, engage, and assess anything, anytime, anywhere. Since the site is a single-purpose location which is not located on a military installation, the Information Directorate has unique requirements for supporting its science and technology mission. As the host unit, the directorate is responsible to provide the Rome Research Site infrastructure at Rome, New York and provide for the continued operations of all Rome Research Site properties, buildings, and services necessary for the research mission. Operations include: logistics and communication services, utilities, maintenance of facilities and structures, safety and security of the workforce and visiting researchers, and ensures compliance with the laws, regulations, and directives that pertain to site operations. These services are host unit responsibilities and are necessary to provide a safe and effective environment for the Research Site's workforce and mission.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Rome Research Infrastructure	20.705	21.426	23.184
Description: Provide the necessary services and support including, but not limited to: fire inspections, refuse collection, water, electricity, steam, heat, custodial, and grounds maintenance services to the Research Site. Provide the necessary support for the maintenance and repair of Research Site facilities (buildings and other structures), vehicle and equipment lease and security/safety inspections and services as necessary for compliance and safety/security of personnel and research assets. Provide the Research Site with long haul communications (using the Government Services Administration set of Networx contracts for Continental United States), trunk connectivity and wireless communications.			
FY 2020 Plans: Continue to provide civilian payroll and non-pay costs for installation operations in support of the Rome Research Site property and all onsite personnel. Continue to provide facilities, facility operations, facility sustainment, support equipment, contracts, and associated costs to plan, manage and execute the following functions: fire prevention, disaster preparedness, plant operation and purchase of commodity, refuse collection, pavement clearance of snow and ice, grounds maintenance including landscaping, real property special inspections, pest control, and custodial services. Continue to provide Real Property Management and Engineering Services, including: (1) Facility Management and Administration and (2) Installation Engineering Services. Facility Management includes public works management costs, contract management, material procurement, facility data management, furnishings management costs, and real estate management. Installation Engineering Services includes annual inspection of facilities, master planning, overhead of planning and design, overhead of construction management, and non Site Recovery			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 62OMMS / <i>Research Site Support</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Management service calls. Continue to provide basic installation communication services, including long haul trunk and telecommunications services. Continue to provide site vehicle lease for logistics, security, and mission support under the Government Services Administration.</p> <p>FY 2021 Plans: Continue to provide civilian payroll and non-pay costs for installation operations in support of the Rome Research Site property and all onsite personnel. Continue to provide facilities, facility operations, facility sustainment, support equipment, contracts, and associated costs to plan, manage and execute the following functions: fire prevention, disaster preparedness, plant operation and purchase of commodity, refuse collection, pavement clearance of snow and ice, grounds maintenance including landscaping, real property special inspections, pest control, and custodial services. Continue to provide Real Property Management and Engineering Services, including: (1) Facility Management and Administration and (2) Installation Engineering Services. Facility Management includes public works management costs, contract management, material procurement, facility data management, furnishings management costs, and real estate management. Installation Engineering Services includes annual inspection of facilities, master planning, overhead of planning and design, overhead of construction management, and non Site Recovery Management service calls. Continue to provide basic installation communication services, including long haul trunk and telecommunications services. Continue to provide site vehicle lease for logistics, security, and mission support under the Government Services Administration.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.758 million. Funding increased due to civilian pay reprice adjustment.</p>				
Accomplishments/Planned Programs Subtotals		20.705	21.426	23.184
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>					R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	40.400	48.221	45.088	0.000	45.088	46.019	46.933	47.872	48.845	Continuing	Continuing
625096: <i>High Energy Laser Research</i>	-	40.400	48.221	45.088	0.000	45.088	46.019	46.933	47.872	48.845	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program funds Department of Defense Directed Energy applied research through the Joint Directed Energy Transition Office. This program is part of an overall Department of Defense Directed Energy Science and Technology program. Directed Energy weapon systems have many potential advantages including speed of light delivery, low collateral damage, significant magazine depth, low incremental cost per kill. Directed Energy Weapon Systems have the potential to perform a wide variety of military missions including high value asset and base protection, precision strike and platform self-protection versus a wide variety of missile, rocket, artillery, mortar and air platforms. Efforts under this program are generally chosen for their potential to have an impact on multiple Directed Energy Weapon systems and multiple Service missions while complementing Service/Agency efforts that are directed at specific Service needs. A broad range of technologies are addressed in key areas such as laser sources, microwave sources, laser beam control, antennas, waveguides, modeling and simulation, and lethality mechanisms. This program provides the enabling technology necessary to demonstrate advanced concepts for high power microwave sources, antennas and waveguides for mission areas not considered to date. The high power microwave lethality, hardware and software improvements and modeling and simulation advances provided by this program are essential to expand and build upon current architectures. This program supports the Senior Official as required. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research	R-1 Program Element (Number/Name) PE 0602890F I High Energy Laser Research
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	43.192	44.221	45.103	0.000	45.103
Current President's Budget	40.400	48.221	45.088	0.000	45.088
Total Adjustments	-2.792	4.000	-0.015	0.000	-0.015
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	4.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.492	0.000			
• Other Adjustments	-1.300	0.000	-0.015	0.000	-0.015

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 625096: High Energy Laser Research

Congressional Add: Program increase - Directed energy fiber lasers

Congressional Add Subtotals for Project: 625096

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	0.000	4.000
	0.000	4.000
	0.000	4.000

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$1.300 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

C. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Directed Energy Technologies	7.168	7.750	7.900
Description: Mature technologies that will provide system level performance commensurate with fieldable directed energy devices.			
FY 2020 Plans:			
Continue to develop high reliability, lower cost, efficient and high temperature diode pump sources. Scale alternate laser wavelengths to additional militarily relevant uses and power levels. Investigate novel high power fiber technologies. Reduce technical risk in solid state lasers for inclusion in future laser weapon systems. Perform trade space analysis to understand performance, fielding, robustness and integration issues for military platforms. Investigate, analyze trade space, and reduce			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>		R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>technical risk for high power microwave devices. Evaluate radiofrequency and microwave capabilities and effects against various threats of interest. Perform analysis and trade studies to determine the most effective microwave parameters and system components needed to defeat classes of selected military targets.</p> <p>FY 2021 Plans: Continue to develop high reliability, lower cost, efficient and high temperature diode pump sources. Continue to scale alternate laser wavelengths to additional militarily relevant uses and power levels. Continue investigations into next generation high power fiber technologies. Continue to reduce technical risk in solid state lasers for inclusion in future laser weapon systems. Continue trade space analysis to understand performance, fielding, robustness and integration issues for military platforms. Continue to investigate, analyze trade space, and reduce technical risk for high power microwave devices. Continue to study radiofrequency and microwave capabilities and effects against various threats. Continue analysis and trades studies to determine the most effective radiofrequency and microwave parameters and system components needed to defeat classes of selected targets.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.150 million. Justification for the increase is described in the plans above.</p>				
<p>Title: Advanced Directed Energy Technologies</p> <p>Description: Investigate new technologies that have revolutionary potential for high energy lasers and high power microwaves.</p> <p>FY 2020 Plans: Explore advanced concepts for high energy laser technologies that will improve efficiency and decrease mass and volume for future weapon systems. Evaluate advanced materials for high energy laser applications. Improve the understanding of laser technologies to include material interaction and propagation. Scale electrically pumped lasers to higher kilowatt class power levels. Characterize and understand the physics of high energy laser atmospheric propagation in adverse environmental conditions such as fog, rain, smoke and dust. Evaluate and test Avoidance and Air Space De-confliction systems on directed energy test ranges. Collaborate with the international directed energy community on progress in the development and application of high energy laser technologies for military missions. Validate predictive models through analysis of atmospheric propagation data and measurements. Study the desired radiofrequency and microwave effects that drive the radiofrequency and microwave component and system design, including power. Improve understanding of required power system components including power generation and storage, high temperature / high power devices, power converters, and power conditioning. Ensure that radiofrequency and microwave effects and power components work is coordinated with and, as appropriate, leveraged by RF microwave and power / energy programs across the Services and Agencies. Characterize and understand the physics of high power microwave propagation in adverse environmental conditions. Collaborate with the international directed energy community</p>		5.826	6.300	6.428

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>		R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>on progress in the development and application of high power radiofrequency directed energy weapon (DEW) technologies for military missions.</p> <p>FY 2021 Plans: Continue to explore advanced concepts for directed energy technologies that will improve efficiency and decrease mass and volume for future weapon systems. Continue to evaluate materials for high energy laser applications. Continue to improve understanding of laser technologies to include material interaction and propagation. Continue to scale electrically pumped lasers to higher kilowatt class power levels. Continue to characterize and understand the physics of high energy laser atmospheric propagation in adverse environmental conditions such as fog, rain, smoke and dust. Continue to evaluate and test Avoidance and Air Space De-confliction systems on directed energy test ranges. Continue to collaborate with the international directed energy community on progress in the development and application of high energy laser technologies for military missions. Validate predictive models through analysis of atmospheric propagation data and measurements. Continue to validate predictive models through analysis of atmospheric propagation data and measurements. Continue to study the desired radiofrequency and microwave effects that drive the radiofrequency and microwave component and system design, including power. Improve understanding of required power system components including power generation and storage, high temperature / high power devices, power converters, and power conditioning. The ongoing radiofrequency and microwave effects and power components work is coordinated with and, as appropriate, leveraged by radiofrequency and microwave and power/energy programs across the Services and Agencies. Continue to characterize and understand the physics of high power microwave propagation in adverse environmental conditions. Continue to collaborate with the international directed energy community on progress in the development and application of high power radiofrequency directed energy weapon (DEW) technologies for military missions.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.128 million. Justification for the increase is described in the plans above.</p>				
<p>Title: Directed Energy Propagation Technologies</p> <p>Description: Develop technology to support high performance beam control systems and integrated demonstrations.</p> <p>FY 2020 Plans: Develop beam control technologies for high energy laser weapon use on multiple platforms (aircraft, ground vehicles and shipboard systems) in stressing environments. Advance the development of a predictive avoidance fire control system for use on multiple platforms with the development of associated kill assessment technologies. Develop hardware and technologies to improve throughput efficiency of the beam director, decrease component weight, and improve tracking and compensation through the atmosphere. Select and develop additional concepts for Service-specific applications. Develop theoretical physical models describing the propagation of a high power microwave pulse through the atmosphere to understand the reflection characteristics of the high power microwave propagation. Study and understand the dynamic behavior of the propagation of</p>		19.790	21.936	22.370

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>		R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>high power microwave pulses and the effects on the intensity, frequency, and width of the pulse and the physical processes occurring during the interaction of the pulse with the air. Select and develop additional concepts for Service-specific applications and associated kill assessment technologies. Develop hardware and technologies to improve throughput efficiency of the antenna, decrease component weight, and improve tracking and compensation through the atmosphere.</p> <p>FY 2021 Plans: Continue to develop beam control technologies for high energy laser weapon use on multiple platforms (aircraft, ground vehicles and shipboard systems) in stressing environments. Continue the development of a predictive avoidance fire control system for use on multiple platforms. Continue to develop kill assessment technologies. Continue to develop hardware and technologies to improve throughput efficiency of the beam director, decrease component weight, and improve tracking and compensation through the atmosphere. Continue to select and develop additional concepts for Service-specific applications. Continue to develop theoretical physical models describing the propagation of a high power microwave pulse through the atmosphere to understand the reflection characteristics of the high power microwave propagation. Continue to study and understand the dynamic behavior of the propagation of high power microwave pulses and the effects on the intensity, frequency, and width of the pulse and the physical processes occurring during the interaction of the pulse with the air. Continue to select and develop additional concepts for Service-specific applications. Continue to develop kill assessment technologies. Continue to develop hardware and technologies to improve throughput efficiency of the antenna, decrease component weight, and improve tracking and compensation through the atmosphere.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.434 million. Justification for the increase is described in the plans above.</p>				
<p>Title: Directed Energy Lethality Research</p> <p>Description: Conduct directed energy vulnerability experiments on materials, components, and targets. Develop a lethality database, and integrate into a systems-level architecture plan and lethality models.</p> <p>FY 2020 Plans: Integrate target lethality data into campaign-level high energy laser system models. Conduct high energy laser vulnerability experiments on materials, components, and targets. Develop a suite of high energy laser weapon tools to be used in a database from which the warfighter can assess target vulnerabilities and mission utility for given high energy laser weapon platform and engagement. Develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards. Develop new predictive modeling software tools to assess the effectiveness of high power microwave weapons on electronic systems of interest for blue-on-red or red-on-blue engagements. Understand and evaluate statistical and deterministic cavity coupling algorithms to estimate the temporal and spectral characteristics of the high power microwave energy coupled into complicated enclosures. Leverage advancements in predictive circuit effects, garnered through several Service and</p>		3.856	4.170	4.250

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>		R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Agency-funded programs, to model and predict the response of complicated electronics to the incident high power microwave stimulus. Develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards.</p> <p>FY 2021 Plans: Continue to integrate lethality data into campaign-level high energy laser system models. Continue to conduct high energy laser vulnerability experiments on materials, components, and targets. Continue to develop a suite of high energy laser weapon tools to be used in a database from which the warfighter can assess target vulnerabilities and mission utility for given high energy laser weapon platform and engagement. Continue to develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards. Continue to develop new predictive modeling software tools to assess the effectiveness of high power microwave weapons on electronic systems of interest for blue-on-red or red-on-blue engagements. Continue to understand and evaluate statistical and deterministic cavity coupling algorithms to estimate the temporal and spectral characteristics of the high power microwave energy coupled into complicated enclosures. Continue to leverage advancements in predictive circuit effects, garnered through several Service and Agency-funded programs, to model and predict the response of complicated electronics to the incident high power microwave stimulus. Continue to develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.080 million. Justification for the increase is described in the plans above.</p>				
<p>Title: Directed Energy Modeling</p> <p>Description: Maintain and evaluate high-fidelity engineering models for high energy laser and high power microwave system scenario evaluation and incorporation into the directed energy toolkit. Provide atmospheric propagation and directed energy system modeling for mission-level war-gaming activities.</p> <p>FY 2020 Plans: Provide maintenance, verification, validation, and accreditation for updated system level atmospheric propagation and high energy laser system models. Collaborate with Service-sponsored field-test planning to correlate model predictions with measured data for surface, maritime and aerospace environments. Incorporate atmospheric data into theater models to support performance characterization tables. Conduct verification and validation planning to support advanced beam control objectives, diagnostics and warfighter tools. Collaborate with Service and Agency sponsored High Power microwave survivability/ lethality community's interest in, and use of, high power microwave engagement models. Provide maintenance, verification, validation, and accreditation for updated system level standalone models that can be used to estimate the probability of electronic upset or damage as a function of the high power microwave power density on the target and associated range. Provide the warfighter tools to determine the power density required on a target to produce a functional kill and understand the required parameters of</p>		3.760	4.065	4.140

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
the high power microwave, such as power, frequency/wavelength, modulation, and engagement angle for the kill. Incorporate atmospheric data into theater models to support performance characterization tables. Conduct verification and validation planning to support advanced beam propagation objectives, diagnostics and warfighter tools. FY 2021 Plans: Continue to provide maintenance, verification, validation, and accreditation for updated system level atmospheric propagation and high energy laser system models. Continue to collaborate with Service-sponsored field-test planning to correlate model predictions with measured data for surface, maritime and aerospace environments. Continue to incorporate atmospheric data into theater models to support performance characterization tables. Continue to conduct verification and validation planning to support advanced beam control objectives, diagnostics and warfighter tools. Continue to collaborate with Service and Agency sponsored High Power microwave survivability / lethality community's interest in, and use of, high power microwave engagement models. Continue to provide maintenance, verification, validation, and accreditation for updated system level standalone model that can be used to estimate the probability of electronic upset or damage as a function of the high power microwave power density on the target and associated range. Continue to provide the warfighter tools to determine the power density required on a target to produce a functional kill and understand the required parameters of the high power microwave, such as power, frequency/wavelength, modulation, and engagement angle for the kill. Continue to incorporate atmospheric data into theater models to support performance characterization tables. Continue to conduct verification and validation planning to support advanced beam propagation objectives, diagnostics and warfighter tools. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$0.075 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	40.400	44.221	45.088

	FY 2019	FY 2020
Congressional Add: Program increase - Directed energy fiber lasers	0.000	4.000
FY 2019 Accomplishments: Not applicable.		
FY 2020 Plans: Conduct Congressional directed efforts.		
Congressional Adds Subtotals	0.000	4.000

D. Other Program Funding Summary (\$ in Millions)
 N/A
Remarks

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity
3600: *Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research*

R-1 Program Element (Number/Name)
PE 0602890F / *High Energy Laser Research*

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	131.341	161.667	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
621010: <i>Space Survivability & Surveillance</i>	-	38.082	43.123	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
624846: <i>Spacecraft Payload Technologies</i>	-	18.934	19.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
625018: <i>Spacecraft Protection Technology</i>	-	17.618	23.753	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
628809: <i>Spacecraft Vehicle Technologies</i>	-	56.707	75.744	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity (BA) 02 due to the creation of a new Appropriation for Space Force.

This program focuses on four major areas. First, the space survivability and surveillance area develops technologies to understand space weather and the geophysics environment for mitigation and exploitation of these effects to Air Force systems. Second, the spacecraft payload technologies area improves satellite payload operations by developing advanced component and subsystem capabilities. Third, the spacecraft protection area develops technologies for protecting United States space assets in potential hostile settings. The last major area, spacecraft vehicles, focuses on spacecraft platform and control technologies, and their interactions. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602298F, 0602602F, 0602605F, 0602788F, and 1206601SF.

This work will still be executed by the Air Force Research Laboratory Space Vehicles (AFRL/RV) Technology Directorate located at Kirtland Air Force Base, New Mexico. This is an administrative realignment and not a New Start.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	138.598	124.667	121.862	0.000	121.862
Current President's Budget	131.341	161.667	0.000	0.000	0.000
Total Adjustments	-7.257	37.000	-121.862	0.000	-121.862
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	37.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-2.039	0.000			
• Other Adjustments	-5.218	0.000	-121.862	0.000	-121.862

Congressional Add Details (\$ in Millions, and Includes General Reductions)

	FY 2019	FY 2020
Project: 624846: <i>Spacecraft Payload Technologies</i>		
Congressional Add: <i>Program increase - advanced materials and process for magnetic graphene memory systems</i>	3.898	0.000
Congressional Add Subtotals for Project: 624846	3.898	0.000
Project: 625018: <i>Spacecraft Protection Technology</i>		
Congressional Add: <i>Program increase-space situational awareness research</i>	0.000	5.000
Congressional Add Subtotals for Project: 625018	0.000	5.000
Project: 628809: <i>Spacecraft Vehicle Technologies</i>		
Congressional Add: <i>Program increase - operational cryogenic upper stage augmentation kit</i>	0.000	10.000
Congressional Add: <i>Program increase - advanced spacecraft technologies</i>	4.872	0.000
Congressional Add: <i>Program increase - MADDIE - modular arrays for energy</i>	11.693	0.000
Congressional Add: <i>Program increase - thin-film photovoltaic energy</i>	0.000	7.000
Congressional Add: <i>Resilient space structure architecture</i>	0.000	15.000
Congressional Add Subtotals for Project: 628809	16.565	32.000
Congressional Add Totals for all Projects	20.463	37.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force Date: February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>
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Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$5.218 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Decrease in FY 2021 of \$121.862 million due to PE 1206601F, Space Technology, efforts and civilian manpower being transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology from Appropriation 3600, Budget Activity (BA) 02 due to the creation of a new Appropriation for Space Force.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>				Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
621010: <i>Space Survivability & Surveillance</i>	-	38.082	43.123	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity (BA) 02 due to the creation of a new Appropriation for Space Force.

This is an administrative realignment and not a New Start.

This project develops technologies to understand and control the space environment for warfighter's future capabilities. The focus is on characterizing and forecasting the battlespace environment for more realistic space system design, modeling, and simulation, as well as the battlespace environment's effect on space systems' performance. This includes technologies to specify and forecast the space environment for planning operations, ensure uninterrupted system performance, optimize space-based surveillance operations, and provide capability to mitigate or exploit the space environment for both offensive and defensive operations. Finally, this project includes the seismic research program that supports national requirements for monitoring nuclear explosions.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Space Environment Research	13.881	20.872	0.000
Description: Develop techniques, forecasting tools, sensors, and technologies for specifying, monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense operational space and radar systems.			
FY 2020 Plans:			
Continue exploitation and data collection of radiation aged materials for electrical and optical property changes to enhance predictive models. Identify and initiate generation-beyond-next trapped and untrapped particle specification model development efforts. Continue space environment sensor and anomaly attribution tool demonstrations to identify key model development requirements and transition roadblocks. Research and develop technologies to exploit and mitigate space environment effects to the Department of Defense's advantage. Develop and demonstrate new ground-based and space-based sensors for monitoring and specifying the state of the space environment for military applications. Continue to develop and enhance space environment modeling capabilities to better enable accurate specification and forecasting of the state of the space environment, and the resulting impacts to Department of Defense and national systems. Advance research into the physics and dynamics of the sun to better specify and forecast solar events and better understand how those events impact the near-earth space environment. Explore fundamental radio frequency and chemical interactions in the near-earth space environment to inform potential utility			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>	Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>for military applications. Continue work on hybrid supersonic solver code development and validation, expanding the solver to include accurate Global Positioning System performance.</p> <p>FY 2021 Plans: For FY 2021, this work will be performed under the Space Environment Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>				
<p>Title: Surveillance Technologies</p> <p>Description: Develop advanced target detection techniques, spectral signature libraries, and decision aids for space-based sensors and surveillance systems.</p> <p>FY 2020 Plans: Initiate development of capability metrics for new satellite constellation architectures, advanced data analytics, and satellite demonstration concepts. Continue study of advanced surveillance and detection technologies for tracking emerging and evolving targets, including ballistic and non-ballistic targets that pose new challenges for missile warning systems. Document findings of innovative computational methods for Missile Warning System Program Office to significantly decrease satellite down-link bandwidth while maintaining high fidelity of missile warning data. Document findings of analysis tasks associated with on-orbit experiments that demonstrated advanced sensor and analytic methods of innovative hypertemporal imaging early missile warning concept, including the collection and analysis of missile and missile like data. Continue investigation of on-board processing capabilities and limitations for large datasets. Continue investigation of advanced surveillance and detection technologies for an expanded range of mission applications.</p> <p>FY 2021 Plans: For FY 2021, this work will be performed under the Surveillance Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>		10.310	6.049	0.000
<p>Title: Radiation Remediation Research</p> <p>Description: Conduct Radiation Belt Remediation research through development and validation of analytical performance models for remediation of Earth radiation belts following high altitude nuclear detonation.</p>		0.095	1.799	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>	Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> Continue space experiment operations, and reduction and exploitation of data sets to finalize end-to-end model validation. Conduct assessment of feasibility and system requirements for space-based and combined ground and space-based remediation systems.</p> <p><i>FY 2021 Plans:</i> For FY 2021, this work will be performed under the Radiation Remediation Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> Not applicable</p>			
<p><i>Title:</i> Seismic Technologies</p> <p><i>Description:</i> Develop seismic technologies to support national requirements for monitoring nuclear explosions with special focus on regional distances less than 2,000 kilometers from the sensors.</p> <p><i>FY 2020 Plans:</i> Test new algorithms on high performance computing capabilities with special focus on improving earth structure models and the resulting automation of the discrimination of seismic events. Exercise earth models in use in high-performance computing modeling and simulation codes for operational expert analysis of difficult-to-discriminate earthquakes and explosions. Continue to test specific algorithms for application of big data heuristics to more quickly characterize seismic events. Further develop new statistical approaches to the behavior of discriminants for local (less than 200 kilometers) and regional (less than 2,000 kilometers) seismic events.</p> <p><i>FY 2021 Plans:</i> For FY 2021, this work will be performed under the Seismic Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> Not applicable</p>	5.659	5.838	0.000
<p><i>Title:</i> Alternative Navigation Technologies</p> <p><i>Description:</i> Develop new technologies based on cold atom physics that provide autonomous jam-proof precision inertial navigation to augment Global Positioning System in case of Global Positioning System-denial. Develop atomic clocks based on new technologies to replace legacy Global Positioning System atomic clocks.</p>	8.137	8.565	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>	Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> Complete rad-hard component development for advanced compact atomic clocks with improved accuracy and stability to replace legacy atomic clocks. Deliver system for integration onto experimental satellite system. Continue transition of advanced atomic clocks to industry with potential on ramp onto future satellites. Continue testing of cold atom 3-axis accelerometers for improved Internal Navigation Systems in Global Position System denied environments.</p> <p><i>FY 2021 Plans:</i> For FY 2021, this work will be performed under the Alternative Navigation Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 621010, Space Survivability & Surveillance.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> Not applicable</p>			
Accomplishments/Planned Programs Subtotals	38.082	43.123	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>				Project (Number/Name) 624846 / <i>Spacecraft Payload Technologies</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624846: <i>Spacecraft Payload Technologies</i>	-	18.934	19.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity (BA) 02 due to the creation of a new Appropriation for Space Force.

This is an administrative realignment and not a New Start.

This project develops advanced technologies that enhance spacecraft payload operations by improving component and subsystem capabilities. The project focuses on development of advanced, space-qualified, survivable electronics, and electronics packaging technologies; development of advanced space data generation and exploitation technologies, including infrared sensors; and development of high-fidelity space simulation models that support space-based surveillance and space asset protection research and development for the warfighter.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Space-Based Detector Technologies	3.039	3.931	0.000
Description: Develop advanced infrared device technologies that enable hardened space detector arrays with improved detection to perform acquisition, tracking, and discrimination of space objects and missile warning.			
FY 2020 Plans: Begin design, development, and assessment of low-cost, high-volume infrared detectors and focal plane arrays for proliferated space architecture layers. Begin development of focal plane array optical data outputs for higher speed and data throughput and begin radiation tolerance characterization of photonic devices. Begin development of alternative infrared focal plane array materials and device architectures. Continue development of resilient scanning and staring digital focal plane arrays. Complete development of 8192 x 8192 pixels, 10 micron pixel pitch focal plane arrays hardened to the natural space environment and focused photons to enable whole-earth staring for Launch Detection and Missile Warning missions.			
FY 2021 Plans: For FY 2021, this work will be performed under the Space-Based Detector Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624846, Spacecraft Payload Technologies			
FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable			
Title: Space Electronics Research	2.601	4.429	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>	Project (Number/Name) 624846 / <i>Spacecraft Payload Technologies</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Description: Develop technologies for space-based payload components such as radiation-hardened electronic devices, microelectro-mechanical system devices, and advanced electronics packaging.</p> <p>FY 2020 Plans: Continue leadership role in Deputy Assistant Secretary of Defense Systems Engineering trusted and assured microelectronics strategy efforts by development of trusted manufacturing techniques that reduce risk to National Security Space systems. Improving benchmarking capabilities on state-of-the-art electronics using latest spacecraft algorithms and transitioning results to acquisition community to enable data-informed payload architecture design decisions. Initiating complete space qualification planning for next generation space processor and begin implementing plan. Continue development of alternative memory approaches for high density memory needed for next-generation space systems. Continue research and development of ultra-low power and neuromorphic/cortical processing architectures to enable game-changing capabilities in future National Security Space systems. Continue advanced transistor research and development, and transitioning techniques to mainstream manufacturing.</p> <p>FY 2021 Plans: For FY 2021, this work will be performed under the Space Electronics Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624846, Spacecraft Payload Technologies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>				
<p>Title: Modeling and Simulation Tools for Space Applications</p> <p>Description: Develop modeling and simulation tools for space-based ground surveillance systems, rendezvous and proximity operations, imaging of space systems, disaggregated satellite architecture, and space control payloads.</p> <p>FY 2020 Plans: Complete mission-level military utility analyses of architecture approaches across multi-domain mission areas. Continue refining guidelines and checkpoints for concept maturation evaluations in context of emerging space technologies. Continue development of models and mission simulations of the National Space Defense Center's new space and space enterprise capabilities.</p> <p>FY 2021 Plans: For FY 2021, this work will be performed under the Modeling and Simulation Tools for Space Applications effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624846, Spacecraft Payload Technologies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		5.084	5.618	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>	Project (Number/Name) 624846 / <i>Spacecraft Payload Technologies</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Not applicable			
<p>Title: Alternative Positioning, Navigation, and Timing Technology</p> <p>Description: Identify and develop technologies that enable new, or enhance existing, United States positioning, navigation, and timing satellite capabilities by increasing resiliency and availability of accuracy, and/or increasing the affordability of providing current capabilities. Develop technologies to meet identified Air Force Space Command/Space and Missile Systems Center positioning, navigation, and timing space payload technology needs.</p> <p>FY 2020 Plans: Develop advanced Precision Navigation and Timing waveforms and begin to examine the interaction of signals between the space, ground, and user equipment segments. Explore new technologies for positioning, navigation, and timing payloads that will improve performance and affordability. Continue studies that explore technologies for multi-layer space-based positioning, navigation, and timing architecture in order to improve resiliency of the space architecture. Work to develop modeling and simulation results of next generation space architecture and the impact of developing technologies.</p> <p>FY 2021 Plans: For FY 2021, this work will be performed under the Alternative Positioning, Navigation, and Timing Technology effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624846, Spacecraft Payload Technologies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>	4.312	5.069	0.000
Accomplishments/Planned Programs Subtotals	15.036	19.047	0.000

	FY 2019	FY 2020
<p>Congressional Add: Program increase - advanced materials and process for magnetic graphene memory systems</p> <p>FY 2019 Accomplishments: Conducted Congressionally directed effort</p> <p>FY 2020 Plans: Not Applicable</p>	3.898	0.000
Congressional Adds Subtotals	3.898	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)
3600 / 2	PE 1206601F / <i>Space Technology</i>	624846 / <i>Spacecraft Payload Technologies</i>

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>				Project (Number/Name) 625018 / <i>Spacecraft Protection Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625018: <i>Spacecraft Protection Technology</i>	-	17.618	23.753	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity (BA) 02 due to the creation of a new Appropriation for Space Force.

This is an administrative realignment and not a New Start.

This project develops the technologies for protecting United States space assets in potentially hostile environments to assure continued space system operation without performance loss in support of warfighter requirements. The project focuses on identifying and assessing spacecraft system vulnerabilities, developing threat warning technologies, and development of technologies to mitigate the effects of both intentional and unintentional threats.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Threat Warning Research	17.618	18.753	0.000
Description: Develop satellite threat warning technologies and tools for space defense. Exploit on-board inherent satellite resources, satellite-as-a-sensor, and self-aware satellite technologies. Develop technologies to detect, assess, and respond to threats and anomalies.			
FY 2020 Plans:			
Continue to develop techniques to detect, track, identify, and characterize satellites using multi-phenomenology to address gaps in knowledge for space situational awareness and consider the tasking, collection, processing, exploitation and dissemination needs. Assess timeliness and persistence of space situational awareness capability and develop techniques to mitigate the growing population of objects that need to be monitored, from newly launched objects to debris. Conduct cooperative development utilizing commercial and international space situational awareness sources. Initiate research and development on an integrated ground and space indications and warnings experiment. Utilize space resiliency testbed to integrate technology solutions, and evaluate effectiveness against notional threats to our space architectures. Develop cyber hardening technologies, and integrate space and cyber operations capabilities. Conduct end-to-end evaluations and hardware-in-the-loop experiments for threat warning and response capabilities for protection of high value space assets. Conduct experiments, integrating commercial space command and control capabilities into Department of Defense ground architectures. Develop and demonstrate autonomous technologies using net-centric space command and control architectures for multi-domain command and control across the full scope of the ground and space-based enterprise. Continue development and demonstration of advanced algorithms for sensor data fusion and satellite threat detection, assessment, and response. Investigate, implement, and demonstrate integrated command and control systems at the tactical, operational, and strategic levels. Continue assessment and development of			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>	Project (Number/Name) 625018 / <i>Spacecraft Protection Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
commercial capability in order to either augment or replace traditional methods for space related command and control. Continue engagements with commercial space data providers for testing new enabling technologies on commercial satellites. Continue to develop on-board autonomous satellite technologies and plan for next generation flight experiments. FY 2021 Plans: For FY 2021, this work will be performed under the Threat Warning Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 625018, Spacecraft Protection Technology. FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable			
Accomplishments/Planned Programs Subtotals	17.618	18.753	0.000

	FY 2019	FY 2020
Congressional Add: Program increase-space situational awareness research	0.000	5.000
FY 2019 Accomplishments: Not applicable.		
FY 2020 Plans: Conduct Congressionally directed effort.		
Congressional Adds Subtotals	0.000	5.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>				Project (Number/Name) 628809 / <i>Spacecraft Vehicle Technologies</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
628809: <i>Spacecraft Vehicle Technologies</i>	-	56.707	75.744	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

In FY 2021, PE 1206601F, Space Technology efforts were transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, from Appropriation 3600, Budget Activity (BA) 02 due to the creation of a new Appropriation for Space Force.

This is an administrative realignment and not a New Start.

This project focuses on spacecraft platforms (for example: structures, power, and thermal management); satellite control (signal processing and control); and space experiments of maturing technologies for space qualification.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Space Power/Thermal Research	4.502	4.095	0.000
Description: Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts.			
FY 2020 Plans: Continue research into advanced space solar cells, solar array, and energy storage technologies. Focus on support for current heritage space systems, while also pivoting towards support of smaller space vehicles that will be utilized for the Space Warfighting Construct. Improve solar cells end of life performance to above 28% power conversion efficiency. Develop solar array structures tailored for small to large missions with specific power greater than 100 watts per kilogram. Develop energy storage chemistries with cell-level specific energy greater than 300 watt-hours per kilogram. Further develop array hardening approaches to provide drop-in replacement panels.			
FY 2021 Plans: For FY 2021, this work will be performed under the Space Power/Thermal Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 628809, Spacecraft Vehicle Technologies.			
FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable			
Title: Space Structures and Controls Research	8.440	10.598	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>	Project (Number/Name) 628809 / <i>Spacecraft Vehicle Technologies</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
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<p>Description: Develop revolutionary and enabling technologies, including lighter weight, lower cost, high performance structures for space platforms; guidance, navigation, and controls hardware and software for next generation of space superiority systems.</p> <p>FY 2020 Plans: Continue reactive maneuver strategies for spacecraft resiliency in hardware-in-the-loop testbeds. Initiate on-orbit experiment planning for reactive maneuver strategies. Apply research in verification and validation techniques for autonomous spacecraft flight software to high-fidelity simulations and brassboard laboratory experiments. Apply improved estimation algorithms for on-orbit navigation software to experimental data to assess performance and robustness. Complete laboratory and high-fidelity simulations/breadboard implementation for navigation algorithms and assess progress towards flight experiment demonstration. Continue development of integrated proof-of-concept experiments for advanced, agile manufacturing and assembly technologies for satellite production to improve performance and affordability. Continue research in functionalized structures using multi-material additive manufacturing. Transition development of research efforts in high-power small satellite technologies and affordable, high-performance phased arrays and electrically steerable antennas for tactical communication and radar concepts for agile, intelligent targets to advanced development and flight experimentation.</p> <p>FY 2021 Plans: For FY 2021, this work will be performed under the Space Structures and Controls Research effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 628809, Spacecraft Vehicle Technologies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>			
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<p>Title: Space Experiments</p> <p>Description: Develop flight experiments to improve the capabilities of existing operational space systems and to enable new transformational space capabilities.</p> <p>FY 2020 Plans: Conduct on-orbit small satellite demonstration of the first ever Link-16 from space to the tactical user enabling a Common Operating Picture for the Warfighter in a contested/degraded environment in support of Multi-Domain Command and Control. On-orbit small satellite demonstration capable of measuring radiation in the inner magnetosphere giving insight into the particle radiation space environment. Conduct a flight selection process and perform trade studies to determine the next flight experiment(s). Develop and mature a reference design, technical objectives, and experiment plan in coordination with Air Force</p>	20.338	22.915	0.000
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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / <i>Space Technology</i>	Project (Number/Name) 628809 / <i>Spacecraft Vehicle Technologies</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Space Command, Space and Missile Systems Center and/or other mission partners. Begin working long term items such as contracting strategy, parts, frequency allocation, and information assurance strategies. FY 2021 Plans: For FY 2021, this work will be performed under the Space Experiments effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 628809, Spacecraft Vehicle Technologies. FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable			
Title: Space Communication Technologies Description: Develop technologies for next-generation space communications terminals and equipment and methods/techniques to enable future space system operational command and control concepts. FY 2020 Plans: Support W/V-band payload operations, telemetry analysis, and health and status monitoring. Continue to develop and conduct technology demonstrations to address future military satellite communications capability and technology needs, for example, high-gain antenna, high-power amplifiers, low-noise amplifiers, cognitive / resilient networks, reconfigurable satellite radios / transponders, and anti-jam signal processing technologies. Support development and demonstration of novel laser communications technologies such as multi-wave length optical routers. Develop network traffic models, multi-spacecraft network models, and spacecraft network simulation support, along with analysis/visualization tools to aid. FY 2021 Plans: For FY 2021, this work will be performed under the Space Communication Technologies effort in Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 628809, Spacecraft Vehicle Technologies. FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable	6.862	6.136	0.000
Accomplishments/Planned Programs Subtotals	40.142	43.744	0.000

	FY 2019	FY 2020
Congressional Add: Program increase - operational cryogenic upper stage augmentation kit FY 2019 Accomplishments: Not applicable FY 2020 Plans: Conduct Congressionally directed effort	0.000	10.000
Congressional Add: Program increase - advanced spacecraft technologies	4.872	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)	
3600 / 2	PE 1206601F / <i>Space Technology</i>	628809 / <i>Spacecraft Vehicle Technologies</i>	
		FY 2019	FY 2020
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed effort			
<i>FY 2020 Plans:</i> Not Applicable			
<i>Congressional Add:</i> Program increase - MADDIE - modular arrays for energy		11.693	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed effort			
<i>FY 2020 Plans:</i> Not Applicable			
<i>Congressional Add:</i> Program increase - thin-film photovoltaic energy		0.000	7.000
<i>FY 2019 Accomplishments:</i> Not applicable			
<i>FY 2020 Plans:</i> Conduct Congressionally directed effort.			
<i>Congressional Add:</i> Resilient space structure architecture		0.000	15.000
<i>FY 2019 Accomplishments:</i> Not applicable			
<i>FY 2020 Plans:</i> Conduct Congressionally directed effort			
Congressional Adds Subtotals		16.565	32.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603030F / <i>AF Foundational Development/Demos</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	0.000	0.000	103.280	0.000	103.280	115.322	113.350	115.538	124.351	Continuing	Continuing
632100: <i>Laser Hardened Materials</i>	-	0.000	0.000	13.734	0.000	13.734	16.304	16.693	17.079	17.425	Continuing	Continuing
633153: <i>Non-Destructive Inspection Development</i>	-	0.000	0.000	6.629	0.000	6.629	6.659	6.841	7.018	7.161	Continuing	Continuing
633946: <i>Materials Transition</i>	-	0.000	0.000	14.806	0.000	14.806	15.807	16.121	16.444	16.778	Continuing	Continuing
635280: <i>Manufacturing Technologies</i>	-	0.000	0.000	40.401	0.000	40.401	45.943	46.987	48.036	49.012	Continuing	Continuing
635323: <i>Directed Energy Bioeffects Parameters</i>	-	0.000	0.000	5.278	0.000	5.278	6.602	6.734	6.869	7.008	Continuing	Continuing
635324: <i>Human Dynamics and Terrain Demonstration</i>	-	0.000	0.000	5.499	0.000	5.499	6.276	3.655	3.407	7.904	Continuing	Continuing
635351: <i>Technology Sustainment</i>	-	0.000	0.000	16.933	0.000	16.933	17.731	16.319	16.685	19.063	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates capabilities that enable sustainment, increase the affordability and reliability of manufacturing, and enhance Airman and weapon system performance and effectiveness to provide compelling advantage to the warfighter. Advances to technologies and materials under this program reduce life cycle costs; ensure the industrial base for Air Force systems; boost quality, increase readiness, and improve safety, survivability, and operability of weapon systems; predict, evaluate, and mitigate bioeffects on personnel and mission performance; and enable airmen performance.

To the greatest extent practical, integrated technology demonstrations will utilize modeling and simulation, cross-discipline system integration (e.g., platforms, avionics, propulsion, materials, manufacturing, human performance, cybersecurity, and counter directed energy weapons) to demonstrate in a near-operational environment advanced science and technology capabilities that reduce operational risk and accelerate incorporation of technologies into existing and future operational systems.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the Secretary of the Air Force in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603030F / <i>AF Foundational Development/Demos</i>	
<p>In FY 2021, the entirety of PE 0603112F, Advanced Materials for Weapon Systems, and associated Projects will be transferred to PE 0603030F, AF Foundational Development/Demos, with the exception of the Pervasive and Affordable Metals Technologies effort which will be transferred to PE 0602102F, Materials, Project 624347, Materials for Structures, Propulsion, and Subsystems.</p> <p>In FY 2021, the entirety of PE 0603199F, Sustainment Science and Technology (S&T), and associated Projects/activities are transferred to PE 0603030F, AF Foundational Development/Demos.</p> <p>In FY 2021, the entirety of PE 0603680F, Manufacturing Technology Program, and associated Projects/Activities are transferred to PE 0603030F, AF Foundational Development/Demos.</p> <p>In FY 2021, the entirety of Project 635323, Directed Energy Bioeffects Parameters; and Project 635324, Human Dynamics and Terrain Demonstration, are transferred from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 060303F, AF Foundational Development/Demos.</p> <p>These transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019.</p> <p>The Air Force Science and Technology portfolio will continued to be managed at the Enterprise level by the Air Force Technology Executive Officer, dual-hatted as the Air Force Research Laboratory (AFRL) Commander, and executed across the various AFRL Technology Directorates and locations.</p> <p>This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.</p> <p>This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.</p>		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	103.280	0.000	103.280
Total Adjustments	0.000	0.000	103.280	0.000	103.280
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	103.280	0.000	103.280

Change Summary Explanation

Increase in FY 2021 of \$103.280 million is due to the following PEs, Projects, and efforts being transferred to PE 0603030F, AF Foundational Development/Demos:

- 1) The entirety of PE 0603112F, Advanced Materials for Weapon Systems, with the exception of the Pervasive and Affordable Metals Technologies effort
- 2) The entirety of PE 0603199F, Sustainment Science and Technology (S&T)
- 3) The entirety of PE 0603680F, Manufacturing Technology Program
- 4) The entirety of Project 635323, Directed Energy Bioeffects Parameters; and Project 635324, Human Dynamics and Terrain Demonstration, from PE 0603456F, Human Effectiveness Advanced Technology Development

These transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos				Project (Number/Name) 632100 / Laser Hardened Materials			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
632100: <i>Laser Hardened Materials</i>	-	0.000	0.000	13.734	0.000	13.734	16.304	16.693	17.079	17.425	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced materials technologies that enhance protection for Air Force aircrews to ensure safety and to enable aircrews to perform required missions in threat environments. Advanced materials technologies also enhance protection for Air Force sensors and systems to ensure safety, survivability, and operability in threat environments.

In FY 2021, the entirety of Project 632100, Laser Hardened Materials, is transferred from PE 0603112F, Advanced Materials for Weapon Systems, to PE 0603030F, AF Foundational Development/Demos, Project 632100, Laser Hardened Materials, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright Patterson Air Force Base, Ohio, This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Aerospace Systems Protection	0.000	0.000	6.455
Description: Develop and demonstrate materials technologies that enhance hardening for sensors, avionics, and components to increase survivability and mission effectiveness of aerospace systems.			
FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Aerospace Systems Protection effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 632100, Laser Hardened Materials.			
FY 2021 Plans: Continue to assess the demonstrated results and transition the use of protection technologies for future sensor designs and strategies to mitigate directed energy damage for visual/near, short-wave, and mid-wave infrared detectors. Continue transitioning new technologies and integrate the developments into light, operator friendly survivable electro-optic sensors that provide full spectrum protection for missile warning. Continue analyzing the high-performance properties of damage limiting semiconductor materials designed to harden electro-optic imaging sensors. Continue to transition developed laser countermeasures for survivability of dynamic electro-optic/infrared imagers. Continue to advance the employment and integration of evolved computational materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings development for use in sensor hardening. Transition and continue technology development and maturation to develop defensive			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / <i>AF Foundational Development/Demos</i>	Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>capability for air systems airframe and anti-access munitions hardening assessments and solutions. Initiate development of materials for survivable next generation aircraft sensor systems.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$6.455 million. Funding increased due to the transfer and realignment of this work from Aerospace Systems Protection effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 632100, Laser Hardened Materials, as part of the Air Force RDT&E BA 03 consolidation.</p>				
<p>Title: Aircrew Protection</p> <p>Description: Develop and demonstrate materials technologies that enhance protection for Air Force aircrews to ensure safety and to enable aircrews to perform required missions in a threat environment.</p> <p>FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Aircrew Protection effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 632100, Laser Hardened Materials.</p> <p>FY 2021 Plans: Continue to develop, validate, demonstrate, and transition laser protection materials and technologies for personnel protection. Continue to validate and develop light-weight helmet-mounted sensor hardening materials focusing on next-generation nighttime specialized sensors. Continue to advance transition efforts and development of visor based aircrew protection materials with agile protection. Continue to evaluate and assess new materials and advances in characterization and demonstration of eye protection technologies using computational materials science tools. Continue to transition, validate, mature, and test improvements to functionality and performance of personnel protection technologies in expected operational conditions. Continue development and testing of materials technologies to protect against nuclear flash blindness.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$7.279 million. Funding increased due to the transfer and realignment of this work from Aircrew Protection effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 632100, Laser Hardened Materials, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	7.279
Accomplishments/Planned Programs Subtotals		0.000	0.000	13.734
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / <i>AF Foundational Development/Demos</i>	Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos				Project (Number/Name) 633153 / Non-Destructive Inspection Development			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633153: <i>Non-Destructive Inspection Development</i>	-	0.000	0.000	6.629	0.000	6.629	6.659	6.841	7.018	7.161	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced nondestructive inspection and evaluation technologies to monitor performance integrity and to detect failure causing conditions in weapon systems components and materials. Nondestructive inspection and evaluation capabilities greatly influence and/or limit many design, manufacturing, and maintenance practices. This project provides technology to satisfy Air Force requirements to extend the lifetime of current systems through increased reliability and cost-effectiveness at field and depot maintenance levels. Equally important is assuring manufacturing quality, integrity, and safety requirements are built in.

In FY 2021, the entirety of Project 633153, Non-Destructive Inspection Development, is transferred from PE 0603112F, Advanced Materials for Weapon Systems, to PE 0603030F, AF Foundational Development/Demos, Project 633153, Non-Destructive Inspection Development, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Advanced Engine Inspection Technologies	0.000	0.000	1.657
Description: Develop and demonstrate advanced technologies to improve capabilities to inspect for cracks and other damage to extend the total safe life of turbine engines.			
FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Advanced Engine Inspection Technologies effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633153, Non-Destructive Inspection Development.			
FY 2021 Plans: Continue nondestructive inspection/evaluation tools to include additive manufacturing processes and to assess materials and damage state of critical turbine engine components for the purpose of extending the useful life without increasing risk of in-flight failure of fracture critical to gas turbine engine components. Continue to mature the validation process for model prediction, accuracy, and effectiveness of digital nondestructive inspection technologies and demonstrate tool automation for high confidence repeatable results, to include advanced manufacturing processes.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos	Project (Number/Name) 633153 / Non-Destructive Inspection Development		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$1.657 million. Funding increased due to the transfer and realignment of this work from the Advanced Engine Inspection Technologies effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633153, Non-Destructive Inspection Development, as part of the Air Force RDT&E BA 03 PE consolidation.				
<p>Title: Special Material Inspection Technologies</p> <p>Description: Develop and demonstrate advanced inspection technologies supporting low-observable (LO) systems to enhance affordability and ensure full performance and survivability.</p> <p>FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Special Material Inspection Technologies effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633153, Non-Destructive Inspection Development.</p> <p>FY 2021 Plans: Continue the transition process to depots and flight lines for improved methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of special materials that enables/ensures more affordable coatings assessment. Continue to validate tools to improve characterization and failure modes of specialty multilayer coatings. Continue to develop automation for robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.260 million. Funding increased is due to the transfer and realignment of this work from the Special Material Inspection Technologies effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633153, Non-Destructive Inspection Development, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	1.260
<p>Title: Advanced System Monitoring Technologies</p> <p>Description: Develop and demonstrate advanced systems status monitoring technologies to provide on-board and embedded sensing to gain continuous awareness of the state of key subsystems.</p> <p>FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Advanced System Monitoring Technologies effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633153, Non-Destructive Inspection Development.</p> <p>FY 2021 Plans: Continue to demonstrate advanced analytical methods to more accurately assess the location, and register spatial location, of damage detected using nondestructive inspection data and results. Develop augmented reality technologies to improve the process of performing non-destructive evaluation tasks, acquiring and archiving data and reporting results, and enabling improved</p>		0.000	0.000	3.712

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos	Project (Number/Name) 633153 / Non-Destructive Inspection Development		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>inspector guidance and visualization. Continue development and transition of novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. Continue enhanced methods for compiling, reporting, collecting and rapidly analyzing digital nondestructive testing and evaluation data necessary for improved damage detection and characterization. Demonstrate and transition technologies to locate damage to composite structures without coating removal and to inspect composite structures with complex geometry. Continue the transition and integration of computational materials science tools with provide data necessary for life prediction methods to enable risk-based life management.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$3.712 million. Funding increased due to the transfer and realignment of this work from the Advanced System Monitoring Technologies in PE 0603112F, Advanced Materials for Weapons Systems, Project 633153, Non-Destructive Inspection Development, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
Accomplishments/Planned Programs Subtotals		0.000	0.000	6.629
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos				Project (Number/Name) 633946 / Materials Transition			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633946: <i>Materials Transition</i>	-	0.000	0.000	14.806	0.000	14.806	15.807	16.121	16.444	16.778	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced materials and processing technologies for fielded and planned Air Force weapon, airframe, and propulsion applications. Advanced materials and processes that have matured beyond applied research are characterized, critical data are collected, and critical evaluations in the proposed operating environment are performed. This design and scale-up data improves the overall affordability of promising materials and processing technologies, providing needed initial incentives for their industrial development.

In FY 2021, the entirety of Project 633946, Materials Transition, is transferred from PE 0603112F, Advanced Materials for Weapon Systems, to PE 0603030F, AF Foundational Development/Demos, Project 633946, Materials Transition, as part of the Air Force RDT&E BA 03 PE consolidation, in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and AF Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Air Vehicle Materials Technologies	0.000	0.000	8.143
Description: Develop and demonstrate materials and processes technologies for air vehicle and subsystems to enhance lift, propulsion, Low-Observable (LO) performance, power generation management, and affordability of air vehicles.			
FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Air Vehicle Materials Technology effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633946, Materials Transition.			
FY 2021 Plans: Continue development of technologies for organic engine lifing analysis for enhanced engine component risk management capability. Continue development, characterization, and transitioning development of materials to protect infrared apertures on next generation hardened assets. Continue to validate and verify results of microstructure-sensitive lifing methodologies that lower life cycle cost and advance performance characteristics of airframe and engine components in order to initiate development of next generation modeling tools that incorporate residual stress effects on component life. Initiate development and characterization of materials for application in nuclear systems and protected infra-red apertures for next-generation hardened assets.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / <i>AF Foundational Development/Demos</i>	Project (Number/Name) 633946 / <i>Materials Transition</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$8.143 million. Funding increased due to the transfer and realignment of this work from the Air Vehicle Materials Technologies effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633946, Materials Transition, as part of the RDT&E BA 03 PE consolidation.				
<p>Title: High Temperature Material Technologies</p> <p>Description: Develop and demonstrate affordable, novel high temperature materials/structures and thermal management concepts to enable future defense capabilities for prompt global strike concepts.</p> <p>FY 2020 Plans: In FY 2020 and prior years, this work is performed under the High Temperature Material Technologies effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633946, Materials Transition.</p> <p>FY 2021 Plans: Continue to work on multimaterial structures that optimally address operational temperature zones for hot structure and expendable thermal protection systems made out of advanced ceramics, ceramic matrix composites, hybrids, advanced and affordable metals, and intermetallics. Complete transition 2700-degree Fahrenheit ceramic matrix composites for turbine hot section components to industry. Continue to develop high performance metals for next-generation turbine disk and low cost propulsion, aerostructure and munitions components. Continue development and demonstrate advanced materials and process control to enable complex structural components via additive manufacturing. Continue establishing a metallic additive design center. Continue development of low cost metallic turbine engine disks made via powder processing technologies for use in high temperature, aggressive environment. Continue transitioning computational and data analytics tools that enable production of affordable, complex shape metal components made via additive manufacturing.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$6.663 million. Funding increased due to the transfer and realignment of this work from High Temperature Material Technologies effort in PE 0603112F, Advanced Materials for Weapons Systems, Project 633946, Materials Transition, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	6.663
Accomplishments/Planned Programs Subtotals		0.000	0.000	14.806
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos				Project (Number/Name) 635280 / Manufacturing Technologies			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635280: Manufacturing Technologies	-	0.000	0.000	40.401	0.000	40.401	45.943	46.987	48.036	49.012	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Project executes technical programs to maintain and develop an affordable and reliable industrial base and manufacturing capability that will be responsive to warfighter needs. The Project develops and improves manufacturing technologies and processes to enable cost reduction, improve component and system quality, and enhance industrial capability. Value stream modifications and manufacturing throughput improvements are effected to shorten cycle times of weapon systems during design, development, production and sustainment. Manufacturing Technologies objectives are conducted through industrial partnerships which enable the demonstration of manufacturing technologies for existing weapon system upgrades and/or for new warfighter systems. Efforts in the program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In FY 2021, the entirety of Project 635280, Manufacturing Technologies, is transferred from PE 0603680F, Manufacturing Technology Program, to PE 0603030F, AF Foundational Development/Demos, Project 635280, Manufacturing Technologies, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Sustainment Manufacturing Technologies	0.000	0.000	11.312
Description: Develop and transition pervasive affordability and producibility technologies for the sustainment of weapons systems and processes.			
FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Sustainment Manufacturing Technologies effort in PE 0603680F, Manufacturing Technology Program, Project 635280, Manufacturing Technologies.			
FY 2021 Plans: Continue to advance high demand specialized manufacturing technologies to develop cost effective conventional production, overhaul, and specialty material repair technologies to enable affordable sustainment of aircraft systems. Continue to develop and distribute advanced manufacturing techniques and concepts for agile sustainment and automation technology development for inspection and depot maintenance.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos	Project (Number/Name) 635280 / Manufacturing Technologies		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$11.312 million. Funding increased due to the transfer and realignment of this work from the Sustainment Manufacturing Technologies effort in PE 0603680F, Manufacturing Technology Program, Project 635280, Manufacturing Technologies, as part of the Air Force RDT&E BA 03 PE consolidation.				
<p>Title: Advanced Manufacturing Technologies</p> <p>Description: Develop and transition affordable advanced manufacturing technologies for weapons systems.</p> <p>FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Advanced Manufacturing Technologies effort in PE 0603680F, Manufacturing Technology Program, Project 635280, Manufacturing Technologies.</p> <p>FY 2021 Plans: Continue to refine development and demonstration of advanced agile manufacturing and repair capabilities for more affordable and increased availability of advanced turbine and small engine propulsion technologies, intelligence, surveillance and reconnaissance and communications technologies, transparent ceramics producibility, and the producibility of air armaments. Continue to refine development of high demand distributed agile manufacturing applications and structures affordability with a focus on low cost attritable systems and open pod architecture. Continue transitioning successful technologies. Continue the development and demonstration of manufacturing capabilities for producibility and affordability of aerospace structures and hypersonics and identification of transformational processing needs.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$5.100 million. Funding increased due to the transfer and realignment of this work from the Advanced Manufacturing Technologies effort in PE 0603680F, Manufacturing Technology Program, Project 635280, Manufacturing Technologies, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	29.089
Accomplishments/Planned Programs Subtotals		0.000	0.000	40.401
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos				Project (Number/Name) 635323 / Directed Energy Bioeffects Parameters			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635323: Directed Energy Bioeffects Parameters	-	0.000	0.000	5.278	0.000	5.278	6.602	6.734	6.869	7.008	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Project develops, demonstrates, and transitions technologies to predict, evaluate, and mitigate the effects of directed energy on personnel and mission performance, and exploits the offensive capabilities of directed energy systems. This project develops the human components of the guidelines for testing, deployment, and protection from high power microwave and high energy laser systems and uses this information to enhance the effectiveness of these weapon systems in air, space, and cyber operations. This project develops tools and plug-ins that enhance mission and engagement models, provide predictive risk analysis for deployment of Directed Energy systems, and analyzes systems for use in the Department of Defense. This project develops tools and analysis techniques to model and demonstrate the use of fielded protection on Airman performance, and informs developers of design specifications to optimize design of novel weapon systems.

In FY 2021, the entirety of Project 635323, Directed Energy Bioeffects Parameters, is transferred from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603030F, AF Foundational Development/Demos, Project 635323, Directed Energy Bioeffects Parameters, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Airman Systems Technology Directorate located in Joint Base San Antonio Fort Sam Houston, Texas. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Directed Energy Bioeffects	0.000	0.000	5.278
Description: This project combined two efforts into a single effort to better align the directed energy modeling simulation and analysis supporting both radio-frequency and laser (optical) bioeffects advanced demonstration. Develop and demonstrate modeling capabilities to assess collateral hazards from high power directed energy laser and radio frequency (RF) systems, including the use of probabilistic risk assessment techniques and analysis of system level effects on the Airman. Develop and demonstrate optical protective technologies for aircrew and ground personnel to provide protection against directed energy threats.			
FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Optical Radiation Bioeffects effort and the Radio Frequency Bioeffects effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635323, Directed Energy Bioeffects Parameters.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos	Project (Number/Name) 635323 / Directed Energy Bioeffects Parameters

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Provide hazard analysis for High Energy Laser flight safety reports. Readdress safety analysis for advancing Department of Defense directed energy concepts for safety review and technical review boards. Continue development of high peak power assessment models and tools to address real world concerns. Conclude evaluation of next generation of nuclear flash-blindness technologies and the impact on mission performance. Continue integration of radio frequency hazard, optical radiation hazard, and vision analysis and tools into Advanced Framework for Simulation, Integration and Modeling (AFSIM) architecture and the Endgame Framework architecture for future transitions in Joint weaponeering and targeteering tool suites. Begin development of Integrated Vision Modeling libraries to inform display design and advance protection technologies.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$5.278 million. Funding increased due to the transfer and realignment of this work from the Radio Frequency Bioeffects effort and the Optical Radiation Bioeffects effort from PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635323, Directed Energy Bioeffects Parameters, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	5.278

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos				Project (Number/Name) 635324 / Human Dynamics and Terrain Demonstration			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635324: <i>Human Dynamics and Terrain Demonstration</i>	-	0.000	0.000	5.499	0.000	5.499	6.276	3.655	3.407	7.904	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Project develops, demonstrates, and transitions technologies to sustain airman performance in adverse operational and/or training environments (e.g., heat, altitude, high G), monitor and mitigate in-flight unexplained physiological events (e.g., hypoxia, hyperoxia), and prevent human performance related mishaps through real-time monitoring and mitigation—particularly through highly automated or autonomous systems.

In FY 2021, the entirety of Project 635324, Human Dynamics and Terrain Demonstration, is transferred from PE 0603456, Human Effectiveness Advanced Technology Development to PE 0603030F, AF Foundational Development/Demos, Project 635324, Human Dynamics and Terrain Demonstration, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Airman Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Sensing and Assessment	0.000	0.000	5.499
Description: This project combined two efforts into a single effort to better align product development. Develop products that integrate biological, physiological, neural, environmental, and behavioral sensing capabilities with validated analytics and assessments to sustain and enhance airman performance in adverse operational and/or training environments.			
FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Human Analyst Augmentation effort and the Human Trust and Interaction effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635324, Human Dynamics and Terrain Demonstration.			
FY 2021 Plans: Initiate Integrated Cockpit Sensing (ICS) effort to develop validated sensor suite providing real-time pilot alerting and data storage for unexplained physiological event (UPE) root cause analysis. Perform sensor component down select following laboratory environmental (altitude chamber, centrifuge) testing. Conduct sensor component flight demonstrations in T-6 and F-16. Conduct ground-based demonstration of prototype integrated capability in F-35 simulation and simulator-based training exercises.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$5.499 million. Funding increased due to the transfer and realignment of this work from the Human Analyst Augmentation effort and the Human Trust and Interaction effort in PE 0603456F, Human Effectiveness			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos	Project (Number/Name) 635324 / Human Dynamics and Terrain Demonstration		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
Advanced Technology Development, Project 635324, Human Dynamics and Terrain Demonstration, as part of the Air Force RDT&E BA 03 PE consolidation.				
Accomplishments/Planned Programs Subtotals		0.000	0.000	5.499
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos				Project (Number/Name) 635351 / Technology Sustainment			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635351: <i>Technology Sustainment</i>	-	0.000	0.000	16.933	0.000	16.933	17.731	16.319	16.685	19.063	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Project develops and demonstrates mature Air Force Research Laboratory (AFRL) sustainment technologies such as: materials, corrosion, maintenance/repair techniques, state awareness/non-destructive inspection, health management, life prediction, low observable materials and processes, composite materials and logistics for transition into fielded Air Force systems to reduce life cycle sustainment costs and increase readiness. Technologies matured and demonstrated impact affordability and availability of fielded aerospace weapon systems by reducing sustainment costs, extending service life, and maintaining mission readiness and capability. This program develops and demonstrates maintenance, life cycle management, and system/fleet decision making technologies that can be implemented to address operational sustainment issues and could influence future system sustainability decisions via risk reduction to support inclusion into new systems. Studies are conducted to analyze processes and methodologies for application of technologies to address sustainment issues across the force, identifying cross cutting applications for fielded systems, and opportunities for building in sustainability into future applications. This program also develops and demonstrates affordable advanced composites for aircraft structures of fielded and emerging systems. This includes studies, analysis, and tests for application of composites to address sustainment and affordability issues across the force. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) process to harmonize efforts and eliminate duplication.

In FY 2021, the entirety of Project 635351, Technology Sustainment, is transferred from PE 0603199F, Sustainment Science and Technology (S&T), to PE 0603030F, AF Foundational Development/Demos, Project 635351, Technology Sustainment, as part of the Air Force RDT&EBA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: System Health Management/Assessment Technologies	0.000	0.000	5.520
Description: Develop, demonstrate, and transition state awareness/system health management technologies. Conduct studies and analyses to design sustainability into future applications. The short-term tasks in this area are selected based on warfighter needs identified via a semi-annual, competitive process.			
FY 2020 Plans: In FY 2020 and prior years, this work is performed under the System Health Management/Assessment Technologies effort in PE 0603199F, Sustainment Science and Technology (S&T), Project 635351, Technology Sustainment.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos	Project (Number/Name) 635351 / Technology Sustainment		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Continue completion of the development of a system to reduce maintenance requirements of carbon monoxide detection system. Continue health assessments and capability development for fielded air/space/cyber systems and components. Continue development and demonstration of diagnostic technology airframe/engine, launch vehicle, spacecraft, intercontinental ballistic missiles (ICBMs), and components. These efforts are in Air Force mission areas of Air, Space, and Cyber. Initiate new efforts based on competitive selection processes in FY 2020.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$5.520 million. Funding increased due to the transfer and realignment of this work from the Systems Health Management/Assessment Technology effort in PE 0603199F, Sustainment Science and Technology (S&T), Project 635351, Technology Sustainment, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Prevention/Enhanced Maintainability Technologies</p> <p>Description: Develop, demonstrate, and transition maintenance and sustainment technologies to improve component design, maintenance, replacement, and concepts for performance improvement and reduced maintenance burden. The short-term tasks in this effort are selected based on warfighter needs identified via a semi-annual, competitive process.</p> <p>FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Prevention/Enhanced Maintainability Technologies effort in PE 0603199F, Sustainment Science and Technology (S&T), Project 635351, Technology Sustainment.</p> <p>FY 2021 Plans: Continue rapid repair and materials development for aircraft battle damage repair of advanced fighter aircraft. Continue advanced canopy technology development. Continue total body nondestructive evaluation system for outer mold line inspection of advanced fighter aircraft. Continue development of materials and processes to reduce maintenance burden on low observable systems. Continue efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions. Continue to develop, demonstrate, and transition maintenance and sustainment technologies to improve component design, maintenance, repair, replacement, and concepts for maintainer training, extending part life, and reduced maintenance burden spanning Air Force mission areas of Air, Space, and Cyber. Continue to develop abrasion resistance coating to protect composite material substrates for low observable systems. Continue to develop a flexible crack-blunting primer. Initiate other new efforts based on competitive selection processes in FY 2020.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		0.000	0.000	5.896

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603030F / AF Foundational Development/Demos	Project (Number/Name) 635351 / Technology Sustainment		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$5.896 million. Funding increased due to the transfer and realignment of this work from the Prevention/Enhanced Maintainability Technologies, PE 0603199F, Sustainment Science and Technology (S&T), Project 635351, Technology Sustainment, as part of the Air Force RDT&E BA 03 PE consolidation.				
Title: Management/Improved Reliability Technologies		0.000	0.000	5.517
Description: Develop, demonstrate, and transition technologies to improve existing and new components, fleet management/decision-making tools, and supply chain/sustainment infrastructure to decrease downtime and costs, and increase reliability. The short-term tasks in this effort are selected based on warfighter needs identified via a semi-annual, competitive process.				
FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Management/Improved Reliability Technologies effort in PE 0603199F, Sustainment Science and Technology (S&T), Project 635351, Technology Sustainment.				
FY 2021 Plans: Continue system development to provide prognostic capabilities for avionics components and analysis techniques to extend engine component service life. Continue efforts to develop system fleet management decision-making tools, maintenance/repair data base technologies and techniques, and supply chain/infrastructure approaches to reduce sustainment costs. These efforts span Air Force mission areas of Air, Space, and Cyber. Initiate new efforts based on competitive selection processes in FY 2020.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$5.517 million. Funding increased due to the transfer and realignment of this work from the Management/Improved Reliability Technologies effort in PE 0603199F, Sustainment Science and Technology (S&T), Project 635351, Technology Sustainment, as part of the Air Force RDT&E BA 03 PE consolidation.				
Accomplishments/Planned Programs Subtotals		0.000	0.000	16.933
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603032F / <i>Future AF Integrated Technology Demos</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	0.000	0.000	157.619	0.000	157.619	87.812	59.427	30.219	28.796	Continuing	Continuing
630320: <i>Air Force Vanguard</i> s	-	0.000	0.000	157.619	0.000	157.619	87.812	59.427	30.219	28.796	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Program develops and delivers transformational operational capabilities through advanced technology solutions that focus on five strategic capabilities: Global Persistent Awareness; Resilient Information Sharing; Rapid, Effective Decision-Making; Complexity, Unpredictability, and Mass; and Speed and Reach of Disruption and Lethality.

Focused Advanced Technology Research efforts may also be referred to as Vanguard or Future Transformational Capabilities. Vanguard programs will advance and accelerate emerging weapon systems and warfighting concepts in the Air Force Science and Technology (S&T) portfolio, while demonstrating the viability of leap-ahead capabilities. High risk by design, their goal answers specific questions and informs future decisions by including the direction of future acquisition programs and identifying gaps where more research is still needed.

These programs are Air Force priority initiatives with enterprise commitment that incorporate multidisciplinary solutions for delivering transformational capabilities through the Air Force Capability Development Council (CDC), co-chaired by the Under Secretary of the Air Force and Vice Chief of Staff of the Air Force, owns the annual Vanguard approval process. The Air Force Warfighting Integration Capability (AFWIC), chartered to develop the Air Force future force design, leads activities that identify and recommend Vanguard candidates that could provide transformational capability.

The first three Air Force Vanguard programs are Golden Horde, Navigation Technology Satellite 3 (NTS-3), and Skyborg. Golden Horde will demonstrate collaborative autonomous networked weapons that share data, interact and execute coordinated actions, and work together to defeat targets. NTS-3 will experiment on key aspects for new GPS receivers that incorporate multiple signals and readily adapt to warfighter needs. The first iteration of Skyborg will integrate artificial intelligence into autonomous unmanned air vehicles to enable future manned-unmanned teaming.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the Secretary of the Air Force in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, the Air Force created PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard, to consolidate Vanguard and Future Transformational Capabilities efforts and funding in order to better align with the Air Force S&T Strategy, April 2019, and execute transformational Advanced Technology Development. This PE creation and realignment of funding from existing Air Force RDT&E Advanced Technology Development PEs is an administrative realignment

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603032F / <i>Future AF Integrated Technology Demos</i>

and not a new start. These efforts and activities continued to be managed by the Air Force Technology Executive Officer (TEO), dual-hatted as the Air Force Research Laboratory (AFRL) Commander, and executed across the various AFRL Technology Directorate locations.

This PE may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in PEs 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	157.619	0.000	157.619
Total Adjustments	0.000	0.000	157.619	0.000	157.619
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	157.619	0.000	157.619

Change Summary Explanation

Increase in FY 2021 of \$157.619 million is due the following:

1) Realignment and consolidation of Skyborg Vanguard activities and funding from PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635327, Warfighter Interfaces; PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Tech Integration; PE 0603211F, Aerospace Technology Dev/Demo, Project 634927, Aerospace Power & Flight Control Integ & Demo; and PE 0603216F, Aerospace Propulsion and Power Technology, Project 634921, Aircraft Propulsion Subsystems Int.

2) Realignment and consolidation of Golden Horde activities and funding from PE 0603601F, Conventional Weapons Technology, Project 63670B, Weapon Concept Development.

3) Realignment and consolidation of Navigation Technology Satellite 3 activities and funding from PE 0603270F, Electronic Combat Technology, Project 63431G, RF Warning & Countermeasures Tech, and PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrated Space Technology Demonstrations.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603032F / <i>Future AF Integrated Technology Demos</i>
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4) Realignment of Future Transformational Capabilities funding from across the various Air Force S&T RDT&E Advanced Technology Development programs.

These transfers in FY 2021 are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force S&T Strategy, April 2019.

C. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Future Transformational Capabilities</p> <p>Description: Competitively develop and mature transformational efforts that may not have been approved as Air Force Vanguard programs. Activities will be responsive to future force design priorities.</p> <p>FY 2020 Plans: In FY 2020, this work is performed under multiple projects and efforts within the following Air Force RDT&E Advanced Technology Development Programs: 0603112F, Advanced Materials for Weapon Systems; 0603203F, Advanced Aerospace Sensors; 0603270F, Electronic Combat Technology; 0603401F, Advanced Spacecraft Technology; 0603444F, Maui Space Surveillance System; 0603456F, Human Effectiveness Advanced Technology Development; 0603601F, Conventional Weapons Technology; 0603605F, Advanced Weapons Technology; 0603680F, Manufacturing Technology Program; 0603788F, Battlespace Knowl Devel and Demo; 0603216F, Aerospace Propulsion and Power Technology; 0603199F, Sustainment Science and Technology; and 0603211F, Aerospace Technology Dev/Demo.</p> <p>FY 2021 Plans: Continue to develop and mature multidisciplinary solutions to provide transformational future force capabilities to connect the Joint Force, dominate Space, generate combat power, and provide logistics under attack.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$20.000 Million. Funding increased due to the realignment and consolidation of Air Force Advanced Technology Development Science and Technology funding for Future Transformational Capabilities efforts, as part of the Air Force RDT&E BA03 PE Consolidation.</p>	0.000	0.000	20.000
<p>Title: Navigation Technology Satellite 3 (NTS-3)</p> <p>Description: Develop and demonstrate advanced space-based navigation system technologies to provide resilient navigation support in contested environments. The demonstration includes a space-based test vehicle, ground based enterprise command and control, and agile software defined receivers for the user.</p> <p>FY 2020 Plans:</p>	0.000	0.000	24.632

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>		R-1 Program Element (Number/Name) PE 0603032F / <i>Future AF Integrated Technology Demos</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>In FY 2020 and prior years, this work is performed under the Electronic Attack effort in PE 0603270F, Electronic Combat Technology, Project 63431G, RF Warning & Countermeasures Tech, and the Integrated Satellite Demonstrations effort in PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrated Space Technology Demonstrations.</p> <p>FY 2021 Plans: Continue development of advanced space-based navigation technology demonstration for Space launch in FY 2022. Complete spacecraft bus. Complete assembly of the spacecraft; prepare for ground test verification campaign. Verify user terminal processing of all signal definitions for one year of on-orbit experimentation. Deliver all ground control system software for integration in mission operations center. Deliver developmental user terminals to verify utility of agile signals in support of experimental objectives and establishing relevance to future concepts of operations.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$24.632 Million. Funding increased due to the realignment and consolidation of NTS-3 Vanguard activities and funding from the Electronic Attack effort in PE 0603270F, Electronic Combat Technology, Project 63431G, RF Warning & Countermeasures Tech, and the Integrated Satellite Demonstrations effort in PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrated Space Technology Demonstrations, as part the Air Force RDT&E BA03 PE consolidation.</p>				
<p>Title: Skyborg</p> <p>Description: Develop and demonstrate an autonomous, attributable vehicle architecture suite which will enable the Air Force to posture, generate, and sustain multi-mission sorties at sufficient tempo to thwart adversary attempts at quick, decisive action in contested and highly contested environments. Develops and demonstrates autonomy architecture and software, enabling machine-machine and manned-unmanned teaming, while ensuring openness, modularity, and expandability. Develops, demonstrates, and integrates hardware components and Open Architecture standards needed to allow modular sensor, communication, and other payload integration into the autonomy and vehicle architectures in systems integration laboratories, platforms, and vehicles. Demonstrates low cost attributable vehicle concepts and technologies for expeditionary mass generation including sortie generation employment concepts. Conducts analysis and tests on concepts of operations and concepts of employment for attributable, autonomous, unmanned systems.</p> <p>FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Battlespace Acoustics effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635327, Warfighter Interfaces; the Aerospace Vehicle Technology Integration effort and the Advanced Aerospace Structure Technologies effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Tech Integration; the Autonomous Systems Control effort in PE 0603211F, Aerospace Technology Dev/Demo,</p>		0.000	0.000	40.900

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>		R-1 Program Element (Number/Name) PE 0603032F / <i>Future AF Integrated Technology Demos</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Project 634927, Aerospace Power & Flight Control Integ & Demo; and the Missile/Remotely Piloted Aircraft Engine Performance effort in PE 0603216F, Aerospace Propulsion and Power Technology, Project 634921, Aircraft Propulsion Subsystems Int.</p> <p>FY 2021 Plans: Initiate development and demonstration of integrated software and hardware architecture and components. Continue flight demonstration of low cost unmanned aerospace systems capable of interoperations with different assets. Continue development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems. Continue demonstration of teaming concepts and technologies among cooperative human-machine teams in networked simulation environments. Initiate integration and demonstration of operational concepts and employment for autonomous attributable aircraft. Initiate integration and demonstrate military utility of multiple lines of effort in an operationally representative exercise.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$40.900 Million. Funding increased due to the realignment and consolidation of Skyborg Vanguard activities and funding from the Battlespace Acoustics effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635327, Warfighter Interfaces; the Aerospace Vehicle Technology Integration effort and the Advanced Aerospace Structure Technologies effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Tech Integration; the Autonomous Systems Control effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634927, Aerospace Power & Flight Control Integ & Demo; and the Missile/Remotely Piloted Aircraft Engine Performance effort in PE 0603216F, Aerospace Propulsion and Power Technology, Project 634921, Aircraft Propulsion Subsystems Int, as part the Air Force RDT&E BA03 PE consolidation.</p>				
<p>Title: Golden Horde</p> <p>Description: Integrate networked collaborative technologies into selected inventory weapon systems. Technologies can include new payloads, weapon datalinks/radios, and autonomous behaviors that are bounded by operator-defined mission rules of engagement. Supports the integration of Air Force weapons into the Joint All-Domain Command/Control network. Perform proof-of-concept demonstrations via simulations, virtual and live testing, and operational analysis, experiments and wargames to show the value of collaborative weapons in increasing combat power across the spectrum of conflict. Work with operational users to define Concepts of Operation (CONOPs).</p> <p>FY 2020 Plans: In FY 2020 and prior years, this work is performed under the Air-to-Ground Concept Development effort in PE 0603601F, Conventional Weapons Technology, Project 63670B, Weapon Concept Development.</p> <p>FY 2021 Plans:</p>		0.000	0.000	72.087

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603032F / <i>Future AF Integrated Technology Demos</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Continue to integrate networked collaborative technologies into selected weapon systems. Continue to develop technologies including new payloads, weapon datalinks/radios, and collaborative software development. Continue to support and define the integration of Air Force weapons into the Joint All-Domain Command/Control network. Continue to implement proof-of-concept demonstrations via simulations, live testing, operational analysis, experiments, and war-games to demonstrate the viability of collaborative weapons in highly contested environments. Continue to work with operational users to define Concepts of Operation (CONOPs) in future force structures and future employment scenarios.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$72.087 Million. Funding increased due to the realignment and consolidation of Golden Horde activities and funding from the Air-to-Ground Concept Development effort in PE 0603601F, Conventional Weapons Technology, Project 63670B, Weapon Concept Development, as part the Air Force RDT&E BA03 PE consolidation.</p>			
Accomplishments/Planned Programs Subtotals	0.000	0.000	157.619

D. Other Program Funding Summary (\$ in Millions)
N/A

Remarks

E. Acquisition Strategy
N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0603033F I Next Gen Platform Dev/Demo
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	0.000	0.000	199.556	0.000	199.556	197.210	230.125	257.613	301.799	Continuing	Continuing
633035: Aerospace Power Technology	-	0.000	0.000	22.368	0.000	22.368	18.492	18.855	19.237	19.628	Continuing	Continuing
633834: Integrated Space Technology Demonstrations	-	0.000	0.000	25.526	0.000	25.526	37.346	47.580	56.864	59.572	Continuing	Continuing
634920: Flight Vehicle Tech Integration	-	0.000	0.000	15.115	0.000	15.115	0.000	14.870	35.859	36.529	Continuing	Continuing
634921: Aircraft Propulsion Subsystems Int	-	0.000	0.000	10.826	0.000	10.826	10.096	8.095	18.855	19.236	Continuing	Continuing
634922: Space & Missile Rocket Propulsion	-	0.000	0.000	28.757	0.000	28.757	27.218	30.443	31.159	31.795	Continuing	Continuing
634926: High Speed Systems Integ & Demo	-	0.000	0.000	16.533	0.000	16.533	18.463	15.640	6.291	35.081	Continuing	Continuing
634927: Aerospace Power & Flight Control Integ & Demo	-	0.000	0.000	5.582	0.000	5.582	11.245	25.259	27.745	28.371	Continuing	Continuing
635098: Advanced Aerospace Propulsion	-	0.000	0.000	20.931	0.000	20.931	22.428	11.940	20.441	35.709	Continuing	Continuing
63681B: Advanced Turbine Engine Gas Generator	-	0.000	0.000	22.176	0.000	22.176	22.820	23.403	23.972	24.458	Continuing	Continuing
63682J: Spacecraft Vehicles	-	0.000	0.000	31.742	0.000	31.742	29.102	34.040	17.190	11.420	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and conducts technology platform demonstrations that provide compelling advantage to the warfighter. The technologies address enabling and enduring Air Force requirements as well as integrated enterprise transformational capabilities intended to reshape the future force. This Program includes space platform technologies, including payloads, protection, vehicles, systems survivability, and in-space propulsion; flight vehicle technologies, including hypersonic flight regime and manned/unmanned systems; propulsion technologies, including turbine-based, high speed/hypersonic, advanced-cycle, space and missile propulsion; and system component technologies, including controls, electrical power, and thermal management. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/Demo</i>	
<p>In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the Secretary of the Air Force in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.</p> <p>In FY 2021, the entirety of 633834, Integrated Space Technology Demonstrations, is transferred from PE 0603401F, Advanced Spacecraft Technology, to PE 0603033F, Next Gen Platform Dev/Demo, with the exception of the work and funding that is associated with the Navigation Technology Satellite-3 Vanguard demonstration which will be realigned to the PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.</p> <p>In FY 2021, the entirety of Project 63682J, Spacecraft Vehicles, is transferred from PE 0603401F, Advanced Spacecraft Technology, to PE 0603033F, Next Gen Platform Dev/Demo.</p> <p>In FY 2021, the entirety of Project 634920, Flight Vehicle Tech Integration, is transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo, with the exception of the work and funding associated with the Skyborg Vanguard demonstration which will be realigned to the PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.</p> <p>In FY 2021, the entirety of Project 634926, High Speed/Hypersonic Integration & Demonstrations, is transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo.</p> <p>In FY 2021, the entirety of Project 634927, Flight Systems Control, is transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo, Project 634927, Flight Systems Control, with the exception of the work and funding associated with the Skyborg Vanguard demonstration which will be realigned to the PE 0603032F, Future AF Integrated Technology Demos.</p> <p>In FY 2021, the entirety of Project 634921, Aircraft Propulsion Subsystems Integration, is transferred from PE 0603216F, Aerospace Propulsion and Power Technology, to PE 0603033F, Next Gen Platform Dev/Demo, with the exception of funding associated with Skyborg Vanguard demonstration which will be realigned to the PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.</p> <p>In FY 2021, the entirety of Project 633035, Aerospace Power Technology; Project 63681B, Advanced Turbine Engine Gas Generator; Project 634922, Space & Missile Rocket Propulsion; and Project 635098, Advanced Aerospace Propulsion, are transferred from PE 0603216F, Aerospace Propulsion and Power Technology, to PE 0603033F, Next Gen Platform Dev/Demo.</p> <p>All these transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start.</p>		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/Demo</i>
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The Air Force Science and Technology portfolio will continued to be managed at the Enterprise level by the Air Force Technology Executive Officer, dual-hatted as the Air Force Research Laboratory (AFRL) Commander, and executed across the various AFRL Technology Directorates and locations.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	199.556	0.000	199.556
Total Adjustments	0.000	0.000	199.556	0.000	199.556
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	199.556	0.000	199.556

Change Summary Explanation

Increase in FY 2021 of \$199.556 million is due to the following PEs, Projects, and efforts being transferred to PE 0603033F, Next Gen Platform Dev/Demo:

- 1) Entirety of Project 63682J, Spacecraft Vehicles, from PE 0603401F, Advanced Spacecraft Technology
- 2) Project 634920, Flight Vehicle Tech Integration, from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo, with the exception of the work and funding associated with the Skyborg Vanguard demonstration.
- 3) Entirety of Project 634926, High Speed/Hypersonic Integration & Demonstrations, from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/Demo</i>	
<p>4) Project 634927, Flight Systems Control, from PE 0603211F, Aerospace Technology Dev/Demo with the exception of the work and funding associated with the Skyborg Vanguard demonstration</p> <p>5) Project 634921, Aircraft Propulsion Subsystems Integration, from PE 0603216F, Aerospace Propulsion and Power Technology, with the exception of funding associated with Skyborg Vanguard demonstration</p> <p>6) Entirety of Project 633035, Aerospace Power Technology; Project 63681B, Advanced Turbine Engine Gas Generator; Project 634922, Space & Missile Rocket Propulsion; and Project 635098, Advanced Aerospace Propulsion, from PE 0603216F, Aerospace Propulsion and Power Technology</p> <p>These transfers in FY 2021 are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019.</p>		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / Next Gen Platform Dev/ Demo				Project (Number/Name) 633035 / Aerospace Power Technology			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633035: Aerospace Power Technology	-	0.000	0.000	22.368	0.000	22.368	18.492	18.855	19.237	19.628	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates system and subsystem integration to include adaptive architectures, actuation, electrical power, thermal management, and distribution for aerospace applications. This project develops and demonstrates the components, controls and systems required to satisfy the operational needs of current and future aircraft and enables the use of future high-power payloads. This technology enhances reliability and survivability, and reduces vulnerability, weight, and life cycle costs of air platforms. The electrical power system components developed are projected to provide a two-fold to five-fold improvement in aircraft reliability and maintainability, and a reduction in power system weight. This project is integrated into energy optimized aircraft efforts and power and thermal programs.

In FY 2021, the entirety of Project 633035, Aerospace Power Technology, is transferred from PE 0603216F, Aerospace Propulsion & Power Technology, Project 633035, to PE 0603033F, Next Gen Platform Dev/Demo, Project 633035, Aerospace Power Technology as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson AFB, OH. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Power Aircraft Subsystem Technologies	0.000	0.000	22.368
Description: Develop and demonstrate integrated architecture, controls and components for power generation, conditioning, and distribution; energy storage components; and thermal management and subsystem technologies for integration into high power aircraft.			
FY 2020 Plans: For FY 2020 and prior years, this work was performed under the High Power Aircraft Subsystem Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 633035, Aerospace Power Technology.			
FY 2021 Plans: Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Continue the development of hybrid-cycle power and thermal management system. Continue development of advanced power generation and distribution system. Continue development and demonstration of integrated, adaptive megawatt- class tactical aircraft power and thermal capability. Continue development and demonstration of megawatt class architecture, controls and integration. Continue development and demonstration of robust electrical power systems for			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>	Project (Number/Name) 633035 / <i>Aerospace Power Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
megawatt applications. Continue development and demonstration of thermal management systems for megawatt applications. Complete development and demonstration of solid state electrical distribution technology for megawatt applications. <i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$22.368 million. Funding increased due to the transfer and realignment of this work from the High Power Aircraft Subsystem Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 633035, Aerospace Power Technology, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	22.368

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / Next Gen Platform Dev/ Demo				Project (Number/Name) 633834 / Integrated Space Technology Demonstrations			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633834: <i>Integrated Space Technology Demonstrations</i>	-	0.000	0.000	25.526	0.000	25.526	37.346	47.580	56.864	59.572	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project is a series of advanced technology demonstrations designed to address mission needs by applying emerging technologies from the Air Force Research Laboratory, other United States government laboratories, and industry. These technologies are integrated into system-level demonstrations that are used to test, evaluate, and validate the technologies in a relevant environment.

In FY 2021, the entirety of Project 633834, Integrated Space Technology Demonstrations, is transferred from PE 0603401F, Advanced Spacecraft Technology, Project 633834, to PE 0603033F, Next Gen Platform Dev/Demo, Project 633834, Integrated Space Technology Demonstrations as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Space Vehicles Technology Directorate located in Kirtland AFB, New Mexico. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Integrated Satellite Demonstrations	0.000	0.000	25.526
Description: Develop satellite technologies for integrated, robust, and flexible satellite demonstrations building on previous work and leveraging investments by other organizations.			
FY 2020 Plans: For FY 2020 and prior years, this work was performed under the Integrated Satellite Demonstration effort in PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrated Space Technology.			
FY 2021 Plans: Continue on-orbit demonstrations of multiple formation flying satellites for near autonomous formation control leveraging opportunities to fly demonstrations and prototypes, where successes can identify quick transition to next generation technology needs. Continue coordination of a manifest timeline for critical space projects prioritizing Air Force Space Command technical, security, and operational development requirements. Continue to utilize the Long Duration Propulsive Evolved Expendable Launch Vehicle Secondary Payload Adaptor launch schedule and other prospects to quickly fly demonstrations and prototypes. Continue payloads maturation tasks from concept proposal to leveraging commercial Low Earth orbit constellations.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>	Project (Number/Name) 633834 / <i>Integrated Space Technology Demonstrations</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$25.526 million. Funding increased due to the transfer and realignment of this work from the Integrated Satellite Demonstrations effort in PE 0603401F, Advanced Spacecraft Technology, Project 633834, Integrated Space Technology, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	25.526

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / Next Gen Platform Dev/ Demo				Project (Number/Name) 634920 / Flight Vehicle Tech Integration			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634920: <i>Flight Vehicle Tech Integration</i>	-	0.000	0.000	15.115	0.000	15.115	0.000	14.870	35.859	36.529	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project demonstrates advanced aerospace vehicle technologies. Aerospace Vehicle Technology Integration efforts are accomplished through integration of various technologies to include avionics, advanced propulsion, and weapon systems for demonstration in near-realistic operational environments. Advanced Aerospace Structures Technologies are demonstrated to enhance the capability of current and future aerospace vehicles.

In FY 2021, Project 634920, Flight Vehicle Tech Integration, non-Vanguard efforts and activities are transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo, Project 634920, Flight Vehicle Tech Integration, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. The Project and associated Non-Vanguard efforts and activities will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Aerospace Vehicle Technology Integration	0.000	0.000	7.117
Description: Develop, simulate, and demonstrate integrated technologies to improve the performance of aerospace platform capabilities.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under Aerospace Vehicle Technology Integration effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Tech Integration.			
FY 2021 Plans: Continue integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility. Continue the flight demonstration of a low cost unmanned aerospace systems capable of interoperations with different unmanned aerospace systems assets; completing the next sensor extension variant in FY 2021 and initiate an off-board weapons station variant. Initiate next variant of a low cost unmanned aerospace system. Complete propulsion integration component validation tests for Air Superiority 2030 requirements. Complete flight demonstrations of practical laminar flow for swept wing aircraft designs.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/Demo</i>	Project (Number/Name) 634920 / <i>Flight Vehicle Tech Integration</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$7.117 million. Funding increased due to the transfer and realignment of this work from the Aerospace Vehicle Technology Integration effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Tech Integration, as part of the Air Force RDT&E BA 03 PE consolidation.				
<p>Title: Advanced Aerospace Structure Technologies</p> <p>Description: Develop and demonstrate affordable, lightweight, adaptive, and multifunctional structural concepts integrated into aerospace systems.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under the Advanced Aerospace Structure Technologies effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Tech Integration.</p> <p>FY 2021 Plans: Complete low cost airframe design and manufacturing demonstrations. Continue fully automated manufacturing demonstrations of large airframe structures. Complete structural life extension demonstration of legacy fleet metallic structures. Continue validation tests of life extension and durability methods for legacy fleet composite structures in support of aircraft Service Life Extension programs.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$7.998 million. Funding increased due to the transfer and realignment of this work from Advanced Aerospace Structure Technologies effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Tech Integration, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	7.998
Accomplishments/Planned Programs Subtotals		0.000	0.000	15.115
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / Next Gen Platform Dev/ Demo				Project (Number/Name) 634921 / Aircraft Propulsion Subsystems Int			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634921: Aircraft Propulsion Subsystems Int	-	0.000	0.000	10.826	0.000	10.826	10.096	8.095	18.855	19.236	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. The Aircraft Propulsion Subsystems Integration (APSI) project includes demonstrator engines for manned systems and efficient small-scale propulsion for remotely piloted aircraft and cruise missile applications. The demonstrator engines integrate the core (high- pressure spool) technology developed under the Versatile Affordable Advanced Turbine Engines (VAATE) project with the engine (low-pressure spool) technology such as fans, turbines, engine controls, mechanical systems, exhaust nozzles, and augmentors. Additionally, this project includes activities to improve propulsion safety and readiness. This project also focuses on integration of inlets, nozzles, engine-to-airframe compatibility, and power and thermal management subsystems technologies. The APSI project provides aircraft with potential for longer range and higher cruise speeds with lower specific fuel consumption, surge power for successful engagements, high sortie rates with reduced maintenance, reduced life cycle cost, and improved survivability, resulting in increased mission effectiveness. Technologies developed are applicable to sustained high-speed vehicles and responsive space launch. The Aircraft Propulsion Subsystems Integration project is focused on improving propulsion capabilities while at the same time reducing the cost of ownership. Anticipated technology advances include turbine engine improvements providing approximately twice the range for a sustained supersonic combat aircraft, doubling the time on station with ten times the power output for surveillance aircraft and propulsion for a high speed supersonic missile with double the range for time sensitive targets. A portion of this project supports the demonstration of adaptive cycle technologies, which develop component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, high power extraction, integrated thermal management, and durability for widely varying mission needs.

In FY 2021, Project 634921, Aircraft Propulsion Subsystems Int, Non-Vanguard efforts and activities are transferred from PE 0603216F, Aerospace Propulsion and Power Technology, to PE 0603033F, Next Gen Platform Dev/Demo, Project 634921, Aircraft Propulsion Subsystems Int, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. The Project and associated Non-Vanguard efforts and activities will continue to be managed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson, OH. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Missile/Remotely Piloted Aircraft Engine Performance	0.000	0.000	6.414
Description: Design, fabricate, and test component technologies for limited-life engines to improve the performance, durability, and affordability of missile and remotely piloted aircraft engines.			
FY 2020 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>	Project (Number/Name) 634921 / <i>Aircraft Propulsion Subsystems Int</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>For FY 2020 and prior years, this work is performed under the Missile/remotely Piloted Aircraft Engine Performance effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634921, Aircraft Propulsion Subsystems Int.</p> <p>FY 2021 Plans: Complete several key risk reduction testing of components for small engines. Finalize conceptual and preliminary design of small engine technology. Identify next innovative architecture, critical technologies and component designs for efficient small engines. Finalize the assembly of advanced concept additive manufacturing heat exchanger for small core engines. Finalize fabrication of recuperator for demonstration of increased core efficiency in small core engines. Initiate operational benefits analysis for missile and UAV systems.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$6.414 million. Funding increased due to the transfer and realignment of this work from the Missile/Remotely Piloted Aircraft Engine Performance effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634921, Aircraft Propulsion Subsystems Int, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Adaptive Turbine Engine Technologies</p> <p>Description: Design, fabricate, and demonstrate performance, durability, and operability technologies to mature adaptive turbine engine technologies.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under the Adaptive Turbine Engine Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634921, Aircraft Propulsion Subsystems Int.</p> <p>FY 2021 Plans: Analyze and evaluate conceptual design of adaptive engine technology and continue technology rig tests to decrease risk in core technology testing. Complete component tests of advanced variable turbine and innovative compression rear block designed to accept flow variations caused by variable turbine operation.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$4.412 million. Funding increased due to the transfer and realignment of this work from the Adaptive Turbine Engine Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634921, Aircraft Propulsion Subsystems Int, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	4.412
Accomplishments/Planned Programs Subtotals		0.000	0.000	10.826
C. Other Program Funding Summary (\$ in Millions)				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>	Project (Number/Name) 634921 / <i>Aircraft Propulsion Subsystems Int</i>

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / Next Gen Platform Dev/ Demo				Project (Number/Name) 634922 / Space & Missile Rocket Propulsion			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634922: <i>Space & Missile Rocket Propulsion</i>	-	0.000	0.000	28.757	0.000	28.757	27.218	30.443	31.159	31.795	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced and innovative low-cost rocket turbo-machinery and components, and low-cost space launch propulsion technologies. Additionally, this project develops technologies for the sustainment of strategic systems (including solid rocket motor boosters and missile propulsion, post boost control, and aging and surveillance efforts) and tactical rockets. Characteristics such as environmental acceptability, affordability, reliability, responsiveness, reduced weight, and reduced operation and launch costs are emphasized. Increased life and performance of propulsion systems are key goals. Technology areas investigated include ground demonstrations of compact, lightweight, advanced propulsion technologies, higher efficiency energy conversion systems (derived from an improved understanding of combustion fundamentals), and high-energy propellants. Technological advances in this project could improve the performance of expendable payload capabilities by approximately twenty to fifty percent and reduce launch, operations, and support costs by approximately thirty percent. Responsiveness and operability of propulsion systems will be enhanced for reusable launch systems. Aging and surveillance thrusts for solid rocket motors could reduce lifetime prediction uncertainties for individual motors by fifty percent, enabling motor replacement for cause. The efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire Department of Defense (DoD) and National Aeronautics and Space Administration (NASA). The efforts in this project are part of the Rocket Propulsion 21 (RP21) program. The efforts in this project are reviewed by a DoD level steering committee annually for relevance to DoD missions and achievement of technical goals defined by the RP21 program.

In FY 2021, the entirety of Project 634922, Space & Missile Rocket Propulsion, is transferred from PE 0603216F, Aerospace Propulsion & Power Technology, to PE 0603033F, Next Gen Platform Demo, Project 634922, Space & Missile Rocket Propulsion as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Edwards AFB, CA. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Liquid Rocket Propulsion Technologies	0.000	0.000	14.842
Description: Develop liquid rocket propulsion technology for current and future space launch vehicles.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under the Liquid Rocket Propulsion Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634922, Space & Missile Rocket Propulsion.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/Demo</i>	Project (Number/Name) 634922 / <i>Space & Missile Rocket Propulsion</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
Continue modular engine feasibility demonstration and flight experiment. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$14.842 million. Funding increased due to the transfer and realignment of this work from the Liquid Rocket Propulsion Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634922, Space & Missile Rocket Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation.				
Title: On-Orbit Propulsion Technologies Description: Develop solar electric, electric, and monopropellant propulsion technologies for existing and future satellites, upper stages, orbit transfer vehicles, and satellite maneuvering. FY 2020 Plans: For FY 2020 and prior years, this work is performed under the On-Orbit Propulsion Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634922, Space & Missile Rocket Propulsion. FY 2021 Plans: Continue to develop and transition experimental, modeling and simulation, and theoretical efforts geared towards advanced thruster development with emphasis on understanding thrust scale-up. Continue to advance capabilities to study next generation of hypergolic fuels, including propellant characterization, drop-in testing, and lab-scale thruster demonstration. Continue analysis and development of multi-mode propulsion opportunities to combine high efficiency and high thrust capabilities on a common propellant. Continue thrust scale-up effort for advanced non-toxic monopropellant thrusters. Continue electric propulsion thruster effort utilizing advanced non-toxic monopropellant. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$11.181 million. Funding increased due to the transfer and realignment of this work from the On-Orbit Propulsion Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634922, Space & Missile Rocket Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation.		0.000	0.000	11.181
Title: Ballistic Missile Technologies Description: Develop and demonstrate missile propulsion and post-boost control systems technologies for ballistic missiles. FY 2020 Plans: For FY 2020 and prior years, this work is performed under the Ballistic Missile Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634922, Space & Missile Rocket Propulsion. FY 2021 Plans:		0.000	0.000	2.734

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>	Project (Number/Name) 634922 / <i>Space & Missile Rocket Propulsion</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Complete current technology maturation and demonstration efforts for post-boost technologies. Continue technology maturation and demonstration efforts for tactical missile technologies. Continue motor component modeling & simulation tool development, assessment, verification, and validations efforts geared towards reducing cost and schedule of new developments in an agile development landscape.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$2.734 million. Funding increased due to the transfer and realignment of this work from the Ballistic Missile Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 634922, Space & Missile Rocket Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
Accomplishments/Planned Programs Subtotals	0.000	0.000	28.757

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>				Project (Number/Name) 634926 / <i>High Speed Systems Integ & Demo</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634926: <i>High Speed Systems Integ & Demo</i>	-	0.000	0.000	16.533	0.000	16.533	18.463	15.640	6.291	35.081	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, integrates and demonstrates, via simulations, ground, and flight tests, advanced flight vehicle technologies that improve the performance and supportability of future high speed/hypersonic vehicles. System level integration brings together air vehicle technologies with avionics, propulsion, and warheads and other aerospace subsystems for demonstration in a near-realistic operational environment. Integration and technology demonstrations reduce the risk and time required to transition technologies into operational systems.

In FY 2021, the entirety of Project 634926, High Speed Systems Integ & Demo, is transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo, Project 634926, High Speed Systems Integ & Demo, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Speed/Hypersonic Vehicle Technologies	0.000	0.000	16.533
Description: Develop, simulate, and demonstrate integrated vehicle technologies to enable and improve the performance of future high-speed and hypersonic systems.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under the High Speed/Hypersonic Vehicle Technologies effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634926, High Speed/Hypersonic Integration & Demo.			
FY 2021 Plans: Complete development and demonstration of tactically-relevant long-range high-speed strike technologies including ground and flight demonstrations needed. Complete some flight test activities for both Hypersonic Air-breathing Weapon Concept and Tactical Boost Glide. Initiate Advanced Airbreathing technology maturation activities to expand performance capabilities of high speed systems.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/Demo</i>	Project (Number/Name) 634926 / <i>High Speed Systems Integ & Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$16.553 million. Funding increased due to the transfer and realignment of this work from the High Speed/Hypersonic Vehicle Technologies effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634926, High Speed/Hypersonic Integration & Demo, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	16.533

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / Next Gen Platform Dev/ Demo				Project (Number/Name) 634927 / Aerospace Power & Flight Control Integ & Demo			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634927: Aerospace Power & Flight Control Integ & Demo	-	0.000	0.000	5.582	0.000	5.582	11.245	25.259	27.745	28.371	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program integrates and demonstrates advanced control technologies that improve the performance, reliability, safety, and survivability of existing and future, manned and unmanned, aerospace systems. Enhanced capabilities are enabled by control, automation, and system level integration of subsystems and systems such as propulsion, airframes, avionics, power & thermal management, weapons, communications, and operator interfaces. Modeling and simulation, integration, and technology demonstrations in a near-operational environment reduce the risk and time required to transition technologies into existing and future aerospace systems.

In FY 2021, Project 634927, Aerospace Power & Flight Control Integ & Demo, Non-Vanguard efforts and activities are transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo, Project 634927, Aerospace Power & Flight Control Integ & Demo, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. The Project and associated Non-Vanguard efforts and activities will continue to be managed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Autonomous Systems Control	0.000	0.000	5.582
Description: Develop, simulate, and demonstrate advanced automation and control-enabled capabilities for manned or unmanned aerospace platforms. Develop, simulate, and demonstrate autonomous flight controls for safe flight and cooperative operations between manned and remotely piloted air platforms.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under the Autonomous Systems Control effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634927, Flight Systems Control.			
FY 2021 Plans: Continue development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems and manned platforms. Continue to incorporate autonomous and safe airspace interoperability for manned and remotely piloted aircraft systems, airborne control of teams of unmanned aircraft, and unmanned sense-and-avoid technologies for ground and air operations to the autonomy spiral demonstrations. Continue development of technologies to reduce risk for transition of collision avoidance technologies to 4th and 5th-gen aircraft. Continue development of foundational autonomy for unmanned systems and spiral demonstrations of capability, including safe airspace interoperability and sense			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>	Project (Number/Name) 634927 / <i>Aerospace Power & Flight Control Integ & Demo</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
and avoid for air and ground operations. Continue spiral autonomy demonstration of manned-unmanned teaming capability incorporating the above technology transitions, including pilot-directed autonomous control.				
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$5.582 million. Funding increased due to the transfer and realignment of this work from the Autonomous Systems Control effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634927, Flight Systems Control, as part of the Air Force RDT&E BA 03 PE consolidation.				
Accomplishments/Planned Programs Subtotals		0.000	0.000	5.582
C. Other Program Funding Summary (\$ in Millions) N/A				
Remarks				
D. Acquisition Strategy N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / Next Gen Platform Dev/ Demo				Project (Number/Name) 635098 / Advanced Aerospace Propulsion			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635098: <i>Advanced Aerospace Propulsion</i>	-	0.000	0.000	20.931	0.000	20.931	22.428	11.940	20.441	35.709	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates, via ground and flight tests, the scramjet propulsion cycle to a technology readiness level appropriate for full integration with other engine cycles (including turbine and rocket-based) to provide the Air Force with transformational military capabilities. The primary focus is on the hydrocarbon-fueled, scramjet engine. Multi-cycle engines will provide the propulsion systems for possible application to support aircraft and weapon platforms operating up to Mach 7. Efforts include: scramjet flow-path optimization to enable operation over the widest possible range of Mach numbers; active combustion control to assure continuous positive thrust (even during mode transition); robust flame-holding to maintain stability through flow distortions; and maximized volume-to-surface area to minimize the thermal load imposed by the high-speed engine. Thermal management plays a vital role in scramjet and combined cycle engines, including considerations for protecting low speed propulsion systems (e.g., turbine engines) during hypersonic flight.

In FY 2021, the entirety of Project 635098, Advanced Aerospace Propulsion, is transferred from PE 0603216F, Aerospace Propulsion & Power Technology, to PE 0603033F, Next Gen Platform Demo, Project 635098, Advanced Aerospace Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Scramjet Technologies	0.000	0.000	20.931
Description: Develop and demonstrate technologies for a hydrocarbon-fueled scramjet with robust operation up to Mach 7.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under the Scramjet Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 635098, Advanced Aerospace Propulsion.			
FY 2021 Plans: Continue development of scramjet technologies to enhance operability including robust operation during maneuvers. Continue accelerated development and demonstration of tactically- relevant, long range, high speed strike scramjet engine designs, technologies, and components including ground and flight demonstrations needed for potential follow-on acquisition program. Initiate propulsion technology maturation activities for Multi-Mission Cruiser concept to expand performance capabilities of high speed systems.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>	Project (Number/Name) 635098 / <i>Advanced Aerospace Propulsion</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$20.931 million. Funding increased due to the transfer and realignment of this work from the Scramjet Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 635098, Advanced Aerospace Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	20.931

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / Next Gen Platform Dev/ Demo				Project (Number/Name) 63681B / Advanced Turbine Engine Gas Generator			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63681B: <i>Advanced Turbine Engine Gas Generator</i>	-	0.000	0.000	22.176	0.000	22.176	22.820	23.403	23.972	24.458	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. The objective is to provide continuous evolution of technologies into an advanced gas generator in which the performance, cost, durability, repairability, and maintainability can be assessed in a realistic engine environment. The gas generator, or core, is the basic building block of the engine and nominally consists of a compressor, a combustor, a high-pressure turbine, mechanical systems, and core subsystems. Experimental core engine demonstration validates engineering design tools and enhances rapid, low-risk transition of key engine technologies into engineering development, where they can be applied to derivative and/or new systems. These technologies are applicable to a wide range of military and commercial systems including aircraft, missiles, land combat vehicles, ships, and responsive space launch. Component technologies are demonstrated in a core (sub-engine). This project also assesses the impact of low spool components such as; inlet systems, fans, low pressure turbines, exhaust systems, and system level technologies such as; integrated power generators and thermal management systems on core engine performance, and durability in ground demonstrations of engine cores. The core performances of this project are validated on demonstrator engines in the Aircraft Propulsion Subsystem Integration Project of this program. A portion of this project supports the demonstration of adaptive cycle technologies, which develop component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, and durability for widely varying mission needs.

In FY 2021, the entirety of Project 63681B, Advanced Turbine Engine Gas Generator, is transferred from PE 0603216F, Aerospace Propulsion & Power Technology, to PE 0603033F, Next Gen Platform Dev/Demo, Project 63681B, Advanced Turbine Engine Gas Generator, as part of the Air Force RDT&E, BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Core Engine Technologies	0.000	0.000	9.333
Description: Design, fabricate, and demonstrate performance predictions in core engines, using innovative engine cycles and advanced materials for turbofan and for turbojet engines.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under the Core Engine Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 63681B, Advanced Turbine Engine Gas Generator.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>	Project (Number/Name) 63681B / <i>Advanced Turbine Engine Gas Generator</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Complete detailed design of medium-scale efficient core demonstrator. Complete rig testing. Continue risk reduction component tests for medium-scale engine advanced fan and core. Complete conceptual design of large-scale adaptive core concepts. Complete design of bladed disks and bearing systems components for small cruise missile size engine. Complete development of small cruise missile engine demonstrator test plans to improve life prediction capability for bladed disks and bearing systems. Initiate core tests for medium scale engines.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$9.333 million. Funding increased due to the transfer and realignment of this work from the Core Engine Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 63681B, Advanced Turbine Engine Gas Generator, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: High Pressure Ratio Core Engine Technologies</p> <p>Description: Design, fabricate, and demonstrate high overall pressure ratio engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under the High Pressure Ratio Core Engine Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 63681B, Advanced Turbine Engine Gas Generator.</p> <p>FY 2021 Plans: Complete several key risk reduction testing of components for small engines (200-800 lbs class). Complete conceptual and preliminary design of small engine technology. Identify and assess innovative architecture, critical technologies and component designs for efficient, small engines. Continue assembly of advanced concept additive manufacturing heat exchanger for small core engines. Continue fabrication of recuperator for demonstration of increased core efficiency in small core engines. Continue to work medium scale core technologies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$3.511 million. Funding increased due to the transfer and realignment of this work from the High Pressure Ratio Core Engine Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 63681B, Advanced Turbine Engine Gas Generator, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	3.511
<p>Title: Adaptive Turbine Engine Core Technologies</p> <p>Description: Design, fabricate, and demonstrate adaptive turbine engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines.</p> <p>FY 2020 Plans:</p>		0.000	0.000	9.332

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/Demo</i>	Project (Number/Name) 63681B / <i>Advanced Turbine Engine Gas Generator</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>For FY 2020 and prior years, this work is performed under the Adaptive Turbine Engine Core Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 63681B, Advanced Turbine Engine Gas Generator.</p> <p>FY 2021 Plans: Complete conceptual design of adaptive engine technology and initiate technology rig tests to decrease risk in core technology testing. Complete and evaluate compressor core test for large engines. Continue component tests of advanced variable turbine and innovative compression rear block designed to accept flow variations caused by variable turbine operation.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$9.332 million. Funding increased due to the transfer and realignment of this work from the Adaptive Turbine Engine Core Technologies effort in PE 0603216F, Aerospace Propulsion & Power Technology, Project 63681B, Advanced Turbine Engine Gas Generator, as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
Accomplishments/Planned Programs Subtotals	0.000	0.000	22.176

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603033F / Next Gen Platform Dev/ Demo				Project (Number/Name) 63682J / Spacecraft Vehicles			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63682J: <i>Spacecraft Vehicles</i>	-	0.000	0.000	31.742	0.000	31.742	29.102	34.040	17.190	11.420	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates compact, low-cost, spacecraft power generation, storage, distribution, and thermal management technologies, including cryogenic cooling technologies. This project also develops composites for spacecraft structures and technologies for spacecraft control and mechanisms.

In FY 2021, the entirety of Project 63682J, Spacecraft Vehicles, is be transferred from PE 0603401F, Advanced Spacecraft Technology, to PE 0603033F, Next Gen Platform Dev/Demo, Project 63682J, Spacecraft Vehicles, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Space Vehicles Technology Directorate located in Kirtland Air Force Base, New Mexico. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Space Communication Technologies	0.000	0.000	13.106
Description: Develop technologies critical to addressing documented MILSATCOM capability gaps and top-ranked Air Force Space Command, Space Force, and/or Space Missile Control technology needs.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under the Space Communication and Control Technologies effort in PE 0603401F, Advanced Spacecraft Technologies, Project 63682J, Spacecraft Vehicles.			
FY 2021 Plans: Continue support of planned five-year W/V-band propagation experiment. Support ground terminal operations, maintenance, and re-deployments. Collect and analyze data to statistically characterize atmospheric propagation effects and correlate to meteorological parameters. Continue research and development to address future military satellite communications capability and technology needs. Continue development of space-qualified V-band high power amplifier technology. Initiate development of W/V-band satellite transponder for on-orbit experiment and demonstration coupled with crosslinks. Continue systems engineering and technology risk-reduction for W/V-band ground terminals.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$9.106 million. Funding increased due to the transfer and realignment of this work from the Space Communication and Control Technologies effort in PE 0603401F, Advanced Spacecraft Technologies, Project 63682J, Spacecraft Vehicles, as part of the Air Force RDT&E BA 03 PE consolidation.			
Title: Inertial Sensor Navigation Technologies	0.000	0.000	18.636

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603033F / <i>Next Gen Platform Dev/ Demo</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Develop next-generation solid state, radiation-hardened strategic advance inertial system components for hostile environment.</p> <p>FY 2020 Plans: For FY 2020 and prior years, this work is performed under the Inertial Sensor Navigation Technologies effort in PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles.</p> <p>FY 2021 Plans: Continue design of gravity gradiometer test bed. Continue design, development and testing of inertial sensor prototypes and radiation hardened electronics and initiate conceptual designs for inertial measurement systems. Continue to mature modeling, simulation and test/validation procedures for inertial sensor systems in relevant strategic environments.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$15.866 million. Funding increased due to the transfer and realignment of this work from Inertial Sensor Navigation Technologies effort in PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles, as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
Accomplishments/Planned Programs Subtotals	0.000	0.000	31.742

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0603034F I Persistent Knowledge, Awareness, & C2 Tech
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	0.000	0.000	102.276	0.000	102.276	117.849	119.079	126.278	134.837	Continuing	Continuing
634335: <i>Cyber Concepts</i>	-	0.000	0.000	4.699	0.000	4.699	6.934	6.971	8.520	14.612	Continuing	Continuing
634868: <i>Maui Space Surveillance System</i>	-	0.000	0.000	12.090	0.000	12.090	12.319	12.924	13.264	13.608	Continuing	Continuing
635321: <i>C4I Battlespace Dev and Demo</i>	-	0.000	0.000	29.201	0.000	29.201	37.095	38.141	39.161	39.956	Continuing	Continuing
635325: <i>Mission Effective Performance</i>	-	0.000	0.000	7.067	0.000	7.067	7.213	6.356	7.503	7.655	Continuing	Continuing
635327: <i>Warfighter Interfaces</i>	-	0.000	0.000	13.881	0.000	13.881	13.308	13.621	16.443	16.778	Continuing	Continuing
63665A: <i>Advanced Aerospace Sensors Technology</i>	-	0.000	0.000	19.471	0.000	19.471	21.750	21.963	22.402	22.857	Continuing	Continuing
6369DF: <i>Target Attack and Recognition Technology</i>	-	0.000	0.000	15.867	0.000	15.867	19.230	19.103	18.985	19.371	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and conducts integrated enterprise advanced technology demonstrations in persistent knowledge, awareness, and command & control that provide compelling advantage to the warfighter in kinetic and non-kinetic multi-domain operations for air, space, cyberspace, land, sea and undersea. This program develops multi-domain battlespace awareness capabilities through advanced aerospace sensors/signals and exploitation algorithms, counter-countermeasures, advanced data handling, multi-domain fusion techniques/visualization, secure net-enabled architectures and communications/networks, and operation/upgrade of the Maui Space Surveillance System (MSSS). This program develops training, simulation, mission rehearsal and other Airman performance-aiding methods including adaptive Airman-machine/interface teaming and multisensory fusion. This program develops electronic and cyber warfare capabilities including trusted sensors/systems, cyber susceptibility discovery and mitigation, and cyber protection/resiliency.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the Secretary of the Air Force in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	
<p>In FY 2021, the entirety of Project 634335, Cyber Concepts, is transferred from PE 0603270F, Electronic Combat Technology, to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech.</p> <p>In FY 2021, the entirety of PE 0603444F, Maui Space Surveillance Systems, and the associated Project/activities are transferred to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech.</p> <p>In FY 2021, the entirety of Project 635321, C4I Battlespace Dev and Demo, is transferred from PE 0603788F, Battlespace Knowledge Development and Demonstration, to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech.</p> <p>In FY 2021, the entirety of Project 635325, Mission Effective Performance is transferred from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech.</p> <p>In FY 2021, non-Vanguard efforts and activities in Project 635327, Warfighter Interfaces, are transferred from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech.</p> <p>In FY 2021, the entirety of PE 0603203F, Advanced Aerospace Sensors, and the associated Projects are transferred to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech.</p> <p>All these transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start.</p> <p>The Air Force Science and Technology portfolio will continued to be managed at the Enterprise level by the Air Force Technology Executive Officer, dual-hatted as the Air Force Research Laboratory (AFRL) Commander, and executed across the various AFRL Technology Directorates and locations.</p> <p>This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F, and 1206601SF.</p> <p>This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.</p>		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	102.276	0.000	102.276
Total Adjustments	0.000	0.000	102.276	0.000	102.276
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	102.276	0.000	102.276

Change Summary Explanation

Increase in FY 2021 of \$102.276 million is due to the following PEs, Projects, and efforts being transferred to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech:

- 1) Entirety of Project 634335, Cyber Concepts, from PE 0603270F, Electronic Combat Technology
- 2) Entirety of PE 0603444F, Maui Space Surveillance Systems, and associated Project 634868, Maui Space Surveillance System
- 3) Entirety of Project 635321, C4I Battlespace Dev and Demo, from PE 0603788F, Battlespace Knowledge Development and Demonstration
- 4) Entirety of Project 635325, Mission Effective Performance from PE 0603456F, Human Effectiveness Advanced Technology Development
- 5) Entirety of Project 635327, Warfighter Interfaces, from PE 0603456F, Human Effectiveness Advanced Technology Development, with the exception of Skyborg Vanguard activities.
- 6) Entirety of PE 0603203F, Advanced Aerospace Sensors, and the associated Projects 6369DF, Target Attack and Recognition Technology and 63655A, Advanced Aerospace Sensors Technology.

These transfers in FY 2021 are part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 634335 / <i>Cyber Concepts</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634335: <i>Cyber Concepts</i>	-	0.000	0.000	4.699	0.000	4.699	6.934	6.971	8.520	14.612	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates methods to discover cyber susceptibilities, assess avionics systems, formulate mitigation strategies, and investigate use of tools and technologies to automate this process. It is designed to apply developed vulnerability discovery, vulnerability mitigation, and cyber protection technology to avionics systems and components and embedded systems. This involves technologies for trusted sensors and trusted systems that deter exploitation of our critical hardware and software. This project aims to develop cyber resilience and protect systems through adaptation of the system to the threat. It demonstrates these technologies in open and adaptable architectures for system integration in field demonstrations and proves out the technologies through rapid integration of sensors and architectures for technology transition. It integrates research efforts in electronic and cyber warfare to rapidly demonstrate a capability for rapid fielding.

In FY 2021, the entirety of Project 634335, Cyber Concepts, is transferred from PE 0603270F, Electronic Combat Technology, to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 634335, Cyber Concepts, as part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and AF Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Avionics Cyber Vulnerabilities</p> <p>Description: Develop and demonstrate methods, techniques, and technical tools to enable, assist, and improve the vulnerability discovery processes. Use developed tools and techniques to assess avionics boxes, systems, busses, and components. Investigate techniques to mitigate discovered vulnerabilities. Develop and demonstrate mitigation and protection technologies on future concept platforms for adaptability and resilience.</p> <p>FY 2020 Plans: For FY 2020 and prior, this work is performed under Avionics Cyber Vulnerabilities effort in PE 0603270F, Electronic Combat Technology, Project 634335, Cyber Concepts.</p> <p>FY 2021 Plans: Complete transition of vulnerability mitigation technologies to legacy weapon systems. Begin demonstrations of agile, resilient and lethal capabilities of next-generation architecture. Provide integration support for emerging technologies such as autonomy, alternative-navigation technologies, open system architecture standards and approaches, multispectral and distributed intelligence surveillance and reconnaissance, and electromagnetic spectrum warfare. Continue to transition next-generation architectures to</p>	0.000	0.000	1.500

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 634335 / <i>Cyber Concepts</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
adopting programs/platforms, and open architecture approaches to rapidly integrate advanced mission system capability for next-generation architectures.				
<p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.500 million. Funding increased due to the transfer and realignment of this work from the Avionics Cyber Vulnerabilities effort in PE 0603270F, Electronic Combat Technology, Project 634335, Cyber Concepts, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Avionics Cyber Protections</p> <p>Description: Develop and demonstrate advanced automated analysis tools and protection techniques to prevent exploitation of cyber susceptibilities in avionics systems. This strategy would include discovery and mitigation of likely attack vectors, remediation of susceptibilities, and safeguards to assure the integrity of embedded software.</p> <p>FY 2020 Plans: For FY 2020 and prior, this work is performed under the Avionics Cyber Protections effort in PE 0603270F, Electronic Combat Technology, Project 634335, Cyber Concepts.</p> <p>FY 2021 Plans: Continue to enhance and extend cyber protection tools, techniques and test beds for manned and unmanned air vehicles, mission and support equipment. Complete development of system integration laboratories to test resilient and agile mission system architecture concepts on avionics; intelligence, surveillance, and reconnaissance; positioning, navigation, and timing systems. Continue to flight test and demonstrate advanced cyber protection capabilities on mission systems. Continue to collaborate with program offices and end-users to transition resilient and agile technologies. Leverage open system architecture standards and approaches to demonstrate agile, resilient and autonomous capabilities for current and next-generation architectures.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY2020 by \$3.199 million. Funding increased due to the transfer and realignment of this work from the Avionics Cyber Protections effort in PE 0603270F, Electronic Combat Technology, Project 634335, Cyber Concepts, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	3.199
Accomplishments/Planned Programs Subtotals		0.000	0.000	4.699
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 634335 / <i>Cyber Concepts</i>

D. Acquisition Strategy
N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>				Project (Number/Name) 634868 / <i>Maui Space Surveillance System</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634868: <i>Maui Space Surveillance System</i>	-	0.000	0.000	12.090	0.000	12.090	12.319	12.924	13.264	13.608	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program funds ground-based optical space situational awareness (SSA) technology development and demonstration at the Maui Space Surveillance System (MSSS) in Hawaii, as well as the operation and upgrade of the facility. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In FY 2021, the entirety of PE 0603444F, Maui Space Surveillance System (MSSS), Project 634868, Maui Space Surveillance System, is transferred to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 634868, Maui Space Surveillance System, as part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and AF Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Directed Energy Technology Directorate located in Kirtland Air Force Base, New Mexico. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Operate and Upgrade Maui Space Surveillance System	0.000	0.000	12.090
Description: Operate and upgrade the Maui Space Surveillance System to support development, demonstration, and integration of ground-based optical space situational awareness technologies.			
FY 2020 Plans: For FY 2020 and prior, the work is performed under the Maui Space Surveillance System effort in PE 0603444F, Maui Space Surveillance System, Project 634868, Maui Space Surveillance System.			
FY 2021 Plans: Continue to maintain Maui Space Surveillance System facility and experimental equipment in a mission-ready state. Perform needed upgrades and modernization to keep facilities and equipment in good working order and allow Maui Space Surveillance System to perform efficiently and reliably. Continue to operate Maui Space Surveillance System facility for development and demonstration of ground based optical space situational awareness capabilities in conjunction with customer programs and an operational Space Situational Awareness mission. Continue to accept control of geosynchronous satellite imaging capability, collecting images as requested by mission partners. Transition of dynamic telescope system operations into Maui Space Surveillance System capability baseline will be complete.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 634868 / <i>Maui Space Surveillance System</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$12.090 million. Funding increased due to the transfer and realignment of this work from the Operate and Upgrade Maui Space Surveillance System effort in PE 0603444F, Maui Space Surveillance System, Project 634868, Maui Space Surveillance System, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	12.090

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>				Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635321: <i>C4I Battlespace Dev and Demo</i>	-	0.000	0.000	29.201	0.000	29.201	37.095	38.141	39.161	39.956	Continuing	Continuing

A. Mission Description and Budget Item Justification

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on technologies in support of multi-domain command and control.

In order to achieve operational agility, the Air Force must be able (a) to monitor, assess, plan, and execute missions rapidly across the full spectrum of operations at all levels of war and during all phases of conflict; (b) to field advanced, secure, net-enabled architectures and communications/network technologies in support of persistent, global, and survivable kinetic and non-kinetic military operations; (c) to process and exploit data and information from a variety of sources and domains to create a common operating picture of the battlespace; and (d) to provide the decision maker and staff with seamless access to tailored information within a mobile, dynamic, and scalable, globally distributed Air Operations Center, as well as among other producers, consumers, and managers of information relevant to other particular Communities of Interest (COI).

In FY 2021, the entirety of Project 635321, C4I Battlespace Dev and Demo, is transferred from PE 0603788F, Battlespace Knowledge Development and Demonstration, to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo, as part of the Air Force RDT&E BA03 PE Consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Information Technology Directorate located in Rome, NY. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Multi-Domain Command and Control	0.000	0.000	6.919
Description: Perform research and development (R&D) that will advance existing, or discover new, command and control capabilities to support multi-domain operations (MDO) for air, space, cyberspace, land, sea, and undersea.			
FY 2020 Plans: In FY 2020 and prior, this work is performed under the Multi-Domain Command and Control effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo.			
FY 2021 Plans: Continue to execute experiments, based on operational scenarios, which incorporate process management execution into the extensible Space command and control framework, and which integrate disparate data and applications, providing a pedigree for			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>proposed tasking options to decision makers. Continue to develop software capabilities that employ cyber, directed energy, and electronic warfare weaponry. Continue to provide on-the-fly valuable quantitative evaluations of cyber assets to cyber operators, enabling them to present viable cyber options to commanders in multi-domain settings. Develop tools, technology, and framework for execution management of operational center process workflows and applications.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$6.919 million. Funding increased due to the transfer and realignment of this work from the Multi-Domain Command and Control effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Nuclear C3 Modernization</p> <p>Description: Develop and demonstrate the advancement of existing nuclear capable forces to ensure command, control, and connectivity for the President without constraints.</p> <p>FY 2020 Plans: In FY 2020 and prior, this work is performed under the Nuclear C3 Modernization effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2021 Plans: Continue to perform real-time monitoring of ionospheric conditions over the Continental United States (CONUS). Continue testing of very-low-frequency (VLF) stub antenna for reachback. Continue testing of prototype compact high-frequency (HF) antennas. Enhance communication link availability prediction for better Command, Control, and Communications (C3) planning and simulation. Develop visualization tool for providing common operation picture (COP) to commanders and Nuclear C3 (NC3) operators.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$3.308 million. Funding increased due to the transfer and realignment of this work from the Nuclear C3 Modernization effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	3.308
<p>Title: Artificial Intelligence/Autonomy/Machine Learning</p> <p>Description: Develop and demonstrate to harness the speed and scale of computers and machines to address problems of complexity.</p> <p>FY 2020 Plans:</p>		0.000	0.000	2.597

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>In FY 2020 and prior, this work is performed under the Artificial Intelligence/Autonomy/Machine Learning effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2021 Plans: Continue to operationalize and implement state of the art learning models. Continue to integrate within the StreamlinedML framework. Continue development of model recommendation & user workflow capabilities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$2.597 million. Funding increased due to the transfer and realignment of the work from the Artificial Intelligence/Autonomy/Machine Learning effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Data to Decisions</p> <p>Description: Develop and demonstrate the collection, management, analysis, and exploitation of complex data for availability to Air Force and other stakeholders.</p> <p>FY 2020 Plans: In FY 2020 and prior, this work is performed under the Data to Decisions effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2021 Plans: Continue to refine and test technologies for ultra-wideband electronics intelligence signal detection and prosecution. Continue development and demonstration of intelligence analysis capabilities from multiple intelligence sources for both near-real time and post mission. Continue research and development in data analytics and strategic indications and warnings. Continue to perform service-based capability development. Complete work for object based production optimized processing and automated-association capability.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$4.543 million. Funding increased due to the transfer and realignment of this work from the Data to Decisions effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	4.543
<p>Title: Assured Communications & Networks</p> <p>Description: Develop and demonstrate secure and reliable communications to ensure the delivery of timely, reliable, and actionable information to warfighters and systems.</p> <p>FY 2020 Plans:</p>		0.000	0.000	8.385

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>In FY 2020 and prior, this work is performed under the Assured Communications & Networks effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2021 Plans: Continue development and demonstration for rapid waveform development of multi-mission software defined radio frequency capability. Continue wideband high frequency waveform development and testing. Continue ionospheric research, propagation modeling and simulation. Continue beacon data collection on both the V and W frequency bands along with waveform development and simulation. Continue development of test platform for Common Very Low Frequency Receiver Increment Two.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$8.385 million. Funding increased due to the transfer and realignment of this work from the Assured Communications & Networks effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635321, C4I Battlespace Dev and Demo, as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
<p>Title: Game Changing Computing Power</p> <p>Description: Develop and demonstrate computer architectures with greater capacity and sophistication to enable game-changing computing power to the warfighter anywhere, anytime.</p> <p>FY 2020 Plans: In FY 2020 and prior, this work is performed under the Game Changing Computing Power effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635329, Cyber Battlespace Development and Demonstration.</p> <p>FY 2021 Plans: Continue work to improve software specifications using evolutionary approaches to optimize computer processing. Continue work in the areas of nanotechnology for autonomous systems. Continue work in the area of neuromorphic intelligent computing systems.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$3.449 million. Funding increased due to the transfer and realignment of the non-cyber work from the Game Changing Computing Power effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635329, Cyber Battlespace Development and Demonstration, as part of the Air Force RDT&E BA 03 PE consolidation.</p>	0.000	0.000	3.449
Accomplishments/Planned Programs Subtotals	0.000	0.000	29.201

C. Other Program Funding Summary (\$ in Millions) N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>				Project (Number/Name) 635325 / <i>Mission Effective Performance</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635325: <i>Mission Effective Performance</i>	-	0.000	0.000	7.067	0.000	7.067	7.213	6.356	7.503	7.655	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, demonstrates, and transitions advanced training, simulation, mission rehearsal, and other performance-aiding methods and technologies to enhance warfighter readiness. This project also develops advanced methods and technologies to enable interactive live, virtual, and constructive (LVC) environments for performance-aiding methods and technologies. Focus areas include integrated high-fidelity weapon systems training technologies for air, space, and cyber; tailored immersive simulation environments for airmen at the tactical and operational levels; and incorporation of performance assessment and feedback tools. These methods and technologies facilitate the development of mission-essential competencies.

In FY 2021, the entirety of Project 635325, Mission Effective Performance, is transferred from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 635325, Mission Effective Performance, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Airman Systems Technology Directorate located in Wright-Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Readiness	0.000	0.000	7.067
Description: Develop and demonstrate secure, persistent, and standardized live, virtual, and constructive training enterprise. Utilize modeling capabilities for technology demonstration efforts focused on developing software-based tools for training that would replace human instructors.			
In FY 2021, this effort is renamed from Continuous Learning to Readiness.			
FY 2020 Plans: In FY 2020 and prior, this work is performed under the Continuous Learning effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635325, Mission Effective Performance.			
FY 2021 Plans: Complete initial development of proficiency-based training metrics and assessments in operational contexts. Continue multi-domain operations training development and demonstration. Continue field evaluations for performance-based after action review visualization tools in unit-level and Red Flag-Level training and rehearsal. Continue assessments and evaluations of common range and simulation architecture technologies for Live, Virtual, and Constructive training capabilities. Complete portfolio migration			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 635325 / <i>Mission Effective Performance</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
focused on advanced research and transitions under a Readiness product line construct with emphases on standards for training and operational data, tools for rapid development of mission-focused software agent applications. Continue to develop realistic in contested degraded operations environment for multi- domain operations training and rehearsal.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$7.067 million. Funding increased due to the transfer and realignment of this work from the Continuous Learning effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635325, Mission Effective Performance, as part of the Air Force RDT&E BA03 PE Consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	7.067

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>				Project (Number/Name) 635327 / <i>Warfighter Interfaces</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635327: <i>Warfighter Interfaces</i>	-	0.000	0.000	13.881	0.000	13.881	13.308	13.621	16.443	16.778	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, demonstrates, and readies the transition of technologies to revolutionize the way airmen optimize the capabilities of Air Force systems, including autonomous machines and adaptive teams of Airmen and machines. Improvements in the presentation of operational information to the community of users, from the system operator to the commander, must be developed in step with advancements in the acquisition, storage, and retrieval of information. This project provides the advances in understanding of human cognitive abilities, as well as the utilization of human interfaces, multisensory fusion, high-resolution image displays, and three-dimensional (3D) audio to customize communications and enhance shared understanding across a diverse user community in air, space, and cyber for maximum situational awareness.

In FY 2021, Project 635327, Warfighter Interfaces, non-Vanguard efforts and activities is transferred from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 635327, Warfighter Interfaces, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. The Project and associated non-Vanguard efforts and activities will continue to be executed by the Air Force Research Laboratory Airman Systems Technology Directorate located in Wright-Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Airman Machine Interfaces	0.000	0.000	4.881
Description: Develops and demonstrates wearable technologies and operator-centric interfaces that increase the Airman's combat capabilities. This is accomplished through integrated solutions that develop synergies, maximize battlespace interoperability, and increase combat power while decreasing Airman physical and cognitive workloads.			
In FY 2021, this effort is renamed from Battlespace Acoustics to Airman Machine Interfaces.			
FY 2020 Plans: In FY 2020 and prior, this work is performed under the Battlespace Acoustics effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635327, Warfighter Interfaces.			
FY 2021 Plans: Prepare for transition of advanced wearable technologies improving situation awareness and enhancing communication effectiveness for dismounted operators. Develop and demonstrate manned-unmanned pilot vehicle interface mission intents			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 635327 / <i>Warfighter Interfaces</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>and team concepts for tactical environments. Develop team collaborative interfaces focusing on cognitive workload reduction. Prototype innovative man-wearable interfaces tailored to Special Warfare operations.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$4.881 million. Funding increased due to the transfer and realignment of this work from the Battlespace Acoustics effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635327, Warfighter Interfaces, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Analytic Tools</p> <p>Description: Develops, demonstrates, and matures software solutions for Command and Control, Intelligence Surveillance & Reconnaissance, Space, and Cyber customers for improved system performance (operator/analyst and software). Software ranges from simplistic decision support systems to sophisticated artificial intelligence and machine learning algorithms designed to handle data at the scale of operations. Heavy emphasis is placed on human-machine teaming including workflow design and integration of both automated and human-generated results. Effort leverages significant infrastructure in big-data design and capture, allowing for rapid prototyping of capabilities directly to web-based platforms on classified environments. Program directly supports contested-denied operations in a multi-domain environment.</p> <p>In FY 2021, this effort is renamed from Human Role in Semiautonomous Systems to Analytic Tools.</p> <p>FY 2020 Plans: In FY 2020 and prior, this work is performed under the Human Role in Semiautonomous Systems effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635327, Warfighter Interfaces.</p> <p>FY 2021 Plans: Prepare to transition speech-to-text technologies for military intelligence producing systems. Enhance and prepare for transition Electronic Order of Battle tools for multiple theaters of operation. Test and host open source speech-to-text methods on multiple networks. Enhance automated speed of detections for national imagery exploitation. Perform technical demonstrations at exercises supporting United States Pacific Command and United States European Command.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$9.000 million. Funding increased due to the transfer and realignment of this work from the Human Role in Semiautonomous Systems effort in PE 0603456F, Human Effectiveness Advanced Technology Development, Project 635327, Warfighter Interfaces, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	9.000
Accomplishments/Planned Programs Subtotals		0.000	0.000	13.881

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 635327 / <i>Warfighter Interfaces</i>

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>				Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63665A: <i>Advanced Aerospace Sensors Technology</i>	-	0.000	0.000	19.471	0.000	19.471	21.750	21.963	22.402	22.857	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project area develops and demonstrates aerospace sensor and processing technologies for intelligence, surveillance, reconnaissance, target, and attack radar applications in both manned and unmanned platforms, including electro-optical sensors and electronic counter-countermeasures for radars. It provides aerospace platforms with the capability to precisely detect, track, and target both airborne (conventional and low radar cross-section) and ground-based, high-value, time-critical targets in adverse clutter and jamming environments. Project activities include developing multi-function radio-frequency systems including radar and electronic warfare technology and the position and timing information to enable distributed sensing. Desired warfighting capabilities include the ability to detect concealed targets in difficult background conditions.

In FY 2021, the entirety of Project 63665A, Advanced Aerospace Sensors Technology is transferred from PE 0603203F, Advanced Aerospace Sensors, to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and AF Science and Technology Strategy, April 2019. This work will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located at Wright Patterson Air Base, Ohio. This is a administrative realignment, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Persistent Sensing in Contested Environment Technologies	0.000	0.000	2.903
Description: Develop active radio frequency sensor solutions to use against difficult-to-detect targets in challenging environments, and advanced radio frequency architectures for open and reconfigurable systems. Enable persistent intelligence, surveillance and reconnaissance over wide areas, and detect advanced air and ground targets.			
FY 2020 Plans: For FY 2020 and prior, this work is performed under the Persistent Sensing in Contested Environment Technologies effort in PE 0603203F, Advanced Aerospace Sensors, Project 63665A, Advanced Aerospace Sensors Technology.			
FY 2021 Plans: Analyze results of airborne ground moving target indication data collections. Continue advanced multi-static ground moving target indication radar demonstration, increasing complexity with additional transmit degrees of freedom from multiple transmit platforms. Continue analysis of asynchronous noise waveform performance with multiple transmitters. Initiate evaluation of space-time adaptive processing algorithm performance using synthetic and real flight data. Initiate investigation of novel algorithms			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
with processing distributed across multiple receive platforms. Initiate system-of-systems design to optimize transmit/receive architecture.				
<p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increase compared to FY2020 by \$2.903 million. Funding increased due to the transfer and realignment of this work from the Persistent Sensing in Contested Environment Technologies effort in PE 0603203F, Advanced Aerospace Sensors, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Passive Radio Frequency Sensing Technologies</p> <p>Description: Develop advanced techniques and prototype passive radio frequency sensors to intercept, collect, locate and track enemy radio frequency sensor systems for intelligence, surveillance and reconnaissance of air and ground targets.</p> <p>FY 2020 Plans: For FY 2020 and prior, this work is performed under the Passive Radio Frequency Sensing Technologies effort in PE 0603203F, Advanced Aerospace Sensors, Project 63665A, Advanced Aerospace Sensors Technology.</p> <p>FY 2021 Plans: Conduct real-time passive radar illumination selection manager demonstrations using realistic operational environments. Conduct development of advanced passive radar modes and signal processing algorithms. Initiate advancement of electronic support subsystems to incorporate wide bandwidth receivers and agile emitter tracking. Initiate implementation of passive radar modes using wideband arrays with rapid digital beamforming capabilities. Initiate integration of electronic support, illumination selection manager, and passive radar subsystems to develop full passive multi-mode radar system for future ground/airborne demonstration.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increase compared to FY2020 by \$5.801 million. Funding increased due to due to the transfer and realignment of this work from the Passive Radio Frequency Sensing Technologies effort in PE 0603203F, Advanced Aerospace Sensors, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	5.801
<p>Title: Long Range Sensing Technologies</p> <p>Description: Develop radio frequency sensor technology to detect, locate, and identify air and ground targets at long ranges, including those that are low-observable, or use deception or camouflage.</p> <p>FY 2020 Plans:</p>		0.000	0.000	2.785

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>For FY 2020 and prior, this work is performed under the Long Range Sensing Technologies effort in PE 0603203F, Advanced Aerospace Sensors, Project 63665A, Advanced Aerospace Sensors Technology.</p> <p>FY 2021 Plans: Initiate analysis of over-the-horizon radar data collections to demonstrate novel algorithms for detection and high accuracy tracking of highly maneuvering targets. Conduct development of passive over-the-horizon radar systems to provide predicted performance against challenging targets including cruise missiles and hypersonic vehicles. Conduct development of low cost radio frequency payloads for small satellites. Initiate detailed component design and prototype payload fabrication.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY2020 by \$2.785 million. Funding increased due to the transfer and realignment of this work from the Long Range Sensing Technologies effort in PE 0603203F, Advanced Aerospace Sensors, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Triple Raven Advanced Technology Demonstration</p> <p>Description: Advance, demonstrate, and transition innovative imaging and non-imaging optical sensing technologies for surveillance and reconnaissance of airborne and ground-based objects of interest in an anti-access/area denial environment. This effort includes the development of systems, subsystems, and components necessary to yield new capabilities.</p> <p>FY 2020 Plans: For FY 2020 and prior, this work is performed under the Laser Radar for Non-Cooperative Identification effort and the Passive Electro-Optical Sensing for Surveillance and Reconnaissance Technologies effort in PE 0603203F, Advanced Aerospace Sensors, Project 63665A, Advanced Aerospace Sensors Technology,</p> <p>FY 2021 Plans: Begin integration of dual-band detector system onto the new unobscured freeform afocal telescope and begin integration into a stable optical gimbal in preparation for flight testing. Perform sensor trade studies to extend dual-band extended range imaging to provide full multi-spectral imaging capabilities - equivalent to today's multi-camera systems. Develop high power agile waveform laser, processing algorithms, and photon-counting detectors. Conduct a bread-board demonstration of the laser radar system on a laboratory-class aircraft at short ranges to allow early risk-reduction of entire system.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY2020 by \$7.982 million. Funding increased due to the transfer and realignment of this work from the Laser Radar for Non-Cooperative Identification effort and Passive Electro-Optical Sensing for Surveillance and</p>		0.000	0.000	7.982

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Reconnaissance Technologies effort in PE 0603203F, Advanced Aerospace Sensors, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	19.471

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>				Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
6369DF: <i>Target Attack and Recognition Technology</i>	-	0.000	0.000	15.867	0.000	15.867	19.230	19.103	18.985	19.371	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project area develops and demonstrates advanced technologies for closed-loop, multi-domain, multi-intelligence sources, multi-platform, multi-sensor automation and autonomy, providing capabilities in battle management, fire control, battlespace awareness and visualization, predictive analytics, target recognition, sensor and information fusion, and sensor / platform asset tasking. This project also conducts advanced investigations to determine solution credibility, in terms of underlying technology and in terms of consistency with future Air Force missions within highly contested environments. This project includes robust techniques to support intelligence, surveillance, and reconnaissance and targeting missions within adverse weather conditions and against adversaries employing deceptive techniques. This project includes development of software-intensive solutions suitable for cloud-based integration and for development/operations-like operational environments. This project develops technology for effective management of online and offline information sources incorporating both constrained and cooperative sensing. In FY 2020, this project was realigned to better reflect technical areas being emphasized such as autonomy, multi-domain and multi-sensor information processing, leverage of machine learning developments and enterprise-level modeling, simulation and analysis.

In FY 2021, the entirety of Project 6369DF, Target Attack and Recognition Technology, is transferred from PE 0603203F, Advanced Aerospace Sensors, to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 6369DF, Target Attack and Recognition Technology, as part of the Air Force RDT&E BA03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and AF Science and Technology Strategy, April 2019. This work will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located at Wright Patterson Air Base, Ohio. This is a administrative realignment, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Multi-INT Analytics Development	0.000	0.000	15.867
Description: Develop advanced techniques for multi-domain closed-loop sensing that apply predictive analytics to available information, inferring candidate course-of-action hypotheses and recommending confirmatory/refutative sensing tasks.			
FY 2020 Plans: For FY 2020 and prior, this work is performed under the Advanced Multi-Source Exploitation effort and the Sensing Assignments and Multisource Analytics effort in PE 0603203F, Advanced Aerospace Sensors, Project 6369DF, Target Attack and Recognition Technology.			
FY 2021 Plans: Develop improvements over state-of-the-art analytics with automated multi-sensor fusion and predictive analytics, Pattern of Life (PoL) modeling and persistent monitoring, and graph-based World Model representation. Mature techniques for persistent and			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603034F / <i>Persistent Knowledge, Awareness, & C2 Tech</i>	Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>immediate observation of anomalous behavior. Continue creation of a government owned testbed and user system with closed-loop reasoning and modular, well-characterized algorithms. Continue development of the World Model representation to improve the current intelligence data/analysis "stovepipes," for deeper analytics.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY2020 by \$15.867 million. Funding increased due to the transfer and realignment of this work from the Advanced Multi-Source Exploitation effort and Sensing Assignments and Multisource Analytics effort in PE 0603203F, Advanced Aerospace Sensors, Project 6369DF, Target Attack and Recognition Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
Accomplishments/Planned Programs Subtotals	0.000	0.000	15.867

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force / BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0603035F / Next Gen Effects Dev/Demos
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	0.000	0.000	215.817	0.000	215.817	304.525	307.975	319.596	338.993	Continuing	Continuing
633151: High Power Solid State Laser Technology	-	0.000	0.000	13.036	0.000	13.036	13.355	8.478	14.366	18.691	Continuing	Continuing
633152: High Power Microwave Development and Integration	-	0.000	0.000	18.409	0.000	18.409	17.966	19.283	20.114	20.103	Continuing	Continuing
633720: EW Quick Reaction Capabilities	-	0.000	0.000	20.960	0.000	20.960	19.259	19.446	20.171	20.736	Continuing	Continuing
63431G: RF Warning & Countermeasures Tech	-	0.000	0.000	6.775	0.000	6.775	9.622	9.967	11.781	12.021	Continuing	Continuing
635329: Cyber Battlespace Dev & Demo	-	0.000	0.000	19.020	0.000	19.020	23.474	24.138	24.787	25.290	Continuing	Continuing
63670A: Weapon Technology Development	-	0.000	0.000	51.814	0.000	51.814	74.854	76.343	77.871	79.453	Continuing	Continuing
63670B: Weapon Concept Development	-	0.000	0.000	82.331	0.000	82.331	141.408	145.708	145.802	157.899	Continuing	Continuing
63691X: EO/IR Warning & Countermeasures Tech	-	0.000	0.000	3.472	0.000	3.472	4.587	4.612	4.704	4.800	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and conducts both kinetic and non-kinetic technology demonstrations to advance warfighter capabilities. The technologies address enabling and enduring Air Force requirements as well as integrated enterprise transformational capabilities intended to reshape the future force. This project includes conventional weapons and component technologies; directed energy weapon technologies; electronic combat technologies; cyber-attack, cyber defense, and cyber support technologies; and development of corresponding susceptibility, vulnerability, and lethality databases. The transformational integrated technology demonstrations will utilize cross-discipline modeling and simulation to demonstrate capabilities in a near-operational environment. Using modeling and simulation, this project seeks to determine advanced science and technology capabilities which reduce operational risk and accelerate transition into existing and future operational systems.

Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T)

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/Demos</i>	
<p>Strategy signed by the Secretary of the Air Force in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.</p> <p>In FY 2021, the entirety of PE 0603605F, Advanced Weapons Technology, and associated Projects 633151, High Power Solid State Laser Technology and 633152, High Power Microwave Technology, are transferred to PE 0603035F, Next Gen Effects Dev/Demos.</p> <p>In FY 2021, the entirety of Project 635329, Cyber Battlespace Dev & Demo, is transferred from PE 0603788F, Battlespace Knowledge Development and Demonstration, to PE 0603035F, Next Gen Effects Dev/Demos.</p> <p>In FY 2021, the entirety of Project 63431G, RF Warning & Countermeasures Tech, is transferred from PE 0603270F, Electronic Combat Technology, to PE 0603035F, Next Gen Effects Dev/Demos, with the exception of the work and funding that is associated with the Navigation Technology Satellite-3 Vanguard demonstration.</p> <p>In FY 2021, the entirety of Project 633720, EW Quick Reaction Capabilities, and Project 63691X, EO/IR Warning & Countermeasures Tech, are transferred from PE 0603270F, Electronic Combat Technology, to PE 0603035F, Next Gen Effects Dev/Demos.</p> <p>In FY 2021, the entirety of Project 63670A, Weapon Technology Development, is transferred from PE 0603601F, Conventional Weapons Technology, to PE 0603035F, Next Gen Effects Dev/Demos.</p> <p>In FY 2021, the entirety of Project 63670B, Weapon Concept Development, is transferred from PE 0603601F, Conventional Weapons Technology, to PE 0603035F, Next Gen Effects Dev/Demos, with the exception of the work and funding that is associated with the Golden Horde Vanguard demonstration.</p> <p>These transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment, and not a new start.</p> <p>The Air Force Science and Technology portfolio will continued to be managed at the Enterprise level by the Air Force Technology Executive Officer, dual-hatted as the Air Force Research Laboratory (AFRL) Commander, and executed across the various AFRL Technology Directorates and locations.</p> <p>This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.</p> <p>This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.</p>		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/Demos</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	215.817	0.000	215.817
Total Adjustments	0.000	0.000	215.817	0.000	215.817
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	215.817	0.000	215.817

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 63670A: *Weapon Technology Development*

Congressional Add: *Program increase - rotary launcher development*

Congressional Add Subtotals for Project: 63670A

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	0.000	0.000
	0.000	0.000
	0.000	0.000

Change Summary Explanation

Increase in FY 2021 of \$215.817 million is due to the following PEs, Projects, and efforts being transferred to PE 0603035F, Next Gen Effects Dev/Demos:

- 1) Entirety of PE 0603605F, Advanced Weapons Technology, and associated Projects 633151, High Power Solid State Laser Technology and 633152, High Power Microwave Technology
- 2) Entirety of Project 635329, Cyber Battlespace Dev & Demo, from PE 0603788F, Battlespace Knowledge Development and Demonstration
- 3) Entirety of Project 63431G, RF Warning & Countermeasures Tech, from PE 0603270F, Electronic Combat Technology, with the exception of the work and funding that is associated with the Navigation Technology Satellite-3 Vanguard demonstration.
- 4) Entirety of Project 633720, EW Quick Reaction Capabilities, and Project 63691X, EO/IR Warning & Countermeasures Tech, from PE 0603270F, Electronic Combat Technology
- 5) Entirety of Project 63670A, Weapon Technology Development, from PE 0603601F, Conventional Weapons Technology.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603035F / <i>Next Gen Effects Dev/Demos</i>

6) Entirety of Project 63670B, Weapon Concept Development, from PE 0603601F, Conventional Weapons Technology, with the exception of the work and funding that is associated with the Golden Horde Vanguard demonstration.

These transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603035F / Next Gen Effects Dev/ Demos				Project (Number/Name) 633151 / High Power Solid State Laser Technology			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633151: High Power Solid State Laser Technology	-	0.000	0.000	13.036	0.000	13.036	13.355	8.478	14.366	18.691	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project provides for the development, integration, demonstration, and detailed technical assessment of high energy laser devices, advanced imaging and beam control technologies needed for applications such as force protection, force application, precision engagement, and aircraft self-protection. Laser system concept assessments to include vulnerability assessments and target effect testing are performed. This project also exploits the synergy between high energy laser beam control and advanced optical imaging for space situational awareness.

In FY 2021, the entirety of Project 633151, High Power Solid State Laser Technology is transferred from PE 0603605F, Advanced Weapons Technology to PE 0603035F, Next Gen Effects Dev/Demos, Project 633151, High Power Solid State Laser Technology, as part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Operating Concept and AF Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Directed Energy Technology Directorate located in Kirtland Air Force Base, New Mexico. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Energy Laser/Beam Control	0.000	0.000	13.036
Description: Develop and demonstrate advanced beam control technologies, integrated laser systems, and aircraft self-protection laser technologies. Demonstrate beam control components integrated with high energy lasers for Air Force utility.			
FY 2020 Plans: For FY 2020 and prior, the work is performed under High Energy Laser/Beam Control effort in PE 0603605F, Advanced Weapons Technology, Project 633151, High Power Solid State Laser Technology.			
FY 2021 Plans: Complete system integration of 50 kilo-Watt high power podded laser system for flight demonstration. Complete high power ground test for podded 50 kilo-Watt laser system. Begin preparations for high power flight test.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$13.036 million. Funding increased due to transfer and realignment of this work from the High Energy Laser/Beam Control effort from PE 0603605F, Advanced Weapons Technology, Project 633151, High Power Solid State Laser Technology, as part of the Air Force RDT&E BA 03 PE Consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	13.036

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 633151 / <i>High Power Solid State Laser Technology</i>

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603035F / Next Gen Effects Dev/ Demos				Project (Number/Name) 633152 / High Power Microwave Development and Integration			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633152: High Power Microwave Development and Integration	-	0.000	0.000	18.409	0.000	18.409	17.966	19.283	20.114	20.103	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates high power microwave and other unconventional electromagnetic field generation and transmission technologies that can be integrated into future weapon systems to support a wide range of Air Force missions such as air base defense or the damage/destruction of an adversary's electronic infrastructure. It also provides inputs to the susceptibility, vulnerability, and lethality databases used across the Department of Defense to understand thresholds for scalable effects of directed energy weapons.

In FY 2021, the entirety of Project 633152, High Power Microwave Development and Integration, is transferred from PE 0603605F, Advanced Weapons Technology, to PE 0603035F, Next Gen Effects Dev/Demos, Project 633152, High Power Microwave Development and Integration, as part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Operating Concept and AF Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Directed Energy Technology Directorate located in Kirtland Air Force Base, New Mexico. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Power Microwave Technologies	0.000	0.000	18.409
Description: Develop and evaluate high power microwave and other unconventional weapon technologies for various platforms, including aerial, for applications such as counter-electronics. Develop and evaluate high power microwave technologies for non-kinetic and counter-electronic weapon applications.			
FY 2020 Plans: For FY 2020 and prior, this work is performed under the High Power Microwave Technologies effort in PE 0603605F, Advanced Weapons Technology, Project 633152, High Power Microwave Development and Integration.			
FY 2021 Plans: Downselect to an advance reuseable platform. Initiate high power microwave payload integration. Continue to characterize, model, test and evaluate current and projected blue directed energy threats on current red assets. Integrate the high power microwave payload into the aerial platform for the joint flight demonstration with the Navy. Design agile waveform high power sources.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 633152 / <i>High Power Microwave Development and Integration</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$18.409 million. Funding increased due to to transfer and realignment of this work from the High Power Microwave Technologies effort in PE 0603605F, Advanced Weapons Technology, Project 633151, High Power Microwave Technology.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	18.409

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / Next Gen Effects Dev/ Demos	Project (Number/Name) 633720 / EW Quick Reaction Capabilities
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633720: EW Quick Reaction Capabilities	-	0.000	0.000	20.960	0.000	20.960	19.259	19.446	20.171	20.736	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project establishes a capability to rapidly assess, develop and demonstrate new electronic warfare concepts, techniques, and capabilities as well as the required position navigation and timing technologies and capabilities in the context of systemic electronic warfare effects in a congested/contested electromagnetic spectrum, system-of-systems environment of the future. It develops disruptive electronic warfare and countermeasures concepts specifically selected for high-impact, game-changing effects; evaluates them in high fidelity virtual and hardware evaluation settings; and demonstrates them in an operationally relevant environment. It establishes and maintains an all-source, physics-based, threat-to-countermeasures electronic warfare systems engineering methodology. It develops a core analytic function, supported by simulation-based wargaming and interactive engineering modeling capabilities to evaluate advanced countermeasures concepts.

In FY 2021, the entirety of Project 633720, EW Quick Reaction Capabilities, from PE 0603270F, Electronic Combat Technology, is transferred to PE 0603035F, Next Gen Effects Dev/Demos, Project 633720, EW Quick Reaction Capabilities, as part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Operating Concept and AF Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Radio Frequency Electronic Warfare</p> <p>Description: Develop electronic warfare focused knowledge databases, engineering models, mission simulations, analysis tools, and assessment environments enabling the development of multi-domain electronic warfare technologies. The primary focus is on emulating complex battlespace radio frequency environments, electronic attack effects against emerging, networked weapon systems, and assessing flexible, software-defined electronic warfare systems with non-deterministic performance such as utilizing cognitive algorithms.</p> <p>FY 2020 Plans: For FY 2020 and prior, this work is performed under Radio Frequency Electronic Warfare effort in PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities.</p> <p>FY 2021 Plans: Continue expansion of simulations to accommodate advanced electronic warfare systems and emulate the complex radio frequency threats and signals environment. Begin implementation of advanced digital signal synthesis to better represent complex emitters operating in complex environments containing sophisticated background emitters. Continue development</p>	0.000	0.000	9.520

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 633720 / <i>EW Quick Reaction Capabilities</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>of higher fidelity threat system and signal propagation models. Continue developing the tools, methods and demonstrations to assess both the performance of future electronic warfare systems as well as their effectiveness including cognitive and autonomous technologies. Continue the development and demonstration efforts to prove the concepts for full spectrum countermeasures capabilities. Continue expansion of software-in-the-loop and hardware-in-the-loop environments to achieve closed-loop system performance.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$9.520 Million. Funding increased due to the transfer and realignment of this work from the Radio Frequency Electronic Warfare effort in PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities, as part of the Air Force RDT&E BA 03 PE Consolidation.</p>				
<p>Title: Position, Navigation and Timing for Contested/Denied Environments</p> <p>Description: Develop and transition robust Global Navigation Satellite System capabilities; resilient complementary position, navigation and timing techniques; precise position, navigation and timing technologies for distributed sensing/effects; position, navigation and timing technology to provide position, navigation and timing electronic warfare situational awareness and training; and position, navigation and timing architectures to enable resiliency against the rapidly evolving threat. Efforts will include prototypes and relevant Open Architecture standards where applicable to enable timely technology transition.</p> <p>FY 2020 Plans: For FY 2020, this work is performed under the Position, Navigation and Timing for Contested/Denied Environments effort in PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities.</p> <p>FY 2021 Plans: Continue to further research techniques to securely certify Global Navigation Satellite System software defined radio technology and methods to trust Global Navigation Satellite Systems. Complete advanced reconfigurable software defined radio navigation receivers to enable spectrum agile systems and integration as the user equipment component to the Navigation Technology Satellite-3 flight experimentation. Continue to develop alternative/complementary position, navigation and timing techniques which increase the availability of the position, navigation and timing solution and support creation of an integrated position, navigation and timing solution focused on increasing the precision needed to support novel radio frequency coherent sensing and electronic warfare techniques. Continue to define and refine navigational open architecture standards to allow for integration of Global Navigation Satellite System and alternative/complementary position, navigation and timing approaches into future systems. Demonstrate integration of improved Global Navigation Satellite System position, navigation and timing and alternative position, navigation and timing solutions into an advanced resilient embedded Global Positioning System-inertial government reference architecture.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		0.000	0.000	9.663

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 633720 / <i>EW Quick Reaction Capabilities</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$9.663 Million. Funding increased due to the transfer and realignment of this work from the Position, Navigation and Timing for Contested/Denied Environments effort in PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities, as part of the Air Force RDT&E BA 03 PE consolidation.				
Title: Electro-Optical/Infrared Threat Warning and Countermeasures		0.000	0.000	1.777
Description: Develop next-generation countermeasure techniques to address the complete range of multispectral threats including advanced techniques versus advanced man portable air defense system and air-to-air threats with multimode capabilities. Develop capabilities for situational awareness and countermeasure to integrated air defense systems and associated multispectral threats.				
FY 2020 Plans: For FY 2020, this work is performed under the Electro-Optical/Infrared Threat Warning and Countermeasures effort in PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities.				
FY 2021 Plans: Apply analysis from field test to develop requirements for proactive detection and situation awareness for multiple Air Force platforms. Iterate and refresh techniques for in-house at range data collection capabilities. Perform test against real threats at significant range. Continue to evaluate acquisition alternatives for a proactive advanced technology demonstration. Continue efforts to develop multispectrum electro-optical/radio frequency countermeasures and insert capabilities into existing engagement modeling and simulation tools.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.777 Million. Funding increased due to transfer and realignment of this work from the Electro-Optical/Infrared Threat Warning and Countermeasures effort in PE 0603270F, Electronic Combat Technology, Project 633720, EW Quick Reaction Capabilities, as part of the Air Force RDT&E BA03 PE consolidation.				
Accomplishments/Planned Programs Subtotals		0.000	0.000	20.960
C. Other Program Funding Summary (\$ in Millions) N/A				
Remarks				
D. Acquisition Strategy N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>				Project (Number/Name) 63431G / <i>RF Warning & Countermeasures Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63431G: <i>RF Warning & Countermeasures Tech</i>	-	0.000	0.000	6.775	0.000	6.775	9.622	9.967	11.781	12.021	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced technologies for radio frequency electronic combat suites, including the required navigation technologies and capabilities, to enhance the survivability of aerospace vehicles and to provide crew situational awareness. The research addresses technologies for missile/threat warning, radio frequency receivers, electronic combat pre-processors, advanced sorting/pre-processing algorithms, and expert software for applications on existing and future electronic combat systems. The research also focuses on the development and demonstration of subsystems and components for generating on-board/off-board radio frequency countermeasure techniques. This includes the development of electronic countermeasures techniques, as well as advanced electronic countermeasures technologies such as antennas, power amplifiers, and preamplifiers.

In FY 2021, Project 63431G, RF Warning & Countermeasures Tech, is transferred from PE 0603270F, Electronic Combat Technology, to PE 0603035F, Next Gen Effects Dev/Demos, Project 63431G, RF Warning & Countermeasures Tech with the exception of the work and funding that is associated with the Navigation Technology Satellite-3 Vanguard demonstration which will be realigned to PE 0603032F, Future Air Force Integrated Tech Demos, Project 630320, Air Force Vanguard. These transfers are part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Operating Concept and AF Science and Technology Strategy, April 2019. The Project and non-Vanguard associated efforts will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Electronic Attack	0.000	0.000	6.775
Description: Develop aerospace platform jamming concepts, technologies and techniques to counter advanced radio frequency threats associated with current and future aerospace weapon systems. Provide position, navigation and system resilience via open architecture solutions.			
FY 2020 Plans: For FY 2020 and prior, this work is performed under the Electronic Attack effort in PE 0603270F, Electronic Combat Technology, Project 633720, RF Warning & Countermeasures Tech.			
FY 2021 Plans: Continue research into radio frequency receiver technologies enhancing the ability to detect threats, measure increased radio frequency features with greater accuracy, identify or classify signals more reliably, track and predict signals, use reasoning algorithms to reduce ambiguities and errors, and deduce greater knowledge from the radio frequency spectrum. Conduct			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 63431G / <i>RF Warning & Countermeasures Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>technology demonstrations to support transition into Air Force platforms. Continue expansion of modeling, simulation and laboratory assessment environments commensurate with technologies being researched, developed and tested including cognitive and autonomous electronic warfare technologies. Start the implementation of emerging electronic attack and electronic support capabilities into open architectures. Demonstrate the capability to rapidly respond to new and unexpected threats in realistic environments.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$6.775 million. Funding increased due to transfer and realignment of this work from the Electronic Attack effort in PE 0603270F, Electronic Combat Technology, Project 633720, RF Warning & Countermeasures Tech, as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
Accomplishments/Planned Programs Subtotals	0.000	0.000	6.775

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>				Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635329: <i>Cyber Battlespace Dev & Demo</i>	-	0.000	0.000	19.020	0.000	19.020	23.474	24.138	24.787	25.290	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force requires the ability to deliver sovereign options in cyberspace through the development and integration of cyber-attack, cyber defense, and cyber support technologies for a strategic capability of cyber dominance. This project develops the ability to deliver cyber-attack capabilities (access, stealth, persistence, intelligence, and weapons delivery), cyber defense capabilities (attack detection, attack attribution, and response automation) and cyber support capabilities (situation awareness and war gaming). This project will also develop 1) a science and engineering capability demonstrating new models of computation, 2) novel approaches for high performance, interactive, net-centric, distributed and embedded computing systems, and 3) the technological tools enabling affordable, large-scale, and complex software-intensive systems.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on cyber technologies in support of multi-domain command and control.

In FY 2021, the entirety of Project 635329, Cyber Battlespace Dev & Demo, is transferred from PE 0603788F, Battlespace Knowledge Development and Demonstration, to PE 0603035F, Next Gen Effects Dev/Demos, Project 635329, Cyber Battlespace Dev & Demo, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Information Technology Directorate located in Rome, New York. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Resiliency	0.000	0.000	7.485
Description: Integrate and demonstrate a resilient and self-generating information enterprise that dynamically recognizes, characterizes, and understands novel cyber attacks, and then reconfigures and self-optimizes to resist new attacks.			
FY 2020 Plans: For FY 2020 and prior, this work is performed under the Resiliency effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635329, Cyber Battlespace Dev & Demo.			
FY 2021 Plans: Continue to develop and evolve software capabilities and concept of operations for active guidance and automated processes addressing cyber resiliency and survivability. Continue to advance capability migration to form factors which more readily align			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>with operational systems. Continue to demonstrate automated cyber survivability using integrated cyber technologies within the operational system laboratory in the context of risk management framework requirements. Continue development of an advanced secure processor hardware capability. Develop processor-agnostic sub-system for golden-image storage, verification, and re-flashing.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$7.485 million. Funding increased due to the transfer and realignment of this work from the Resiliency effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635329, Cyber Battlespace Dev & Demo, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Autonomous, Multi-level Access and Transfer</p> <p>Description: Develop autonomous, secure information access and sharing capabilities required by the Air Force net-centric information enterprise.</p> <p>FY 2020 Plans: For FY 2020 and prior, this work is performed under the Autonomous, Multi-level Access and Transfer effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635329, Cyber Battlespace Dev & Demo.</p> <p>FY 2021 Plans: Continue to develop and integrate polyglot file identification filters to mitigate data exfiltration risks. Continue to sustain development of a modularized filter store to maximize filter re-usability and increase the agility of cross-domain solutions to support new file types.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$1.042 million. Funding increased due to the transfer and realignment of this work from the Autonomous, Multi-level Access and Transfer effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635329, Cyber Battlespace Dev & Demo, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	0.000	1.042
<p>Title: Cyber Power Projection</p> <p>Description: Develop and demonstrate offensive cyber capabilities in contested environments through a series of experiments and exercises.</p> <p>FY 2020 Plans: For FY 2020 and prior, this work is performed under the Cyber Power Projection effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635329, Cyber Battlespace Dev & Demo.</p> <p>FY 2021 Plans:</p>		0.000	0.000	10.493

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Continue the development of systems to identify items of interest associated with the Internet of Things. Continue to advance the development of a counter small unmanned aerial system open architecture specification to enable interoperability between disparate protection systems. Develop processor-agnostic sub-system for golden-image storage, verification, and re-flashing. Continue to integrate and transition multiple Air Force Research Laboratory and Air Force Lifecycle Management Center counter small unmanned aerial system capabilities. Continue to develop a capability to enable the warfighter access into congested environments as directed by warfighter requirements. Research multiple-input, multiple-output state matrices to detect physical changes in base electromagnetic environments to monitor large areas using passive techniques for detection of commercial-off-the-shelf small unmanned aerial systems.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$10.493 million. Funding increased due to the transfer and realignment of this work from the Cyber Power Projection effort in PE 0603788F, Battlespace Knowledge Development and Demonstration, Project 635329, Cyber Battlespace Dev & Demo, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	19.020

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603035F / Next Gen Effects Dev/ Demos				Project (Number/Name) 63670A / Weapon Technology Development			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63670A: <i>Weapon Technology Development</i>	-	0.000	0.000	51.814	0.000	51.814	74.854	76.343	77.871	79.453	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, matures, assesses, and demonstrates advanced/innovative ordnance and guidance component and subsystem technologies for air-launched conventional weapons. The project focuses on maturation of advanced explosives, fuzes, warheads, sub-munitions, and weapon airframes, carriage and dispensing. Additionally, this project develops innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation.

In FY 2021, the entirety of Project 63670A, Weapon Technology Development, is transferred from PE 0603601F, Conventional Weapons Technology, to PE 0603035F, Next Gen Effects Dev/Demos, Project 63670A, Weapon Technology Development, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Munitions Technology Directorate located in Eglin Air Force Base, Florida. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Ordnance Technologies	0.000	0.000	27.082
Description: Develop and demonstrate integrated ordnance technologies to improve conventional air-delivered munitions. Specific technical areas of focus include energetic materials, fuze technology, warhead sciences, and modeling and simulation tools.			
FY 2020 Plans: For FY 2020 and prior, this work is performed under the Ordnance Technologies effort in PE 0603601F, Conventional Weapons Technology, Project 63670A, Weapon Technology Development.			
FY 2021 Plans: Complete joint technology demonstration for dialable effects technologies. Continue to demonstrate distributed, embedded fuzing concepts for close-controlled strike, area attack, and penetration applications such as layer counting at high speed, including assessing long-term safety, survivability, and functionality. Continue development of ordnance technologies to allow tailored lethality by controlling weapon fragmentation. Continue to mature ordnance technologies for rapid transition into high-speed strike weapon concepts, collecting complex arena test data for implementation into lethality modeling and simulation tools. Continue to develop test capabilities and high-fidelity analysis tools to generate more accurate, faster-running weaponing data. Continue to develop ordnance technologies/methodologies for high-speed impact and functional defeat. Continue research into armament systems for Special Operations applications. Continue to conduct lethality analyses for weapons and improve lethality and			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 63670A / <i>Weapon Technology Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>survivability tools at the meso-scale and micro-scale. Continue to mature research on distributed, collaborative, cooperative effects munition technologies. Continue the development of high-fidelity test capabilities and analysis tools to evaluate ordnance technologies in relevant environments. Continue incorporation of previously developed material models and improve/advance additional joint kinetic/directed energy common target models. Continue synthesis and incorporation of warhead models for progressive collapse, multiple point initiation, secondary debris and others.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$27.082 million. Funding increased due to transfer and realignment of this work from the Ordnance Technologies effort in PE 0603601F, Conventional Weapons Technology, Project 63670A, Weapon Technology Development, as part of the Air Force RDT&E PE consolidation.</p>			
<p>Title: Guidance Technologies</p> <p>Description: Develop guidance technologies to improve the precision, controlled lethality, and flexibility of conventional, air-delivered munitions. Specific technical areas include precision navigation and terminal seekers.</p> <p>FY 2020 Plans: For FY 2020 and prior, this work is performed under the Guidance Technologies effort in PE 0603601F, Conventional Weapons Technology, Project 63670A, Weapon Technology Development.</p> <p>FY 2021 Plans: Continue integration of hardware-in-the-loop, software-in-the-loop, and other Modeling and Simulation technologies for the demonstration of open architecture, high-speed, cooperative, and modular munition concepts. Continue the design and development of seeker subsystem prototypes for platform self-defense. Continue development of advanced, high-resolution infrared scene projectors, distributed simulation concepts, software defined radio frequency test chamber, scene generation, mission, engagement, campaign level simulations, and panoramic infrared dome technologies. Continue to develop technologies for precision navigation of weapons in Global Positioning System-denied scenarios. Continue to mature and integrate advanced carriage and release concepts and sub-systems. Continue providing multi-security level, cross-domain distributed Modeling and Simulation support for munition research using distributed connectivity between multiple Eglin Air Force Base facilities. Begin integration of lethality models into guidance and control simulation to enhance weapon integrated performance. Begin development of sensor test technologies to enable verification of autonomous munition concepts. Initiate the integration of higher fidelity constructive analysis tools with engagement and mission level Modeling and Simulation.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	0.000	0.000	24.732

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 63670A / <i>Weapon Technology Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by \$24.732 million. Funding increased due to transfer and realignment of this work from the Guidance Technologies effort in PE 0603601F, Conventional Weapons Technology, Project 63670A, Weapon Technology Development.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	51.814

	FY 2019	FY 2020
Congressional Add: Program increase - rotary launcher development	0.000	0.000
FY 2019 Accomplishments: Conducted Congressionally directed efforts		
FY 2020 Plans: Not applicable		
Congressional Adds Subtotals	0.000	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>				Project (Number/Name) 63670B / <i>Weapon Concept Development</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63670B: <i>Weapon Concept Development</i>	-	0.000	0.000	82.331	0.000	82.331	141.408	145.708	145.802	157.899	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, refines, integrates, demonstrates, and assesses ordnance and guidance technologies to reduce risk for potential air-launched conventional weapons acquisitions. The project concentrates in two effort areas, Air-to-Air Concept Development and Air-to-Ground Concept Development. The project focuses on risk reduction of advanced explosives, fuzes, warheads, sub-munitions, and weapon airframes, carriage and dispensing; as well as innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation.

In FY 2021, Project 63670B, Weapon Concept Development, is transferred from PE 0603601F, Conventional Weapons Technology, to PE 0603035F, Next Gen Effects Dev/Demo, Project 63670B, Weapon Concept Development with the exception of the work and funding that is associated with the Golden Horde Vanguard demonstration which will be realigned to PE 0603032F, Future Air Force Integrated Tech Demos, Project 630320, Air Force Vanguard. These transfers are part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Operating Concept and AF Science and Technology Strategy, April 2019. The Project and non-Vanguard associated efforts will continue to be executed by the Air Force Research Laboratory Munitions Technology Directorate located in Eglin Air Force Base, Florida. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Air-to-Air Concept Development	0.000	0.000	52.091
Description: Mature, integrate, and demonstrate air-to-air weapon components and systems to include ordnance, guidance, carriage and release technologies to demonstrate war-fighter capability.			
FY 2020 Plans: For FY 2020 and prior, this work is performed under the Air-to-Air Concept Development effort in PE 0603601F, Conventional Weapons Technology, Project 63670B, Weapon Concept Development.			
FY 2021 Plans: Continue developing the technology trade space to enable air-to-air weapons with robust capability in the future threat environment, including technologies for efficient propulsion, high lethality, efficient flight / high agility, miniaturization, and cost and risk reduction for both offensive and defensive purposes. Continue to develop and test prototype propulsion systems with flexibility to enable more adaptable next generation air-to-air weapons. Continue to conduct lethality studies to enable design of small form factor warheads lethal against the 2030 plus target set. Transition advanced target models to other AF and DoD offices. Continue to develop preliminary design of air-to-air weapon concepts for sixth generation platforms. Continue to document missile flight dynamics trade space and conduct wind-tunnel experiments to characterize airframes and validate aerodynamic			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 63670B / <i>Weapon Concept Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>codes leading to development of highly maneuverable and efficient missiles to counter advanced targets, and improve persistence and survivability of future platforms. Continue to conduct ground and arena tests of advanced weapons experimental carriages for sixth generation weapon concept and prepare for flight worthiness testing. Continue to mature simulation architectures to assess the trade and synergies between kinetic and directed energy weapons. Continue to perform experiments with small warheads to obtain data for lethality analysis to validate and improve designs. Continue to plan and execute integrated subsystem experiments. Complete self defense munition maturation of hardware and software elements, integrate, assemble and test the complete munition.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$52.091 million. Funding increased due to transfer and realignment of this work from the Air-to-Air Concept Development effort in PE 0603601F, Conventional Weapons Technology, Project 63670B, Weapon Concept Development, as part of the Air Force RDT&E BA03 PE Consolidation.</p>			
<p>Title: Air-to-Ground Concept Development</p> <p>Description: Mature, integrate, and demonstrate air-to-ground weapon components and systems such as ordnance, guidance, and carriage and release technologies to demonstrate war-fighter capability.</p> <p>FY 2020 Plans: For FY 2020 and prior, this work is performed under the Air-to-Ground Concept Development effort in 0603601F, Conventional Weapons Technology, Project 63670B, Weapon Concept Development.</p> <p>FY 2021 Plans: Complete hypersonic boost glide testing. Initiate expanded integration of collaborative weapon technology onto additional weapon systems. Continue system integration of algorithms and software defined radios onto pathfinder weapon system to enable synchronized collaborative weapon effects. Continue planning and technology risk reduction including demonstration and flight testing for weapons concepts responsive to the future threat environment (including hypersonic and cooperative/collaborative concepts). Continue to mature simulation architectures to assess the trades and synergies between kinetic and directed energy weapons. Continue to develop kinetic/non-kinetic payloads, seeker, and fuze technology for hypersonic applications.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 increased compared to FY 2020 by \$30.240 million. Funding increased due to transfer and realignment of this work from the Air-to-Ground Concept Development effort in 0603601F, Conventional Weapons Technology, Project 63670B, Weapon Concept Development, as part of the Air Force RDT&E BA 03 PE Consolidation.</p>	0.000	0.000	30.240
Accomplishments/Planned Programs Subtotals	0.000	0.000	82.331

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 63670B / <i>Weapon Concept Development</i>

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603035F / Next Gen Effects Dev/ Demos				Project (Number/Name) 63691X / EO/IR Warning & Countermeasures Tech			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63691X: EO/IR Warning & Countermeasures Tech	-	0.000	0.000	3.472	0.000	3.472	4.587	4.612	4.704	4.800	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates the advanced warning and countermeasure technologies required to negate electro-optical/infrared and laser threats to aerospace platforms. Develops off-board (decoys and expendables) and on-board countermeasure technologies for aircraft self-protection to provide robust, affordable solutions for protection against infrared missiles with autonomous seekers, multi-spectral threats, laser-guided weapons, and electro-optical/infrared tracking systems used to direct electro-optical/infrared and radar-guided missiles.

In FY 2021, the entirety of Project 63691X, EO/IR Warning & Countermeasures Tech is transferred from PE 0603270F, Electronic Combat Technologies to PE 0603035F, Project 63691X, EO/IR Warning & Countermeasures Tech, as part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Operating Concept and AF Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Advanced Electro-Optical/Infrared Warning and Countermeasure Technologies	0.000	0.000	3.472
Description: Analyze the vulnerabilities of current infrared missile systems and future imaging infrared sensors. Develop advanced countermeasure system techniques to exploit vulnerabilities for use against infrared and electro-optical guided missile threats. Develop advanced optical and infrared sensor systems for airborne and space situational awareness and threat warning.			
FY 2020 Plans: For FY 2020 and prior, this work is performed under the Advanced Electro-Optical/Infrared Warning and Countermeasure Technologies effort in PE 0603270F, Electronic Combat Technology, Project 63691X, EO/IR Warning & Countermeasures Tech.			
FY 2021 Plans: Continue threat characterization and countermeasures development and field testing of new advanced threats to include laser jam codes and techniques. Continue the incorporation of air to air threat radio frequency data links into validated engagement models and examine the combination of the infrared models with equivalent radio frequency models into the overarching Advanced Framework for Simulation, Integration and Modeling software environment to address multispectrum threats. Continue assessment of missile warning technologies and techniques for a variety of Air Force platforms. Develop the requirements			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603035F / <i>Next Gen Effects Dev/ Demos</i>	Project (Number/Name) 63691X / <i>EO/IR Warning & Countermeasures Tech</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
for next generation laser threat sensors for combat aircraft and space situation awareness. Start the integration of the testbed supporting development of space sensors. <i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 increased compared to FY 2020 by \$3.472 Million. Funding increased due to transfer and realignment of this work from the Advanced Electro-Optical/Infrared Warning and Countermeasure Technologies effort in PE 0603270F, Electronic Combat Technology, Project 63691X, EO/IR Warning & Countermeasures Tech, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	3.472

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	44.099	60.086	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
632100: <i>Laser Hardened Materials</i>	-	15.442	18.307	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
633153: <i>Non-Destructive Inspection Development</i>	-	3.994	8.501	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
633946: <i>Materials Transition</i>	-	24.663	33.278	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates advanced materials and process technologies to satisfy Air Force requirements in areas such as survivability, readiness, affordability, and new processes and materials. These projects ensure the Air Force weapon systems are ready and able when needed.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, PE 0603112F, Advanced Materials for Weapon Systems and associated Projects will be transferred to PE 0603030F, AF Foundational Development/ Demos, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. This work will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright Patterson AFB, Ohio. This is an administrative realignment for consolidation, and not a new start.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	47.426	36.586	38.181	0.000	38.181
Current President's Budget	44.099	60.086	0.000	0.000	0.000
Total Adjustments	-3.327	23.500	-38.181	0.000	-38.181
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	23.500			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.215	0.000			
• Other Adjustments	-2.112	0.000	-38.181	0.000	-38.181

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 632100: *Laser Hardened Materials*

Congressional Add: *Advanced ballistic eyewear*

Congressional Add Subtotals for Project: 632100

	FY 2019	FY 2020
	0.000	2.500
	0.000	2.500

Project: 633153: *Non-Destructive Inspection Development*

Congressional Add: *Artificial intelligence enhanced life cycle management*

Congressional Add Subtotals for Project: 633153

	0.000	2.000
	0.000	2.000

Project: 633946: *Materials Transition*

Congressional Add: *Program increase - Materials Transition of Metals for Hypersonics*

Congressional Add: *Program increase - Metals Affordability Research*

Congressional Add: *Program Increase - Composites technology*

Congressional Add Subtotals for Project: 633946

Congressional Add Totals for all Projects

	2.923	0.000
	9.744	10.000
	0.000	9.000
	12.667	19.000
	12.667	23.500

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$2.112 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603112F / <i>Advanced Materials for Weapon Systems</i>

Decrease in FY 2021 of \$38.181 million is due to the following:

- 1) Civilian pay reprice adjustments
- 2) Reduced emphasis in materials transition based on higher Air Force priorities
- 3) Realignment of the Pervasive and Affordable Metals Technologies effort to PE 0602102F, Materials, Project 624347, Materials for Structure, Propulsion and Subsystems
- 4) The rest of PE 0603112F, Advanced Materials for Weapon Systems, and associated Projects being transferred to PE 0603030F, AF Foundational Development/Demos, as part of the Air Force RDT&E BA 03 PE consolidation to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>				Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
632100: <i>Laser Hardened Materials</i>	-	15.442	18.307	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced materials technologies that enhance protection for Air Force aircrews to ensure safety and to enable aircrews to perform required missions in threat environments. Advanced materials technologies also enhance protection for Air Force sensors and systems to ensure safety, survivability, and operability in threat environments.

In FY 2021, the entirety of Project 632100, Laser Hardened Materials, will be transferred to 0603030F, AF Foundational Development/Demos, Project 632100, Laser Hardened Materials, as part of the Air Force Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright-Patterson AFB, OH. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Aerospace Systems Protection	7.258	7.429	0.000
Description: Develop and demonstrate materials technologies that enhance hardening for sensors, avionics, and components to increase survivability and mission effectiveness of aerospace systems.			
FY 2020 Plans: Assess demonstrated protection materials for visual/near infrared Intelligence, Surveillance, and Reconnaissance sensors. Assess the demonstrated results and transition the use of protection technologies for future sensor designs and strategies to mitigate directed energy damage for visual/near, short-wave, and mid-wave infrared detectors. Transition gained technologies and integrate the developments into light, operator friendly survivable electro-optic sensors that provide full spectrum protection for missile warning. Continue analyzing the high-performance properties of damage limiting semiconductor materials designed to harden electro-optic imaging sensors. Transition developed laser countermeasures for survivability of dynamic electro-optic/infrared imagers. Advance the employment and integration of evolved computational materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings development for use in sensor hardening. Transition and continue technology development and maturation to develop defensive capability for air systems airframe and anti-access munitions hardening assessments and solutions.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>In FY 2021, this work is performed under the Aerospace Systems Protection effort in PE 0603030F, AF Foundational Development/Demos, Project 632100, Laser Hardened Materials.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$7.429 million. Funding decreased due to the transfer and realignment of this work to the Aerospace Systems Protection effort in PE 0603030F, AF Foundational Development/Demos, Project 632100, Laser Hardened Materials, as part of the Air Force RDT&E BA03 consolidation.</p>				
<p>Title: Aircrew Protection</p> <p>Description: Develop and demonstrate materials technologies that enhance protection for Air Force aircrews to ensure safety and to enable aircrews to perform required missions in a threat environment.</p> <p>FY 2020 Plans: Continue to develop, validate, demonstrate, and transition laser protection materials and technologies for personnel protection. Continue to validate and develop light-weight helmet-mounted sensor hardening materials focusing on next-generation nighttime specialized sensors. Advance transition efforts and development of visor based aircrew protection materials with agile protection. Evaluate and assess new materials and advances in characterization and demonstration of eye protection technologies using computational materials science tools. Transition, validate, mature, and test improvements to functionality and performance of personnel protection technologies in expected operational conditions. Continue development and testing of materials technologies to protect against nuclear flash blindness.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Aircrew Protection effort in PE 0603030F, AF Foundational Development/Demos, Project 632100, Laser Hardened Materials.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$8.378 million. Funding decreased due to the transfer and realignment of this work to the Aircrew Protection effort in PE 0603030F, AF Foundational Development/Demos, Project 632100, Laser Hardened Materials, as part of the Air Force RDT&E BA 03 consolidation.</p>		8.184	8.378	0.000
Accomplishments/Planned Programs Subtotals		15.442	15.807	0.000
		FY 2019	FY 2020	
Congressional Add: Advanced ballistic eyewear		0.000	2.500	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>
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	FY 2019	FY 2020
FY 2019 Accomplishments: Not Applicable		
FY 2020 Plans: Conduct Congressionally directed efforts.		
Congressional Adds Subtotals	0.000	2.500

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>				Project (Number/Name) 633153 / <i>Non-Destructive Inspection Development</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633153: <i>Non-Destructive Inspection Development</i>	-	3.994	8.501	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced nondestructive inspection and evaluation technologies to monitor performance integrity and to detect failure causing conditions in weapon systems components and materials. Nondestructive inspection and evaluation capabilities greatly influence and/or limit many design, manufacturing, and maintenance practices. This project provides technology to satisfy Air Force requirements to extend the lifetime of current systems through increased reliability and cost-effectiveness at field and depot maintenance levels. Equally important is assuring manufacturing quality, integrity, and safety requirements are built in.

In FY 2021, the entirety of Project 633153, Non-Destructive Inspection Development, will be transferred to 0603030F, AF Foundational Development/Demos, Project 633153, Non-Destructive Inspection Development, as part of the Air Force Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright-Patterson AFB, OH. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Advanced Engine Inspection Technologies	0.999	1.625	0.000
Description: Develop and demonstrate advanced technologies to improve capabilities to inspect for cracks and other damage to extend the total safe life of turbine engines.			
FY 2020 Plans: Continue development of nondestructive inspection/evaluation approaches to include additive manufacturing and to assess materials and damage state of critical turbine engine components for the purpose of extending the useful life without increasing risk of in-flight failure of fracture critical to gas turbine engine components. Advance the validation process for model prediction, accuracy, and effectiveness of digital nondestructive inspection technologies and demonstrate tool automation for high confidence repeatable results, to include advanced manufacturing processes.			
FY 2021 Plans: In FY 2021, this work is performed under the Advanced Engine Inspection Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633153, Non-Destructive Inspection Development.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633153 / <i>Non-Destructive Inspection Development</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$1.625 million. Funding decreased due to the transfer and realignment of this work to the Advanced Engine Inspection Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633153, Non-Destructive Inspection Development, as part of the Air Force RDT&E BA 03 consolidation.				
<p>Title: Special Material Inspection Technologies</p> <p>Description: Develop and demonstrate advanced inspection technologies supporting low-observable (LO) systems to enhance affordability and ensure full performance and survivability.</p> <p>FY 2020 Plans: Continue the transition process to depots and flight lines for improved methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of special materials that enables/ensures more affordable coatings assessment. Validate tools to improve characterization and failure modes of specialty multilayer coatings. Continue to develop automation for robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Special Material Inspection Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633153, Non-Destructive Inspection Development.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.235 million. Funding decreased due to the transfer and realignment of this work to the Special Material Inspection Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633153, Non-Destructive Inspection Development, as part of the Air Force RDT&E BA 03 consolidation.</p>		0.759	1.235	0.000
<p>Title: Advanced System Monitoring Technologies</p> <p>Description: Develop and demonstrate advanced systems status monitoring technologies to provide on-board and embedded sensing to gain continuous awareness of the state of key subsystems.</p> <p>FY 2020 Plans: Continue to demonstrate advanced analytical methods to more accurately assess the location, and register spatial location, of damage detected using nondestructive inspection data and results. Enhance the automated robotic nondestructive inspection methods with augmented reality technologies to minimize disassembly and reduce maintenance burden to perform inspections of aircraft structures. Continue development and transition of novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. Continue enhanced methods for compiling, reporting, collecting and rapidly analyzing digital nondestructive testing/evaluation data necessary for improved damage detection and characterization. Continue</p>		2.236	3.641	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633153 / <i>Non-Destructive Inspection Development</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
the transition and integration of computational materials science tools to provide data necessary for life prediction methods to enable risk-based life management.			
<i>FY 2021 Plans:</i> In FY 2021, this work is performed under the Advanced Systems Monitoring Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633153, Non-Destructive Inspection Development.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$3.641 million. Funding decreased due to the transfer and realignment of this work to the Advanced System Monitoring Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633153, Non-Destructive Inspection Development, as part of the Air Force RDT&E BA 03 consolidation.			
Accomplishments/Planned Programs Subtotals	3.994	6.501	0.000

	FY 2019	FY 2020
<i>Congressional Add:</i> Artificial intelligence enhanced life cycle management	0.000	2.000
<i>FY 2019 Accomplishments:</i> Not Applicable		
<i>FY 2020 Plans:</i> Conduct Congressionally directed efforts.		
Congressional Adds Subtotals	0.000	2.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>				Project (Number/Name) 633946 / <i>Materials Transition</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633946: <i>Materials Transition</i>	-	24.663	33.278	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced materials and processing technologies for fielded and planned Air Force weapon, airframe, and propulsion applications. Advanced materials and processes that have matured beyond applied research are characterized, critical data are collected, and critical evaluations in the proposed operating environment are performed. This design and scale-up data improves the overall affordability of promising materials and processing technologies, providing needed initial incentives for their industrial development.

In FY 2021, with the exception of the Pervasive and Affordable Metals Technologies activities which are transferring to PE 0602102F, Materials, Project 624347, Materials for Structure, Propulsion and Subsystems, the entirety of Project 633946, Material Transition, will be transferred to 0603030F, AF Foundational Development/Demos, Project 633946, Material Transition, as part of the Air Force Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright-Patterson AFB, OH. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Air Vehicle Materials Technologies	10.006	8.136	0.000
Description: Develop and demonstrate materials and processes technologies for air vehicle and subsystems to enhance lift, propulsion, Low-Observable (LO) performance, power generation management, and affordability of air vehicles.			
FY 2020 Plans: Continue development and transition of advanced directed energy protection technologies. Continue development of advanced technologies for electromagnetic hardening acquisition and field support. Assess date, compile, report and continue development of technologies for organic engine lifing analysis for enhanced engine component risk management capability. Transition development of materials to protect infrared apertures on next generation hardened assets. Validate and verify results of microstructure-sensitive lifing methodologies that lower life cycle cost and advance performance characteristics of airframe and engine components in order to initiate development of next generation modeling tools that incorporate residual stress effects on component life.			
FY 2021 Plans: In FY 2021, this work is performed under the Air Vehicle Materials Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633946, Material Transition.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633946 / <i>Materials Transition</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$8.136 million. Funding decreased due to the transfer and realignment of this work to the Air Vehicle Materials Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633946, Material Transition, as part of the Air Force RDT&E BA 03 consolidation.				
<p>Title: High Temperature Material Technologies</p> <p>Description: Develop and demonstrate affordable, novel high temperature materials/structures and thermal management concepts to enable future defense capabilities for prompt global strike concepts.</p> <p>FY 2020 Plans: Continue to work on multimaterial structures that optimally address operational temperature zones for hot structure and expendable thermal protection systems made out of advanced ceramics, ceramic matrix composites, hybrids, advanced and affordable metals, and intermetallics. Continue to transition 2700-degree Fahrenheit ceramic matrix composites for turbine hot section components to industry. Continue to develop high performance and affordable metals for next-generation turbine disk and low cost propulsion, aerostructure and munitions components. Continue development and demonstrate advanced materials and process control to enable complex structural components via additive manufacturing. Initiate establishment of a metallic additive design center. Continue development of low cost metallic turbine engine disks made via powder processing technologies for use in high temperature, aggressive environment. Transition computational and data analytics tools that enable production of affordable, complex shape metal components made via additive manufacturing.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the High Temperature Material Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633946, Material Transition.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$2.142 million. Funding decreased due to the transfer and realignment of this work to the High Temperature Material Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 633946, Material Transition.</p>		1.990	2.142	0.000
<p>Title: Pervasive and Affordable Metals Technologies</p> <p>Description: Develop and demonstrate affordable, novel high temperature powder processing materials/structures and additive metals technology concepts to enable future defense capabilities air vehicle propulsion and computational prediction models.</p> <p>In FY 2019 and prior, this work is performed under multiple efforts and projects within PE 0603112F, Advanced Materials for Weapons Systems.</p> <p>FY 2020 Plans:</p>		0.000	4.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633946 / <i>Materials Transition</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Continue to demonstrate affordable metallic turbine engine disks made through powder processing technologies through high temperature, aggressive environment testing. Continue to develop low cost, complex shape metallic component made through additive manufacturing for advanced weapon system component prototypes. Continue to develop computational methodologies that incorporate impact of surface residual stress on ability to extend life and lower life cycle cost of air vehicle propulsion system components.</p> <p>FY 2021 Plans: In FY 2021, this effort will move to the Pervasive and Affordable Metals Technologies effort in PE 0602102F, Materials, Project 624347, Materials for Structures, Propulsion, and Subsystems.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.000 million. Funding decrease is due to transfer and realignment of this effort to the Pervasive and Affordable Metals Technologies effort in PE 0602102F, Materials, Project 624347, Materials for Structures, Propulsion, and Subsystems.</p>			
Accomplishments/Planned Programs Subtotals	11.996	14.278	0.000

	FY 2019	FY 2020
Congressional Add: Program increase - Materials Transition of Metals for Hypersonics	2.923	0.000
FY 2019 Accomplishments: Conducted Congressional directed efforts.		
FY 2020 Plans: Not Applicable		
Congressional Add: Program increase - Metals Affordability Research	9.744	10.000
FY 2019 Accomplishments: Conducted Congressional directed efforts.		
FY 2020 Plans: Conducted Congressional directed efforts.		
Congressional Add: Program Increase - Composites technology	0.000	9.000
FY 2019 Accomplishments: Not Applicable		
FY 2020 Plans: Conduct Congressionally directed efforts.		
Congressional Adds Subtotals	12.667	19.000

C. Other Program Funding Summary (\$ in Millions)
N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633946 / <i>Materials Transition</i>

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					PE 0603199F / <i>Sustainment Science and Technology (S&T)</i>							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	13.353	16.249	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635351: <i>Technology Sustainment</i>	-	13.353	16.249	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates mature Air Force Research Laboratory (AFRL) sustainment technologies such as: materials, corrosion, maintenance/repair techniques, state awareness/non-destructive inspection, health management, life prediction, low observable materials and processes, composite materials and logistics for transition into fielded Air Force systems to reduce life cycle sustainment costs and increase readiness. Technologies matured and demonstrated impact affordability and availability of fielded aerospace weapon systems by reducing sustainment costs, extending service life, and maintaining mission readiness and capability. This program develops and demonstrates maintenance, life cycle management, and system/fleet decision making technologies that can be implemented to address operational sustainment issues and could influence future system sustainability decisions via risk reduction to support inclusion into new systems. Studies are conducted to analyze processes and methodologies for application of technologies to address sustainment issues across the force, identifying cross cutting applications for fielded systems, and opportunities for building in sustainability into future applications. This program also develops and demonstrates affordable advanced composites for aircraft structures of fielded and emerging systems. This includes studies, analysis, and tests for application of composites to address sustainment and affordability issues across the force. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, the entirety of PE 0603199F, Sustainment Science and Technologies (S&T), and associated Project will be transferred to PE 0603030F, Air Force Foundational Development/Demos, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright-Patterson AFB, OH. This is an administrative realignment for consolidation, and not a new start.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0603199F I Sustainment Science and Technology (S&T)
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This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	15.150	16.249	16.938	0.000	16.938
Current President's Budget	13.353	16.249	0.000	0.000	0.000
Total Adjustments	-1.797	0.000	-16.938	0.000	-16.938
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-0.471	0.000			
• Other Adjustments	-1.326	0.000	-16.938	0.000	-16.938

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$1.326 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Decrease in FY 2021 \$16.938 million is due to the entirety of PE 0603199F, Sustainment Science and Technology (S&T), and associated Project being transferred to PE 0603030F, AF Foundational Development/Demos, as part of the Air Force RDT&E BA 03 PE consolidation to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force S&T Strategy, April 2019.

C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Title: System Health Management/Assessment Technologies</p> <p>Description: Develop, demonstrate, and transition state awareness/system health management technologies. Conduct studies and analyses to design sustainability into future applications. The short-term tasks in this area are selected based on warfighter needs identified via a semi-annual, competitive process.</p> <p>FY 2020 Plans: Complete development of diagnostic system to assess aircraft wiring and avionics subsystems. Complete development of system to reduce maintenance requirements of carbon monoxide detection system. Continue health assessments capability development for fielded air/space/cyber systems and components. Continue development and demonstration of diagnostic technology airframe/</p>	4.558	5.100	0.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>		R-1 Program Element (Number/Name) PE 0603199F / <i>Sustainment Science and Technology (S&T)</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>engine, launch vehicle, spacecraft, intercontinental ballistic missiles (ICBMs), and components. These efforts are in Air Force mission areas of Air, Space, and Cyber. Initiate new efforts based on competitive selection processes in FY 2019.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the System Health Management/ Assessment Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 635351, Technology Sustainment.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.100 million. Funding decreased due to the transfer and realignment of this work to the System Health Management/Assessment Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 635351, Technology Sustainment.</p>				
<p>Title: Prevention/Enhanced Maintainability Technologies</p> <p>Description: Develop, demonstrate, and transition maintenance and sustainment technologies to improve component design, maintenance, replacement, and concepts for performance improvement and reduced maintenance burden. The short-term tasks in this effort are selected based on warfighter needs identified via a semi-annual, competitive process.</p> <p>FY 2020 Plans: Complete adaptive gaming concept development for maintainer training. Continue rapid repair requirements materials development for aircraft battle damage repair of advanced fighter aircraft. Continue advanced canopy technology development. Continue total body nondestructive evaluation system for outer mold line inspection of advanced fighter aircraft. Continue development of materials and processes to reduce maintenance burden on low observable systems. Continue efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions. Continue to develop, demonstrate, and transition maintenance and sustainment technologies to improve component design, maintenance, repair, replacement, and concepts for maintainer training, extending part life, and reduced maintenance burden spanning Air Force mission areas of Air, Space, and Cyber. Initiate abrasion resistance coating development to protect composite material substrates for low observable systems. Initiate development on a flexible crack-blunting primer. Initiate development on a mid-temp flexible light weight radiation-absorbent material system. Initiate other new efforts based on competitive selection processes in FY 2019.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Prevention/Enhanced Maintainability Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 635351, Technology Sustainment.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		4.558	5.896	0.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>		R-1 Program Element (Number/Name) PE 0603199F / <i>Sustainment Science and Technology (S&T)</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$5.896 million. Funding decreased due to the transfer and realignment of this work to the Prevention/Enhanced Maintainability Technologies effort in PE 060303F, AF Foundational Development/Demos, Project 635351, Technology Sustainment.				
<p>Title: Management/Improved Reliability Technologies</p> <p>Description: Develop, demonstrate, and transition technologies to improve existing and new components, fleet management/decision-making tools, and supply chain/sustainment infrastructure to decrease downtime and costs, and increase reliability. The short-term tasks in this effort are selected based on warfighter needs identified via a semi-annual, competitive process.</p> <p>FY 2020 Plans: Complete effort to assess and accurately determine B-2 exhaust liner thermal profile and structural environment, and demonstrate performance of exhaust structures coatings. Complete software development to increase speed and accuracy of solid rocket motor inspections to reduce sustainment costs and improve reliability. Continue system development to provide prognostic capabilities for avionics components and analysis techniques to extend engine component service life. Continue efforts to develop system fleet management decision-making tools, maintenance/repair data base technologies and techniques, and supply chain/infrastructure approaches to reduce sustainment costs. These efforts span Air Force mission areas of Air, Space, and Cyber. Initiate new efforts based on competitive selection processes in FY 2019.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Management/Improved Reliability Technologies in PE 0603030F, AF Foundational Development/Demos, Project 635351, Technology Sustainment.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.253 million. Funding decreased due to the transfer and realignment of this work to the Management/Improved Reliability Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 635351, Technology Sustainment.</p>		3.547	5.253	0.000
<p>Title: Composite Certification</p> <p>Description: Develop, demonstrate and transition reliability-based design of advanced composites for aircraft structures. This includes studies and analysis of processes and methodologies for application of composites to address sustainment and affordability issues across the force.</p> <p>FY 2020 Plans:</p>		0.690	0.000	0.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603199F / <i>Sustainment Science and Technology (S&T)</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Starting in FY 2020, Composite Certification activities will be performed under the Advanced Aerospace Structure Technologies effort in PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Technology Integration in order to integrate engineering efforts for transition. <i>FY 2021 Plans:</i> Not applicable <i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> Not applicable			
Accomplishments/Planned Programs Subtotals	13.353	16.249	0.000

D. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 3: <i>Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	41.462	42.292	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
63665A: <i>Advanced Aerospace Sensors Technology</i>	-	22.785	25.277	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
6369DF: <i>Target Attack and Recognition Technology</i>	-	18.677	17.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

The program develops and demonstrates advanced technologies for electro-optical sensors, radar sensors and electronic counter-countermeasures, and components and algorithms. It also develops and demonstrates radio frequency (RF) and electro-optical (EO) sensors for detecting, locating, and targeting airborne, fixed, and time-critical mobile ground targets obscured by natural or man-made means. This program develops the means to find, fix, target, track, and engage air and ground targets anytime, anywhere, and in any weather. This program has been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, the entirety of PE 0603203F, Advanced Aerospace Sensors, and associated Projects will be transferred to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. This work will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson AFB, Ohio.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	44.968	38.292	38.538	0.000	38.538
Current President's Budget	41.462	42.292	0.000	0.000	0.000
Total Adjustments	-3.506	4.000	-38.538	0.000	-38.538
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	4.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-0.902	0.000			
• Other Adjustments	-2.604	0.000	-38.538	0.000	-38.538

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 63665A: *Advanced Aerospace Sensors Technology*

Congressional Add: *Program increase - sensor integration*

Congressional Add: *Program increase - Sensor integration to support ISR operations*

Congressional Add Subtotals for Project: 63665A

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	4.900	0.000
	0.000	4.000
	4.900	4.000
	4.900	4.000

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$2.604 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Decrease in FY 2021 of \$38.538 million is due to the entirety of PE 0603203F, Advanced Aerospace Sensors, and associated projects being transferred to PE 0603034, Persistent Knowledge, Awareness, & C2 Tech, as part of the Air Force RDT&E BA 03 PE consolidation to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3				R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>				Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63665A: <i>Advanced Aerospace Sensors Technology</i>	-	22.785	25.277	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project area develops and demonstrates aerospace sensor and processing technologies for intelligence, surveillance, reconnaissance, target, and attack radar applications in both manned and unmanned platforms, including electro-optical sensors and electronic counter-countermeasures for radars. It provides aerospace platforms with the capability to precisely detect, track, and target both airborne (conventional and low radar cross-section) and ground-based, high-value, time-critical targets in adverse clutter and jamming environments. Project activities include developing multi-function radio-frequency systems including radar and electronic warfare technology and the position and timing information to enable distributed sensing. Desired warfighting capabilities include the ability to detect concealed targets in difficult background conditions.

In FY 2021, the entirety of Project 63665A, Advanced Aerospace Sensors Technology, will be transferred to Program Element 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Persistent Sensing in Contested Environment Technologies	1.991	2.987	0.000
Description: Develop active radio frequency sensor solutions to use against difficult-to-detect targets in challenging environments, and advanced radio frequency architectures for open and reconfigurable systems. Enable persistent intelligence, surveillance and reconnaissance over wide areas, and detect advanced air and ground targets.			
FY 2020 Plans: Analyze results of ground-based data collections extending models to include more complex platform motion and timing synchronization as a foundation for FY 2022 airborne distributed coherent radar proof-of-concept.			
FY 2021 Plans: For FY 2021, this work is performed under Persistent Sensing in Contested Environment Technologies effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>FY 2021 decreased compared to FY 2020 by \$2.987 million. Funding decreased due to the transfer and realignment of this work to the Persistent Sensing in Contested Environment Technologies effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p> <p>Title: Passive Radio Frequency Sensing Technologies</p> <p>Description: Develop advanced techniques and prototype passive radio frequency sensors to intercept, collect, locate and track enemy radio frequency sensor systems for intelligence, surveillance and reconnaissance of air and ground targets.</p> <p>FY 2020 Plans: Conduct outdoor range testing of integrated millimeter-wave hardware and software radio frequency sensor suite against calibrated radio frequency signals to validate operating conditions.</p> <p>FY 2021 Plans: For FY 2021, this work is performed under the Passive Radio Frequency Sensing Technologies effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.500 million. Funding decreased due to the transfer and realignment of this work to the Passive Radio Frequency Sensing Technologies effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p>	4.102	5.500	0.000
<p>Title: Long Range Sensing Technologies</p> <p>Description: Develop radio frequency sensor technology to detect, locate, and identify air and ground targets at long ranges, including those that are low-observable, or use deception or camouflage.</p> <p>FY 2020 Plans: Conduct additional Passive Radar Illumination Selection Manager data collection by increasing the number of emitters and raise the complexity of the radio frequency waveforms used in order to further test the automated operation of the illumination selection manager hardware/software suite. Conduct additional air and space radio frequency sensor detection and location of air/ground radio frequency emitters to improve fidelity of multi-mode radar signal processing tools.</p> <p>FY 2021 Plans: For FY 2021, this work is performed under the Long Range Sensing Technologies effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	1.841	2.903	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$2.903 million. Funding decreased due to the transfer and realignment of this work to the Long Range Sensing Technologies effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA 03 PE consolidation.				
<p>Title: Passive Electro-Optical Sensing for Surveillance and Reconnaissance Technologies</p> <p>Description: Advance, demonstrate, and transition innovative imaging and non-imaging optical sensing technologies for surveillance and reconnaissance of airborne and ground-based objects of interest in an anti-access/area denial environment. This effort includes the development of systems, subsystems, and components necessary to yield new capabilities.</p> <p>FY 2020 Plans: Complete fabrication of read-out integrated circuit, focal plane and prototype integrated dewar assembly for the flight infrared search and track system. Conduct flight testing and report performance of both the hardware and detection and tracking algorithms. Procure and integrate dual-band test components for tower collection. Complete dual-band infrared tower collection to analyze imaging improvements with new focal plane array technologies.</p> <p>FY 2021 Plans: For FY 2021, this work is performed under the Triple Raven Advanced Technology Demonstration effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.998 million. Funding decreased due to the transfer and realignment of this work to the Triple Raven Advanced Technology Demonstration effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		6.512	5.998	0.000
<p>Title: Laser Radar for Non-Cooperative Identification</p> <p>Description: Advance, demonstrate, and transition innovative laser radar sensing technologies for non-cooperative identification of airborne and ground objects of interest in an anti-access/area denial environment. This effort includes the development of systems, subsystems and components necessary to yield new capabilities.</p> <p>FY 2020 Plans: Conduct flight test of pathfinder laser for novel 3 dimension shape sensing waveform. Continue development of agile waveform, high power laser. Continue flight testing of synthetic aperture lidar capability with an emphasis on collecting data for processing improvements, for automatic target recognition, and for anchoring modeling and simulation for future performance predictions. Continue flight testing of a vibration sensing system to collect data for an aided target recognition study.</p> <p>FY 2021 Plans:</p>		3.439	3.889	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
For FY 2021, this work is performed under the Triple Raven Advanced Technology Demonstration effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$3.889 million. Funding decreased due to the transfer and realignment of this work to the Triple Raven Advanced Technology Demonstration effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 63665A, Advanced Aerospace Sensors Technology, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	17.885	21.277	0.000

	FY 2019	FY 2020
<i>Congressional Add:</i> Program increase - sensor integration	4.900	0.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts		
<i>FY 2020 Plans:</i> Not applicable		
<i>Congressional Add:</i> Program increase - Sensor integration to support ISR operations	0.000	4.000
<i>FY 2019 Accomplishments:</i> Not applicable		
<i>FY 2020 Plans:</i> Conduct Congressional directed efforts		
Congressional Adds Subtotals	4.900	4.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>				Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
6369DF: <i>Target Attack and Recognition Technology</i>	-	18.677	17.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project area develops and demonstrates advanced technologies for closed-loop, multi-domain, multi-intelligence sources, multi-platform, multi-sensor automation and autonomy, providing capabilities in battle management, fire control, battlespace awareness and visualization, predictive analytics, target recognition, sensor and information fusion, and sensor / platform asset tasking. This project also conducts advanced investigations to determine solution credibility, in terms of underlying technology and in terms of consistency with future Air Force missions within highly contested environments. This project includes robust techniques to support intelligence, surveillance, and reconnaissance and targeting missions within adverse weather conditions and against adversaries employing deceptive techniques. This project includes development of software-intensive solutions suitable for cloud-based integration and for development/operations-like operational environments. This project develops technology for effective management of online and offline information sources incorporating both constrained and cooperative sensing. This project has been realigned to better reflect technical areas being emphasized such as autonomy, multi-domain and multi-sensor information processing, leverage of machine learning developments and enterprise-level modeling, simulation and analysis.

In FY 2021, the entirety of Project 6369DF, Target Attack and Recognition Technology will be transferred to Program Element 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 6369DF, Target Attack and Recognition Technology, as part of the Air Force Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Integrated Sensor Targeting Technologies	3.264	0.000	0.000
Description: Develop an advanced suite of sensors with automatic target recognition, fusion, and target tracking, all working in concert to provide a high-confidence identification capability.			
FY 2020 Plans: In FY 2020, this work will be performed under the Advanced Multisource Exploitation effort within Project 6369DF, Target Attack and Recognition Technology.			
FY 2021 Plans: Not applicable			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
Not applicable				
<p>Title: Multi-Sensor Target Recognition</p> <p>Description: Develop and assess multi-sensor automatic target recognition for intelligence, surveillance, reconnaissance, strike, and weapon systems.</p> <p>FY 2020 Plans: In FY 2020, this work will be performed under the Advanced Modeling Simulation and Analysis for Multi-Intelligence/Domain Fusion effort and the Sensing Assignments and Multisource Analytics effort within Project 6369DF, Target Attack and Recognition Technology.</p> <p>FY 2021 Plans: Not applicable</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>		7.783	0.000	0.000
<p>Title: Wide-Angle Continuously-Staring Technologies</p> <p>Description: Develop wide angle, continuous staring, multi-sensor/wavelength sensing and automated exploitation technology to detect, track, and identify targets over large areas at high sensor update rates.</p> <p>FY 2020 Plans: In FY 2020, this work will be performed under the Advanced Modeling, Simulation and Analysis for Multi-Intelligence/Domain Fusion effort and the Sensing Assignments and Multisource Analytics effort within Project 6369DF, Target Attack and Recognition Technology.</p> <p>FY 2021 Plans: Not applicable</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not applicable</p>		7.630	0.000	0.000
<p>Title: Advanced Multi-Source Exploitation</p> <p>Description: Demonstrate multi-source behavioral and physical knowledge generation algorithms on operational data sets for specific customers and evaluate the performance of the algorithms with respect to contested environment scenarios. Investigate methods for reducing the size, weight and power footprint of information fusion techniques to enable technology transition. Automate algorithm components to increase warfighter efficiency by reducing human-in-the-loop timeframes. Develop intelligent</p>		0.000	3.655	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>reasoning capabilities that inform operators with respect to information requirements to improve/enable mission success, for example, autonomously recommend additional data collection geometries/scenarios to enhance fusion for synthesis performance.</p> <p>In FY 2019 and prior years, this work was performed under the Integrated Sensor Targeting Technologies effort within this project.</p> <p>FY 2020 Plans: Mature and transition technology to three customers: Air Combat Command Combat Identification, Air Force Distributed Common Ground System, and Space. Candidate technologies include decision/feature-level fusion for stationary target classification given multi-sensor imagery, and deep/machine learning detect/track/identification techniques.</p> <p>FY 2021 Plans: For FY 2021, this work is performed under the Multi-INT Analytics Development effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 6369DF, Target Attack and Recognition Technology.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$3.655 million. Funding decreased due to the transfer and realignment of this work to the Multi-INT Analytics Development effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 6369DF, Target Attack and Recognition Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Advanced Modeling, Simulation and Analysis for Multi-Intelligence/Domain Fusion</p> <p>Description: This advanced research will concentrate on leveraging existing modeling, simulation and analysis tactics, techniques and procedures as well as advancing the multi int/domain fusion of information to understand with greater fidelity how current and future generations of intelligence, surveillance and reconnaissance air, space and cyber sensing can be most effectively applied to the battlespace.</p> <p>In FY 2019 and prior years, this work was performed under Multi-Sensor Target Recognition effort and the Wide-Angle Continuously Starring Technologies effort within this project.</p> <p>FY 2020 Plans: Advanced research investments will be made in the following: 1) increased fidelity and integration of air, space, cyber, and fusion performance models into modeling and simulation capabilities for phase 0 and phase 1/2 analysis, 2) specific analysis support to the Air Force Research Laboratory Enterprise modeling, simulation and analysis 3) Integration of distributed small satellites, cyber physical sensing, electronic warfare, and passive and multi-static radio frequency capabilities into the modeling, simulation and analysis baseline, and 4) increase focus on synthetic data generation as an alternative test method to measured data.</p> <p>FY 2021 Plans:</p>		0.000	4.815	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>FY 2021 Plans: For FY 2021, this work is performed under the Multi-INT Analytics Development effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 6369DF, Target Attack and Recognition Technology.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.815 million. Funding decreased due to the transfer and realignment of this work to the Multi-INT Analytics Development effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 6369DF, Target Attack and Recognition Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Sensing Assignments and Multisource Analytics</p> <p>Description: Develop advanced techniques for multi-domain closed-loop sensing that apply predictive analytics to available information, inferring candidate course-of-action hypotheses and recommending confirmatory/refutative sensing tasks.</p> <p>In FY 2019 and prior years, this work was performed under Multi-Sensor Target Recognition effort and the Wide-Angle Continuously Starring Technologies effort within this project.</p> <p>FY 2020 Plans: Develop algorithms to generate and modify rule-based representations of adversary courses of action, and conduct laboratory tests to assess utility and streamline performance. Develop advanced representations of available sensing and platform assets, and develop techniques to correctly and automatically convert high-level sensing requests into detailed asset plans.</p> <p>FY 2021 Plans: For FY 2021, this work is performed under the Multi-INT Analytics Development effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 6369DF, Target Attack and Recognition Technology.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$8.545 million. Funding decreased due to the transfer and realignment of this work to the Multi-INT Analytics Development effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 6369DF, Target Attack and Recognition Technology, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	8.545	0.000
Accomplishments/Planned Programs Subtotals		18.677	17.015	0.000
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					PE 0603211F / <i>Aerospace Technology Dev/Demo</i>							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	115.406	127.949	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
634920: <i>Flight Vehicle Tech Integration</i>	-	28.807	56.969	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
634926: <i>High Speed Systems Integ & Demo</i>	-	77.479	48.959	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
634927: <i>Aerospace Power & Flight Control Integ & Demo</i>	-	9.120	22.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program supports Department of Defense (DoD) priorities for demonstrations in hypersonics and manned/unmanned systems, respectively. This effort integrates and demonstrates advanced flight vehicle technologies that improve the performance and supportability of existing and future aerospace vehicles. System level integration brings together aerospace vehicle technologies along with avionics, propulsion, and weapon systems for demonstration in a near-realistic operational environment. Integration and technology demonstrations reduce the risk and time required to transition technologies into operational aircraft. Projects in this program have been coordinated through the DoD Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, Project 634920, Flight Vehicle Tech Integration, and Project 634927, Aerospace Power & Flight Control Integ & Demo, non-Vanguard efforts and activities will be transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo. Skyborg Vanguard activities under these Projects will be consolidated and transferred in FY 2021 from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.

In FY 2021, the entirety of Project 634926, High Speed Systems Integ & Demo, will be transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platforms Dev/Demo.

All these transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. This work will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/Demo</i>
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This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	126.002	102.949	79.994	0.000	79.994
Current President's Budget	115.406	127.949	0.000	0.000	0.000
Total Adjustments	-10.596	25.000	-79.994	0.000	-79.994
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	25.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-3.966	0.000			
• Other Adjustments	-6.630	0.000	-79.994	0.000	-79.994

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 634920: *Flight Vehicle Tech Integration*

Congressional Add: *Program increase - aircraft winglets and drag reduction devices*

Congressional Add: *Unfunded Requirement - Agility Prime*

Congressional Add Subtotals for Project: 634920

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	4.843	0.000
	0.000	25.000
	4.843	25.000
	4.843	25.000

Change Summary Explanation

Decrease in FY 2019 of \$6.630 million in Other Adjustments is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2358

Decrease in FY 2021 of \$79.994 million is due to the following:

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603211F / <i>Aerospace Technology Dev/Demo</i>

- 1) Realignment of the entirety of Project 634926, High Speed Systems Integ & Demo to PE 0603033F, Next Gen Platforms Dev/Demo.

 - 2) Realignment of Project 634920, Flight Vehicle Tech Integration, and Project 634927, Aerospace Power & Flight Control Integ & Demo non-Vanguard efforts and activities will be transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platforms Dev/Demo. Skyborg Vanguard activities under these Projects will be consolidated and transferred in FY 2021 to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguards.
- These FY 2021 transfers are all part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603211F / Aerospace Technology Dev/ Demo				Project (Number/Name) 634920 / Flight Vehicle Tech Integration			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634920: <i>Flight Vehicle Tech Integration</i>	-	28.807	56.969	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project demonstrates advanced aerospace vehicle technologies. Aerospace Vehicle Technology Integration efforts are accomplished through integration of various technologies to include avionics, advanced propulsion, and weapon systems for demonstration in near-realistic operational environments. Advanced Aerospace Structures Technologies are demonstrated to enhance the capability of current and future aerospace vehicles.

In FY 2021, Project 634920, Flight Vehicle Tech Integration Non-Vanguard efforts and activities will be transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo. Skyborg Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vandards. These transfers are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. The Project and associated Non-Vanguard efforts and activities will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Aerospace Vehicle Technology Integration	8.984	15.052	0.000
Description: Develop, simulate, and demonstrate integrated technologies to improve the performance of aerospace platform capabilities.			
FY 2020 Plans: Continue integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility. Continue the flight demonstration of a low cost unmanned aerospace systems capable of interoperations with different unmanned aerospace systems assets; completing a sensor extension variant in FY 2020 and initiating an off-board weapons station variant. Continue propulsion integration component validation tests for Air Superiority 2030 requirements. Initiate flight demonstrations of practical laminar flow for swept wing aircraft designs.			
FY 2021 Plans: For FY 2021 and future years, non-Vanguard work is performed under the Aerospace Vehicle Technology Integration effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634920, Flight Vehicle Tech Integration. Skyborg Vanguard work is performed under the Skyborg effort in PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vandards.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/Demo</i>	Project (Number/Name) 634920 / <i>Flight Vehicle Tech Integration</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$15.052 million. Funding decreased due to the transfer and realignment of this work to the High Power Aircraft Subsystems Technology effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 633035, Aerospace Power Technology; and PE 0603032F Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard as part of the Air Force RDT&E BA 03 PE consolidation.			
<p>Title: Advanced Aerospace Structure Technologies</p> <p>Description: Develop and demonstrate affordable, lightweight, adaptive, and multifunctional structural concepts integrated into aerospace systems.</p> <p>FY 2020 Plans: Continue low cost airframe design and manufacturing demonstrations: completing rapid manufacturing demonstrations of airframe components in FY 2020, and initiating fully automated manufacturing demonstrations of large airframe structures. Complete low cost attritable aircraft flight demonstration analysis and support. Continue structural life extension demonstration of legacy fleet metallic structures. Initiate validation tests of life extension and durability methods for legacy fleet composite structures in support of aircraft Service Life Extension programs.</p> <p>FY 2021 Plans: For FY 2021 and future years, non-Vanguard work is performed under the Advanced Aerospace Structure Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634920, Flight Vehicle Tech Integration. Skyborg Vanguard work is performed under the Skyborg effort in PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$16.917 million. Funding decreased due to the transfer and realignment of this work to the Advanced Aerospace Structure Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 633035, Aerospace Power Technology, and PE 0603032F Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard, as part of the Air Force RDT&E BA 03 PE consolidation.</p>	14.980	16.917	0.000
Accomplishments/Planned Programs Subtotals	23.964	31.969	0.000

	FY 2019	FY 2020
Congressional Add: Program increase - aircraft winglets and drag reduction devices	4.843	0.000
FY 2019 Accomplishments: Conducted Congressionally directed efforts		
FY 2020 Plans: Not Applicable		
Congressional Add: Unfunded Requirement - Agility Prime	0.000	25.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/ Demo</i>	Project (Number/Name) 634920 / <i>Flight Vehicle Tech Integration</i>
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	FY 2019	FY 2020
FY 2019 Accomplishments: Not Applicable		
FY 2020 Plans: Conduct Congressionally directed efforts		
Congressional Adds Subtotals	4.843	25.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/ Demo</i>				Project (Number/Name) 634926 / <i>High Speed Systems Integ & Demo</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634926: <i>High Speed Systems Integ & Demo</i>	-	77.479	48.959	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, integrates and demonstrates, via simulations, ground, and flight tests, advanced flight vehicle technologies that improve the performance and supportability of future high speed/hypersonic vehicles. System level integration brings together air vehicle technologies with avionics, propulsion, and warheads and other aerospace subsystems for demonstration in a near-realistic operational environment. Integration and technology demonstrations reduce the risk and time required to transition technologies into operational systems.

In 2021, the entirety of Project 634926, High Speed/Hypersonic Integration & Demonstrations will be transferred to PE 0603033F, Next Gen Platform Demo, Project 634926, High Speed/Hypersonic Integration & Demonstrations, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate in Wright Patterson Air Force Base, Ohio.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Speed/Hypersonic Vehicle Technologies	77.479	48.959	0.000
Description: Develop, simulate, and demonstrate integrated vehicle technologies to enable and improve the performance of future high-speed and hypersonic systems.			
FY 2020 Plans: Continue development and demonstration of tactically-relevant long-range high-speed strike technologies including ground and flight demonstrations needed. Complete Hypersonic Air-breathing Weapon Concept (HAWC) and Tactical Boost Glide (TBG) integration, assembly, test, and checkout. Continue some flight test activities for both HAWC and TBG.			
FY 2021 Plans: For FY 2021 and future years, this work is performed under the High Speed/ Hypersonic Vehicle Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634926, High Speed/Hypersonic Integration & Demo.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/Demo</i>	Project (Number/Name) 634926 / <i>High Speed Systems Integ & Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$48.959 million. Funding decreased due to the transfer and realignment of this work to the High Speed/Hypersonic Vehicle Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634926, High Speed Systems Integ & Demo, as part of the Air Force RDT&E BA 03 PE consolidation.-			
Accomplishments/Planned Programs Subtotals	77.479	48.959	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/Demo</i>				Project (Number/Name) 634927 / <i>Aerospace Power & Flight Control Integ & Demo</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634927: <i>Aerospace Power & Flight Control Integ & Demo</i>	-	9.120	22.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program integrates and demonstrates advanced control technologies that improve the performance, reliability, safety, and survivability of existing and future, manned and unmanned, aerospace systems. Enhanced capabilities are enabled by control, automation, and system level integration of subsystems and systems such as propulsion, airframes, avionics, power & thermal management, weapons, communications, and operator interfaces. Modeling and simulation, integration, and technology demonstrations in a near-operational environment reduce the risk and time required to transition technologies into existing and future aerospace systems.

In FY 2021, Project 634927, Flight Systems Control Non-Vanguard efforts and activities will be transferred from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603033F, Next Gen Platform Dev/Demo. Skyborg Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603211F, Aerospace Technology Dev/Demo, to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vandguards. These transfers are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. The Project and associated Non-Vanguard efforts and activities will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, OH. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Autonomous Systems Control	9.120	22.021	0.000
Description: Develop, simulate, and demonstrate advanced automation and control-enabled capabilities for manned or unmanned aerospace platforms. Develop, simulate, and demonstrate autonomous flight controls for safe flight and cooperative operations between manned and remotely piloted air platforms.			
FY 2020 Plans: Continue development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems and manned platforms. Incorporate autonomous and safe airspace interoperability for manned and remotely piloted aircraft systems, airborne control of teams of unmanned aircraft, and unmanned sense-and-avoid technologies for ground and air operations to the autonomy spiral demonstrations. Complete development and demonstration of reduced crew operations of future mobility aircraft. Continue development of technologies to reduce risk for transition of collision avoidance technologies to 4th and 5th-gen aircraft. Continue development of foundational autonomy for unmanned systems and spiral demonstrations of capability, including safe airspace interoperability and sense and avoid for air and ground operations. Initiated spiral autonomy			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/Demo</i>	Project (Number/Name) 634927 / <i>Aerospace Power & Flight Control Integ & Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
demonstration of manned-unmanned teaming capability incorporating the above technology transitions, including pilot-directed autonomous control.			
<i>FY 2021 Plans:</i> For FY 2021 and future years, non-Vanguard work is performed under the Autonomous Systems Control effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634927, Flight Systems Control. Skyborg Vanguard work is performed under the Skyborg effort in PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguards.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$22.021 million. Funding decreased due to the transfer and realignment of this work to the Autonomous Systems Control effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634927, Aerospace Power & Flight Control Integ & Demo; and PE 0603032F Future AF Integrated Technology Demos, Project 630320, Air Force Vanguards, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	9.120	22.021	0.000

C. Other Program Funding Summary (\$ in Millions) N/A
Remarks
D. Acquisition Strategy N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	140.247	170.973	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
632480: <i>Aerospace Fuels</i>	-	2.028	2.386	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
633035: <i>Aerospace Power Technology</i>	-	32.926	39.670	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
634921: <i>Aircraft Propulsion Subsystems Int</i>	-	18.961	18.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
634922: <i>Space & Missile Rocket Propulsion</i>	-	33.383	53.256	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635098: <i>Advanced Aerospace Propulsion</i>	-	29.913	18.814	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
63681B: <i>Advanced Turbine Engine Gas Generator</i>	-	23.036	38.831	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates technologies to achieve enabling and revolutionary advances in turbine, advanced-cycle, rocket, and space propulsion as well as electrical power, thermal management, and fuels. The program has six projects, each focusing on technologies with a high potential to enhance the performance of existing and future Air Force weapon systems. The Aerospace Fuels project develops and demonstrates improved hydrocarbon fuels and advanced propulsion systems, including those for air-breathing, high-speed/hypersonic flight. The Aerospace Power Technology project develops and demonstrates adaptive power and thermal management components, controls, and systems for high-power payloads and aircraft as part of energy-optimized aircraft development. The Aircraft Propulsion Subsystems Integration project develops demonstrator engines by integrating the engine cores demonstrated in the Advanced Turbine Engine Gas Generator project with low-pressure components. The Space and Missile Rocket Propulsion project develops and demonstrates innovative rocket propulsion technologies, propellants, and manufacturing techniques. The Advanced Aerospace Propulsion project develops the scramjet propulsion cycle to a technology readiness level appropriate for in-flight demonstration and for full integration with other engine cycles (including turbine and rocket based). The Advanced Turbine Engine Gas Generator project develops and demonstrates core turbine engine technologies for current and future aircraft propulsion systems.

Portions of the Aerospace Fuels, Aircraft Propulsion Subsystems Integration, and Advanced Turbine Gas Generator projects support adaptive cycle technology demonstrations, which develop component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, and durability for widely varying mission needs.

Projects in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	
<p>In FY 2021, the efforts and activities under Project 632480, Aerospace Fuels, will be transferred from PE 0603216F, Aerospace Propulsion and Power Technology to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, in order to consolidate Aerospace Fuel research for increased transparency for Congress.</p> <p>In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.</p> <p>In FY 2021, the entirety of Project 633035, Aerospace Power Technology; Project 634922, Space & Missile Rocket Propulsion; Project 635098, Advanced Aerospace Propulsion, and Project 63681B, Advanced Turbine Engine Gas Generator, will be transferred from PE 0603216F, Aerospace Propulsion and Power Technology, to PE 0603033F, Next Gen Platforms Dev/Demo.</p> <p>In FY 2021, Project 634921, Aircraft Propulsion Subsystems Int, non-Vanguard efforts and activities will be transferred from PE 0603216F, Aerospace Propulsion Subsystems Int, to PE 0603033F, Next Gen Platforms Dev/Demo. Skyborg Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603216F, Aerospace Propulsion and Power, to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.</p> <p>All these transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. This work will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in either Wright Patterson Air Force Base, Ohio or Edwards Air Force Base, California.</p> <p>This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.</p> <p>This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.</p>		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	148.418	113.973	115.142	0.000	115.142
Current President's Budget	140.247	170.973	0.000	0.000	0.000
Total Adjustments	-8.171	57.000	-115.142	0.000	-115.142
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	57.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-4.674	0.000			
• Other Adjustments	-3.497	0.000	-115.142	0.000	-115.142

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 633035: *Aerospace Power Technology*

Congressional Add: *Program increase - silicon carbide research*

Congressional Add: *Program increase - low spool generator capabilities*

Congressional Add Subtotals for Project: 633035

Project: 634922: *Space & Missile Rocket Propulsion*

Congressional Add: *Program increase - chemical apogee engines*

Congressional Add: *Program increase - upper stage engine maturation*

Congressional Add: *Program increase - space propulsion technologies*

Congressional Add Subtotals for Project: 634922

Project: 63681B: *Advanced Turbine Engine Gas Generator*

Congressional Add: *Program increase - advanced turbine engine gas generator*

Congressional Add Subtotals for Project: 63681B

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	14.528	10.000
	0.000	5.000
Congressional Add Subtotals for Project: 633035	14.528	15.000
	2.421	5.000
	8.232	18.000
	0.000	2.000
Congressional Add Subtotals for Project: 634922	10.653	25.000
	6.780	17.000
Congressional Add Subtotals for Project: 63681B	6.780	17.000
Congressional Add Totals for all Projects	31.961	57.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force Date: February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0603216F I Aerospace Propulsion and Power Technology
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Change Summary Explanation

Decrease in FY 2019 of \$3.497 million in Other Adjustments is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2358.

Decrease in FY 2021 of \$115.142 million is due to the following:

- 1) Realignment of the entirety of Project 632480, Aerospace Fuels from PE 0603216F, Aerospace Propulsion and Power Technology to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology to consolidate the Aerospace Fuels research for increased transparency for Congress.
- 2) Realignment of the entirety of Project 633035, Aerospace Power Technology; Project 634922, Space & Missile Rocket Propulsion; Project 635098, Advanced Aerospace Propulsion; and Project 63681B, Advanced Turbine Engine Gas Generator to PE 0603033F, Next Gen Platforms Dev/Demo.
- 3) Realignment of Project 634921, Aircraft Propulsion Subsystems Int non-Vanguard efforts and activities to PE 0603033F, Next Gen Platforms Dev/Demo. Skyborg Vanguard activities under this Project will be consolidated and transferred in FY 2021 to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.

These transfers in FY 2021 are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 632480 / <i>Aerospace Fuels</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
632480: <i>Aerospace Fuels</i>	-	2.028	2.386	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project evaluates and demonstrates improved hydrocarbon fuels, unique special application fuels, alternate fuels and advanced, novel aerospace propulsion technologies for Air Force applications, including high-speed and hypersonic flight and technologies to increase turbine engine operational reliability, durability, mission flexibility, and performance, while reducing weight, fuel consumption, and cost of ownership. The advanced fuel emphasis is on demonstrating new thermally stable, high-heat sink, and controlled chemically reacting fuels for a conventional turbine engine, turbine-based combined cycle engines, and other advanced propulsion systems. The project also evaluates and demonstrates fuel system components that minimize cost, reduce maintenance, and improve performance of future aerospace systems. The advanced propulsion emphasis is on demonstrating concepts for combined cycle, ramjet, and scramjet engines. A portion of this project supports the demonstration of adaptive cycle technologies. This project develops component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, and durability for widely varying mission needs.

In FY 2021, the efforts and activities under Project 632480, Aerospace Fuels, will be transferred from PE 06030216F, Aerospace Propulsion and Power Technology to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology to consolidate the Aerospace Fuels research increasing the transparency for Congress. The transferred efforts and activities will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Fuel-Related Thermal Management	0.607	0.731	0.000
Description: Demonstrate thermally stable fuels and fuel system hardware concepts to enhance cooling capacity (performance), minimize fuel coking, and reduce fuel system maintenance.			
FY 2020 Plans: Continue investigation of fuel heat sink approaches for thermal management of adaptive engines, such as on-board fuel deoxygenation. Initiate investigation of heat exchangers including additive manufactured units. Initiate the development of integrated test rigs to tests these approaches and assess efficiency of these approaches.			
FY 2021 Plans: Starting in FY 2021, this work is performed under the Fuel-Related Thermal Management effort in PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 632480 / <i>Aerospace Fuels</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$0.731 million. Funding decreased due to realignment of Fuel-Related Thermal Management research to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Fuel-Related Thermal Management effort.				
Title: Gas Turbine Combustion, Emissions, and Performance		0.543	0.621	0.000
Description: Develop and demonstrate efficacy of low-cost, environmentally friendly fuel approaches to assess and reduce soot/particulate emissions from gas turbine engines.				
FY 2020 Plans: Continue development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions. Initiate study of fuel temperature limitations and use data to validate models.				
FY 2021 Plans: Starting in FY 2021, this work is performed under the Gas Turbine Combustion, Emissions, and Performance effort in PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.621 million. Funding decreased due to realignment of Gas Turbine Combustion, Emissions, and Performance research to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Gas Turbine Combustion, Emissions, and Performance effort.				
Title: Fuel Logistics		0.749	0.827	0.000
Description: Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Air Force.				
FY 2020 Plans: Continue development of fuel composition in-situ sensors to ensure thermal stability throughout platform mission. Continue development of fuel sensors and mitigation products to detect and mitigate fuel bio-contamination.				
FY 2021 Plans: Starting in FY 2021, this work is performed under the Fuel Logistics effort in PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.827 million. Funding decreased due to realignment of Fuel Logistics research to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Fuel Logistics effort.				
Title: Alternative Jet Fuels		0.129	0.207	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 632480 / <i>Aerospace Fuels</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Characterize and demonstrate the use of alternative hydrocarbon jet fuel to comply with Air Force certifications and standards for jet fuels.</p> <p>FY 2020 Plans: Complete development of generic alternative fuel specification annexes for commercial jet fuels used by Air Force.</p> <p>FY 2021 Plans: Starting in FY 2021, this work is performed under the Alternative Jet Fuels effort in PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.207 million. Funding decreased due to realignment of Alternative Jet Fuels research to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology, Alternative Jet Fuels effort.</p>			
Accomplishments/Planned Programs Subtotals	2.028	2.386	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 633035 / <i>Aerospace Power Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633035: <i>Aerospace Power Technology</i>	-	32.926	39.670	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates system and subsystem integration to include adaptive architectures, actuation, electrical power, thermal management, and distribution for aerospace applications. This project develops and demonstrates the components, controls and systems required to satisfy the operational needs of current and future aircraft and enables the use of future high-power payloads. This technology enhances reliability and survivability, and reduces vulnerability, weight, and life cycle costs of air platforms. The electrical power system components developed are projected to provide a two-fold to five-fold improvement in aircraft reliability and maintainability, and a reduction in power system weight. This project is integrated into energy optimized aircraft efforts and power and thermal programs.

In FY 2021, the entirety of Project 633035, Aerospace Power Technology, will be transferred to PE 0603033F, Next Gen Platforms Dev/Demo, Project 633035, Aerospace Power Technology, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Power Aircraft Subsystem Technologies	18.398	24.670	0.000
Description: Develop and demonstrate integrated architecture, controls and components for power generation, conditioning, and distribution; energy storage components; and thermal management and subsystem technologies for integration into high power aircraft.			
FY 2020 Plans: Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Complete development of actuation technology for applications with power, volume, and thermal limitations. Continue the development of hybrid-cycle power and thermal management system. Continue development of advanced power generation and distribution system. Continue development and demonstration of integrated, adaptive megawatt-class tactical aircraft power and thermal capability. Continue development and demonstration of megawatt class architecture, controls and integration. Continue development and demonstration of robust electrical power systems for megawatt applications. Continue development and demonstration of thermal management systems for megawatt applications. Continue development and demonstration of solid state electrical distribution technology for megawatt applications.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 633035 / <i>Aerospace Power Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
For FY 2021 and future years, this work is performed under the High Power Aircraft System effort in PE 0603033F, Next Gen Platform Dev/Demo, Project BPAC 633035, Aerospace Power Technology.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$24.670 million. Funding decreased due to the transfer and realignment of this work to the High Power Aircraft Subsystems Technology effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 633035, Aerospace Power Technology.			
Accomplishments/Planned Programs Subtotals	18.398	24.670	0.000

	FY 2019	FY 2020
<i>Congressional Add:</i> Program increase - silicon carbide research	14.528	10.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts		
<i>FY 2020 Plans:</i> Not Applicable		
<i>Congressional Add:</i> Program increase - low spool generator capabilities	0.000	5.000
<i>FY 2019 Accomplishments:</i> Not Applicable		
<i>FY 2020 Plans:</i> Conduct Congressionally directed efforts.		
Congressional Adds Subtotals	14.528	15.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 634921 / <i>Aircraft Propulsion Subsystems Int</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634921: <i>Aircraft Propulsion Subsystems Int</i>	-	18.961	18.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. The Aircraft Propulsion Subsystems Integration (APSI) project includes demonstrator engines for manned systems and efficient small-scale propulsion for remotely piloted aircraft and cruise missile applications. The demonstrator engines integrate the core (high- pressure spool) technology developed under the Versatile Affordable Advanced Turbine Engines (VAATE) project with the engine (low-pressure spool) technology such as fans, turbines, engine controls, mechanical systems, exhaust nozzles, and augmentors. Additionally, this project includes activities to improve propulsion safety and readiness. This project also focuses on integration of inlets, nozzles, engine-to-airframe compatibility, and power and thermal management subsystems technologies. The APSI project provides aircraft with potential for longer range and higher cruise speeds with lower specific fuel consumption, surge power for successful engagements, high sortie rates with reduced maintenance, reduced life cycle cost, and improved survivability, resulting in increased mission effectiveness. Technologies developed are applicable to sustained high-speed vehicles and responsive space launch. The Aircraft Propulsion Subsystems Integration project is focused on improving propulsion capabilities while at the same time reducing the cost of ownership. Anticipated technology advances include turbine engine improvements providing approximately twice the range for a sustained supersonic combat aircraft, doubling the time on station with ten times the power output for surveillance aircraft and propulsion for a high speed supersonic missile with double the range for time sensitive targets. A portion of this project supports the demonstration of adaptive cycle technologies, which develop component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, high power extraction, integrated thermal management, and durability for widely varying mission needs.

In FY 2021, Project 634921, Aircraft Propulsion Subsystems Int, non-Vanguard efforts and activities will be transferred from PE 0603216F, Aerospace Propulsion and Power Technology, to PE 0603033F, Next Gen Platform Dev/Demo. Skyborg Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603216F, Aerospace Propulsion and Power Technology, to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanduaards. These transfers are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. The Project and associated Non-Vanguard efforts and activities will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Missile/Remotely Piloted Aircraft Engine Performance	11.198	10.674	0.000
Description: Design, fabricate, and test component technologies for limited-life engines to improve the performance, durability, and affordability of missile and remotely piloted aircraft engines.			
FY 2020 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 634921 / <i>Aircraft Propulsion Subsystems Int</i>

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Continue risk reduction component testing of a medium-scale efficient core demonstrator. Continue risk reduction testing of components for small expendable turbojet/turbofans (100-900 lbs class). Initiate and complete conceptual and detailed design of a medium-scale high power, high efficiency turboprop. Initiate risk reduction component rig testing and initiate fabrication of components in preparation for engine testing for this turboprop. Initiate and complete conceptual design of a high efficiency medium-scale embedded propulsion concept. Continue development of derivative supersonic turbojet engines for missile and high speed accelerators. Complete design and review of advanced turbine based accelerator with reusable high speed applications. Complete vehicle and propulsion system integration analysis.</p> <p>FY 2021 Plans: For FY 2021 and future years, non-Vanguard work is performed under the Missile/Remotely Piloted Aircraft effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634921, Aircraft Propulsion Subsystems Integration. Skyborg Vanguard activities are performed under the Skyborg effort in PE 0603032F, Next Gen Platform Dev/Demo.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$10.674 million. Funding decreased due to the transfer and realignment of this work to the Missile/Remotely Piloted Aircraft Engine Performance effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634921, Aircraft Propulsion Subsystem Int, and PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard, as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
<p>Title: Adaptive Turbine Engine Technologies</p> <p>Description: Design, fabricate, and demonstrate performance, durability, and operability technologies to mature adaptive turbine engine technologies.</p> <p>FY 2020 Plans: Continue to provide subject matter expert support to Adaptive Engine Transition Program. Complete hardware fabrication for an adaptive engine for utilization as an integrated power and thermal management engine demonstrator. Initiate and complete conceptual design review of adaptive engine core technologies and initiate technology rig tests to decrease risk in core technology testing. Initiate detailed design, fabrication and testing of component technology rig for an adaptive core demonstrator. Initiate conceptual design of fully adaptive architectures and mature critical technologies for future weapon systems.</p> <p>FY 2021 Plans: For FY 2021 and future years, this work is performed under the Adaptive Turbine Engine Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634921, Aircraft Propulsion Subsystems Integration.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	7.763	7.342	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 634921 / <i>Aircraft Propulsion Subsystems Int</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$7.342 million. Funding decreased due to the transfer and realignment of this work to the Adaptive Turbine Engine Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634921, Aircraft Propulsion Subsystems Int as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	18.961	18.016	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 634922 / <i>Space & Missile Rocket Propulsion</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634922: <i>Space & Missile Rocket Propulsion</i>	-	33.383	53.256	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced and innovative low-cost rocket turbo-machinery and components, and low-cost space launch propulsion technologies. Additionally, this project develops technologies for the sustainment of strategic systems (including solid rocket motor boosters and missile propulsion, post boost control, and aging and surveillance efforts) and tactical rockets. Characteristics such as environmental acceptability, affordability, reliability, responsiveness, reduced weight, and reduced operation and launch costs are emphasized. Increased life and performance of propulsion systems are key goals. Technology areas investigated include ground demonstrations of compact, lightweight, advanced propulsion technologies, higher efficiency energy conversion systems (derived from an improved understanding of combustion fundamentals), and high-energy propellants. Technological advances in this project could improve the performance of expendable payload capabilities by approximately twenty to fifty percent and reduce launch, operations, and support costs by approximately thirty percent. Responsiveness and operability of propulsion systems will be enhanced for reusable launch systems. Aging and surveillance thrusts for solid rocket motors could reduce lifetime prediction uncertainties for individual motors by fifty percent, enabling motor replacement for cause. The efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire Department of Defense (DoD) and National Aeronautics and Space Administration (NASA). The efforts in this project are part of the Rocket Propulsion 21 (RP21) program. The efforts in this project are reviewed by a DoD level steering committee annually for relevance to DoD missions and achievement of technical goals defined by the RP21 program.

In FY 2021, the entirety of Project 634922, Space & Missile Rocket Propulsion, will be transferred from PE 0603216F, Aerospace Propulsion & Power Technology, Project 634922, Space & Missile Rocket Propulsion to PE 0603033F, Next Gen Platform Demo, Project 634922, Space & Missile Rocket Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Edwards Air Force Base, California. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Liquid Rocket Propulsion Technologies	15.002	15.258	0.000
Description: Develop liquid rocket propulsion technology for current and future space launch vehicles.			
FY 2020 Plans: Complete study for next generation liquid propulsion technology demonstration effort focused on modularity and cost reduction. Complete testing of hydrocarbon engine components. Initiate modular engine feasibility demonstration.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 634922 / <i>Space & Missile Rocket Propulsion</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>In FY 2021, this work is performed under the Liquid Rocket Propulsion Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634922, Space & Missile Rocket Propulsion.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$15.258 million. Funding decreased due to the transfer and realignment of this work to the Liquid Rocket Propulsion Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634922, Space & Missile Rocket Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: On-Orbit Propulsion Technologies</p> <p>Description: Develop solar electric, electric, and monopropellant propulsion technologies for existing and future satellites, upper stages, orbit transfer vehicles, and satellite maneuvering.</p> <p>FY 2020 Plans: Continue to develop and transition experimental, modeling and simulation, and theoretical efforts geared towards advanced thruster development with additional emphasis on understanding thrust scale-up. Continue to extend capability to study next generation of hypergolic fuels, including propellant characterization, drop-in testing, and lab-scale thruster demonstration. Continue analysis and development of multi-mode propulsion opportunities to combine high efficiency and high thrust capabilities on a common propellant. Continue thrust scale-up effort for advanced non-toxic mono-propellant thrusters. Initiate electric propulsion thruster effort utilizing advanced non-toxic mono-propellant.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the On-Orbit Propulsion Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634922, Space & Missile Rocket Propulsion.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$3.391 million. Funding decreased due to the transfer and realignment of this work to the On-Orbit Propulsion Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634922, Space & Missile Rocket Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		1.364	3.391	0.000
<p>Title: Ballistic Missile Technologies</p> <p>Description: Develop and demonstrate missile propulsion and post-boost control systems technologies for ballistic missiles.</p> <p>FY 2020 Plans:</p>		3.637	5.934	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 634922 / <i>Space & Missile Rocket Propulsion</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Continue technology maturation and demonstration efforts for post-boost technologies and tactical missile technologies. Initiate motor component modeling & simulation tool development efforts geared towards reducing cost and schedule of new developments.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Ballistic Missile Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634922, Space & Missile Rocket Propulsion.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.934 million. Funding decreased due to the transfer and realignment of this work to the Ballistic Missile Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634922, Space & Missile Rocket Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
<p>Title: Strategic System Motor Surveillance</p> <p>Description: Develop and demonstrate aging and surveillance technologies for strategic systems to reduce lifetime prediction uncertainty for individual motors, enabling motor replacement for cause.</p> <p>FY 2020 Plans: Continue to apply next generation of chemical and aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, and non-destructive analysis tools. Continue advanced sensor analysis development efforts to further improve data acquisition and reduce uncertainty in ballistic missile life predictions. Continue to improve the fidelity and precision of non-destructive evaluation tools to increase the capability to determine flaw size, orientation, and location. Continue to support the transition of previous tools, models, data management system to user. Continue long-term validation of tools through long-term aging of sub-scale motors. Continue sub-scale motors dissection to validate the sensor and analytical analysis of each motor. Continue maturation and demonstration of advanced sensor, non-destructive evaluation, modeling and supporting technology development efforts to detect and explain phenomena to further improve data acquisition and reduce uncertainty in ballistic and tactical missile solid rocket motor life predictions.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Strategic System Motor Surveillance effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634922, Space & Missile Rocket Propulsion.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	2.727	3.673	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 634922 / <i>Space & Missile Rocket Propulsion</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$3.673 million. Funding decreased due to the transfer and realignment of this work to the Strategic System Motor Surveillance effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 634922, Space & Missile Rocket Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	22.730	28.256	0.000

	FY 2019	FY 2020
Congressional Add: Program increase - chemical apogee engines <i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts. <i>FY 2020 Plans:</i> Conduct Congressionally directed efforts	2.421	5.000
Congressional Add: Program increase - upper stage engine maturation <i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts. <i>FY 2020 Plans:</i> Conduct Congressionally directed efforts	8.232	18.000
Congressional Add: Program increase - space propulsion technologies <i>FY 2019 Accomplishments:</i> Not Applicable <i>FY 2020 Plans:</i> Conduct Congressionally directed efforts	0.000	2.000
Congressional Adds Subtotals	10.653	25.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 635098 / <i>Advanced Aerospace Propulsion</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635098: <i>Advanced Aerospace Propulsion</i>	-	29.913	18.814	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates, via ground and flight tests, the scramjet propulsion cycle to a technology readiness level appropriate for full integration with other engine cycles (including turbine and rocket-based) to provide the Air Force with transformational military capabilities. The primary focus is on the hydrocarbon-fueled, scramjet engine. Multi-cycle engines will provide the propulsion systems for possible application to support aircraft and weapon platforms operating up to Mach 7. Efforts include: scramjet flow-path optimization to enable operation over the widest possible range of Mach numbers; active combustion control to assure continuous positive thrust (even during mode transition); robust flame-holding to maintain stability through flow distortions; and maximized volume-to-surface area to minimize the thermal load imposed by the high-speed engine. Thermal management plays a vital role in scramjet and combined cycle engines, including considerations for protecting low speed propulsion systems (e.g., turbine engines) during hypersonic flight.

In FY 2021, the entirety of Project 635098, Advanced Aerospace Propulsion, will be transferred from PE 0603216F, Aerospace Propulsion & Power Technology, Project 635098, Advanced Aerospace Propulsion to PE 0603033F, Next Gen Platform Demo, Project 635098, Advanced Aerospace Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Scramjet Technologies	29.913	18.814	0.000
Description: Develop and demonstrate technologies for a hydrocarbon-fueled scramjet with robust operation up to Mach 7.			
FY 2020 Plans: Complete scramjet combustor maturation efforts for flight-compliant designs based on results from direct connect testing of medium scale engine components at Aerodynamic and Propulsion Test Unit. Continue development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and active engine controls. Continue development of scramjet technologies to enhance operability including robust operation during maneuvers. Continue accelerated development and demonstration of tactically- relevant long range high speed strike scramjet engine technologies including ground and flight demonstrations needed for potential follow-on acquisition program.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 635098 / <i>Advanced Aerospace Propulsion</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
For FY 2021 and future years, this work is performed under PE 0603033F, Next Gen Platform Dev/Demo, Project 635098, Advanced Aerospace Propulsion, Scramjet Technologies effort.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$18.814 million. Funding decreased due to the transfer and realignment of this work to the Scramjet Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 635098, Advanced Aerospace Propulsion, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	29.913	18.814	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 63681B / <i>Advanced Turbine Engine Gas Generator</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63681B: <i>Advanced Turbine Engine Gas Generator</i>	-	23.036	38.831	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. The objective is to provide continuous evolution of technologies into an advanced gas generator in which the performance, cost, durability, repairability, and maintainability can be assessed in a realistic engine environment. The gas generator, or core, is the basic building block of the engine and nominally consists of a compressor, a combustor, a high-pressure turbine, mechanical systems, and core subsystems. Experimental core engine demonstration validates engineering design tools and enhances rapid, low-risk transition of key engine technologies into engineering development, where they can be applied to derivative and/or new systems. These technologies are applicable to a wide range of military and commercial systems including aircraft, missiles, land combat vehicles, ships, and responsive space launch. Component technologies are demonstrated in a core (sub-engine). This project also assesses the impact of low spool components such as; inlet systems, fans, low pressure turbines, exhaust systems, and system level technologies such as; integrated power generators and thermal management systems on core engine performance, and durability in ground demonstrations of engine cores. The core performances of this project are validated on demonstrator engines in the Aircraft Propulsion Subsystem Integration Project of this program. A portion of this project supports the demonstration of adaptive cycle technologies, which develop component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, and durability for widely varying mission needs.

In FY 2021, the entirety of Project 63681B, Advanced Turbine Engine Gas Generator, will be transferred from PE 0603216F, Aerospace Propulsion & Power Technology, Project 63681B, to PE 0603033F, Next Gen Platform Demo, Project 63681B, Advanced Turbine Engine Gas Generator, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be managed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located in Wright Patterson Air Force, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Core Engine Technologies	6.958	9.188	0.000
Description: Design, fabricate, and demonstrate performance predictions in core engines, using innovative engine cycles and advanced materials for turbofan and for turbojet engines.			
FY 2020 Plans: Complete detailed design of medium-scale efficient core demonstrator. Continue risk reduction component tests for medium-scale engine advanced fan and core. Continue build of medium-scale engine. Complete conceptual design of large-scale adaptive core concepts. Complete design of bladed disks and bearing systems components for small cruise missile size engine. Complete			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 63681B / <i>Advanced Turbine Engine Gas Generator</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
development of small cruise missile engine demonstrator test plans to improve life prediction capability for bladed disks and bearing systems. FY 2021 Plans: In FY 2021, this work is performed under the Core Engine Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 63681B, Advanced Turbine Engine Gas Generator. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$9.188 million. Funding decreased due to the transfer and realignment of this work to the Core Engine Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 63681B, Advanced Turbine Engine Gas Generator, as part of the Air Force RDT&E BA 03 PE consolidation.				
Title: High Pressure Ratio Core Engine Technologies Description: Design, fabricate, and demonstrate high overall pressure ratio engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines. FY 2020 Plans: Complete several key risk reduction testing of components for small engines (200-800 lbs class). Initiate conceptual and preliminary design of small engine technology: Identify innovative architecture, critical technologies and component designs for efficient, recuperated turbo shaft engines. Continue assembly of advanced concept additive manufacturing heat exchanger for small core engines. Continue fabrication of recuperator for demonstration of increased core efficiency in small core engines. FY 2021 Plans: In FY 2021, this work is performed under the High Pressure Ratio Core Engine Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 63681B, Advanced Turbine Engine Gas Generator. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$3.456 million. Funding decreased due to the transfer and realignment of this work to the High Pressure Ratio Core Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 63681B, Advanced Turbine Engine Gas Generator, as part of the Air Force RDT&E BA 03 PE consolidation.		2.524	3.456	0.000
Title: Adaptive Turbine Engine Core Technologies Description: Design, fabricate, and demonstrate adaptive turbine engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines. FY 2020 Plans:		6.774	9.187	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 63681B / <i>Advanced Turbine Engine Gas Generator</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Complete conceptual design of adaptive engine technology and initiate technology rig tests to decrease risk in core technology testing. Continue component tests of advanced variable turbine and innovative compression rear block designed to accept flow variations caused by variable turbine operation.			
<i>FY 2021 Plans:</i> In FY 2021, this work is performed under the Adaptive Turbine Engine Core Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 63681B, Advanced Turbine Engine Gas Generator.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$9.187 million. Funding decreased due to the transfer and realignment of this work to the Adaptive Turbine Core Engine Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 63681B, Advanced Turbine Engine Gas Generator, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	16.256	21.831	0.000

	FY 2019	FY 2020
<i>Congressional Add:</i> Program increase - advanced turbine engine gas generator	6.780	17.000
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed efforts		
<i>FY 2020 Plans:</i> Conduct Congressionally directed efforts		
Congressional Adds Subtotals	6.780	17.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	53.704	48.408	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
633720: <i>EW Quick Reaction Capabilities</i>	-	32.885	29.454	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
63431G: <i>RF Warning & Countermeasures Tech</i>	-	8.113	11.691	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
634335: <i>Cyber Concepts</i>	-	3.309	2.903	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
63691X: <i>EO/IR Warning & Countermeasures Tech</i>	-	9.397	4.360	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates technologies to support Air Force electronic combat warfighting capabilities. The program focuses on developing components, subsystems, and technologies with potential aerospace, special operations, and airlift electronic combat applications. It develops and demonstrates technologies for integrating electronic combat sensors and systems into a fused and seamless whole. It integrates and focuses research efforts in electronic warfare and cyber warfare to rapidly demonstrate a capability for rapid fielding. It develops and demonstrates technologies for navigation and timing in radio frequency (RF) contested and denied environments. It develops and demonstrates advanced technologies for radio frequency electronic combat suites and advanced warning and countermeasure technologies to defeat electro-optical, infrared, and laser threats to aerospace platforms. It also develops and demonstrates technologies that will enable mission systems to be more resilient, agile, autonomous, and be able to operate in multiple domains. This program has been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, the entirety of Project 633720, EW Quick Reaction Capabilities, and Project 63691X, EO/IR Warning & Countermeasures Tech, will be transferred from PE 0603270F, Electronic Combat Technology, to PE 0603035F, Next Gen Effects Dev/Demos, Project 633720, EW Quick Reaction Capabilities.

In FY 2021, Project 63431G, RF Warning & Countermeasures Tech, non-Vanguard efforts and activities will be transferred from PE 0603270F, Electronic Combat Technology, to PE 0603035F, Next Gen Effects Dev/Demos, Project 63431G, RF Warning & Countermeasures Tech. Navigation Technology Satellite-3 (NTS-3) Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603270F, Electronic Combat Technology, to the PE 0603032F, Future Air Force Integrated Tech Demos, Project 630320, Air Force Vanguard.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>
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In FY 2021, the entirety of Project 634335, Cyber Concepts, will be transferred from PE 0603270F, Electronic Combat Technology, to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 634335, Cyber Concepts.

All of these transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. This work will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	55.054	48.408	47.116	0.000	47.116
Current President's Budget	53.704	48.408	0.000	0.000	0.000
Total Adjustments	-1.350	0.000	-47.116	0.000	-47.116
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.350	0.000			
• Other Adjustments	0.000	0.000	-47.116	0.000	-47.116

Change Summary Explanation

Decrease in FY 2021 of \$47.116 million is due to the following:

- 1) Entirety of Project 634335, Cyber Concepts, transferring to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech.
- 2) Entirety of Project 633720, EW Quick Reaction Capabilities and Project 63691X, EO/IR Warning & Countermeasures Tech, transferring to PE 0603035F, Next Gen Effects Dev/Demos.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	
<p>3) Project 63431G, RF Warning & Countermeasure Tech, non-Vanguard efforts and activities transferring to PE 0603035F, Next Gen Effects Dev/Demos, Project 63431G, RF Warning & Countermeasure Tech.</p> <p>4) Navigation Technology Satellite-3 Vanguard activities under Project 63431G, RF Warning & Countermeasure Tech, transferring to PE 0603032F, Future Air Force Integrated Tech Demos, Project 630320, Air Force Vanduaards.</p> <p>These transfers in FY 2021 are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019.</p>		

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>				Project (Number/Name) 633720 / <i>EW Quick Reaction Capabilities</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633720: <i>EW Quick Reaction Capabilities</i>	-	32.885	29.454	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project establishes a capability to rapidly assess, develop and demonstrate new electronic warfare concepts, techniques, and capabilities as well as the required position navigation and timing (PNT) technologies and capabilities in the context of systemic electronic warfare (EW) effects (electronic warfare threat interactions) in a congested/contested electromagnetic spectrum, system-of-systems (SoS) environment of the future. It develops disruptive electronic warfare and countermeasures concepts specifically selected for high-impact, game-changing effects; evaluates them in high fidelity virtual and hardware evaluation settings; and demonstrates them in an operationally relevant environment. It establishes and maintains an all-source, physics-based, threat-to-countermeasures electronic warfare systems engineering methodology. It develops a core analytic function, supported by simulation-based wargaming and interactive engineering modeling capabilities to evaluate advanced countermeasures concepts.

In FY 2021, the entirety of Project 633720, EW Quick Reaction Capabilities, will be transferred to PE 0603035F, Next Gen Effects Dev/Demos, Project 633720, EW Quick Reaction Capabilities, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright-Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Radio Frequency Electronic Warfare	10.289	10.503	0.000
Description: Develop electronic warfare focused knowledge databases, engineering models, mission simulations, analysis tools and assessment environments which enable the development of multi-domain electronic warfare technologies. The primary focus is on emulating complex battlespace radio frequency environments, electronic attack effects against emerging, networked weapon systems, and assessing flexible, software-defined electronic warfare systems with non-deterministic performance (for example, utilizing cognitive algorithms).			
FY 2020 Plans: Continue expansion of simulations to accommodate advanced electronic warfare systems, and to emulate the complex radio frequency threats and signal environments for which they're designed. Continue development of higher fidelity threat system and signal propagation models. Continue developing the tools, methods and demonstrations to assess both the performance of future electronic warfare systems as well as their effectiveness including cognitive and autonomous technologies. Continue the development and demonstration efforts to prove the concepts for full spectrum countermeasures capabilities. Continue the select			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 633720 / <i>EW Quick Reaction Capabilities</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>development of threat seeker surrogates with which to test emerging electronic warfare technologies. Continue expansion of software-in-the-loop and hardware-in-the-loop environments to achieve closed-loop system performance.</p> <p>FY 2021 Plans: For FY 2021, this work is performed under the Radio Frequency Electronic Warfare effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 633720, EW Quick Reaction Capabilities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$10.503 million. Funding decreased due to the transfer and realignment of this work to the Radio Frequency Electronic Warfare effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 633720, EW Quick Reaction Capabilities, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Position, Navigation and Timing for Contested/Denied Environments</p> <p>Description: Develop and transition robust Global Navigation Satellite System capabilities; resilient complementary position, navigation and timing techniques; precise position, navigation and timing technologies for distributed sensing/effects; position, navigation and timing technology to provide position, navigation and timing electronic warfare situational awareness and training; and position, navigation and timing architectures to enable resiliency against the rapidly evolving threat. Efforts will include prototypes and relevant Open Architecture standards where applicable to enable timely technology transition.</p> <p>FY 2020 Plans: Continue to further research techniques to securely certify Global Navigation Satellite System software defined radio technology and methods to trust Global Navigation Satellite System and integrate into the Navigation Technology Satellite-3 flight experiment. Develop advanced reconfigurable software defined radio navigation receivers to enable spectrum agile systems and integrate into the Navigation Technology Satellite-3 flight experiment. Develop alternative position, navigation and timing techniques which increase the availability of the position, navigation and timing solution as well as increase the precision for radio frequency coherent sensing and electronic warfare. Evolve open architecture standards to allow for integration of Global Navigation Satellite System and alternative position, navigation and timing into future systems. Demonstrate integration of Global Navigation Satellite System position, navigation and timing and datalink-based complementary position, navigation and timing into a resilient embedded Global Positioning System inertial (R-EGI) government reference architecture.</p> <p>FY 2021 Plans: For FY 2021, this work is performed under the Position Navigation and Timing for Contested/Denied Environments effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 633720, EW Quick Reaction Capabilities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		17.111	16.336	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 633720 / <i>EW Quick Reaction Capabilities</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$16.335 million. Funding decreased due to the transfer and realignment of this work to the Position Navigation and Timing for Contested/Denied Environments effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 633720, EW Quick Reaction Capabilities, as part of the Air Force RDT&E BA 03 PE consolidation.				
Title: Electro-Optical/Infrared Threat Warning and Countermeasures		5.485	2.615	0.000
Description: Develop next generation countermeasure techniques to address the complete range of multispectral (for example, dual band infrared) threats including advanced techniques versus advanced man portable air defense system and air-to-air threats with multimode capabilities. Develop capabilities for situational awareness and countermeasure to integrated air defense systems and associated multispectral threats.				
FY 2020 Plans: Continue at range evaluation of next generation high sensitivity focal plane array for proactive detection. Start requirements definition and evaluate acquisition alternatives for a proactive advanced technology demonstration. Start laboratory tests and continue modeling and simulation efforts to support the multispectrum electro-optical/radio frequency countermeasures. Continue advance technique countermeasure at range tests to support requirements definition.				
FY 2021 Plans: For FY 2021, this work is performed under the Electro-Optical/Infrared Threat Warning and Countermeasures effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 633720, EW Quick Reaction Capabilities.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$2.615 million. Funding decreased due to the transfer and realignment of this work to the Electro-Optical/Infrared Threat Warning and Countermeasures effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 633720, EW Quick Reaction Capabilities, as part of the Air Force RDT&E BA 03 PE consolidation.				
Accomplishments/Planned Programs Subtotals		32.885	29.454	0.000
C. Other Program Funding Summary (\$ in Millions) N/A				
Remarks				
D. Acquisition Strategy N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>				Project (Number/Name) 63431G / <i>RF Warning & Countermeasures Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63431G: <i>RF Warning & Countermeasures Tech</i>	-	8.113	11.691	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced technologies for radio frequency electronic combat suites, including the required navigation technologies and capabilities, to enhance the survivability of aerospace vehicles and to provide crew situational awareness. The research addresses technologies for missile/threat warning, radio frequency receivers, electronic combat pre-processors, advanced sorting/pre-processing algorithms, and expert software for applications on existing and future electronic combat systems. The research also focuses on the development and demonstration of subsystems and components for generating on-board/off-board radio frequency countermeasure techniques. This includes the development of electronic countermeasures techniques, as well as advanced electronic countermeasures technologies such as antennas, power amplifiers, and preamplifiers.

In FY 2021, Project 63431G, RF Warning & Countermeasure Tech, will be transferred from PE 0603270F, Electronic Combat Technology to PE 0603035F, Next Gen Effects Dev/Demos, Project 63431G, RF Warning & Countermeasure Tech with the exception of the work and funding that is associated with the Navigation Technology Satellite-3 Vanguard demonstration which will be realigned to PE 0603032F, Future Air Force Integrated Tech Demos, Project 630320, Air Force Vanguard. These transfers are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start. This Project and associated non-Vanguard efforts and activities will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Electronic Attack	8.113	11.691	0.000
Description: Develop aerospace platform jamming concepts, technologies and techniques to counter advanced radio frequency threats associated with current and future aerospace weapon systems. Provide position, navigation and system resilience via open architecture solutions.			
FY 2020 Plans:			
Continue research into radio frequency receiver technologies that will better detect threats, measure more radio frequency features with greater accuracy, identify or classify signals more reliably, track and predict signals, and use reasoning algorithms to reduce ambiguities and errors, and deduce greater knowledge from the radio frequency spectrum. Continue development of countermeasures toward explicit, underserved threat weapon systems, with an emphasis on chamber and field testing for validation. Continue research and development of novel multi-domain electronic attack methods and tactics to include distributed operations. Continue expansion of modeling, simulation and laboratory assessment environments commensurate			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 63431G / <i>RF Warning & Countermeasures Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
with technologies being researched, developed and tested including cognitive and autonomous electronic warfare technologies. Continue the study, research and/or development of merged autonomy and electronic warfare technologies. <i>FY 2021 Plans:</i> For FY 2021, non-Vanguard work is performed under the Electronic Attack effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 63431G, RF Warning & Countermeasures Tech. Navigation Technology Satellite 3 activities are performed under the Navigation Technology Satellite 3 effort in PE 0603032F, Future Air Force Integrated Tech Demos, Project 630320, Air Force Vanguard. <i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$11.691 million. Funding decreased due to realignment to PE 0603035F, Next Gen Effects Dev/Demos, Project 63431G, RF Warning & Countermeasures Tech, Electronic Attack effort; and PE 0603032F, Future Air Force Integrated Tech Demos, Project 630320, Air Force Vanguard, Navigation Technology Satellite 3 effort, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	8.113	11.691	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>			Project (Number/Name) 634335 / <i>Cyber Concepts</i>				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634335: <i>Cyber Concepts</i>	-	3.309	2.903	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates methods to discover cyber susceptibilities, assess avionics systems, formulate mitigation strategies, and investigate use of tools and technologies to automate this process. It is designed to apply developed vulnerability discovery, vulnerability mitigation, and cyber protection technology to avionics systems and components and embedded systems. This involves technologies for trusted sensors and trusted systems that deter exploitation of our critical hardware and software. This project aims to develop cyber resilience and protect systems through adaptation of the system to the threat. It demonstrates these technologies in open and adaptable architectures for system integration in field demonstrations and proves out the technologies through rapid integration of sensors and architectures for technology transition. It integrates research efforts in electronic and cyber warfare to rapidly demonstrate a capability for rapid fielding.

In FY 2021, the entirety of Project 634335, Cyber Concepts, will be transferred to PE 0603034F, Persistent Knowledge, Awareness, C2 Tech, Project 634335, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Avionics Cyber Vulnerabilities	1.980	1.613	0.000
Description: Develop and demonstrate methods, techniques, and technical tools to enable, assist, and improve the vulnerability discovery processes. Use developed tools and techniques to assess avionics boxes, systems, busses, and components. Investigate techniques to mitigate discovered vulnerabilities. Develop and demonstrate mitigation and protection technologies on future concept platforms for adaptability and resilience.			
FY 2020 Plans: Continue to transition vulnerability mitigation technologies to address enduring issues with legacy weapon systems. Increase efforts to demonstrate next-generation architecture capabilities, providing integration support for emerging technologies such as autonomy, alternative-navigation technologies, open system architecture standards and approaches, and multispectral and distributed intelligence surveillance and reconnaissance and electronic warfare. Transition next-generation architectures to adopting programs/platforms, and open architecture approaches to rapidly integrate advanced mission system capability for next-generation architectures.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 634335 / <i>Cyber Concepts</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
For FY 2021, this work is performed under the Avionics Cyber Vulnerabilities effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 634335, Cyber Concepts.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.613 million. Funding decreased due to the transfer and realignment of this work to the Avionics Cyber Vulnerabilities effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 634335, Cyber Concepts, as part of the Air Force RDT&E BA 03 PE consolidation.				
Title: Avionics Cyber Protections		1.329	1.290	0.000
Description: Develop and demonstrate advanced automated analysis tools and protection techniques to prevent exploitation of cyber susceptibilities in avionics systems. This strategy would include discovery and mitigation of likely attack vectors, remediation of susceptibilities, and safeguards to assure the integrity of embedded software.				
FY 2020 Plans: Enhance and extend cyber protection tools, techniques and test beds for manned and unmanned air vehicles, mission and support equipment. Demonstrate a cyber defense-in-depth by integrating software, firmware and hardware-assisted protection technologies. Develop system integration laboratory capabilities to develop, integrate, and test real-time cyber protections for avionics; intelligence, surveillance, and reconnaissance; positioning, navigation, and timing; and other systems. Develop test samples to demonstrate the effectiveness of cyber protections. Flight test and demonstrate advanced cyber protection capabilities to reduce the risk to programs of record. Collaborate with program offices and end-users to transition cyber protection technologies. Leverage open system architecture standards and approaches to demonstrate cyber protections for current and next-generation architectures.				
FY 2021 Plans: For FY 2021, this work is performed under the Avionics Cyber Protections effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 634335, Cyber Concepts.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.290 million. Funding decreased due to the transfer and realignment of this work to the Avionics Cyber Protections effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 634335, Cyber Concepts, as part of the Air Force RDT&E BA 03 PE consolidation.				
Accomplishments/Planned Programs Subtotals		3.309	2.903	0.000
C. Other Program Funding Summary (\$ in Millions)				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 634335 / <i>Cyber Concepts</i>

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>				Project (Number/Name) 63691X / <i>EO/IR Warning & Countermeasures Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63691X: <i>EO/IR Warning & Countermeasures Tech</i>	-	9.397	4.360	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates the advanced warning and countermeasure technologies required to negate electro-optical/infrared and laser threats to aerospace platforms. Develops off-board (decoys and expendables) and on-board countermeasure technologies for aircraft self-protection to provide robust, affordable solutions for protection against infrared missiles with autonomous seekers, multi-spectral threats, laser-guided weapons, and electro-optical/infrared tracking systems used to direct electro-optical/infrared and radar-guided missiles.

In FY 2021, the entirety of Project 63691X, EO/IR Warning & Countermeasures Tech, will be transferred to PE 0603035F, Next Gen Effects Dev/Demos, Project 63691X, EO/IR Warning & Countermeasures Tech, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Sensors Technology Directorate located in Wright Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Advanced Electro-Optical/Infrared Warning and Countermeasure Technologies	9.397	4.360	0.000
Description: Analyze the vulnerabilities of current infrared missile systems and future imaging infrared sensors. Develop advanced countermeasure system techniques to exploit vulnerabilities for use against infrared and electro-optical guided missile threats. Develop advanced optical and infrared sensor systems for airborne and space situational awareness and threat warning.			
FY 2020 Plans: Continue threat characterization and countermeasures development and field testing of new threats to include new jam codes and countermeasure techniques. Continue to work with customers to determine impacts on current systems. Continue flight test of the low cost missile warning capabilities. Conduct critical experiments of long range missile warning technologies. Start incorporation of Modeling System for Advanced Investigation of Countermeasures and Radio Frequency engagement model development to meet the multispectral and multispectrum threats.			
FY 2021 Plans: For FY 2021, this work is performed under the Advanced Electro-Optical/Infrared Warning and Countermeasure Technologies effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 63691X, EO/IR Warning & Countermeasures Tech.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 63691X / <i>EO/IR Warning & Countermeasures Tech</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$4.360 million. Funding decreased due to the transfer and realignment of this work to the Advanced Electro-Optical/Infrared Warning and Countermeasure Technologies effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 63691X, EO/IR Warning & Countermeasures Tech, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	9.397	4.360	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 3: <i>Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	65.727	80.525	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
632181: <i>Spacecraft Payloads</i>	-	19.287	23.176	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
633834: <i>Integrated Space Technology Demonstrations</i>	-	17.543	18.856	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
634400: <i>Space Systems Protection</i>	-	9.078	7.708	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635021: <i>Space Systems Survivability</i>	-	1.646	1.581	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
63682J: <i>Spacecraft Vehicles</i>	-	18.173	29.204	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops, integrates, and demonstrates space technologies in the areas of spacecraft payloads, spacecraft protection, spacecraft vehicles, and space systems survivability. The integrated space technologies are demonstrated by component or system level tests on the ground or in flight. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, Project 633834, Integrated Space Technology Demonstrations, non-Vanguard efforts and activities will be transferred from PE 0603401F, Advanced Spacecraft Technology to PE 0603033F, Next Gen Platform Dev/Demo. Navigation Technology Satellite-3 (NTS-3) Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603401F, Advanced Spacecraft Technology to the PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.

In FY 2021, the entirety of Project 63682J, Spacecraft Vehicles, will be transferred from PE 0603401F, Advanced Spacecraft Technology, to PE 0603033F, Next Gen Platform Dev/Demo.

For FY 2021 and future years, efforts and activities under Project 632181, Spacecraft Payloads; Project 634400, Space Systems Protection; and Project 635021, Space Systems Survivability, have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>
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All these transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment and not a new start. This work will continued to be executed by the Air Force Research Laboratory Space Vehicles Technology Directorate located in Kirtland Air Force Base, New Mexico.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 0602298F, and 1206601SF.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	70.734	70.525	80.358	0.000	80.358
Current President's Budget	65.727	80.525	0.000	0.000	0.000
Total Adjustments	-5.007	10.000	-80.358	0.000	-80.358
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	10.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-2.309	0.000			
• Other Adjustments	-2.698	0.000	-80.358	0.000	-80.358

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 632181: *Spacecraft Payloads*

Congressional Add: *Congressional Add: Program increase - radiation hardened memory*

Congressional Add: *Program increase - radiation hardened microelectronic processors*

Congressional Add Subtotals for Project: 632181

Project: 63682J: *Spacecraft Vehicles*

Congressional Add: *Program increase - space laser communications systems*

Congressional Add Subtotals for Project: 63682J

	FY 2019	FY 2020
	0.000	10.000
	5.805	0.000
	5.805	10.000
	9.674	0.000
	9.674	0.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>
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Congressional Add Details (\$ in Millions, and Includes General Reductions)		FY 2019		FY 2020
	Congressional Add Totals for all Projects	15.479		10.000

Change Summary Explanation

Decrease in FY 2019 of \$2.698 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Decrease in FY 2021 of \$80.356 million is due to:

- 1) Postponement/curtailment of efforts and activities under Project 632181, Spacecraft Payloads; Project 634400, Space Systems Protection; and Project 635021, Space Systems Survivability, to higher Air Force, Space Force, and Department of Defense priorities.
- 2) Entirety of Project 63682J, Spacecraft Vehicles, transferring to PE 0603033F, Next Gen Platform Dev/Demo
- 3) Project 633834, Integrated Space Technology Demonstrations, non-Vanguard efforts and activities transferring to PE 0603033F, Next Gen Platform Dev/Demo.
- 4) Navigation Technology Satellite-3 (NTS-3) Vanguard activities under Project 633834, Integrated Space Technology Demonstrations, transferring to the PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.

These transfers in FY 2021 are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 632181 / <i>Spacecraft Payloads</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
632181: <i>Spacecraft Payloads</i>	-	19.287	23.176	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds the development, demonstration, and evaluation of radiation-hardened space electronic hardware, satellite control hardware, and software for advanced satellite surveillance operations. Future improved space-qualifiable electronics and software for data and signal processing will be more interchangeable, interoperable, and standardized. In the near-term, this project's work concentrates on converting (for example, radiation-hardening) commercial data and signal processor technologies for use in Air Force space systems. For mid-term applications, this project merges advanced, radiation-hardened space processor, memory, and interconnect technologies with commercially-derived, open system architectures to develop and demonstrate robust, on-board processing capabilities for 21st century Department of Defense satellites. In the long-term, this project area focuses on developing low-cost, easily modifiable software and hardware architectures for fully autonomous constellations of intelligent satellites capable of performing all mission related functions without operator intervention.

In FY 2021 and future years, the efforts and activities under Project 632181, Spacecraft Payloads, have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Advanced Space Electronics	3.000	3.197	0.000
Description: Develop microelectronic devices, including radiation-hardened data processors and high-density hardened memories, advanced packaging technologies, and micro-electro-mechanical system components and applications.			
FY 2020 Plans: Complete the productization stage of electron-beam lithography manufacturing capability. Continue leading trusted Field-Programmable Gate Array development and begin space qualification planning. Continue development of next generation memory technologies for space. Oversee qualification of next generation space processor development and planning memory technology development qualification planning. Continue assessments of tolerance of advanced electronic circuit components to space radiation environmental conditions. Continue development of novel payload processor technologies and architectures, and the electronic memory necessary to support them. Begin development of heterogeneous processing payload architecture for future on-orbit experiment.			
FY 2021 Plans: In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 632181 / <i>Spacecraft Payloads</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$3.197 million. Funding decreased due to postponement/curtailment of Advanced Space Electronics activities based on higher Air Force, Space Force, and Department of Defense priorities.				
<p>Title: Advanced Space Modeling and Simulation Tools</p> <p>Description: Develop modeling, simulation, and analysis tools for space-based surveillance systems, space capability protection technologies, access/mobility technologies, and flight experiments.</p> <p>FY 2020 Plans: Begin leveraging multiple domain analyses across space and terrestrial missions with model-test-model in support of multi-mission geosynchronous space flight demonstrations. Initiate simultaneous trade studies using utility analyses for concept maturation of emergent space technologies for space flight experiments and applications in commercial space.</p> <p>FY 2021 Plans: In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.749 million. Funding decreased due to postponement/curtailment of Advanced Space Modeling and Simulation Tools activities based on higher Air Force, Space Force, and Department of Defense priorities.</p>		0.800	0.749	0.000
<p>Title: Advanced Space Sensors</p> <p>Description: Develop space infrared technology and hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of hot targets, as well as "cold body" objects.</p> <p>FY 2020 Plans: Continue to develop III-V alternative infrared detector materials for space environments. Continue development of scanning and staring focal plane arrays for missile warning capability demonstrations during laser impingement. Continue performance characterization of visible through infrared focal plane arrays in representative space environments, including natural and man-made radiation, i.e. focused photons, to identify and resolve any shortfalls impeding the technology transition.</p> <p>FY 2021 Plans: In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		2.000	2.070	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 632181 / <i>Spacecraft Payloads</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$2.070 million. Funding decreased due to postponement/curtailment of Advanced Space Sensors activities based on higher Air Force, Space Force, and Department of Defense priorities.				
Title: Positioning, Navigation, and Timing Space Payload Technologies		7.682	7.160	0.000
Description: Develop, validate, and transition technologies that: enable new, or enhance existing, United States positioning, navigation, and timing satellite capabilities by increasing resiliency and availability of accuracy; and/or increase the affordability of providing current capabilities. Develop, validate, and transition technologies to meet identified Air Force Space Command/Space and Missile Systems Center positioning, navigation, and timing space payload technology needs.				
FY 2020 Plans: Complete developing advanced positioning, navigation, and timing signals for experimentation on the Navigation Technology Satellite-3 flight experiment. Conduct preliminary assessments of broadband components for use in satellite payloads for Precision Navigation and Timing. Test reprogrammability aspects of on-orbit reprogrammable digital waveform generator and explore use cases for enterprise reprogrammability.				
FY 2021 Plans: In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.				
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$7.160 million. Funding decreased due to postponement/curtailment of Positioning, Navigation, and Timing Space Payload Technologies activities based on higher Air Force, Space Force, and Department of Defense priorities.				
Accomplishments/Planned Programs Subtotals		13.482	13.176	0.000
		FY 2019	FY 2020	
Congressional Add: Congressional Add: Program increase - radiation hardened memory		0.000	10.000	
FY 2019 Accomplishments: Not applicable				
FY 2020 Plans: Conduct Congressionally directed effort				
Congressional Add: Program increase - radiation hardened microelectronic processors		5.805	0.000	

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 632181 / <i>Spacecraft Payloads</i>
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	FY 2019	FY 2020
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed effort		
<i>FY 2020 Plans:</i> Not applicable.		
Congressional Adds Subtotals	5.805	10.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 633834 / <i>Integrated Space Technology Demonstrations</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633834: <i>Integrated Space Technology Demonstrations</i>	-	17.543	18.856	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project is a series of advanced technology demonstrations designed to address mission needs by applying emerging technologies from the Air Force Research Laboratory, other United States government laboratories, and industry. These technologies are integrated into system-level demonstrations that are used to test, evaluate, and validate the technologies in a relevant environment.

In FY 2021, Project 633834, Integrated Space Technologies Demonstrations, non-Vanguard efforts and activities will be transferred from PE 0603401F, Advanced Spacecraft Technology to PE 0603033F, Next Gen Platform Dev/Demo. Navigation Technology Satellite-3 Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603401F, Advanced Spacecraft Technology, to the PE 0603032F, Future AF Integrated Tech Demos, Project 630320, Air Force Vanguards. These transfers are part of the Air Force RDT&E BA 03 PE Consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated Non-Vanguard efforts and activities will continue to be executed by the Air Force Research Laboratory Space Vehicles Technology Directorate located in Kirtland Air Force Base, New Mexico. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Integrated Satellite Demonstrations	17.543	18.856	0.000
Description: Develop satellite technologies for integrated, robust, and flexible satellite demonstrations building on previous work and leveraging investments by other organizations.			
FY 2020 Plans:			
Conclude on-orbit operations; complete and close-out experimental flight operations of spacecraft, hypertechnical imaging sensor, integrated on-board sensing, threat assessment and autonomy payload, and advanced proximity operations. Complete final reports for spacecraft, payloads and experiments. Complete transition of spacecraft operations to Air Force Space Command. Continue space segment components and sub-systems development with a focus on breadboard test and verification results for next generation navigation test satellites. Continue payload and user equipment development and complete user equipment and system software compatibility review to support a projected FY 2023 launch. Conduct on-orbit demonstration of a Geosynchronous orbit small satellite extending the maturity of multiple communication technologies and operational concepts for future small satellites. Continue on-orbit demonstrations of multiple formation flying satellites for near autonomous formation control. Leverage opportunities to fly demonstrations and prototypes, where successes can identify quick transition to next generation technology needs. Coordinate a manifest timeline for critical space projects prioritizing Air Force Space Command technical, security, and operational development requirements. Utilize the Long Duration Propulsive Evolved Expendable Launch			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 633834 / <i>Integrated Space Technology Demonstrations</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Vehicle Secondary Payload Adaptor launch schedule and other prospects to quickly fly demonstrations and prototypes. Mature payloads from concept proposal to leverage commercial Low Earth orbit constellations. Milestones for these efforts are a Systems Requirements Review and a Preliminary Design Review. Deliverables will be a preliminary system design package and a system interface document.</p> <p>FY 2021 Plans: In FY 2021, non-Vanguard work is performed under the Integrated Satellite Demonstrations effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 633834, Integrated Space Technology Demonstrations. Navigation Technology Satellite-3 Vanguard activities will be performed under the Navigation Technology Satellite-3 effort in PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vandguards.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$18.856 million. Funding decreased due to the transfer and realignment of this work to the Integrated Satellite Demonstrations effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 633834, Integrated Space Technology Demonstrations with the exception of the Navigation Technology Satellite-3 Vanguard work which will be transferred to the Navigation Technology Satellite-3 effort in PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vandguards, as part the Air Force RDT&E BA 03 PE consolidation.</p>				
Accomplishments/Planned Programs Subtotals		17.543	18.856	0.000
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 634400 / <i>Space Systems Protection</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
634400: <i>Space Systems Protection</i>	-	9.078	7.708	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates tools, instruments, and mitigation techniques required to assure operation of United States space assets in hostile warfighting environments. The project performs assessments of critical components and subsystems, and evaluates susceptibility and vulnerability to radio frequency and laser threats. This project also develops technologies that mitigate identified vulnerabilities. These technologies support balanced satellite protection strategies for detecting and avoiding threats in a hostile space environment.

In FY 2021 and future years, the efforts and activities under Project 634400, Space Systems Protection, have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Space Situational Awareness Capability Development</p> <p>Description: Develop tools and technologies that advance space-based proximity awareness capabilities and enable protection and countermeasure courses of action. Efforts will assess a variety of phenomenologies and concepts in response to multiple threat classes and scenarios.</p> <p>FY 2020 Plans: Continue to develop and integrate processing techniques into evolved operations centers to autonomously detect, track, identify and characterize satellites to meet timelines needed for implementation of courses of actions mitigating potential gaps for evolving threats. Continue to further develop prototypes utilizing multi-phenomenology based on the observables indicating a potential threat to mitigate knowledge gaps. Continue to conduct an integrated ground and space experiment for space situational awareness with available sensors.</p> <p>FY 2021 Plans: In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.409 million. Funding decreased due to postponement/curtailment of Space Situational Awareness Capability Development activities based on higher Air Force, Space Force, and Department of Defense priorities.</p>	2.227	1.409	0.000
<p>Title: Space Indicators and Warning Research</p>	2.851	2.182	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 634400 / <i>Space Systems Protection</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>Description: Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites.</p> <p>FY 2020 Plans: Conduct RED-vs-BLUE space-cyber experiment campaign with 50th Space Wing and other government agency partners, utilizing an on-orbit space platform. Evaluate technology solutions, and develop concepts of operation and tactics, techniques, and procedures for satellite operations in a cyber-contested space environment. Utilize space resiliency testbed to integrate and assess technology solutions for a projected FY 2021 on-orbit experiment campaign.</p> <p>FY 2021 Plans: In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$2.182 million. Funding decreased due to postponement/curtailment of Space Indicators and Warning Research activities based on higher Air Force, Space Force, and Department of Defense priorities.</p>				
<p>Title: Spacecraft Threat Detection</p> <p>Description: Develop active satellite local space awareness technologies and exploitation tools for satellite systems.</p> <p>FY 2020 Plans: Continue to develop advanced software related technology for on-board threat detection and course-of-action generation and response using live satellite data. Continue advanced technology development for enterprise-level situation monitoring and demonstrate concepts of space battle management command and control through experimentation with ground stations and flight experiments. Perform ground based demonstration of multi-domain command and control using space based assets. Initiate advanced autonomy demonstrations to prove advanced concepts in multi-domain real-time command and control. Plan for flight demonstration of satellite autonomy technologies with an emphasis on on-board planning systems. Demonstrate and experiment with prototype threat warning and response systems within an integrated multi-domain testbed.</p> <p>FY 2021 Plans: In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.117 million. Funding decreased due to postponement/curtailment of Spacecraft Threat Detection activities based on higher Air Force, Space Force, and Department of Defense priorities.</p>		4.000	4.117	0.000
Accomplishments/Planned Programs Subtotals		9.078	7.708	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 634400 / <i>Space Systems Protection</i>

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 635021 / <i>Space Systems Survivability</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635021: <i>Space Systems Survivability</i>	-	1.646	1.581	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates technologies to improve space system survivability and reliability of current and future Department of Defense space systems that must continue operation despite natural space hazards. It develops and demonstrates cost-effective solutions to mitigate hazardous space environmental interactions including electrical charge buildup and electronics failures due to both single radiation events and long-term radiation doses.

In FY 2021 and future years, the efforts and activities under Project 635021, Space Systems Survivability, have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Spacecraft Survivability/Reliability	1.646	1.581	0.000
Description: Develop technologies to provide improved space radiation and ionospheric hazard specification and forecasting.			
FY 2020 Plans: Continue updating standard radiation belt model for satellite design and complete transition. Mature next-generation highly-miniaturized energetic charged particle sensor for use in contested space. Continue spiral two demonstration of anomaly attribution tool and incorporate next-generation models for enhanced exploitation of sensor data. Initiate development and demonstration of tools to specify impacts of the ionosphere and near-earth space environment dynamics on Department of Defense systems to support strategic, operational, and tactical users.			
FY 2021 Plans: In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.581 million. Funding decreased due to postponement/curtailment of Spacecraft Survivability/Reliability activities based on higher Air Force, Space Force, and Department of Defense priorities.			
Accomplishments/Planned Programs Subtotals	1.646	1.581	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 635021 / <i>Space Systems Survivability</i>

C. Other Program Funding Summary (\$ in Millions)

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63682J: <i>Spacecraft Vehicles</i>	-	18.173	29.204	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates compact, low-cost, spacecraft power generation, storage, distribution, and thermal management technologies, including cryogenic cooling technologies. This project also develops composites for spacecraft structures and technologies for spacecraft control and mechanisms.

In FY 2021, the entirety of Project 63682J, Spacecraft Vehicles, will be transferred to PE 0603033F, Next Gen Platform Dev/Demo, Project 63682J, Spacecraft Vehicles, as part of the Air Force RDT&E PE BA 03 PE Consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Space Vehicles Technology Directorate located in Kirtland Air Force Base, New Mexico. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Space Power Technologies</p> <p>Description: Develop power generation space technologies such as multi-junction solar cells, thin-film solar cells, lightweight solar cell arrays, and radiation resistant solar cell modules and arrays.</p> <p>FY 2020 Plans: Continue on-orbit flight experiment development for advanced solar cells, solar arrays, and batteries. Target integration with small, experimental satellites to leverage system-level developments. Further development of on-orbit directed energy sensing approaches.</p> <p>FY 2021 Plans: In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.065 million. Funding decreased due to postponement/curtailment of Space Power Technologies activities based on higher Air Force, Space Force, and Department of Defense priorities.</p>	1.000	1.065	0.000
<p>Title: Spacecraft Structures Technologies</p> <p>Description: Develop, integrate, and demonstrate composite spacecraft structures and thermal technologies for deployable structures, antennas, electronics cooling, and structural sensing.</p>	1.000	1.415	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> Complete integrated experiments testing structures and thermal technologies for high energy density, full spectrum radio frequency reconfigurability, adaptability, and protection. Complete integrated ground experiment or flight experiment for extremely thin, multi-mission, radio frequency antennas for ensured capability in highly contested environments. Initiate integrated ground experiment or flight experiment for high-power small satellites technologies.</p> <p><i>FY 2021 Plans:</i> In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$1.415 million. Funding decreased due to postponement/curtailment of Spacecraft Structures Technologies activities based on higher Air Force, Space Force, and Department of Defense priorities.</p>				
<p><i>Title:</i> On-Orbit Satellite Controls</p> <p><i>Description:</i> Develop technologies for spacecraft controls and mechanisms for on-orbit applications.</p> <p><i>FY 2020 Plans:</i> Complete testing of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions. Initiate experiments with algorithms using on-orbit data collected from past missions.</p> <p><i>FY 2021 Plans:</i> In FY 2021, all activities in this effort have been postponed/curtailed due to higher Air Force, Space Force, and Department of Defense priorities.</p> <p><i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$0.416 million. Funding decreased due to postponement/curtailment of On-Orbit Satellite Controls activities based on higher Air Force, Space Force, and Department of Defense priorities.</p>		0.415	0.416	0.000
<p><i>Title:</i> Space Communication and Control Technologies</p> <p><i>Description:</i> Develop technologies for next-generation space communications terminals and equipment, along with methods/ techniques to enable future space system operational command and control concepts.</p> <p><i>FY 2020 Plans:</i> Continue support of planned five-year W/V-band propagation experiment. Support ground terminal operations, maintenance, and re-deployments. Collect and analyze data to statistically characterize atmospheric propagation effects and correlate</p>		2.080	12.001	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020	
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020
to meteorological parameters. Continue development of space-qualified V-band high power amplifier technology. Initiate development of W/V-band satellite transponder for on-orbit experiment and demonstration coupled with crosslinks. Continue systems engineering and technology risk-reduction for W/V-band ground terminals. FY 2021 Plans: In FY 2021, this work will be performed under the Space Communication Technologies effort in PE 0603033, Next Gen Platform Dev/Demo, Project 63682J, Spacecraft Vehicles. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$12.001 million. Funding decreased due to the transfer and realignment of this work to the Space Communication Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 63682J, Spacecraft Vehicles, as part of the Air Force RDT&E BA 03 PE Consolidation.			
Title: Inertial Sensor Navigation Technologies Description: Develop and test radiation hardened solid state inertial sensors. FY 2020 Plans: Continue design, development and testing of inertial sensor prototypes and radiation hardened electronics and initiate conceptual designs for inertial measurement systems. Continue to mature modelling, simulation and test/validation procedures for inertial sensor systems in relevant strategic environments. FY 2021 Plans: In FY 2021, this work is performed under the Inertial Sensor Navigation Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 63682J, Spacecraft Vehicles. FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$14.307 million. Funding decreased due to the transfer and realignment of this work to the Inertial Sensor Navigation Technologies effort in PE 0603033F, Next Gen Platform Dev/Demo, Project 63682J, Spacecraft Vehicles, as part of the Air Force RDT&E BA 03 PE Consolidation.		4.004	14.307
Accomplishments/Planned Programs Subtotals		8.499	29.204
		FY 2019	FY 2020
Congressional Add: Program increase - space laser communications systems		9.674	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>
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	FY 2019	FY 2020
<i>FY 2019 Accomplishments:</i> Conducted Congressionally directed effort		
<i>FY 2020 Plans:</i> Not applicable.		
Congressional Adds Subtotals	9.674	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					PE 0603444F / <i>Maui Space Surveillance System (MSSS)</i>							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	10.268	11.878	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
634868: <i>Maui Space Surveillance System</i>	-	10.268	11.878	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program funds ground-based optical space situational awareness (SSA) technology development and demonstration at the Maui Space Surveillance System (MSSS) in Hawaii, as well as the operation and upgrade of the facility. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, the entirety of PE 0603444F, Maui Space Surveillance System (MSSS), and associated Projects will be transferred to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Directed Energy Technology Directorate located in Kirtland Air Force Base, New Mexico.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0603444F I Maui Space Surveillance System (MSSS)
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	10.674	11.878	12.094	0.000	12.094
Current President's Budget	10.268	11.878	0.000	0.000	0.000
Total Adjustments	-0.406	0.000	-12.094	0.000	-12.094
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-0.086	0.000			
• Other Adjustments	-0.320	0.000	-12.094	0.000	-12.094

Change Summary Explanation

Decrease in FY 2021 of \$12.094 million is due to the entirety of PE 0603444F, Maui Space Surveillance System (MSSS), and associated Projects being transferred to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, as part of the Air Force RDT&E BA 03 PE consolidation to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force S&T Strategy, April 2019.

C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
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Title: Operate and Upgrade Maui Space Surveillance System	10.268	11.878	0.000
Description: Operate and upgrade the Maui Space Surveillance System to support development, demonstration, and integration of ground-based optical space situational awareness technologies.			
FY 2020 Plans: Continue to maintain Maui Space Surveillance System (MSSS) facility and experimental equipment in a mission ready state. Perform needed upgrades and modernization to keep facilities and equipment in good working order and allow Maui Space Surveillance System to perform efficiently and reliably. Continue to operate Maui Space Surveillance System facility for development and demonstration of ground based optical space situational awareness (SSA) capabilities in conjunction with customer programs and an operational Space Situational Awareness mission. Continue to accept control of geosynchronous satellite imaging capability, collecting images as requested by mission partners. Begin transition of dynamic telescope system operations into Maui Space Surveillance System capability baseline.			
FY 2021 Plans:			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603444F / <i>Maui Space Surveillance System (MSSS)</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
In FY 2021, this work is performed under the Operate and Upgrade Maui Space Surveillance System effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 634868, Maui Space Surveillance System.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$11.878 million. Funding decreased due to the transfer and realignment of this work to the Operate and Upgrade Maui Space Surveillance System effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 634868, Maui Space Surveillance System, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	10.268	11.878	0.000

D. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	32.624	37.542	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635323: <i>Directed Energy Bioeffects Parameters</i>	-	4.720	5.154	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635324: <i>Human Dynamics and Terrain Demonstration</i>	-	4.086	5.886	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635325: <i>Mission Effective Performance</i>	-	6.222	6.930	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635327: <i>Warfighter Interfaces</i>	-	17.596	19.572	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates technologies to enhance Airman performance and effectiveness in the aerospace force. State-of-the-science advances are made in warfighter training, warfighter system interfaces, directed energy bioeffects, deployment and sustainment of warfighters in extreme environments, and understanding and shaping adversarial behavior. The Directed Energy Bioeffects Parameters project develops, demonstrates, and transitions technologies to predict, evaluate, and mitigate the effects of directed energy on personnel and mission performance, and exploits the offensive capabilities of directed energy systems. The Human Dynamics and Terrain Demonstration develops, demonstrates, and transitions technologies to sustain airman performance in adverse operational and/or training environments, monitor and mitigate in-flight unexplained physiological events, and prevent human performance related mishaps through real-time monitoring and mitigation—particularly through highly automated or autonomous systems. The Mission Effective Performance project develops, demonstrates, and transitions advanced training, simulation, mission rehearsal, and other performance-aiding methods and technologies to enhance warfighter readiness. The Warfighter Interfaces project develops, demonstrates, and transitions technologies to revolutionize the way airmen synergistically use Air Force systems, including autonomous machines and adaptive teams of airmen and machines. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, the entirety of Project 635323, Directed Energy Bioeffects Parameters, and Project 635324, Human Dynamics and Terrain Demonstration, will be transferred from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603030F, AF Foundational Development/Demos.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>
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In FY 2021, the entirety of Project 635325, Mission Effective Performance, will be transferred from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech.

In FY 2021, Project 635327, Warfighter Interfaces, non-Vanguard efforts and activities will be transferred from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603034F, Persistent Knowledge, Awareness and C2 Tech. Skyborg Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguards.

All these transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. This work will continue to be executed by the Air Force Research Laboratory Airman Systems Technology Directorate located in Wright-Patterson Air Force Base, Ohio, and Joint Base San Antonio - Fort Sam Houston, Texas.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	36.420	37.542	36.237	0.000	36.237
Current President's Budget	32.624	37.542	0.000	0.000	0.000
Total Adjustments	-3.796	0.000	-36.237	0.000	-36.237
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.041	0.000			
• Other Adjustments	-2.755	0.000	-36.237	0.000	-36.237

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$2.755 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>

Decrease in FY 2021 is due to the following:

- 1) Entirety of Project 635323, Directed Energy Bioeffects Parameters, and Project 635324, Human Dynamics and Terrain Demonstration, transferring to PE 0603030F, AF Foundational Development/Demos.
- 2) Project 635327, Warfighter Interfaces, non-Vanguard efforts and activities transferring to PE 0603034F, Persistent Knowledge, Awareness and C2 Tech.
- 3) Skyborg Vanguard activities under Project 635327, Warfighter Interfaces, transferring to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguards.

These transfers in FY 2021 are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>				Project (Number/Name) 635323 / <i>Directed Energy Bioeffects Parameters</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635323: <i>Directed Energy Bioeffects Parameters</i>	-	4.720	5.154	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, demonstrates, and transitions technologies to predict, evaluate, and mitigate the effects of directed energy on personnel and mission performance, and exploits the offensive capabilities of directed energy systems. This project develops the human components of the guidelines for testing, deployment, and protection from high-power microwave and high-energy laser systems and uses this information to enhance the effectiveness of these weapon systems in air, space, and cyber operations. This project develops tools and plug-ins that enhance mission and engagement models, provide predictive risk analysis for deployment of Directed Energy systems, and analyzes systems for use in the Department of Defense. This project develops tools and analysis techniques to model and demonstrate the use of fielded protection on Airman performance, and informs developers of design specifications to optimize design of novel weapon systems.

In FY 2021, the entirety of Project 635323, Directed Energy Bioeffects Parameters, will be transferred to PE 0603030F, AF Foundational Development/Demos, Project 635323, Directed Energy Bioeffects Parameters, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Airman Systems Technology Directorate located in Joint Base San Antonio - Fort Sam Houston, Texas. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Optical Radiation Bioeffects	3.716	4.169	0.000
Description: Develop and demonstrate optical protective technologies for aircrew and ground personnel to provide protection against directed energy threats. Develop modeling capabilities to assess collateral hazards from high-power directed energy laser systems.			
FY 2020 Plans: Provide hazard analysis for Self Protect High Energy Laser Demonstrator (SHIELD) ATD flight safety reports. Complete safety analysis for advancing Department of Defense directed energy concepts for safety review and technical review boards. Continue updates to glare models that predict mission impact from bright light exposures with real-world background illumination using validation and verification experimental results. Continue evaluation of next generation nuclear flash-blindness technologies and the impact on mission performance. Continue integration of optical radiation hazard and vision analysis and tools into Advanced Framework for Simulation, Integration and Modeling (AFSIM) architecture.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635323 / <i>Directed Energy Bioeffects Parameters</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>In FY 2021, this work is performed under the Directed Energy Bioeffects effort in PE 0603030F, AF Foundational Development/Demos, Project 635323, Directed Energy Bioeffects Parameters.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.169 million. Funding decreased due to the transfer and realignment of this work to the Directed Energy Bioeffects effort in PE 0603030F, AF Foundational Development/Demos, Project 635323, Directed Energy Bioeffects Parameters, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Radio Frequency Bioeffects</p> <p>Description: Develop and demonstrate technologies to assess radio frequency (RF) bioeffects and collateral hazards from high-power RF directed energy systems.</p> <p>FY 2020 Plans: Continue development and refinement of fast thermal gradient effects dosimetry validation models and continue effect model validation strategy. Continue development of high peak power assessment models and tools to address real world concerns. Investigate probability of injury from RF exposures through use of modeling and empirical comparisons. Continue integration of RF hazard analysis and tools into Advanced Framework for Simulation, Integration and Modeling (AFSIM) architecture.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Directed Energy Bioeffects effort in PE 0603030F, AF Foundational Development/Demos, Project 635323, Directed Energy Bioeffects Parameters.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$0.985 million. Funding decreased due to the transfer and realignment of this work to the Directed Energy Bioeffects effort in PE 0603030F, AF Foundational Development/Demos, Project 635323, Directed Energy Bioeffects Parameters, as part of the Air Force RDT&E BA 03 PE consolidation.</p>		1.004	0.985	0.000
Accomplishments/Planned Programs Subtotals		4.720	5.154	0.000
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>				Project (Number/Name) 635324 / <i>Human Dynamics and Terrain Demonstration</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635324: <i>Human Dynamics and Terrain Demonstration</i>	-	4.086	5.886	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops, demonstrates, and transitions technologies to sustain airman performance in adverse operational and/or training environments (e.g., heat, altitude, high G), monitor and mitigate in-flight unexplained physiological events (e.g., hypoxia, hyperoxia), and prevent human performance related mishaps through real-time monitoring and mitigation—particularly through highly automated or autonomous systems.

In FY 2021, the entirety of Project 635324, Human Dynamics and Terrain Demonstration, will be transferred to PE 0603030F, AF Foundational Development/Demos, Project 635324, Human Dynamics and Terrain Demonstration, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Airman Systems Technology Directorate located in Wright-Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Human Analyst Augmentation	2.771	4.104	0.000
Description: Develop and demonstrate human-centered design processes and operational tools that optimize Intelligence, Surveillance and Reconnaissance information exploitation and analysis.			
FY 2020 Plans: Develop and transition multi-intelligence analysis tools and airman-machine collaboration technologies to Air Force Distributed Common Ground System (AF-DCGS) via enhanced research Content Management System (ICMS) and DCGS Open-Architecture. Prepare to transition global situation-awareness and decision-making capabilities to Air and Space Operations Center (AOC) and multi-domain operations centers.			
FY 2021 Plans: In FY 2021, this work is performed under the Sensing and Assessment effort in PE 0603030F, AF Foundational Development/Demos, Project 635324, Human Dynamics and Terrain Demonstration.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.104 million. Funding decreased due to the transfer and realignment of this work to the Sensing and Assessment effort in PE 0603030F, AF Foundational Development/Demos, Project 635324, Human Dynamics and Terrain Demonstration, as part of the Air Force RDT&E BA 03 PE consolidation.			
Title: Human Trust and Interaction	1.315	1.782	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635324 / <i>Human Dynamics and Terrain Demonstration</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Develop and demonstrate machine translation and speech-to-text tools to support the span of Air Force mission areas including intelligence, surveillance, and reconnaissance and cyber operations.</p> <p>FY 2020 Plans: Continue to advance and mature deep neural networks to improve automatic speech recognition, machine translation, and natural language processing technologies as applied to multimedia information.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Sensing and Assessment effort in PE 0603030F, AF Foundational Development/ Demos, Project 635324, Human Dynamics and Terrain Demonstration.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.782 million. Funding decreased due to the transfer and realignment of this work to the Sensing and Assessment effort in PE 0603030F, AF Foundational Development/Demos, Project 635324, Human Dynamics and Terrain Demonstration, as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
Accomplishments/Planned Programs Subtotals	4.086	5.886	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>					Project (Number/Name) 635325 / <i>Mission Effective Performance</i>		
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635325: <i>Mission Effective Performance</i>	-	6.222	6.930	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, demonstrates, and transitions advanced training, simulation, mission rehearsal, and other performance-aiding methods and technologies to enhance warfighter readiness. This project also develops advanced methods and technologies to enable interactive live, virtual, and constructive (LVC) environments for performance-aiding methods and technologies. Focus areas include integrated high-fidelity weapon systems training technologies for air, space, and cyber; tailored immersive simulation environments for airmen at the tactical and operational levels; and incorporation of performance assessment and feedback tools. These methods and technologies facilitate the development of mission-essential competencies.

In FY 2021, the entirety of Project 635325, Mission Effective Performance, will be transferred to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 635325, Mission Effective Performance, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Airman Systems Technology Directorate located in Wright-Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Continuous Learning	6.222	6.930	0.000
Description: Develop and demonstrate secure, persistent, and standardized LVC training enterprise. Utilize modeling capabilities for technology demonstration efforts focused on developing software-based tools for training that would replace human instructors.			
FY 2020 Plans: Continue development of proficiency-based training metrics and assessments in operational contexts. Continue multi-domain operations training development and demonstration. Continue field evaluations for performance-based after action review visualization tools in unit-level and Red Flag-Level training and rehearsal. Continue assessments and evaluations of common range and simulation architecture technologies for Live, Virtual, and Constructive training capabilities. Create methods for rapid development of mission-oriented software agent applications. Develop contested degraded operations environment for multi-domain operations training and rehearsal.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635325 / <i>Mission Effective Performance</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
In FY 2021, this work is performed under the Readiness effort in PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 635325, Mission Effective Performance.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$6.930 million. Funding decreased due to the transfer and realignment of this work to the Readiness effort in PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 635325, Mission Effective Performance, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	6.222	6.930	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>				Project (Number/Name) 635327 / <i>Warfighter Interfaces</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635327: <i>Warfighter Interfaces</i>	-	17.596	19.572	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, demonstrates, and readies the transition of technologies to revolutionize the way airmen optimize the capabilities of Air Force systems, including autonomous machines and adaptive teams of Airmen and machines. Improvements in the presentation of operational information to the community of users, from the system operator to the commander, must be developed in step with advancements in the acquisition, storage, and retrieval of information. This project provides the advances in understanding of human cognitive abilities, as well as the utilization of human interfaces, multisensory fusion, high-resolution image displays, and three-dimensional (3D) audio to customize communications and enhance shared understanding across a diverse user community in air, space, and cyber for maximum situational awareness.

In FY 2021, Project 635327, Warfighter Interfaces, non-Vanguard efforts and activities will be transferred to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech. Skyborg Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603456F, Human Effectiveness Advanced Technology Development, to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard. These transfers are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. The Project and associated non-Vanguard efforts and activities will continue to be executed by the Air Force Research Laboratory Airman Systems Technology Directorate located in Wright-Patterson Air Force Base, Ohio. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Battlespace Acoustics	4.342	4.862	0.000
Description: Develops and demonstrates wearable technologies and operator-centric interfaces that increase the Airman's combat capabilities. This is accomplished through integrated solutions that develop synergies, maximize battlespace interoperability, and increase combat power while decreasing Airman physical and cognitive workloads.			
FY 2020 Plans: Validate understanding of limitations in human auditory perception to build acoustic countermeasures to control perception of special aviation acoustic signatures. Continue to develop 3D audibility models for special operations aviation through the exploitation of high-fidelity acoustic measurements focusing on effects of atmospheric and terrain. Conduct usability testing and employ advanced engineering methodologies for rapid prototyping, testing and seamless integration of man-wearable communication systems, mobile interfaces, and physiological sensors into tactical ensembles supporting Battlefield Airmen and Para-rescue operations. Expected transitions include a suite of e-textile solutions eliminating conventional cabling through-			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635327 / <i>Warfighter Interfaces</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>out tactical vests, an integrated/wireless hub transfer of power and data to body-worn peripheral devices, and an array rapidly developed technology in response to urgent needs of dismounted operators.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Airman Machine Interfaces effort in PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 635327, Warfighter Interfaces with the exception of funding associated with the Skyborg Vanguard demonstration which is performed under the Skyborg effort in PE 0603032F, Future AF Integrated Tech Demos, Project 630320, Air Force Vanguards.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$4.862 million. Funding decreased due to the transfer and realignment of this work to the Airman Machine Interfaces effort in PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 635327, Warfighter Interfaces with the exception of funding associated with the Skyborg Vanguard demonstration which is performed under the Skyborg effort in PE 0603032F, Future AF Integrated Tech Demos, Project 630320, Air Force Vanguards, as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Human Role in Semiautonomous Systems</p> <p>Description: Develops, demonstrates, and matures software solutions for Command and Control, Intelligence Surveillance & Reconnaissance, Space, and Cyber customers for improved system performance (operator/analyst and software). Software ranges from simplistic decision support systems to sophisticated artificial intelligence and machine learning algorithms designed to handle data at the scale of operations. Heavy emphasis is placed on human-machine teaming including workflow design and integration of both automated and human-generated results. Effort leverages significant infrastructure in big-data design and capture, allowing for rapid prototyping of capabilities directly to web-based platforms on classified environments. Program directly supports contested-denied operations in a multi-domain environment.</p> <p>FY 2020 Plans: Flight demonstrate airman-directed control and management of multiple unmanned tactical behaviors involving increasingly complex mission sets (e.g., dynamic mission objectives, high uncertainty, unreliable communication links). Demonstrate integrated decision support and embedded intelligent agent capabilities to assess and reason about manned-unmanned team performance and overall mission effectiveness. Continue to demonstrate adaptive human-machine interfaces and task allocation methods in virtual and live tests in operationally relevant environments. Demonstrate teaming concepts and technologies among cooperative human-machine teams in networked simulation environments.</p> <p>FY 2021 Plans:</p>		13.254	14.710	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635327 / <i>Warfighter Interfaces</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
In FY 2021, this work is performed under the Analytic Tools effort in PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 635327, Warfighter Interfaces, with the exception of funding associated with the Skyborg Vanguard demonstration which is performed under the Skyborg effort in PE 0603032F, Future AF Integrated Tech Demos, Project 630320, Air Force Vanguard.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$14.710 million. Funding decreased due to realignment of research from the Human Role in Semiautonomous Systems effort to PE 0603034F, Persistent Knowledge, Awareness & C2 Tech, Project 635327, Warfighter Interfaces, Analytic Tools effort with the exception of funding associated with the Skyborg Vanguard demonstration which will be realigned to PE 0603032F, Future AF Integrated Tech Demos, Project 630320, Air Force Vanguard, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	17.596	19.572	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	191.704	225.817	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
63670A: <i>Weapon Technology Development</i>	-	118.868	57.895	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
63670B: <i>Weapon Concept Development</i>	-	72.836	167.922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, integrates, and demonstrates advance ordnance and guidance technologies for air-launched conventional weapons. The effort focuses on conventional ordnance component technologies such as war-heads, fuzes, and explosives, as well as munition guidance component technologies such as navigation and control systems and seekers. Technologies to be developed, demonstrated, and integrated into system concepts will address blast, fragmentation, penetration, low collateral damage, variable depth/location fuzing, precise guidance, and high-performance and insensitive explosives. Efforts in this project have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, the entirety of Project 63670A, Weapon Technology Development will be transferred from PE 0603601F, Conventional Weapons Technology, to PE 0603035F, Next Generation Effects Dev/ Demo.

In FY 2021, Project 63670B, Weapon Concept Development, non-Vanguard efforts and activities will be transferred from PE 0603601F, Conventional Weapon Technology, to PE 063035F, Next Gen Effects Dev/Demo. Golden Horde Vanguard activities under this project will be consolidated and transferred in FY 2021 from PE 0603601F, Conventional Weapon Technology to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard.

All these transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. This work will continue to be executed by the Air Force Research Laboratory Munitions Technology Directorate located in Eglin Air Force Base, Florida.

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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>
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This program element may include necessary civilian pay expenses required to manage, execute, and deliver science and technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	204.756	225.817	206.783	0.000	206.783
Current President's Budget	191.704	225.817	0.000	0.000	0.000
Total Adjustments	-13.052	0.000	-206.783	0.000	-206.783
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-7.202	0.000			
• Other Adjustments	-5.850	0.000	-206.783	0.000	-206.783

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 63670A: *Weapon Technology Development*

Congressional Add: *Program increase - rotary launcher development*

Congressional Add Subtotals for Project: 63670A

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	9.649	0.000
	9.649	0.000
	9.649	0.000

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$5.850 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Decrease in FY 2021 of \$206.783 million is due to PE 0603601F, Conventional Weapons Tech, and associated non-Vanguard Projects being transferred to PE 0603035F, Next Gen Effects Dev/Demo. Golden Horde Vanguard activities under Project 63670B, Weapon Concept Development, will be consolidated and transferred in FY 2021 from PE 0603601F, Conventional Weapon Technology, to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603601F / <i>Conventional Weapons Technology</i>

Force Vanguard. These transfers are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>				Project (Number/Name) 63670A / <i>Weapon Technology Development</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63670A: <i>Weapon Technology Development</i>	-	118.868	57.895	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, matures, assesses, and demonstrates advanced/innovative ordnance and guidance component and subsystem technologies for air-launched conventional weapons. The project focuses on maturation of advanced explosives, fuzes, warheads, sub-munitions, and weapon airframes, carriage and dispensing; as well as innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation.

In FY 2021, the entirety of Project 63670A, Weapon Technology Development, will be transferred to PE 0603035F, Next Generation Effects Dev/Demos, Project 63670A, Weapon Technology Development as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Munitions Technology Directorate located in Eglin Air Force Base, Florida. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

<p>Title: Ordnance Technologies</p> <p>Description: Develop and demonstrate integrated ordnance technologies to improve conventional air-delivered munitions. Specific technical areas of focus include energetic materials, fuze technology, warhead sciences, and modeling and simulation tools.</p> <p>FY 2020 Plans: Complete characterization of weapon effects for distributed, multi-point detonation fuze technology including safe and arm functions. Complete multiple-hit target demonstration against hard and deeply buried targets. Continue demonstration of distributed, embedded fuzing concepts for close-controlled strike, area attack, and penetration applications such as layer counting at high speed, including assessing long-term safety, survivability, and functionality. Continue development of ordnance technologies to allow tailored lethality by controlling weapon fragmentation. Continue to mature ordnance technologies for rapid transition into high-speed strike weapon concepts, collecting complex arena test data for implementation into lethality modeling and simulation tools. Continue to develop test capabilities and high fidelity analysis tools into higher level engineering and fast-running models to enable the war-fighter to make more accurate weaponeering choices. Continue to develop ordnance technologies/methodologies for high-speed impact and functional defeat. Continue research into armament systems for Special Operations applications. Continue to conduct lethality analyses for air-to-air weaponry, and improve lethality and survivability tools at the mesoscale and micro-scale. Continue to mature research on distributed, collaborative, cooperative effects munitions technologies. Continue the development of high-fidelity test capabilities and analysis tools to evaluate ordnance technologies</p>	FY 2019	FY 2020	FY 2021
	57.335	29.582	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>	Project (Number/Name) 63670A / <i>Weapon Technology Development</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>in relevant environments. Continue development of improved material models and develop further joint kinetic/directed energy common target models. Continue to develop models for progressive collapse, multiple point initiation, secondary debris and others.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Ordinance Technologies effort in PE 0603035F, Next Generation Effects Dev/Demos, Project 63670A, Weapon Technology Development.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$29.582 million. Funding decreased due to the transfer and realignment of this work to the Ordinance Technologies effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 63670A, Weapon Technology Development as part of the Air Force RDT&E BA 03 PE consolidation.</p>				
<p>Title: Guidance Technologies</p> <p>Description: Develop guidance technologies to improve the precision, controlled lethality, and flexibility of conventional, air-delivered munitions. Specific technical areas include precision navigation and terminal seekers.</p> <p>FY 2020 Plans: Complete hardware-in-the-loop and software-in-the-loop characterization air-to-air and air-to-ground guidance and control technologies. Continue integration of hardware-in-the-loop, software-in-the-loop, and other Modeling and Simulation technologies for the demonstration of open architecture, high-speed, cooperative, and modular weapon munition concepts. Continue the design and development of seeker subsystem prototypes for platform self-defense. Continue development of advanced, high-resolution infrared scene projectors, distributed simulation concepts, software defined Radio Frequency test chamber, scene generation, mission, engagement, campaign level simulations, and panoramic infrared dome technologies. Continue to develop technologies for precision navigation of weapons in Global Positioning System-denied scenarios. Continue to mature and integrate advanced carriage and release concepts and sub-systems. Complete fabrication of Modeling and Simulation center and initiate processes to enable simultaneous multi-level security Modeling and Simulation activities.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Guidance Technologies effort in Program Element 0603035F, Next Generation Effects Dev/Demos, Project 63670A, Weapon Technology Development.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>		51.884	28.313	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>	Project (Number/Name) 63670A / <i>Weapon Technology Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$28.313 million. Funding decreased due to the transfer and realignment of this work to the Guidance Technologies effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 63670A, Weapon Technology Development as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	109.219	57.895	0.000

	FY 2019	FY 2020
Congressional Add: Program increase - rotary launcher development	9.649	0.000
FY 2019 Accomplishments: Conducted Congressionally directed efforts		
FY 2020 Plans: Not applicable		
Congressional Adds Subtotals	9.649	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>				Project (Number/Name) 63670B / <i>Weapon Concept Development</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
63670B: <i>Weapon Concept Development</i>	-	72.836	167.922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, refines, integrates, demonstrates, and assesses ordnance and guidance technologies to reduce risk for potential air-launched conventional weapons acquisitions. The project concentrates in two effort areas, Air-to-Air Concept Development and Air-to-Ground Concept Development. The project focuses on risk reduction of advanced explosives, fuzes, warheads, sub-munitions, and weapon airframes, carriage and dispensing; as well as innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation.

In FY 2021, Project 63670B, Weapon Concept Development, non-Vanguard efforts and activities will be transferred from PE 0603601F, Conventional Weapons Technology, to PE 0603035F, Next Gen Effects Dev/Demo. Golden Horde Vanguard activities under this Project will be consolidated and transferred in FY 2021 from PE 0603601F, Conventional Weapons Technology to PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguard. These transfers are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated non-Vanguard efforts and activities will continue to be executed by the Air Force Research Laboratory Munitions Technology Directorate located in Eglin Air Force Base, Florida. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Air-to-Air Concept Development	22.071	81.207	0.000
Description: Mature, integrate, and demonstrate air-to-air weapon components and systems to include ordnance, guidance, and carriage and release technologies to demonstrate war-fighter capability.			
FY 2020 Plans:			
Continue developing the technology trade space to enable air-to-air weapons with robust capability in the future-years threat environment, including technologies for efficient propulsion, high lethality, efficient flight/high-agility, miniaturization, and cost and risk reduction for both offensive and defensive purposes. Continue to develop and test prototype propulsion systems with flexibility to enable more adaptable next generation air-to-air weapons. Continue to conduct lethality studies to enable design of small form factor warheads lethal against the future plus target set. Continue to develop preliminary design of air-to-air weapon concepts for sixth generation platforms. Continue to document missile flight dynamics trade space and conduct wind-tunnel experiments to characterize airframes and validate aerodynamic codes leading to development of highly maneuverable and efficient missiles to counter advanced targets, and improve persistence and survivability of future platforms. Continue to conduct ground and arena tests of advanced weapons experimental-carriages for sixth generation weapon concept and prepare for flight worthiness testing. Continue to mature simulation architectures to assess the trades and synergies between kinetic and directed			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>	Project (Number/Name) 63670B / <i>Weapon Concept Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>energy weapons. Continue to incorporate higher fidelity methodologies into systems level analysis including joint weapons effectiveness and perform experiments with small warheads to obtain data for lethality analysis and validate designs. Continue to plan and execute highly agile airframe ground tests and integrated sub-system experimentation. Initiate planning for major subsystem component tests to verify baseline performance for future counter-air application and platform integration.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under Air-to-Air Concept Development effort under PE 0603035F, Next Generation Effects Dev/Demos, Project 63670B, Weapon Concept Development.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$81.207 million. Funding decreased due to the transfer and realignment of this work to the Air-to-Air Concept Development effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 63670B, Weapon Concept Development as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
<p>Title: Air-to-Ground Concept Development</p> <p>Description: Mature, integrate, and demonstrate air-to-ground weapon components and systems (ordnance, guidance, and carriage and release technologies) to demonstrate war-fighter capability.</p> <p>FY 2020 Plans: Complete low-cost cruise missile/small engine flight test demo. Continue to conduct relevant long range strike weapon technology demonstrations to reduce risk for potential follow-on acquisition programs, and finalize system detailed design for flying hypersonic munition demonstrator flight. Continue the development of munition concepts to incorporate technologies for carriage and terminal impact at high speed. Continue planning and technology risk reduction including demonstration and initial flight testing for weapons concepts responsive to the future-year time-frame threat environment including hypersonic and cooperative/collaborative concepts. Consolidate collaborative munition technology efforts into Air Force Vanguard Golden Horde to include hardware/software development/testing, flight , and modeling and simulations efforts. Continue to mature simulation architectures to assess the trades and synergies between kinetic and directed energy weapons. Continue to incorporate higher fidelity methodologies into systems level analysis including joint weapons effectiveness and to apply methodology to support future air dominance analysis. Continue to investigate kinetic/non-kinetic payloads, seeker, and fuze technology for hypersonic applications. Continue system integration of algorithms and software defined radios onto pathfinder weapon system to enable synchronized collaborative weapon effects.</p> <p>FY 2021 Plans: In FY 2021, non-Vanguard efforts are performed under Air-to-Ground Concept Development effort in PE 0603035F, Next Generation Effects Dev/Demos, Project 63670B, Weapon Concept Development. Golden Horde Vanguard activities are</p>	50.765	86.715	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>	Project (Number/Name) 63670B / <i>Weapon Concept Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
performed under the Golden Horde effort in PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguards.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$86.715 million. Funding decreased due to the transfer and realignment of this work to the Air-to-Ground Concept Development effort in PE 0603035F, Next Gen Effects Dev/Demos, Project 63670B, Weapon Concept Development, with the execution of Golden Horde Vanguard activities which will be realigned to the Golden Horde effort in PE 0603032F, Future AF Integrated Technology Demos, Project 630320, Air Force Vanguards, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	72.836	167.922	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>							
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	39.438	37.404	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
633151: <i>High Power Solid State Laser Technology</i>	-	26.022	19.244	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
633152: <i>High Power Microwave Development and Integration</i>	-	13.416	18.160	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program provides for the development, integration, demonstration, and detailed assessment of directed energy (DE) weapon technologies for potential application on Air Force platforms. These include high energy laser (HEL), high power microwaves (HPM), and other unconventional weapon generation and transmission technologies, which can support a wide range of Air Force applications. The program develops a corresponding susceptibility, vulnerability, and lethality database for directed energy weapons. This program also develops laser-enabled atmospheric-compensated optical imaging for space situational awareness (SSA). Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, the entirety of PE 0603605F, Advanced Weapons Technology, and associated Projects will be transferred to PE 0603035F, Next Gen Effects Dev/Demo, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. This is an administrative realignment and not a new start. This work will continue to be executed by the Air Force Research Laboratory Directed Energy Technology Directorate located in Kirtland Air Force Base, New Mexico.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this program element would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	43.368	37.404	30.971	0.000	30.971
Current President's Budget	39.438	37.404	0.000	0.000	0.000
Total Adjustments	-3.930	0.000	-30.971	0.000	-30.971
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.135	0.000			
• Other Adjustments	-2.795	0.000	-30.971	0.000	-30.971

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of \$2.795 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Decrease in FY 2021 is due to the entirety of PE 0603605F, Advanced Weapons Technology, and associated Projects being transferred to PE 0603035F, Next Gen Effects Dev/Demo, as part of the Air Force RDT&E BA 03 PE consolidation to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>				Project (Number/Name) 633151 / <i>High Power Solid State Laser Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633151: <i>High Power Solid State Laser Technology</i>	-	26.022	19.244	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project provides for the development, integration, demonstration, and detailed technical assessment of high energy laser (HEL) devices, advanced imaging and beam control technologies needed for applications such as force protection, force application, precision engagement, and aircraft self-protection. Laser system concept assessments to include vulnerability assessments and target effect testing are performed. This project also exploits the synergy between high energy laser beam control and advanced optical imaging for space situational awareness (SSA).

In FY 2021, the entirety of Project 633151, High Power Solid State Laser Technology, will be transferred to PE 0603035F, Next Gen effects Dev/Demo, Project 633151, High Power Solid State Laser Technology, as part of the Air Force Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Directed Energy Technology Directorate located in Kirtland Air Force Base, New Mexico. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Energy Laser/Beam Control	25.526	19.244	0.000
Description: Develop and demonstrate advanced beam control technologies, integrated laser systems, and aircraft self-protection laser technologies. Demonstrate beam control components integrated with high energy lasers (HEL) for Air Force utility.			
FY 2020 Plans: Demonstrate the integrated low power laser system in a pod for Phase 1 aircraft self-protect demonstration. Begin integration of a medium power laser system into the pod for Phase 2 aircraft self-protect demonstration. Complete integration of the laser control subsystem for directing the laser onto the target for aircraft self-protect demonstration. Complete development of ground support and aircraft interface. Complete first amplifier prototype for ultra-compact laser and transition into laser subsystem development.			
FY 2021 Plans: In FY 2021, this work is performed under the High Energy Laser/Beam Control effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 633151, High Power Solid State Laser Technology.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>	Project (Number/Name) 633151 / <i>High Power Solid State Laser Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$19.244 million. Funding decreased due to the transfer and realignment of this work to the High Energy Laser/Beam Control effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 633151, High Power Solid State Laser Technology, as part of the Air Force RDT&E BA 03 PE consolidation.				
<p>Title: Optical Space Situational Awareness and Satellite Vulnerability</p> <p>Description: Mature development of laser-enabled, long-range, electro-optical technologies that enable 24/7 ground-based optical space situational awareness delivering characterization results on tactical timelines. Develop and demonstrate technologies that accurately assess the vulnerability of blue satellite systems to lasers. Manage and operate research assets in support of development, demonstration, and integration of ground-based optical space situational awareness technologies.</p> <p>FY 2020 Plans: Starting in FY 2020, this work will be performed under the PE 0602605F, Directed Energy Technology, Project 624866, Lasers & Imaging Technology, Optical Space Situational Awareness and Satellite Vulnerability effort to consolidate Optical Space Situational Awareness and Satellite Vulnerability research efforts.</p> <p>FY 2021 Plans: Not Applicable.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: Not Applicable.</p>		0.496	0.000	0.000
Accomplishments/Planned Programs Subtotals		26.022	19.244	0.000
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>				Project (Number/Name) 633152 / <i>High Power Microwave Development and Integration</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
633152: <i>High Power Microwave Development and Integration</i>	-	13.416	18.160	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates high power microwave (HPM) and other unconventional electromagnetic field generation and transmission technologies that can be integrated into future weapon systems to support a wide range of Air Force missions such as air base defense or the damage/destruction of an adversary's electronic infrastructure. It also provides inputs to the susceptibility, vulnerability, and lethality databases used across the Department of Defense (DoD) to understand thresholds for scalable effects of directed energy weapons.

In FY 2021, the entirety of Project 633152, High Power Microwave Development and Integration, will be transferred to PE 0603035F, Next Gen Effects Dev/Demos, Project 633152, High Power Microwave Development and Integration, as part of the Air Force Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Directed Energy Technology Directorate located in Kirtland Air Force Base, New Mexico. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: High Power Microwave Technologies	13.416	18.160	0.000
Description: Develop and evaluate high power microwave (HPM) and other unconventional weapon technologies for various platforms, including aerial, for applications such as counter-electronics. Develop and evaluate high power microwave technologies for non-kinetic and counter-electronic weapon applications.			
FY 2020 Plans: Test a class of reusable, multi-pulse, multi-target counter-electronics payloads capable of being hosted in various advanced platforms. Continue to characterize, model, test and evaluate current and projected blue directed energy threats on current red assets. Develop and test the high power microwave payload for the joint flight demonstration with the Navy. Design agile waveform high power sources.			
FY 2021 Plans: In FY 2021, this work is performed under the High Power Microwave Technologies effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 633152, High Power Microwave Technology.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>	Project (Number/Name) 633152 / <i>High Power Microwave Development and Integration</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$18.160 million. Funding decreased due to the transfer and realignment of this work to the High Power Microwave Technologies effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 633152, High Power Microwave Technology, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	13.416	18.160	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603680F / <i>Manufacturing Technology Program</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	62.187	130.916	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635280: <i>Manufacturing Technologies</i>	-	62.187	130.916	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program executes technical programs to maintain and develop an affordable and reliable industrial base and manufacturing capability that will be responsive to warfighter needs. The program develops and improves manufacturing technologies and processes to enable cost reduction, improve component and system quality, and enhance industrial capability. Value stream modifications and manufacturing throughput improvements are effected to shorten cycle times of weapon systems during design, development, production and sustainment. Manufacturing Technologies objectives are conducted through industrial partnerships which enable the demonstration of manufacturing technologies for existing weapon system upgrades and/or for new warfighter systems. Efforts in the program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.

In FY 2021, the entirety of PE 0603680F, Manufacturing Technology Program and associated Project will be transferred to PE 0603030F, AF Foundational Development/Demonstration, as part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force S&T Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Materials and Manufacturing Technology Directorate located in Wright Patterson AFB, Ohio. This is an administrative realignment for consolidation, and not a new start.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0603680F I Manufacturing Technology Program
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	65.760	43.116	44.416	0.000	44.416
Current President's Budget	62.187	130.916	0.000	0.000	0.000
Total Adjustments	-3.573	87.800	-44.416	0.000	-44.416
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	87.800			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.782	0.000			
• Other Adjustments	-1.791	0.000	-44.416	0.000	-44.416

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 635280: *Manufacturing Technologies*

- Congressional Add: *Program increase - F-35 Battery Technology*
- Congressional Add: *Program increase - Thermal protection for hypersonic vehicles*
- Congressional Add: *Program increase - Materials Development Research*
- Congressional Add: *Program Increase - Modeling Technology for Small Turbine Engines*
- Congressional Add: *Program increase - Low cost manufacturing methods for hypersonic vehicle components*
- Congressional Add: *Program increase - Flexible hybrid electronics*
- Congressional Add: *Program increase - Aerospace composite structures*
- Congressional Add: *Program increase - Certification of bonded aircraft structures*
- Congressional Add: *Program increase - Industrialization of ceramic matrix composites for hypersonic weapons*
- Congressional Add: *Program increase - Thermal batteries*
- Congressional Add: *Program increase - Technologies to repair fastener holes*
- Congressional Add: *Program increase - Manufacturing technology for reverse engineering*
- Congressional Add: *Program increase - Solid state battery research*
- Congressional Add: *Program increase - Agile manufacturing initiatives*

	FY 2019	FY 2020
	9.535	9.800
	0.000	10.000
	9.729	5.000
	3.892	5.000
	0.000	8.000
	0.000	5.000
	0.000	5.000
	0.000	5.000
	0.000	10.000
	0.000	2.000
	0.000	5.000
	0.000	5.000
	0.000	3.000
	0.000	10.000
Congressional Add Subtotals for Project: 635280	23.156	87.800

Congressional Add Subtotals for Project: 635280

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020	
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>		R-1 Program Element (Number/Name) PE 0603680F / <i>Manufacturing Technology Program</i>	
Congressional Add Details (\$ in Millions, and Includes General Reductions)		FY 2019	FY 2020
Congressional Add Totals for all Projects		23.156	87.800
Change Summary Explanation			
Decrease in FY 2019 in Other Adjustments of \$1.791 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).			
Decrease in FY 2021 of \$44.416 million is due to the entirety of PE 0603680F, Manufacturing Technology Program, and associated Project being transferred to PE 0603030F, AF Foundational Development/Demos, as part of the Air Force RDT&E BA 03 PE consolidation to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force S&T Strategy, April 2019.			
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020
Title: Sustainment Manufacturing Technologies		10.929	12.072
Description: Develop and transition pervasive affordability and producibility technologies for the sustainment of weapons systems and processes.			
FY 2020 Plans: Advance high demand specialized manufacturing technologies to develop cost effective conventional production and special material repair technologies to enable affordable sustainment of aircraft systems. Align distributed advanced manufacturing techniques and concepts for agile sustainment and automation technology development for depot maintenance and flight line repair efficiency.			
FY 2021 Plans: In FY 2021, this work is performed under the Sustainment Manufacturing Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 635280, Manufacturing Technologies.			
FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$12.072 million. Funding decreased due to the transfer and realignment of this work to the Sustainment Manufacturing Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 635280, Manufacturing Technologies.			
Title: Advanced Manufacturing Technologies		28.102	31.044
Description: Develop and transition affordable advanced manufacturing technologies for weapons systems.			
FY 2020 Plans:			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603680F / <i>Manufacturing Technology Program</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Continue to refine the development and demonstrate advanced agile manufacturing and repair capabilities for more affordable and increased availability of advanced turbine engine propulsion technologies, intelligence surveillance and reconnaissance and communications technologies, transparent ceramics producibility, and the producibility of air armaments. Continue and refine development of high demand distributed agile manufacturing applications and structures affordability with a focus on low cost attritable aircrafts with a focus on open architecture. Transition successful technologies. Continue the development and demonstrate manufacturing capabilities for producibility and affordability of aerospace structures, and hypersonics.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Advanced Manufacturing Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 635280, Manufacturing Technologies.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$31.044 million. Funding decreased due to the transfer and realignment of this work to the Advanced Manufacturing Technologies effort in PE 0603030F, AF Foundational Development/Demos, Project 635280, Manufacturing Technologies.</p>			
Accomplishments/Planned Programs Subtotals	39.031	43.116	0.000

	FY 2019	FY 2020
<p>Congressional Add: Program increase - F-35 Battery Technology</p> <p>FY 2019 Accomplishments: Conducted Congressionally directed efforts.</p> <p>FY 2020 Plans: Conduct Congressionally directed efforts.</p>	9.535	9.800
<p>Congressional Add: Program increase - Thermal protection for hypersonic vehicles</p> <p>FY 2019 Accomplishments: Not Applicable</p> <p>FY 2020 Plans: Conduct Congressionally directed efforts.</p>	0.000	10.000
<p>Congressional Add: Program increase - Materials Development Research</p> <p>FY 2019 Accomplishments: Conducted Congressionally directed efforts.</p> <p>FY 2020 Plans: Conduct Congressionally directed efforts.</p>	9.729	5.000
<p>Congressional Add: Program Increase - Modeling Technology for Small Turbine Engines</p>	3.892	5.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020	
Appropriation/Budget Activity	R-1 Program Element (Number/Name)		
3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	PE 0603680F I Manufacturing Technology Program		
	FY 2019	FY 2020	
FY 2019 Accomplishments: Conducted Congressionally directed efforts.			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Add: Program increase - Low cost manufacturing methods for hypersonic vehicle components	0.000	8.000	
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Add: Program increase - Flexible hybrid electronics	0.000	5.000	
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Add: Program increase - Aerospace composite structures	0.000	5.000	
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Add: Program increase - Certification of bonded aircraft structures	0.000	5.000	
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Add: Program increase - Industrialization of ceramic matrix composites for hypersonic weapons	0.000	10.000	
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Add: Program increase - Thermal batteries	0.000	2.000	
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Add: Program increase - Technologies to repair fastener holes	0.000	5.000	
FY 2019 Accomplishments: Not Applicable			
FY 2020 Plans: Conduct Congressionally directed efforts.			
Congressional Add: Program increase - Manufacturing technology for reverse engineering	0.000	5.000	

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603680F / <i>Manufacturing Technology Program</i>
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	FY 2019	FY 2020
FY 2019 Accomplishments: Not Applicable		
FY 2020 Plans: Conduct Congressionally directed efforts.		
Congressional Add: Program increase - Solid state battery research	0.000	3.000
FY 2019 Accomplishments: Not Applicable		
FY 2020 Plans: Conduct Congressionally directed efforts.		
Congressional Add: Program increase - Agile manufacturing initiatives	0.000	10.000
FY 2019 Accomplishments: Not Applicable		
FY 2020 Plans: Conduct Congressionally directed efforts.		
Congressional Adds Subtotals	23.156	87.800

D. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0603788F I Battlespace Knowledge Development and Demonstration
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	58.369	56.414	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635319: Anticipatory OPS Intent and Response	-	7.978	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.978
635320: Assured Worldwide Connectivity	-	24.308	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	24.308
635321: C4I Battlespace Dev and Demo	-	7.395	36.303	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
635322: Knowledge Management and Computing	-	3.479	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.479
635329: Cyber Battlespace Dev & Demo	-	15.209	20.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates Air Force enterprise-centric information technologies for the warfighter. The Anticipatory Operations Intent and Response project develops the technologies for dynamic planning and execution with the accuracy, fidelity, and timeliness needed to dominate the battlespace. The Assured Worldwide Connectivity project provides advanced net-enabled architectures and communications technologies in support of global military operations, including a secure information grid for worldwide information exchange of near-real-time multimedia (i.e., voice, data, video, and imagery) information. In addition, this project develops and demonstrates advanced optical networking and communications for Air Force air and space-based information exchange on and between platforms. These optical networks will be rapidly deployable, mobile, interoperable, and seamless between Air and Space Operations Centers (AOCs) and air and space-based platforms either en route or in theater. This project also provides tools and applications leading to the development and integration of cyber deterrence technologies resulting in a strategic capability of cyber dominance within the secure information grid. The Global Battlespace Awareness project develops, integrates, and demonstrates advanced technologies to achieve comprehensive net-centric operations and total battlespace awareness by using and exploiting information from all sources. The Knowledge Management and Computing project develops the technology applications that will provide for a secure, tailored, seamless exchange of information among producers, consumers, and managers of information relevant to a particular community of interest (COI). The project also provides the development of interactive and real-time computing technologies that greatly improve the usability of high-performance computing for the exchange, utilization, and management of information in the enterprise. The Cyber Battlespace Development and Demonstration project develops the ability to deliver sovereign options in cyberspace through the development and integration of cyber attack, cyber defense, and cyber support technologies for a strategic capability of cyber dominance.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. Operational agility will require flexibility (manifested as multi-domain operations), speed (manifested as superior decision speed), coordination (manifested as dynamic command and control), balance (manifested as presenting a balanced capability mix), and strength (manifested as performance-optimized teams). In order to enable operational agility, this program will

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	
<p>begin to shape future research and development (R&D) to focus on technologies in support of operational agility through multi-domain command and control (MDC2) capabilities.</p> <p>This program has been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.</p> <p>In FY 2020, Project 635319, Anticipatory OPS Intent and Response; Project 635320, Assured Worldwide Connectivity; and Project 635322, Knowledge Management and Computing efforts were transferred to Project 635321, C4I Battlespace Dev and Demo, in order to realign planning and decision support, intelligent networking transport and management, and information management advanced technology development.</p> <p>In the FY 2021, the Air Force is consolidating its existing thirteen Advanced Technology Development (ATD), Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PEs into five new capability focused RDT&E BA 03 PEs to better align with the Air Force Science and Technology (S&T) Strategy signed by the SECAF in April 2019. This consolidation will improve and accelerate delivery of integrated transformational, multidisciplinary, collaborative technology solutions necessary to enable new Air Force warfighting capabilities that support of the National Defense Strategy. This new structure will provide the Air Force and Congress with a clearer understanding and increased transparency of integrated technology solutions and demonstrations key to enabling the Air Force future force design.</p> <p>In FY 2021, the entirety of Project 635321, C4I Battlespace Dev and Demo, will be transferred from PE 0603788F, Battlespace Knowledge Development and Demonstration, to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech.</p> <p>In FY 2021, the entirety of Project 635329, Cyber Battlespace Dev & Demo, will be transferred from PE 0603788F, Battlespace Knowledge Development and Demonstration, to PE 0603035F, Next Gen Effects Dev/Demos.</p> <p>All these transfers detailed above are part of the Air Force RDT&E BA 03 PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force S&T Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start. The Projects and associated efforts will continue to be executed by the Air Force Research Laboratory Information Technology Directorate located in Rome, New York.</p> <p>This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.</p> <p>This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.</p>		

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	60.017	56.414	56.746	0.000	56.746
Current President's Budget	58.369	56.414	0.000	0.000	0.000
Total Adjustments	-1.648	0.000	-56.746	0.000	-56.746
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.648	0.000			
• Other Adjustments	0.000	0.000	-56.746	0.000	-56.746

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 635320: *Assured Worldwide Connectivity*

Congressional Add: *Program Increase - Assured Worldwide Connectivity*

	FY 2019	FY 2020
Congressional Add Subtotals for Project: 635320	8.753	0.000
Congressional Add Totals for all Projects	8.753	0.000

Change Summary Explanation

Decrease in FY 2021 of \$56.746 million is due to the entirety of PE 0603788F, Battlespace Knowledge Development and Demonstration, and associated Projects being transferred to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech and PE 0603035F, Next Gen Effects Dev/Demos, as part of the Air Force RDT&E BA 03 PE consolidation to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force S&T Strategy, April 2019.

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>				Project (Number/Name) 635319 / <i>Anticipatory OPS Intent and Response</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635319: <i>Anticipatory OPS Intent and Response</i>	-	7.978	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.978

A. Mission Description and Budget Item Justification

In order to achieve information dominance, the Air Force must be able to monitor, assess, plan, and execute missions rapidly across the full spectrum of operations (air, space, and cyberspace) at all levels of war (strategic, operational, and tactical) and during all phases of conflict (pre-conflict, conflict through stability operations). This project develops and integrates decision support technologies that will enhance the commander's ability to anticipate and dominate the future battlespace by more effectively forecasting the evolution of the battlespace and by more rapidly generating options to "virtually checkmate" the adversary. It develops the decision aid technologies and processes to plan the use of various assets and assess their effects in the battlespace. It provides a tailorable information environment to effectively portray complex data sets accurately in real-time.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on technologies in support of multi-domain command and control.

In FY 2020, Project 635319, Anticipatory OPS Intent and Response, efforts transferred to Project 635321, C4I Battlespace Dev and Demo, in order to realign technology areas that better support both the Air Force Future Operating Concept and National Defense Strategy.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
<p>Title: Adaptive Planning and Decision Tools</p> <p>Description: Develop and demonstrate the integration of planning tools and information-based intelligent agents for adaptive replanning and decision support tools.</p> <p>FY 2020 Plans: Starting in FY 2020, this work is performed under the Multi-Domain Command and Control effort within Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2021 Plans: Not Applicable</p>	3.618	0.000	0.000
<p>Title: Next Generation Planning and Assessment Tools</p> <p>Description: Develop and demonstrate an effects-based approach for the next generation of planning and assessment techniques that enable decision makers to determine operational effects.</p>	4.360	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635319 / <i>Anticipatory OPS Intent and Response</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p><i>FY 2020 Plans:</i> Starting in FY 2020, this work is performed under both Multi-Domain Command and Control and Artificial Intelligence/Autonomy/ Machine Learning efforts within Project 635321, C4I Battlespace Dev and Demo.</p> <p><i>FY 2021 Plans:</i> Not Applicable</p>			
Accomplishments/Planned Programs Subtotals	7.978	0.000	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>					Project (Number/Name) 635320 / <i>Assured Worldwide Connectivity</i>		
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635320: <i>Assured Worldwide Connectivity</i>	-	24.308	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	24.308

A. Mission Description and Budget Item Justification

The Air Force requires advanced, net-enabled architectures and communications technologies in support of global kinetic and non-kinetic military operations, including a secure information grid for worldwide information delivery and exchange of near-real-time information including voice, data, video, and imagery. This secure environment will be rapidly deployable, mobile, interoperable, and seamless between the Air Operations Center and aircraft, either en route or in theater. This project provides secure information transmission capabilities for a persistent, global, survivable communications backbone network accessible for warfighters operating in all domains. It provides self-healing, self-configuration, anti-jam communication networking capabilities, and provides enterprise networking capabilities for agile, policy-based network management. In addition, this project develops and demonstrates flight ready systems consisting of high capacity radio frequency (RF) and optical components and architectures for next generation communications.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, the Air Force requires world-wide connectivity that is resilient and self-healing in the face of enemy attacks on communication and information assurance, able to withstand breaks in connectivity while still allowing users to collaborate with other connected operators to maintain localized situational awareness. The network balances the respective strengths of both forward-deployed forces and rear-based nodes.

In FY 2020, Project 635320, Assured Worldwide Connectivity, efforts transferred to Project 635321, C4I Battlespace Dev and Demo, in order to realign technology areas that better support both the Air Force Future Operating Concept and National Defense Strategy.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Connectivity Technologies	15.555	0.000	0.000
Description: Develop and demonstrate intelligent networking transport and management technology to provide assured, seamless, battlespace connectivity to the Air Force tailored to anti-access/area denial environments and contested operations.			
FY 2020 Plans: Starting in FY 2020, this work is performed under both Assured Communications & Networks and Nuclear C3 Modernization efforts within Project 635321, C4I Battlespace Dev and Demo.			
FY 2021 Plans: Not Applicable			
Accomplishments/Planned Programs Subtotals	15.555	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635320 / <i>Assured Worldwide Connectivity</i>

	FY 2019	FY 2020
Congressional Add: Program Increase - Assured Worldwide Connectivity	8.753	0.000
FY 2019 Accomplishments: Conducted Congressionally directed efforts.		
FY 2020 Plans: Not Applicable		
Congressional Adds Subtotals	8.753	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>				Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635321: <i>C4I Battlespace Dev and Demo</i>	-	7.395	36.303	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on technologies in support of multi-domain command and control.

In order to achieve operational agility, the Air Force must be able (a) to monitor, assess, plan, and execute missions rapidly across the full spectrum of operations at all levels of war and during all phases of conflict; (b) to field advanced, secure, net-enabled architectures and communications/network technologies in support of persistent, global, and survivable kinetic and non-kinetic military operations; (c) to process and exploit data and information from a variety of sources and domains to create a common operating picture of the battlespace; and (d) to provide the decision maker and staff with seamless access to tailored information within a mobile, dynamic, and scalable, globally distributed Air Operations Center, as well as among other producers, consumers, and managers of information relevant to other particular Communities of Interest (COI).

In FY 2020, Project 635319, Anticipatory OPS Intent and Response; Project 635320, Assured Worldwide Connectivity; and Project 635322, Knowledge Management and Computing efforts transferred to Project 635321, C4I Battlespace Dev and Demo, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept.

In FY 2021, the entirety of Project 635321, C4I Battlespace Dev and Demo, will be transferred to PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo, in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Information Technology Directorate located in Rome, New York. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Advanced Signal and Data Exploitation Technologies	1.321	0.000	0.000
Description: Demonstrate advanced signal and data exploitation technologies for detection, tracking, identification, and targeting of time-critical targets, and information extraction.			
FY 2020 Plans: In FY 2020, this work is performed within this Project, under the Data to Decisions effort.			
FY 2021 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
Not Applicable				
<p>Title: Advanced Data Handling, Visualization and Distributed Data Fusion</p> <p>Description: Develop and demonstrate advanced data handling, event visualization technologies, and distributed data fusion to enable a more effective utilization of data available.</p> <p>FY 2020 Plans: In FY 2020, this work is performed within this Project, under the Data to Decisions effort.</p> <p>FY 2021 Plans: Not Applicable</p>		4.363	0.000	0.000
<p>Title: Adversary Courses of Action</p> <p>Description: Develop models to provide detailed understanding of the adversary's probable intent and future strategy to identify adversary courses of action, the most likely course of action, and the course of action most dangerous to friendly forces and mission accomplishment.</p> <p>FY 2020 Plans: In FY 2020, this work is performed within this Project, under the Multi-Domain Command and Control effort.</p> <p>FY 2021 Plans: Not Applicable</p>		1.711	0.000	0.000
<p>Title: Multi-Domain Command and Control</p> <p>Description: Perform research and development (R&D) that will advance existing, or discover new, command and control capabilities to support multi-domain operations (MDO) for air, space, cyberspace, land, sea, and undersea.</p> <p>For FY 2019 and prior years, Adversary Courses of Action activities were performed within this Project under the Adversary Courses of Action effort.</p> <p>For FY 2019 and prior years, Adaptive Planning and Decision Tools and the Next Generation Planning and Assessment Tools activities were performed within Project 635319, Anticipatory OPS Intent and Response under the Adaptive Planning and Decision Tools and Next Generation Planning and Assessment Tools efforts.</p>		0.000	8.418	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>For FY 2019 and prior years, Advanced Information Management activities were performed within Project 635322, Knowledge Management and Computing under the Advanced Information Management effort.</p> <p>FY 2020 Plans: Continue to execute experiments, based on operational scenarios, which incorporate process management execution into the extensible Space command and control framework, and which integrate disparate data and applications, providing a pedigree for proposed tasking options to decision makers. Continue to develop software capabilities that employ cyber, directed energy, and electronic warfare weaponry. Provide on-the-fly valuable quantitative evaluations of cyber assets to cyber operators, enabling them to present viable cyber options to commanders in multi-domain settings.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Multi-Domain Command and Control effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$8.418 million. Funding decreased due to the transfer and realignment of this work to the Multi-Domain Command and Control effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
<p>Title: Nuclear C3 Modernization</p> <p>Description: Develop and demonstrate the advancement of existing nuclear capable forces to ensure command, control, and connectivity for the President without constraints.</p> <p>For FY 2019 and prior years, Connectivity Technologies activities were performed within Project 635320, Assured Worldwide Connectivity under the Connectivity Technologies effort.</p> <p>FY 2020 Plans: Continue to perform real-time monitoring of ionospheric conditions over the Continental United States (CONUS). Continue testing of very-low-frequency (VLF) stub antenna for reachback. Continue testing of prototype compact high-frequency (HF) antennas.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Nuclear C3 Modernization effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	0.000	4.804	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
<p>FY 2021 decreased compared to FY 2020 by \$4.804 million. Funding decreased due to the transfer and realignment of this work to the Nuclear C3 Modernization effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo as part of the Air Force RDT&E BA 03 PE consolidation.</p> <p>Title: Artificial Intelligence/Autonomy/Machine Learning</p> <p>Description: Develop and demonstrate to harness the speed and scale of computers and machines to address problems of complexity.</p> <p>For FY 2019 and prior years, Next Generation Planning and Assessment Tools activities were performed within Project 635319, Anticipatory OPS Intent and Response under the Next Generation Planning and Assessment Tools effort.</p> <p>FY 2020 Plans: Continue to identify and implement state of the art learning models. Continue development of data-efficient learning. Continue to integrate within the StreamlinedML framework. Continue development of end-to-end baseline learning capability. Continue development of model recommendation & user workflow capabilities. Continue investigations of real-time deep learning algorithms.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Artificial Intelligence/Autonomy/Machine Learning effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$5.295 million. Funding decreased due to the transfer and realignment of this work to the Artificial Intelligence/Autonomy/Machine Learning effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo as part of the Air Force RDT&E BA 03 PE consolidation.</p>		0.000	5.295	0.000
<p>Title: Data to Decisions</p> <p>Description: Develop and demonstrate the collection, management, analysis, and exploitation of complex data for availability to Air Force and other stakeholders.</p> <p>For FY 2019 and prior years, the Advanced Signal and Data Exploitation Technologies and Advanced Data Handling, Visualization and Distributed Data Fusion activities were performed within this Project under Advanced Signal and Data Exploitation Technologies and the Advanced Data Handling, Visualization and Distributed Data Fusion efforts.</p> <p>FY 2020 Plans:</p>		0.000	7.254	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Continue to refine and test technologies for ultra-wideband electronics intelligence signal detection and prosecution. Continue development and demonstration of intelligence analysis capabilities from multiple intelligence sources for both near-real time and post mission. Continue research and development in data analytics and strategic indications and warnings. Perform service-based capability development. Continue with object based production optimized processing and automated-association capability.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Data to Decisions effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$7.254 million. Funding decreased due to the transfer and realignment of this work to the Data to Decisions effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo.</p>			
<p>Title: Assured Communications & Networks</p> <p>Description: Develop and demonstrate secure and reliable communications to ensure the delivery of timely, reliable, and actionable information to warfighters and systems.</p> <p>For FY 2019 and prior years, Connectivity Technologies activities were performed within Project 635320, Assured Worldwide Connectivity under the Connectivity Technologies effort.</p> <p>FY 2020 Plans: Continue development and demonstration for rapid waveform development of multi-mission software defined radio frequency capability. Continue Wideband high frequency waveform development and testing. Investigate ionospheric research, propagation modeling and simulation. Continue beacon data collection on both the V and W frequency bands along with waveform development and simulation. Continue development of test platform for Common Very Low Frequency Receiver Increment Two.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Assured Communications & Networks effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$10.532 million. Funding decreased due to the transfer and realignment of this work to the Assured Communications & Networks effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo as part of the Air Force RDT&E BA 03 PE consolidation.</p>	0.000	10.532	0.000
Accomplishments/Planned Programs Subtotals	7.395	36.303	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635321 / <i>C4I Battlespace Dev and Demo</i>

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3				R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>				Project (Number/Name) 635322 / <i>Knowledge Management and Computing</i>				
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635322: <i>Knowledge Management and Computing</i>	-	3.479	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.479

A. Mission Description and Budget Item Justification

The Air Force requires technologies that will provide the decision maker and staff with seamless access to tailored information within a mobile, dynamic, and scalable, globally distributed Air Operations Center, as well as among other producers, consumers, and managers of information relevant to other particular Communities of Interest (COI). This project demonstrates the enterprise management capabilities needed for the rapid distribution of actionable information, as well as the needed advances in high performance computing to ensure this complex capability. This project develops an agile information environment that focuses on quality of service, transformation and brokering, a federated information environment focusing the relationship among the members of the environment, a secure cross-domain information sharing capability that focuses on the security layer and inter-COI information exchange in different security domains, and a collaboration environment focusing on the information workflow layer of the enterprise.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on technologies in support of multi-domain command and control.

In FY 2020, Project 635322, Knowledge Management and Computing, efforts transferred to Project 635321, C4I Battlespace Dev and Demo, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Advanced Information Management	3.479	0.000	0.000
Description: Demonstrate how a publish, subscribe, and query information management paradigm can enable vertical and horizontal integration of Air Force information systems.			
FY 2020 Plans: Starting in FY 2020, this work is performed under the Multi-Domain Command and Control effort within Project 635321, C4I Battlespace Dev and Demo.			
FY 2021 Plans: Not Applicable			
Accomplishments/Planned Programs Subtotals	3.479	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635322 / <i>Knowledge Management and Computing</i>

C. Other Program Funding Summary (\$ in Millions)
N/A

Remarks

D. Acquisition Strategy
N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force										Date: February 2020		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>				Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
635329: <i>Cyber Battlespace Dev & Demo</i>	-	15.209	20.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force requires the ability to deliver sovereign options in cyberspace through the development and integration of cyber-attack, cyber defense, and cyber support technologies for a strategic capability of cyber dominance. This project develops the ability to deliver cyber-attack capabilities (access, stealth, persistence, intelligence, and weapons delivery), cyber defense capabilities (attack detection, attack attribution, and response automation) and cyber support capabilities (situation awareness and war gaming). This project will also develop 1) a science and engineering capability demonstrating new models of computation, 2) novel approaches for high performance, interactive, net-centric, distributed and embedded computing systems, and 3) the technological tools enabling affordable, large-scale, and complex software-intensive systems.

The National Defense Strategy and Air Force Future Operating Concept established science and technology challenges to enable operational agility (the ability to rapidly generate and shift among multiple solutions for a given challenge) as a way to adapt swiftly to any situation or enemy action. In order to enable multi-domain operations, this project will begin to shape future research and development to focus on cyber technologies in support of multi-domain command and control.

In FY 2021, the entirety of Project 635329, Cyber Battlespace Dev & Demo, will be transferred to Program Element 0603035F, Next Gen Effects Dev/Demos, Project 635329, Cyber Battlespace Dev & Demo, as part of the Air Force Research Development Test and Evaluation (RDT&E), Budget Activity 03 (BA 03) PE consolidation in order to realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. The Project and associated efforts will continue to be executed by the Air Force Research Laboratory Information Technology Directorate located in Rome, New York. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021
Title: Cyber Offense	3.881	0.000	0.000
Description: Develop and demonstrate offensive cyber operations capabilities in a series of experimental technology demonstrations.			
FY 2020 Plans: Starting in FY 2020, this work is performed within this Project, under the Cyber Power Projection effort.			
FY 2021 Plans: Not Applicable			
Title: Resiliency	5.437	7.339	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
<p>Description: Integrate and demonstrate a resilient and self-generating information enterprise that dynamically recognizes, characterizes, and understands novel cyber attacks, and then reconfigures and self-optimizes itself to resist new attacks.</p> <p>FY 2020 Plans: Continue to develop and evolve of software capabilities and Concept of Operations for active guidance and automated processes addressing cyber resiliency and survivability. Continue to advance capability migration to form factors which more readily align with operational systems. Continue to demonstrate automated cyber survivability using integrated cyber technologies within the operational system laboratory in the context of risk management framework requirements. Continue development of an advanced secure processor hardware capability.</p> <p>FY 2021 Plans: In FY 2021, this work is performed under the Resiliency effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 635329, Cyber Battlespace Dev & Demo.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$7.339 million. Funding decreased due to the transfer and realignment of this work to the Resiliency effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 635329, Cyber Battlespace Dev & Demo as part of the Air Force RDT&E BA 03 PE consolidation.</p>			
<p>Title: Game Changing Computing Power</p> <p>Description: Develop and demonstrate computer architectures with greater capacity and sophistication to enable game-changing computing power to the warfighter anywhere, anytime.</p> <p>FY 2020 Plans: Continue and complete work to improve software specifications using evolutionary approaches to optimize computer processing. Extend Robust AI/Autonomy/Machine Learning upgrades and development. Complete the research and development to demonstrate a trusted and resilient embedded system (e.g. autonomous vehicle) that is capable of identifying, localizing and automatically repairing previously unknown or unintended vulnerabilities in the software</p> <p>FY 2021 Plans: In FY 2021, the cyber component of this work is completed and the non-cyber component of this work is performed under the Game Changing Computing Power effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement:</p>	4.779	4.962	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by \$4.962 million. Funding decreased due to the transfer and realignment of this work to the Game Changing Computing Power effort in PE 0603034F, Persistent Knowledge, Awareness, & C2 Tech, Project 635321, C4I Battlespace Dev and Demo as part of the Air Force RDT&E BA 03 PE consolidation.				
<p>Title: Autonomous, Multi-level Access and Transfer</p> <p>Description: Develop autonomous, secure information access and sharing capabilities required by the Air Force net-centric information enterprise.</p> <p>FY 2020 Plans: Extend development and integration of polyglot file identification filter to mitigate data exfiltration risk. Sustain development of a modularized filter store to maximize filter re-usability and increase the agility of cross-domain solutions to support new file types.</p> <p>FY 2021 Plans: For FY 2021, this work is performed under the Autonomous, Multi-level Access and Transfer effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 635329, Cyber Battlespace Dev & Demo.</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: FY 2021 decreased compared to FY 2020 by \$1.422 million. Funding decreased due to the transfer and realignment of this work to the Autonomous, Multi-level Access and Transfer effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 635329, Cyber Battlespace Dev & Demo as part of the Air Force RDT&E BA 03 PE consolidation.</p>		1.112	1.422	0.000
<p>Title: Cyber Power Projection</p> <p>Description: Develop and demonstrate offensive cyber capabilities in contested environments through a series of experiments and exercises.</p> <p>For FY 2019 and prior years, Cyber offense activities were performed under the Cyber Offense effort within this project.</p> <p>FY 2020 Plans: Extend development of systems to identify items of interest associated with the Internet of Things. Advance the development of a counter small unmanned aerial system open architecture specification to enable interoperability between disparate protection systems. Continue to integrate and transition multiple Air Force Research Laboratory and Air Force Lifecycle Management Center counter small unmanned aerial system capabilities. Provide capability to enable the warfighter access into congested environments as directed by warfighter requirements.</p> <p>FY 2021 Plans:</p>		0.000	6.388	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
In FY 2021, this work is performed under the Cyber Power Projection effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 635329, Cyber Battlespace Dev & Demo.			
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> FY 2021 decreased compared to FY 2020 by \$6.388 million. Funding decreased due to the transfer and realignment of this work to the Cyber Power Projection effort in PE 0603035F, Next Gen Effects Dev/Demo, Project 635329, Cyber Battlespace Dev & Demo, as part of the Air Force RDT&E BA 03 PE consolidation.			
Accomplishments/Planned Programs Subtotals	15.209	20.111	0.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0604445F / <i>Wide Area Surveillance</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	0.000	20.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.000
834240: <i>Wide Area Surveillance (WAS)</i>	-	0.000	20.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.000

Note

In FY2017, Project 675895, Wide Area Surveillance was terminated.
 In FY2018, Project 675899, Wide Area Surveillance EMD effort was completed.
 In FY2020, Project 834240, Wide Area Surveillance was a new start and will execute from Project 675899.

A. Mission Description and Budget Item Justification

The Wide Area Surveillance (WAS) program provides homeland defense sensors to North American Aerospace Defense Command/US Northern Command (NORAD/USNORTHCOM) for air surveillance and cruise missile defense of the National Capital Region.

WAS consists of two advanced sensor systems, the Stateside Affordable Radar System (STARS) and Scorpion, incorporated into a single WAS System. Based on existing technological capabilities, WAS detects/tracks low, slow and other asymmetrical threats in the airspace and meet the user needs of sensing stressing airborne targets in complex environments with affordable sensors. The sensor outputs are incorporated into the Battle Control Systems-Fixed (BCS-F) air picture and utilized as the NORAD/USNORTHCOM Command and Control (C2) air surveillance system of record.

Aspects of the WAS program are classified and information will be provided on a need-to-know basis.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver WAS weapon system capability. The use of such program funds would be in addition to the civilian pay expenses budgeted in program element 0605831F.

This program is in Budget Activity 7, Operational System Development because this budget activity includes development efforts to upgrade systems that have been fielded or have received approval for full rate production and anticipate production funding in the current or subsequent fiscal year.

This exhibit, and the statement below, erroneously show development effort in Budget Activity 3 (project 834240). The congressionally directed transfer of \$20M RDT&E funding will be received and executed in Budget Activity 7 (project 675899) corresponding to operational system development.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0604445F I Wide Area Surveillance
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B. Program Change Summary (\$ in Millions)	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021 Base</u>	<u>FY 2021 OCO</u>	<u>FY 2021 Total</u>
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	20.000	0.000	0.000	0.000
Total Adjustments	0.000	20.000	0.000	0.000	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	20.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

Change Summary Explanation

FY20 Budget Appeal Paper requested transfer of \$20M from Procurement to RDT&E. Reference OP,AF line 34 and RDT&E,AF line 155.

C. Accomplishments/Planned Programs (\$ in Millions)	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021</u>
Title: Development, Test & Fielding	-	20.000	0.000
Description: Development, Test & Fielding			
FY 2020 Plans: Support STARS (S1) Block 2 Configuration Upgrade			
FY 2021 Plans: Support STARS (S1) Block 2 Configuration Upgrade			
FY 2020 to FY 2021 Increase/Decrease Statement: FY20 Appropriations bill directed transfer of \$20M to support development of STARS Block 2 digital upgrade for improved operational capability and reduced lifecycle support costs.			
Accomplishments/Planned Programs Subtotals	-	20.000	0.000

D. Other Program Funding Summary (\$ in Millions)											<u>Cost To</u>
<u>Line Item</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021 Base</u>	<u>FY 2021 OCO</u>	<u>FY 2021 Total</u>	<u>FY 2022</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>FY 2025</u>	<u>Complete</u>	<u>Total Cost</u>
• OPAF 03 834240: Wide Area Surveillance (WAS)	75.532	42.118	59.633	-	59.633	53.049	8.292	0.000	0.000	243.071	481.695

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0604445F / <i>Wide Area Surveillance</i>
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D. Other Program Funding Summary (\$ in Millions)

<u>Line Item</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021</u> <u>Base</u>	<u>FY 2021</u> <u>OCO</u>	<u>FY 2021</u> <u>Total</u>	<u>FY 2022</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>FY 2025</u>	<u>Cost To</u> <u>Complete</u>	<u>Total Cost</u>
• OPAF 05 0604445F: <i>Wide Area Surveillance</i>	0.000	3.007	1.904	-	1.904	8.904	5.057	5.413	5.471	0.000	29.756

Remarks

E. Acquisition Strategy

The Wide Area Surveillance (WAS) strategy is a single step acquisition approach for full capability to develop, produce, and field highly capable and sustainable advanced sensors in the National Capital Region. Science & technology contracts were let prior to the Engineering and Manufacturing Development phase for both sub-systems. The Cost Plus Fixed-Fee (CPFF) contract for Stateside Affordable Radar System (STARS) was awarded to a single developer to design, build, integrate, and test the STARS system. A subsequent task order was awarded (Jul 17) to include pre-operational site support. The CPFF contract for Scorpion was awarded (Aug 17) to a single developer to complete the design, build, integration, and testing of the Scorpion system, and conduct pre-operational site support. This strategy includes a single delivery approach with 11 STARS and 18 Scorpion systems for a total of 29 sub-systems delivered to achieve FOC. The pre-operational contract for the Scorpion system transitioned to Interim Contract Support (ICS) in Dec 2018, STARS system transitioned to ICS in June 2019.

Air Force Program Executive Officer (PEO) DIGITAL (AFPEO DIGITAL) is the PEO for WAS. Air Force Life Cycle Management Center (AFLCMC) is the Contracting Authority for the WAS program and provides contracts, legal, and comptroller support. The Secretary of the Air Force for Acquisition (SAF/AQ) is the program's Milestone Decision Authority (MDA).

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0303467F / <i>SENSR Spectrum Pipeline SRF</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	7.265	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
632610: <i>Activities</i>	-	7.265	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Commercial Spectrum Enhancement Act (CSEA) of 2004 created the Spectrum Relocation Fund (CSEA, Title II of P.L. 108-494) to provide a centralized and streamlined funding mechanism through which Federal agencies can recover the costs associated with relocating their radio communications systems from certain spectrum bands, which were authorized to be auctioned for commercial purposes.

The Department of Defense (DoD) Spectrum Access Research and Development Program (SAR&DP) encompasses spectrum technology development that enables Department of Defense spectrum-dependent systems to satisfy operational readiness and capability needs. Being able to operate in accordance with spectrum allocations resulting after the spectrum auction is necessary, but not sufficient, for pursued technology solutions. The Department of Defense transition out of or sharing of the auctioned bands can only be successful if the research and development solutions are effective (for example, survivable, electronically protected, et cetera) while operating in both the United States and congested/contested spectrum environments wherever forces will be deployed.

This program represents the Air Force investment within the SAR&DP. Budget for the Air Force portion of the DoD SAR&DP is created from the auction of Advanced Wireless Service licenses in execution year.

Funding supports Spectrum relocation and sharing activities.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0303467F I SENSR Spectrum Pipeline SRF
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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	7.265	0.000	0.000	0.000	0.000
Total Adjustments	7.265	0.000	0.000	0.000	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	7.265	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

Change Summary Explanation

Other Adjustment of \$7.265 million in FY 2019 due to Air Force portion of the Department of Defense Spectrum Access Research and Development Program created from the auction of Advanced Wireless Service licenses. Receive funds during execution year through a transfer from OMB.

C. Accomplishments/Planned Programs (\$ in Millions)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Air Force Spectrum Access Research & Development Program (SAR&DP)	7.265	0.000	0.000	0.000	0.000
Description: The SAR&DP encompasses spectrum technology development that enables Department of Defense spectrum-dependent systems to satisfy operational readiness and capability needs. Being able to operate in accordance with spectrum allocations resulting after the spectrum auction is necessary, but not sufficient, for pursued technology solutions. The Department of Defense transition out of or sharing of the auctioned bands can only be successful if the research and development solutions are effective (for example, survivable, electronically protected, et cetera) while operating in both the United States and congested/contested spectrum environments wherever forces will be deployed.					
FY 2020 Plans: N/A					
FY 2021 Base Plans: N/A					
FY 2021 OCO Plans:					

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0303467F / <i>SENSR Spectrum Pipeline SRF</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
N/A					
<i>FY 2020 to FY 2021 Increase/Decrease Statement:</i> N/A					
Accomplishments/Planned Programs Subtotals	7.265	0.000	0.000	0.000	0.000

D. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force **Date:** February 2020

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0303567F / <i>Non-SENSR Spectrum Pipeline SRF</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	0.155	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
632610: <i>Activities</i>	-	0.155	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

Funding supports Spectrum relocation and sharing activities as provided in 47 U.S.C. Sec 928 - Spectrum Relocation Fund

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

B. Program Change Summary (\$ in Millions)

	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021 Base</u>	<u>FY 2021 OCO</u>	<u>FY 2021 Total</u>
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.155	0.000	0.000	0.000	0.000
Total Adjustments	0.155	0.000	0.000	0.000	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.155	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

C. Accomplishments/Planned Programs (\$ in Millions)

	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021</u>
Title: Spectrum Relocation Fund	0.155	0.000	0.000
Description: Funding supports Spectrum relocation and sharing activities as provided in 47 U.S.C. Sec 928 - Spectrum Relocation Fund.			
FY 2020 Plans: Not applicable			
FY 2021 Plans: Not applicable			
FY 2020 to FY 2021 Increase/Decrease Statement:			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0303567F / <i>Non-SENSR Spectrum Pipeline SRF</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020	FY 2021
Not applicable			
Accomplishments/Planned Programs Subtotals	0.155	0.000	0.000

D. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A