Department of Defense
Fiscal Year (FY) 2019 Budget Estimates

February 2018

Air Force

Justification Book Volume 1 of 3

Research, Development, Test & Evaluation, Air Force

Vol–I

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Volume 1 Table of Contents

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Fiscal Year (FY) 2019 Budget Estimates
RDT&E Descriptive Summaries
Scientific and Technology Budget Activities
February 2018

INTRODUCTION AND EXPLANATION OF CONTENTS

1. (U) GENERAL

A. 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 2019 President's Budget (PB).

1) All exhibits in this document have been assembled in accordance with DoD 7000.14R, Financial Management Regulation, Volume 2B, Chapter 5, Section 050402. Exception:

a) Exhibit R-1, RDT&E Program, which was distributed under a separate cover due to classification.

2) Other comments on exhibit contents in this document:

a) Exhibits R-2/2a and R-3 provide narrative information for all RDT&E program elements and projects within the USAF FY 2019 RDT&E program with the exception of classified program elements. The format sand contents of this document are in accordance to the guidelines and requirements of the Congressional committees in so far as possible.

b) 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.

2. (U) CLASSIFICATION

A. 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.

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Department of Defense
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

01 Feb 2018

Appropriation	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO
Research, Development, Test & Eval, AF	28,381,681	27,577,477	27,577,477	365,205	365,205
Total Research, Development, Test & Evaluation	28,381,681	27,577,477	27,577,477	365,205	365,205

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Department of Defense
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

01 Feb 2018

Appropriation	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency
Research, Development, Test & Eval, AF	255,744	-255,744		28,198,426	-255,744	27,942,682
Total Research, Development, Test & Evaluation	255,744	-255,744		28,198,426	-255,744	27,942,682

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Department of Defense
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

01 Feb 2018

Appropriation	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Research, Development, Test & Eval, AF	39,892,149	600,465	40,492,614
Total Research, Development, Test & Evaluation	39,892,149	600,465	40,492,614

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Department of Defense
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

01 Feb 2018

Summary Recap of Budget Activities	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO
Basic Research	521,594	505,259	505,259		
Applied Research	1,314,271	1,284,114	1,284,114		
Advanced Technology Development	792,497	794,017	794,017		
Advanced Component Development & Prototypes	2,822,781	4,605,030	4,605,030	13,200	13,200
System Development & Demonstration	3,983,019	4,476,762	4,476,762		
Management Support	1,690,840	2,663,875	2,663,875		
Operational Systems Development	17,256,679	20,585,302	20,585,302	122,158	122,158
Undistributed		-7,336,882	-7,336,882	229,847	229,847
Total Research, Development, Test & Evaluation	28,381,681	27,577,477	27,577,477	365,205	365,205

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Department of Defense
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Basic Research				505,259		505,259
Applied Research				1,284,114		1,284,114
Advanced Technology Development				794,017		794,017
Advanced Component Development & Prototypes	90,500	-90,500		4,708,730	-90,500	4,618,230
System Development & Demonstration				4,476,762		4,476,762
Management Support				2,663,875		2,663,875
Operational Systems Development	165,244	-165,244		20,872,704	-165,244	20,707,460
Undistributed				-7,107,035		-7,107,035
Total Research, Development, Test & Evaluation	255,744	-255,744		28,198,426	-255,744	27,942,682

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(Dollars in Thousands)

01 Feb 2018

Summary Recap of Budget Activities	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Basic Research	517,819		517,819
Applied Research	1,312,342		1,312,342
Advanced Technology Development	814,797		814,797
Advanced Component Development & Prototypes	6,529,943	13,495	6,543,438
System Development & Demonstration	5,272,191		5,272,191
Management Support	2,839,511		2,839,511
Operational Systems Development	22,605,546	586,970	23,192,516
Undistributed			
Total Research, Development, Test & Evaluation	39,892,149	600,465	40,492,614

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01 Feb 2018

	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO
Summary Recap of FYDP Programs					
Strategic Forces	658,404	825,038	825,038		
General Purpose Forces	2,060,061	2,962,365	2,962,365	9,750	9,750
Intelligence and Communications	2,048,032	1,466,925	1,466,925	5,400	5,400
Mobility Forces	476,577	602,629	602,629		
Research and Development	10,034,179	10,713,989	10,713,989	7,800	7,800
Central Supply and Maintenance	93,625	109,419	109,419		
Training Medical and Other	3,251	3,615	3,615		
Administration and Associated Activities	31,237	-7,214,983	-7,214,983	229,847	229,847
Support of Other Nations	4,626	4,569	4,569		
Space		3,165,909	3,165,909		
Classified Programs	12,971,689	14,938,002	14,938,002	112,408	112,408
Total Research, Development, Test & Evaluation	28,381,681	27,577,477	27,577,477	365,205	365,205

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Summary Recap of FYDP Programs						
Strategic Forces				825,038		825,038
General Purpose Forces				2,972,115		2,972,115
Intelligence and Communications	90,500	-90,500		1,562,825	-90,500	1,472,325
Mobility Forces				602,629		602,629
Research and Development				10,721,789		10,721,789
Central Supply and Maintenance				109,419		109,419
Training Medical and Other				3,615		3,615
Administration and Associated Activities				-6,985,136		-6,985,136
Support of Other Nations				4,569		4,569
Space				3,165,909		3,165,909
Classified Programs	165,244	-165,244		15,215,654	-165,244	15,050,410
Total Research, Development, Test & Evaluation	255,744	-255,744		28,198,426	-255,744	27,942,682

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Summary Recap of FYDP Programs			
Strategic Forces	1,064,875		1,064,875
General Purpose Forces	3,287,655	53,049	3,340,704
Intelligence and Communications	1,394,674	54,600	1,449,274
Mobility Forces	916,041		916,041
Research and Development	12,027,571		12,027,571
Central Supply and Maintenance	97,134		97,134
Training Medical and Other	3,578		3,578
Administration and Associated Activities	130,882		130,882
Support of Other Nations	3,998		3,998
Space	4,717,811	18,495	4,736,306
Classified Programs	16,247,930	474,321	16,722,251
Total Research, Development, Test & Evaluation	39,892,149	600,465	40,492,614

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Department of the Air Force
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

01 Feb 2018

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

Line No	Program Element Number	Item	Act	FY 2017 (Base + OCO)	FY 2018 PB Request with CR Adj Base	FY 2018 Total PB Requests* with CR Adj Base	FY 2018 PB Request with CR Adj OCO	FY 2018 Total PB Requests+ with CR Adj OCO	Sec
1	0601102F	Defense Research Sciences	01	370,595	342,919	342,919			U
2	0601103F	University Research Initiatives	01	137,775	147,923	147,923			U
3	0601108F	High Energy Laser Research Initiatives	01	13,224	14,417	14,417			U
	Basic Research			521,594	505,259	505,259			
4	0602102F	Materials	02	158,243	124,264	124,264			U
5	0602201F	Aerospace Vehicle Technologies	02	130,923	124,678	124,678			U
6	0602202F	Human Effectiveness Applied Research	02	110,012	108,784	108,784			U
7	0602203F	Aerospace Propulsion	02	192,583	192,695	192,695			U
8	0602204F	Aerospace Sensors	02	160,339	152,782	152,782			U
9	0602298F	Science and Technology Management - Major Headquarters Activities	02		8,353	8,353			U
10	0602601F	Space Technology	02	119,670	116,503	116,503			U
11	0602602F	Conventional Munitions	02	110,074	112,195	112,195			U
12	0602605F	Directed Energy Technology	02	127,365	132,993	132,993			U
13	0602788F	Dominant Information Sciences and Methods	02	165,517	167,818	167,818			U
14	0602890F	High Energy Laser Research	02	39,545	43,049	43,049			U
15	1206601F	Space Technology	02						U
	Applied Research			1,314,271	1,284,114	1,284,114			

16	0603112F	Advanced Materials for Weapon Systems	03	54,095	37,856	37,856		U

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Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
1	0601102F	Defense Research Sciences	01				342,919		342,919	U
2	0601103F	University Research Initiatives	01				147,923		147,923	U
3	0601108F	High Energy Laser Research Initiatives	01				14,417		14,417	U
	Basic Research						505,259		505,259	
4	0602102F	Materials	02				124,264		124,264	U
5	0602201F	Aerospace Vehicle Technologies	02				124,678		124,678	U
6	0602202F	Human Effectiveness Applied Research	02				108,784		108,784	U
7	0602203F	Aerospace Propulsion	02				192,695		192,695	U
8	0602204F	Aerospace Sensors	02				152,782		152,782	U
9	0602298F	Science and Technology Management - Major Headquarters Activities	02				8,353		8,353	U
10	0602601F	Space Technology	02				116,503		116,503	U
11	0602602F	Conventional Munitions	02				112,195		112,195	U
12	0602605F	Directed Energy Technology	02				132,993		132,993	U
13	0602788F	Dominant Information Sciences and Methods	02				167,818		167,818	U
14	0602890F	High Energy Laser Research	02				43,049		43,049	U
15	1206601F	Space Technology	02							U
	Applied Research						1,284,114		1,284,114	

16	0603112F	Advanced Materials for Weapon Systems	03		37,856	37,856	U

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Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
1	0601102F	Defense Research Sciences	01	348,322		348,322	U
2	0601103F	University Research Initiatives	01	154,991		154,991	U
3	0601108F	High Energy Laser Research Initiatives	01	14,506		14,506	U
	Basic Research			517,819		517,819	
4	0602102F	Materials	02	125,373		125,373	U
5	0602201F	Aerospace Vehicle Technologies	02	130,547		130,547	U
6	0602202F	Human Effectiveness Applied Research	02	112,518		112,518	U
7	0602203F	Aerospace Propulsion	02	190,919		190,919	U
8	0602204F	Aerospace Sensors	02	166,534		166,534	U
9	0602298F	Science and Technology Management - Major Headquarters Activities	02	8,288		8,288	U
10	0602601F	Space Technology	02				U
11	0602602F	Conventional Munitions	02	112,841		112,841	U
12	0602605F	Directed Energy Technology	02	141,898		141,898	U
13	0602788F	Dominant Information Sciences and Methods	02	162,420		162,420	U
14	0602890F	High Energy Laser Research	02	43,359		43,359	U
15	1206601F	Space Technology	02	117,645		117,645	U
	Applied Research			1,312,342		1,312,342	

16	0603112F	Advanced Materials for Weapon Systems	03	34,426		34,426	U

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17	0603199F	Sustainment Science and Technology (S&T)	03	19,994	22,811	22,811			U
18	0603203F	Advanced Aerospace Sensors	03	39,854	40,978	40,978			U
19	0603211F	Aerospace Technology Dev/Demo	03	128,358	115,966	115,966			U
20	0603216F	Aerospace Propulsion and Power Technology	03	104,695	104,499	104,499			U
21	0603270F	Electronic Combat Technology	03	64,591	60,551	60,551			U
22	0603401F	Advanced Spacecraft Technology	03	69,338	58,910	58,910			U
23	0603444F	Maui Space Surveillance System (MSSS)	03	11,493	10,433	10,433			U
24	0603456F	Human Effectiveness Advanced Technology Development	03	25,784	33,635	33,635			U
25	0603601F	Conventional Weapons Technology	03	105,487	167,415	167,415			U
26	0603605F	Advanced Weapons Technology	03	47,358	45,502	45,502			U
27	0603680F	Manufacturing Technology Program	03	62,272	46,450	46,450			U
28	0603788F	Battlespace Knowledge Development and Demonstration	03	52,274	49,011	49,011			U
29	0303467F	SENSR Spectrum Pipeline SRF	03	6,904					U
		Advanced Technology Development		792,497	794,017	794,017			
30	0603260F	Intelligence Advanced Development	04	5,598	5,652	5,652			U
31	0603438F	Space Control Technology	04	8,506			7,800	7,800	U

32	0603742F	Combat Identification Technology	04	23,551	24,397	24,397		U

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17	0603199F	Sustainment Science and Technology (S&T)	03				22,811		22,811	U
18	0603203F	Advanced Aerospace Sensors	03				40,978		40,978	U
19	0603211F	Aerospace Technology Dev/Demo	03				115,966		115,966	U
20	0603216F	Aerospace Propulsion and Power Technology	03				104,499		104,499	U
21	0603270F	Electronic Combat Technology	03				60,551		60,551	U
22	0603401F	Advanced Spacecraft Technology	03				58,910		58,910	U
23	0603444F	Maui Space Surveillance System (MSSS)	03				10,433		10,433	U
24	0603456F	Human Effectiveness Advanced Technology Development	03				33,635		33,635	U
25	0603601F	Conventional Weapons Technology	03				167,415		167,415	U
26	0603605F	Advanced Weapons Technology	03				45,502		45,502	U
27	0603680F	Manufacturing Technology Program	03				46,450		46,450	U
28	0603788F	Battlespace Knowledge Development and Demonstration	03				49,011		49,011	U
29	0303467F	SENSR Spectrum Pipeline SRF	03							U
		Advanced Technology Development					794,017		794,017	
30	0603260F	Intelligence Advanced Development	04				5,652		5,652	U
31	0603438F	Space Control Technology	04				7,800		7,800	U

32	0603742F	Combat Identification Technology	04		24,397	24,397	U

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17	0603199F	Sustainment Science and Technology (S&T)	03	15,150		15,150	U
18	0603203F	Advanced Aerospace Sensors	03	39,968		39,968	U
19	0603211F	Aerospace Technology Dev/Demo	03	121,002		121,002	U
20	0603216F	Aerospace Propulsion and Power Technology	03	115,462		115,462	U
21	0603270F	Electronic Combat Technology	03	55,319		55,319	U
22	0603401F	Advanced Spacecraft Technology	03	54,895		54,895	U
23	0603444F	Maui Space Surveillance System (MSSS)	03	10,674		10,674	U
24	0603456F	Human Effectiveness Advanced Technology Development	03	36,463		36,463	U
25	0603601F	Conventional Weapons Technology	03	194,981		194,981	U
26	0603605F	Advanced Weapons Technology	03	43,368		43,368	U
27	0603680F	Manufacturing Technology Program	03	42,025		42,025	U
28	0603788F	Battlespace Knowledge Development and Demonstration	03	51,064		51,064	U
29	0303467F	SENSR Spectrum Pipeline SRF	03				U
		Advanced Technology Development		814,797		814,797	
30	0603260F	Intelligence Advanced Development	04	5,568		5,568	U
31	0603438F	Space Control Technology	04				U

32	0603742F	Combat Identification Technology	04	18,194			18,194	U

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33	0603790F	NATO Research and Development	04	4,174	3,851	3,851			U
34	0603830F	Space Security and Defense Program	04	32,399					U
35	0603851F	Intercontinental Ballistic Missile - Dem/Val	04	99,949	10,736	10,736			U
36	0603859F	Pollution Prevention - Dem/Val	04	3,500	2	2			U
37	0604015F	Long Range Strike - Bomber	04	1,290,307	2,003,580	2,003,580			U
38	0604201F	Integrated Avionics Planning and Development	04		65,458	65,458			U
39	0604257F	Advanced Technology and Sensors	04	34,818	68,719	68,719			U
40	0604288F	National Airborne Ops Center (NAOC) Recap	04		7,850	7,850			U
41	0604317F	Technology Transfer	04	8,080	3,295	3,295			U
42	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	04	52,706	17,365	17,365			U
43	0604414F	Cyber Resiliency of Weapon Systems-ACS	04		32,253	32,253			U
44	0604422F	Weather System Follow-on	04	82,506					U
45	0604425F	Space Situation Awareness Systems	04	9,901					U
46	0604776F	Deployment & Distribution Enterprise R&D	04	25,890	26,222	26,222			U
47	0604857F	Operationally Responsive Space	04	17,976					U

48	0604858F	Tech Transition Program	04	378,126	840,650	840,650	U
49	0605230F	Ground Based Strategic Deterrent	04	109,260	215,721	215,721	U

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33	0603790F	NATO Research and Development	04				3,851		3,851	U
34	0603830F	Space Security and Defense Program	04							U
35	0603851F	Intercontinental Ballistic Missile - Dem/Val	04				10,736		10,736	U
36	0603859F	Pollution Prevention - Dem/Val	04				2		2	U
37	0604015F	Long Range Strike - Bomber	04				2,003,580		2,003,580	U
38	0604201F	Integrated Avionics Planning and Development	04				65,458		65,458	U
39	0604257F	Advanced Technology and Sensors	04				68,719		68,719	U
40	0604288F	National Airborne Ops Center (NAOC) Recap	04				7,850		7,850	U
41	0604317F	Technology Transfer	04				3,295		3,295	U
42	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	04				17,365		17,365	U
43	0604414F	Cyber Resiliency of Weapon Systems-ACS	04				32,253		32,253	U
44	0604422F	Weather System Follow-on	04							U
45	0604425F	Space Situation Awareness Systems	04							U
46	0604776F	Deployment & Distribution Enterprise R&D	04				26,222		26,222	U
47	0604857F	Operationally Responsive Space	04							U

48	0604858F	Tech Transition Program	04		840,650	840,650	U
49	0605230F	Ground Based Strategic Deterrent	04		215,721	215,721	U

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33	0603790F	NATO Research and Development	04	2,305		2,305	U
34	0603830F	Space Security and Defense Program	04				U
35	0603851F	Intercontinental Ballistic Missile - Dem/Val	04	41,856		41,856	U
36	0603859F	Pollution Prevention - Dem/Val	04				U
37	0604015F	Long Range Strike - Bomber	04	2,314,196		2,314,196	U
38	0604201F	Integrated Avionics Planning and Development	04	14,894		14,894	U
39	0604257F	Advanced Technology and Sensors	04	34,585		34,585	U
40	0604288F	National Airborne Ops Center (NAOC) Recap	04	9,740		9,740	U
41	0604317F	Technology Transfer	04	12,960		12,960	U
42	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	04	71,501		71,501	U
43	0604414F	Cyber Resiliency of Weapon Systems-ACS	04	62,618		62,618	U
44	0604422F	Weather System Follow-on	04				U
45	0604425F	Space Situation Awareness Systems	04				U
46	0604776F	Deployment & Distribution Enterprise R&D	04	28,350		28,350	U
47	0604857F	Operationally Responsive Space	04				U

48	0604858F	Tech Transition Program	04	1,186,075		1,186,075	U
49	0605230F	Ground Based Strategic Deterrent	04	345,041		345,041	U

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50	0207110F	Next Generation Air Dominance	04	22,272	294,746	294,746			U
51	0207455F	Three Dimensional Long-Range Radar (3DELRR)	04	47,166	10,645	10,645			U
52	0208099F	Unified Platform (UP)	04						U
53	0305164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04	297,975					U
54	0305236F	Common Data Link Executive Agent (CDL EA)	04	40,293	41,509	41,509			U
55	0305601F	Mission Partner Environments	04						U
56	0306250F	Cyber Operations Technology Development	04	205,048	226,287	226,287	5,400	5,400	U
57	0306415F	Enabled Cyber Activities	04	15,842	16,687	16,687			U
58	0408011F	Special Tactics / Combat Control	04		4,500	4,500			U
59	0901410F	Contracting Information Technology System	04	6,938	15,867	15,867			U
60	1203164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04		253,939	253,939			U
61	1203710F	EO/IR Weather Systems	04		10,000	10,000			U
62	1206422F	Weather System Follow-on	04		112,088	112,088			U
63	1206425F	Space Situation Awareness Systems	04		34,764	34,764			U
64	1206434F	Midterm Polar MILSATCOM System	04		63,092	63,092			U

65	1206438F	Space Control Technology	04	7,842	7,842		U
66	1206730F	Space Security and Defense Program	04	41,385	41,385		U

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50	0207110F	Next Generation Air Dominance	04				294,746		294,746	U
51	0207455F	Three Dimensional Long-Range Radar (3DELRR)	04				10,645		10,645	U
52	0208099F	Unified Platform (UP)	04							U
53	0305164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04							U
54	0305236F	Common Data Link Executive Agent (CDL EA)	04				41,509		41,509	U
55	0305601F	Mission Partner Environments	04							U
56	0306250F	Cyber Operations Technology Development	04	90,500	-90,500		322,187	-90,500	231,687	U
57	0306415F	Enabled Cyber Activities	04				16,687		16,687	U
58	0408011F	Special Tactics / Combat Control	04				4,500		4,500	U
59	0901410F	Contracting Information Technology System	04				15,867		15,867	U
60	1203164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04				253,939		253,939	U
61	1203710F	EO/IR Weather Systems	04				10,000		10,000	U
62	1206422F	Weather System Follow-on	04				112,088		112,088	U
63	1206425F	Space Situation Awareness Systems	04				34,764		34,764	U
64	1206434F	Midterm Polar MILSATCOM System	04				63,092		63,092	U

65	1206438F	Space Control Technology	04	7,842	7,842	U
66	1206730F	Space Security and Defense Program	04	41,385	41,385	U

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50	0207110F	Next Generation Air Dominance	04	503,997		503,997	U
51	0207455F	Three Dimensional Long-Range Radar (3DELRR)	04	40,326		40,326	U
52	0208099F	Unified Platform (UP)	04	29,800		29,800	U
53	0305164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04				U
54	0305236F	Common Data Link Executive Agent (CDL EA)	04	41,880		41,880	U
55	0305601F	Mission Partner Environments	04	10,074		10,074	U
56	0306250F	Cyber Operations Technology Development	04	253,825		253,825	U
57	0306415F	Enabled Cyber Activities	04	16,325		16,325	U
58	0408011F	Special Tactics / Combat Control	04				U
59	0901410F	Contracting Information Technology System	04	17,577		17,577	U
60	1203164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04	286,629		286,629	U
61	1203710F	EO/IR Weather Systems	04	7,940		7,940	U
62	1206422F	Weather System Follow-on	04	138,052		138,052	U
63	1206425F	Space Situation Awareness Systems	04	39,338		39,338	U
64	1206434F	Midterm Polar MILSATCOM System	04	383,113		383,113	U

65	1206438F	Space Control Technology	04	91,018	1,100	92,118	U
66	1206730F	Space Security and Defense Program	04	45,542		45,542	U

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67	1206760F	Protected Tactical Enterprise Service (PTES)	04		18,150	18,150			U
68	1206761F	Protected Tactical Service (PTS)	04		24,201	24,201			U
69	1206855F	Protected SATCOM Services (PSCS) - Aggregated	04		16,000	16,000			U
70	1206857F	Operationally Responsive Space	04		87,577	87,577			U
		Advanced Component Development & Prototypes		2,822,781	4,605,030	4,605,030	13,200	13,200	
71	0604200F	Future Advanced Weapon Analysis & Programs	05		5,100	5,100			U
72	0604201F	Integrated Avionics Planning and Development	05		101,203	101,203			U
73	0604222F	Nuclear Weapons Support	05		3,009	3,009			U
74	0604270F	Electronic Warfare Development	05	4,986	2,241	2,241			U
75	0604281F	Tactical Data Networks Enterprise	05	78,167	38,250	38,250			U
76	0604287F	Physical Security Equipment	05	63,101	19,739	19,739			U
77	0604329F	Small Diameter Bomb (SDB) - EMD	05	37,603	38,979	38,979			U
78	0604421F	Counterspace Systems	05	32,618					U
79	0604425F	Space Situation Awareness Systems	05	25,540					U
80	0604426F	Space Fence	05	162,510					U
81	0604429F	Airborne Electronic Attack	05	8,589	7,091	7,091			U

82	0604441F	Space Based Infrared System (SBIRS) High EMD	05	161,966	U

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67	1206760F	Protected Tactical Enterprise Service (PTES)	04				18,150		18,150	U
68	1206761F	Protected Tactical Service (PTS)	04				24,201		24,201	U
69	1206855F	Protected SATCOM Services (PSCS) - Aggregated	04				16,000		16,000	U
70	1206857F	Operationally Responsive Space	04				87,577		87,577	U
		Advanced Component Development & Prototypes		90,500	-90,500		4,708,730	-90,500	4,618,230	
71	0604200F	Future Advanced Weapon Analysis & Programs	05				5,100		5,100	U
72	0604201F	Integrated Avionics Planning and Development	05				101,203		101,203	U
73	0604222F	Nuclear Weapons Support	05				3,009		3,009	U
74	0604270F	Electronic Warfare Development	05				2,241		2,241	U
75	0604281F	Tactical Data Networks Enterprise	05				38,250		38,250	U
76	0604287F	Physical Security Equipment	05				19,739		19,739	U
77	0604329F	Small Diameter Bomb (SDB) - EMD	05				38,979		38,979	U
78	0604421F	Counterspace Systems	05							U
79	0604425F	Space Situation Awareness Systems	05							U
80	0604426F	Space Fence	05							U
81	0604429F	Airborne Electronic Attack	05				7,091		7,091	U

82 0604441F Space Based Infrared System (SBIRS) High EMD 05 U

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67	1206760F	Protected Tactical Enterprise Service (PTES)	04	51,419		51,419	U
68	1206761F	Protected Tactical Service (PTS)	04	29,776		29,776	U
69	1206855F	Protected SATCOM Services (PSCS) - Aggregated	04	29,379		29,379	U
70	1206857F	Operationally Responsive Space	04	366,050	12,395	378,445	U
		Advanced Component Development & Prototypes		6,529,943	13,495	6,543,438	
71	0604200F	Future Advanced Weapon Analysis & Programs	05	39,602		39,602	U
72	0604201F	Integrated Avionics Planning and Development	05	58,531		58,531	U
73	0604222F	Nuclear Weapons Support	05	4,468		4,468	U
74	0604270F	Electronic Warfare Development	05	1,909		1,909	U
75	0604281F	Tactical Data Networks Enterprise	05	207,746		207,746	U
76	0604287F	Physical Security Equipment	05	14,421		14,421	U
77	0604329F	Small Diameter Bomb (SDB) - EMD	05	73,158		73,158	U
78	0604421F	Counterspace Systems	05				U
79	0604425F	Space Situation Awareness Systems	05				U
80	0604426F	Space Fence	05				U
81	0604429F	Airborne Electronic Attack	05	7,153		7,153	U

82 0604441F Space Based Infrared System (SBIRS) High EMD 05 U

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83	0604602F	Armament/Ordnance Development	05	21,507	46,540	46,540			U
84	0604604F	Submunitions	05	2,503	2,705	2,705			U
85	0604617F	Agile Combat Support	05	49,005	31,240	31,240			U
86	0604618F	Joint Direct Attack Munition	05	9,901					U
87	0604706F	Life Support Systems	05	8,710	9,060	9,060			U
88	0604735F	Combat Training Ranges	05	57,200	87,350	87,350			U
89	0604800F	F-35 - EMD	05	433,903	292,947	292,947			U
90	0604853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05	381,360					U
91	0604932F	Long Range Standoff Weapon	05	102,350	451,290	451,290			U
92	0604933F	ICBM Fuze Modernization	05	172,946	178,991	178,991			U
93	0605030F	Joint Tactical Network Center (JTNC)	05	1,131	12,736	12,736			U
94	0605031F	Joint Tactical Network (JTN)	05		9,319	9,319			U
95	0605213F	F-22 Modernization Increment 3.2B	05	67,717	13,600	13,600			U
96	0605214F	Ground Attack Weapons Fuze Development	05	903					U
97	0605221F	KC-46	05	211,509	93,845	93,845			U
98	0605223F	Advanced Pilot Training	05	7,107	105,999	105,999			U
99	0605229F	Combat Rescue Helicopter	05	263,327	354,485	354,485			U

100	0605278F	HC/MC-130 Recap RDT&E	05	8,707		U
101	0605431F	Advanced EHF MILSATCOM (SPACE)	05	221,584		U

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83	0604602F	Armament/Ordnance Development	05				46,540		46,540	U
84	0604604F	Submunitions	05				2,705		2,705	U
85	0604617F	Agile Combat Support	05				31,240		31,240	U
86	0604618F	Joint Direct Attack Munition	05							U
87	0604706F	Life Support Systems	05				9,060		9,060	U
88	0604735F	Combat Training Ranges	05				87,350		87,350	U
89	0604800F	F-35 - EMD	05				292,947		292,947	U
90	0604853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05							U
91	0604932F	Long Range Standoff Weapon	05				451,290		451,290	U
92	0604933F	ICBM Fuze Modernization	05				178,991		178,991	U
93	0605030F	Joint Tactical Network Center (JTNC)	05				12,736		12,736	U
94	0605031F	Joint Tactical Network (JTN)	05				9,319		9,319	U
95	0605213F	F-22 Modernization Increment 3.2B	05				13,600		13,600	U
96	0605214F	Ground Attack Weapons Fuze Development	05							U
97	0605221F	KC-46	05				93,845		93,845	U
98	0605223F	Advanced Pilot Training	05				105,999		105,999	U
99	0605229F	Combat Rescue Helicopter	05				354,485		354,485	U

100	0605278F	HC/MC-130 Recap RDT&E	05	U
101	0605431F	Advanced EHF MILSATCOM (SPACE)	05	U

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83	0604602F	Armament/Ordnance Development	05	58,590		58,590	U
84	0604604F	Submunitions	05	2,990		2,990	U
85	0604617F	Agile Combat Support	05	20,028		20,028	U
86	0604618F	Joint Direct Attack Munition	05	15,787		15,787	U
87	0604706F	Life Support Systems	05	8,919		8,919	U
88	0604735F	Combat Training Ranges	05	35,895		35,895	U
89	0604800F	F-35 - EMD	05	69,001		69,001	U
90	0604853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05				U
91	0604932F	Long Range Standoff Weapon	05	614,920		614,920	U
92	0604933F	ICBM Fuze Modernization	05	172,902		172,902	U
93	0605030F	Joint Tactical Network Center (JTNC)	05				U
94	0605031F	Joint Tactical Network (JTN)	05				U
95	0605213F	F-22 Modernization Increment 3.2B	05				U
96	0605214F	Ground Attack Weapons Fuze Development	05				U
97	0605221F	KC-46	05	88,170		88,170	U
98	0605223F	Advanced Pilot Training	05	265,465		265,465	U
99	0605229F	Combat Rescue Helicopter	05	457,652		457,652	U

100	0605278F	HC/MC-130 Recap RDT&E	05	U
101	0605431F	Advanced EHF MILSATCOM (SPACE)	05	U

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102	0605432F	Polar MILSATCOM (SPACE)	05	44,306					U
103	0605433F	Wideband Global SATCOM (SPACE)	05	73,901					U
104	0605458F	Air & Space Ops Center 10.2 RDT&E	05	21,109	119,745	119,745			U
105	0605830F	Acq Workforce- Global Battle Mgmt	05						U
106	0605931F	B-2 Defensive Management System	05	278,437	194,570	194,570			U
107	0101125F	Nuclear Weapons Modernization	05	131,063	91,237	91,237			U
108	0207171F	F-15 EPAWSS	05	241,495	209,847	209,847			U
109	0207328F	Stand In Attack Weapon	05		3,400	3,400			U
110	0207423F	Advanced Communications Systems	05						U
111	0207701F	Full Combat Mission Training	05	10,809	16,727	16,727			U
112	0303267F	Auctioned Spectrum Relocation Fund	05	54,499					U
113	0303367F	Spectrum Access Research and Development	05	62,053					U
114	0305176F	Combat Survivor Evader Locator	05	30,282					U
115	0307581F	JSTARS Recap	05	113,334	417,201	417,201			U
116	0401310F	C-32 Executive Transport Recapitalization	05		6,017	6,017			U
117	0401319F	Presidential Aircraft Recapitalization (PAR)	05	311,252	434,069	434,069			U
118	0701212F	Automated Test Systems	05	14,029	18,528	18,528			U

119	1203176F	Combat Survivor Evader Locator	05		24,967	24,967		U

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102	0605432F	Polar MILSATCOM (SPACE)	05							U
103	0605433F	Wideband Global SATCOM (SPACE)	05							U
104	0605458F	Air & Space Ops Center 10.2 RDT&E	05				119,745		119,745	U
105	0605830F	Acq Workforce- Global Battle Mgmt	05							U
106	0605931F	B-2 Defensive Management System	05				194,570		194,570	U
107	0101125F	Nuclear Weapons Modernization	05				91,237		91,237	U
108	0207171F	F-15 EPAWSS	05				209,847		209,847	U
109	0207328F	Stand In Attack Weapon	05				3,400		3,400	U
110	0207423F	Advanced Communications Systems	05							U
111	0207701F	Full Combat Mission Training	05				16,727		16,727	U
112	0303267F	Auctioned Spectrum Relocation Fund	05							U
113	0303367F	Spectrum Access Research and Development	05							U
114	0305176F	Combat Survivor Evader Locator	05							U
115	0307581F	JSTARS Recap	05				417,201		417,201	U
116	0401310F	C-32 Executive Transport Recapitalization	05				6,017		6,017	U
117	0401319F	Presidential Aircraft Recapitalization (PAR)	05				434,069		434,069	U
118	0701212F	Automated Test Systems	05				18,528		18,528	U

119	1203176F	Combat Survivor Evader Locator	05		24,967	24,967	U

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102	0605432F	Polar MILSATCOM (SPACE)	05				U
103	0605433F	Wideband Global SATCOM (SPACE)	05				U
104	0605458F	Air & Space Ops Center 10.2 RDT&E	05				U
105	0605830F	Acq Workforce- Global Battle Mgmt	05	3,617		3,617	U
106	0605931F	B-2 Defensive Management System	05	261,758		261,758	U
107	0101125F	Nuclear Weapons Modernization	05	91,907		91,907	U
108	0207171F	F-15 EPAWSS	05	137,095		137,095	U
109	0207328F	Stand In Attack Weapon	05	43,175		43,175	U
110	0207423F	Advanced Communications Systems	05	14,888		14,888	U
111	0207701F	Full Combat Mission Training	05	1,015		1,015	U
112	0303267F	Auctioned Spectrum Relocation Fund	05				U
113	0303367F	Spectrum Access Research and Development	05				U
114	0305176F	Combat Survivor Evader Locator	05				U
115	0307581F	JSTARS Recap	05				U
116	0401310F	C-32 Executive Transport Recapitalization	05	7,943		7,943	U
117	0401319F	Presidential Aircraft Recapitalization (PAR)	05	673,032		673,032	U
118	0701212F	Automated Test Systems	05	13,653		13,653	U

119	1203176F	Combat Survivor Evader Locator	05	939		939	U	

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120	1203269F	GPS IIIC	05						U
121	1203940F	Space Situation Awareness Operations	05		10,029	10,029			U
122	1206421F	Counterspace Systems	05		66,370	66,370			U
123	1206425F	Space Situation Awareness Systems	05		48,448	48,448			U
124	1206426F	Space Fence	05		35,937	35,937			U
125	1206431F	Advanced EHF MILSATCOM (SPACE)	05		145,610	145,610			U
126	1206432F	Polar MILSATCOM (SPACE)	05		33,644	33,644			U
127	1206433F	Wideband Global SATCOM (SPACE)	05		14,263	14,263			U
128	1206441F	Space Based Infrared System (SBIRS) High EMD	05		311,844	311,844			U
129	1206442F	Evolved SBIRS	05		71,018	71,018			U
130	1206853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05		297,572	297,572			U
		System Development & Demonstration		3,983,019	4,476,762	4,476,762			
131	0604256F	Threat Simulator Development	06	21,377	35,405	35,405			U
132	0604759F	Major T&E Investment	06	64,538	82,874	82,874			U
133	0605101F	RAND Project Air Force	06	33,373	34,346	34,346			U
134	0605502F	Small Business Innovation Research	06	407,570					U
135	0605712F	Initial Operational Test & Evaluation	06	13,829	15,523	15,523			U

136	0605807F	Test and Evaluation Support	06	676,417	678,289	678,289			U

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120	1203269F	GPS IIIC	05							U
121	1203940F	Space Situation Awareness Operations	05				10,029		10,029	U
122	1206421F	Counterspace Systems	05				66,370		66,370	U
123	1206425F	Space Situation Awareness Systems	05				48,448		48,448	U
124	1206426F	Space Fence	05				35,937		35,937	U
125	1206431F	Advanced EHF MILSATCOM (SPACE)	05				145,610		145,610	U
126	1206432F	Polar MILSATCOM (SPACE)	05				33,644		33,644	U
127	1206433F	Wideband Global SATCOM (SPACE)	05				14,263		14,263	U
128	1206441F	Space Based Infrared System (SBIRS) High EMD	05				311,844		311,844	U
129	1206442F	Evolved SBIRS	05				71,018		71,018	U
130	1206853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05				297,572		297,572	U
		System Development & Demonstration					4,476,762		4,476,762	
131	0604256F	Threat Simulator Development	06				35,405		35,405	U
132	0604759F	Major T&E Investment	06				82,874		82,874	U
133	0605101F	RAND Project Air Force	06				34,346		34,346	U
134	0605502F	Small Business Innovation Research	06							U
135	0605712F	Initial Operational Test & Evaluation	06				15,523		15,523	U

136	0605807F	Test and Evaluation Support	06			678,289	678,289	U

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120	1203269F	GPS IIIC	05	451,889		451,889	U
121	1203940F	Space Situation Awareness Operations	05	46,668		46,668	U
122	1206421F	Counterspace Systems	05	20,676		20,676	U
123	1206425F	Space Situation Awareness Systems	05	134,463		134,463	U
124	1206426F	Space Fence	05	20,215		20,215	U
125	1206431F	Advanced EHF MILSATCOM (SPACE)	05	151,506		151,506	U
126	1206432F	Polar MILSATCOM (SPACE)	05	27,337		27,337	U
127	1206433F	Wideband Global SATCOM (SPACE)	05	3,970		3,970	U
128	1206441F	Space Based Infrared System (SBIRS) High EMD	05	60,565		60,565	U
129	1206442F	Evolved SBIRS	05	643,126		643,126	U
130	1206853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05	245,447		245,447	U
		System Development & Demonstration		5,272,191		5,272,191	
131	0604256F	Threat Simulator Development	06	34,256		34,256	U
132	0604759F	Major T&E Investment	06	91,844		91,844	U
133	0605101F	RAND Project Air Force	06	34,614		34,614	U
134	0605502F	Small Business Innovation Research	06				U
135	0605712F	Initial Operational Test & Evaluation	06	18,043		18,043	U

136	0605807F	Test and Evaluation Support	06	692,784			692,784	U

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137	0605826F	Acq Workforce- Global Power	06		219,809	219,809			U
138	0605827F	Acq Workforce- Global Vig & Combat Sys	06		223,179	223,179			U
139	0605828F	Acq Workforce- Global Reach	06		138,556	138,556			U
140	0605829F	Acq Workforce- Cyber, Network, & Bus Sys	06		221,393	221,393			U
141	0605830F	Acq Workforce- Global Battle Mgmt	06		152,577	152,577			U
142	0605831F	Acq Workforce- Capability Integration	06		196,561	196,561			U
143	0605832F	Acq Workforce- Advanced Prgm Technology	06		28,322	28,322			U
144	0605833F	Acq Workforce- Nuclear Systems	06		126,611	126,611			U
145	0605860F	Rocket Systems Launch Program (SPACE)	06	10,899					U
146	0605864F	Space Test Program (STP)	06	40,507					U
147	0605898F	Management HQ - R&D	06		9,154	9,154			U
148	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	06	134,111	135,507	135,507			U
149	0605978F	Facilities Sustainment - Test and Evaluation Support	06	28,091	28,720	28,720			U
150	0606017F	Requirements Analysis and Maturation	06	45,134	35,453	35,453			U

151	0606116F	Space Test and Training Range Development	06	17,912		U

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137	0605826F	Acq Workforce- Global Power	06				219,809		219,809	U
138	0605827F	Acq Workforce- Global Vig & Combat Sys	06				223,179		223,179	U
139	0605828F	Acq Workforce- Global Reach	06				138,556		138,556	U
140	0605829F	Acq Workforce- Cyber, Network, & Bus Sys	06				221,393		221,393	U
141	0605830F	Acq Workforce- Global Battle Mgmt	06				152,577		152,577	U
142	0605831F	Acq Workforce- Capability Integration	06				196,561		196,561	U
143	0605832F	Acq Workforce- Advanced Prgm Technology	06				28,322		28,322	U
144	0605833F	Acq Workforce- Nuclear Systems	06				126,611		126,611	U
145	0605860F	Rocket Systems Launch Program (SPACE)	06							U
146	0605864F	Space Test Program (STP)	06							U
147	0605898F	Management HQ - R&D	06				9,154		9,154	U
148	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	06				135,507		135,507	U
149	0605978F	Facilities Sustainment - Test and Evaluation Support	06				28,720		28,720	U
150	0606017F	Requirements Analysis and Maturation	06				35,453		35,453	U

151	0606116F	Space Test and Training Range Development	06	U

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Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
137	0605826F	Acq Workforce- Global Power	06	233,924		233,924	U
138	0605827F	Acq Workforce- Global Vig & Combat Sys	06	263,488		263,488	U
139	0605828F	Acq Workforce- Global Reach	06	153,591		153,591	U
140	0605829F	Acq Workforce- Cyber, Network, & Bus Sys	06	232,315		232,315	U
141	0605830F	Acq Workforce- Global Battle Mgmt	06	169,868		169,868	U
142	0605831F	Acq Workforce- Capability Integration	06	226,219		226,219	U
143	0605832F	Acq Workforce- Advanced Prgm Technology	06	38,400		38,400	U
144	0605833F	Acq Workforce- Nuclear Systems	06	125,761		125,761	U
145	0605860F	Rocket Systems Launch Program (SPACE)	06				U
146	0605864F	Space Test Program (STP)	06				U
147	0605898F	Management HQ - R&D	06	10,642		10,642	U
148	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	06	162,216		162,216	U
149	0605978F	Facilities Sustainment - Test and Evaluation Support	06	28,888		28,888	U
150	0606017F	Requirements Analysis and Maturation	06	35,285		35,285	U

151	0606116F	Space Test and Training Range Development	06	U

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152	0606392F	Space and Missile Center (SMC) Civilian Workforce	06	171,666					U
153	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	06	4,265	29,049	29,049			U
154	0702806F	Acquisition and Management Support	06	14,168	14,980	14,980			U
155	0804731F	General Skill Training	06	1,353	1,434	1,434			U
156	0909999F	Financing for Cancelled Account Adjustments	06	1,004					U
157	1001004F	International Activities	06	4,626	4,569	4,569			U
158	1206116F	Space Test and Training Range Development	06		25,773	25,773			U
159	1206392F	Space and Missile Center (SMC) Civilian Workforce	06		169,887	169,887			U
160	1206398F	Space & Missile Systems Center - MHA	06		9,531	9,531			U
161	1206860F	Rocket Systems Launch Program (SPACE)	06		20,975	20,975			U
162	1206864F	Space Test Program (STP)	06		25,398	25,398			U
		Management Support		1,690,840	2,663,875	2,663,875			
163	0603423F	Global Positioning System III - Operational Control Segment	07	376,645					U
164	0604222F	Nuclear Weapons Support	07		27,579	27,579			U
165	0604233F	Specialized Undergraduate Flight Training	07	17,754	5,776	5,776			U

166	0604445F	Wide Area Surveillance	07	50,486	16,247	16,247		U

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152	0606392F	Space and Missile Center (SMC) Civilian Workforce	06							U
153	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	06				29,049		29,049	U
154	0702806F	Acquisition and Management Support	06				14,980		14,980	U
155	0804731F	General Skill Training	06				1,434		1,434	U
156	0909999F	Financing for Cancelled Account Adjustments	06							U
157	1001004F	International Activities	06				4,569		4,569	U
158	1206116F	Space Test and Training Range Development	06				25,773		25,773	U
159	1206392F	Space and Missile Center (SMC) Civilian Workforce	06				169,887		169,887	U
160	1206398F	Space & Missile Systems Center - MHA	06				9,531		9,531	U
161	1206860F	Rocket Systems Launch Program (SPACE)	06				20,975		20,975	U
162	1206864F	Space Test Program (STP)	06				25,398		25,398	U
		Management Support					2,663,875		2,663,875	
163	0603423F	Global Positioning System III - Operational Control Segment	07							U
164	0604222F	Nuclear Weapons Support	07				27,579		27,579	U
165	0604233F	Specialized Undergraduate Flight Training	07				5,776		5,776	U

166	0604445F	Wide Area Surveillance	07		16,247	16,247	U

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152	0606392F	Space and Missile Center (SMC) Civilian Workforce	06				U
153	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	06	20,545		20,545	U
154	0702806F	Acquisition and Management Support	06	12,367		12,367	U
155	0804731F	General Skill Training	06	1,448		1,448	U
156	0909999F	Financing for Cancelled Account Adjustments	06				U
157	1001004F	International Activities	06	3,998		3,998	U
158	1206116F	Space Test and Training Range Development	06	23,254		23,254	U
159	1206392F	Space and Missile Center (SMC) Civilian Workforce	06	169,912		169,912	U
160	1206398F	Space & Missile Systems Center - MHA	06	10,508		10,508	U
161	1206860F	Rocket Systems Launch Program (SPACE)	06	19,721		19,721	U
162	1206864F	Space Test Program (STP)	06	25,620		25,620	U
		Management Support		2,839,511		2,839,511	
163	0603423F	Global Positioning System III - Operational Control Segment	07				U
164	0604222F	Nuclear Weapons Support	07				U
165	0604233F	Specialized Undergraduate Flight Training	07	11,344		11,344	U

166 0604445F Wide Area Surveillance 07 U

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167	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	07	9,956	21,915	21,915			U
168	0605024F	Anti-Tamper Technology Executive Agency	07	32,646	33,150	33,150			U
169	0605117F	Foreign Materiel Acquisition and Exploitation	07	58,360	66,653	66,653			U
170	0605278F	HC/MC-130 Recap RDT&E	07		38,579	38,579			U
171	0606018F	NC3 Integration	07		12,636	12,636			U
172	0606942F	Assessments and Evaluations Cyber Vulnerabilities	07						U
173	0101113F	B-52 Squadrons	07	74,550	111,910	111,910			U
174	0101122F	Air-Launched Cruise Missile (ALCM)	07	437	463	463			U
175	0101126F	B-1B Squadrons	07	4,562	62,471	62,471			U
176	0101127F	B-2 Squadrons	07	122,973	193,108	193,108			U
177	0101213F	Minuteman Squadrons	07	173,718	210,845	210,845			U
178	0101313F	Integrated Strategic Planning and Analysis Network (ISPAN) - USSTRATCOM	07	39,120	25,736	25,736			U
179	0101316F	Worldwide Joint Strategic Communications	07	5,876	6,272	6,272			U
180	0101324F	Integrated Strategic Planning & Analysis Network	07		11,032	11,032			U

181	0101328F	ICBM Reentry Vehicles	07					U
183	0102110F	UH-1N Replacement Program	07	86,856	108,617	108,617		U

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Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
167	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	07				21,915		21,915	U
168	0605024F	Anti-Tamper Technology Executive Agency	07				33,150		33,150	U
169	0605117F	Foreign Materiel Acquisition and Exploitation	07				66,653		66,653	U
170	0605278F	HC/MC-130 Recap RDT&E	07				38,579		38,579	U
171	0606018F	NC3 Integration	07				12,636		12,636	U
172	0606942F	Assessments and Evaluations Cyber Vulnerabilities	07							U
173	0101113F	B-52 Squadrons	07				111,910		111,910	U
174	0101122F	Air-Launched Cruise Missile (ALCM)	07				463		463	U
175	0101126F	B-1B Squadrons	07				62,471		62,471	U
176	0101127F	B-2 Squadrons	07				193,108		193,108	U
177	0101213F	Minuteman Squadrons	07				210,845		210,845	U
178	0101313F	Integrated Strategic Planning and Analysis Network (ISPAN) - USSTRATCOM	07				25,736		25,736	U
179	0101316F	Worldwide Joint Strategic Communications	07				6,272		6,272	U
180	0101324F	Integrated Strategic Planning & Analysis Network	07				11,032		11,032	U

181	0101328F	ICBM Reentry Vehicles	07				U
183	0102110F	UH-1N Replacement Program	07	108,617	108,617		U

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167	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	07	47,287		47,287	U
168	0605024F	Anti-Tamper Technology Executive Agency	07	32,770		32,770	U
169	0605117F	Foreign Materiel Acquisition and Exploitation	07	68,368		68,368	U
170	0605278F	HC/MC-130 Recap RDT&E	07	32,574		32,574	U
171	0606018F	NC3 Integration	07	26,112		26,112	U
172	0606942F	Assessments and Evaluations Cyber Vulnerabilities	07	99,100		99,100	U
173	0101113F	B-52 Squadrons	07	280,414		280,414	U
174	0101122F	Air-Launched Cruise Missile (ALCM)	07	5,955		5,955	U
175	0101126F	B-1B Squadrons	07	76,030		76,030	U
176	0101127F	B-2 Squadrons	07	105,561		105,561	U
177	0101213F	Minuteman Squadrons	07	156,047		156,047	U
178	0101313F	Integrated Strategic Planning and Analysis Network (ISPAN) - USSTRATCOM	07				U
179	0101316F	Worldwide Joint Strategic Communications	07	10,442		10,442	U
180	0101324F	Integrated Strategic Planning & Analysis Network	07	22,833		22,833	U

181	0101328F	ICBM Reentry Vehicles	07	18,412		18,412	U
183	0102110F	UH-1N Replacement Program	07	288,022		288,022	U

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184	0102326F	Region/Sector Operation Control Center Modernization Program	07	10,868	3,347	3,347			U
185	0105921F	Service Support to STRATCOM - Space Activities	07	8,381					U
186	0205219F	MQ-9 UAV	07	167,239	201,394	201,394			U
187	0205671F	Joint Counter RCIED Electronic Warfare	07						U
188	0207131F	A-10 Squadrons	07	11,353	17,459	17,459			U
189	0207133F	F-16 Squadrons	07	132,113	246,578	246,578			U
190	0207134F	F-15E Squadrons	07	344,184	320,271	320,271			U
191	0207136F	Manned Destructive Suppression	07	12,697	15,106	15,106			U
192	0207138F	F-22A Squadrons	07	364,691	610,942	610,942			U
193	0207142F	F-35 Squadrons	07	73,905	334,530	334,530			U
194	0207161F	Tactical AIM Missiles	07	51,499	34,952	34,952			U
195	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	53,320	61,322	61,322			U
196	0207227F	Combat Rescue - Pararescue	07	350	693	693			U
197	0207247F	AF TENCAP	07	28,412					U
198	0207249F	Precision Attack Systems Procurement	07	625	1,714	1,714			U
199	0207253F	Compass Call	07	13,723	14,040	14,040			U

200	0207268F	Aircraft Engine Component Improvement Program	07	106,049	109,243	109,243		U

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184	0102326F	Region/Sector Operation Control Center Modernization Program	07				3,347		3,347	U
185	0105921F	Service Support to STRATCOM - Space Activities	07							U
186	0205219F	MQ-9 UAV	07				201,394		201,394	U
187	0205671F	Joint Counter RCIED Electronic Warfare	07							U
188	0207131F	A-10 Squadrons	07				17,459		17,459	U
189	0207133F	F-16 Squadrons	07				246,578		246,578	U
190	0207134F	F-15E Squadrons	07				320,271		320,271	U
191	0207136F	Manned Destructive Suppression	07				15,106		15,106	U
192	0207138F	F-22A Squadrons	07				610,942		610,942	U
193	0207142F	F-35 Squadrons	07				334,530		334,530	U
194	0207161F	Tactical AIM Missiles	07				34,952		34,952	U
195	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07				61,322		61,322	U
196	0207227F	Combat Rescue - Pararescue	07				693		693	U
197	0207247F	AF TENCAP	07							U
198	0207249F	Precision Attack Systems Procurement	07				1,714		1,714	U
199	0207253F	Compass Call	07				14,040		14,040	U

200	0207268F	Aircraft Engine Component Improvement Program	07	109,243	109,243	U

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184	0102326F	Region/Sector Operation Control Center Modernization Program	07	9,252		9,252	U
185	0105921F	Service Support to STRATCOM - Space Activities	07				U
186	0205219F	MQ-9 UAV	07	115,345	4,500	119,845	U
187	0205671F	Joint Counter RCIED Electronic Warfare	07		4,000	4,000	U
188	0207131F	A-10 Squadrons	07	26,738	1,000	27,738	U
189	0207133F	F-16 Squadrons	07	191,564		191,564	U
190	0207134F	F-15E Squadrons	07	192,883		192,883	U
191	0207136F	Manned Destructive Suppression	07	15,238		15,238	U
192	0207138F	F-22A Squadrons	07	603,553		603,553	U
193	0207142F	F-35 Squadrons	07	549,501		549,501	U
194	0207161F	Tactical AIM Missiles	07	37,230		37,230	U
195	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	61,393		61,393	U
196	0207227F	Combat Rescue - Pararescue	07	647		647	U
197	0207247F	AF TENCAP	07				U
198	0207249F	Precision Attack Systems Procurement	07	14,891		14,891	U
199	0207253F	Compass Call	07	13,901		13,901	U

200	0207268F	Aircraft Engine Component Improvement Program	07	121,203		121,203	U

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201	0207277F	ISR Innovations	07				5,750	5,750	U
202	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	07	23,108	29,932	29,932			U
203	0207410F	Air & Space Operations Center (AOC)	07	29,916	26,956	26,956			U
204	0207412F	Control and Reporting Center (CRC)	07	12,854	2,450	2,450			U
205	0207417F	Airborne Warning and Control System (AWACS)	07	85,727	151,726	151,726			U
206	0207418F	Tactical Airborne Control Systems	07	2,353	3,656	3,656			U
208	0207431F	Combat Air Intelligence System Activities	07	15,461	13,420	13,420			U
209	0207444F	Tactical Air Control Party-Mod	07	11,437	10,623	10,623			U
210	0207448F	C2ISR Tactical Data Link	07	1,406	1,754	1,754			U
211	0207452F	DCAPES	07	13,286	17,382	17,382			U
212	0207573F	National Technical Nuclear Forensics	07		2,307	2,307			U
213	0207581F	Joint Surveillance/Target Attack Radar System (JSTARS)	07						U
214	0207590F	Seek Eagle	07	28,204	25,397	25,397			U
215	0207601F	USAF Modeling and Simulation	07	14,828	10,175	10,175			U
216	0207605F	Wargaming and Simulation Centers	07	4,090	12,839	12,839			U
217	0207610F	Battlefield Abn Comm Node (BACN)	07						U

218	0207697F	Distributed Training and Exercises	07	4,241	4,190	4,190		U
219	0208006F	Mission Planning Systems	07	69,104	85,531	85,531		U

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201	0207277F	ISR Innovations	07				5,750		5,750	U
202	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	07				29,932		29,932	U
203	0207410F	Air & Space Operations Center (AOC)	07				26,956		26,956	U
204	0207412F	Control and Reporting Center (CRC)	07				2,450		2,450	U
205	0207417F	Airborne Warning and Control System (AWACS)	07				151,726		151,726	U
206	0207418F	Tactical Airborne Control Systems	07				3,656		3,656	U
208	0207431F	Combat Air Intelligence System Activities	07				13,420		13,420	U
209	0207444F	Tactical Air Control Party-Mod	07				10,623		10,623	U
210	0207448F	C2ISR Tactical Data Link	07				1,754		1,754	U
211	0207452F	DCAPES	07				17,382		17,382	U
212	0207573F	National Technical Nuclear Forensics	07				2,307		2,307	U
213	0207581F	Joint Surveillance/Target Attack Radar System (JSTARS)	07							U
214	0207590F	Seek Eagle	07				25,397		25,397	U
215	0207601F	USAF Modeling and Simulation	07				10,175		10,175	U
216	0207605F	Wargaming and Simulation Centers	07				12,839		12,839	U
217	0207610F	Battlefield Abn Comm Node (BACN)	07							U

218	0207697F	Distributed Training and Exercises	07		4,190	4,190	U
219	0208006F	Mission Planning Systems	07		85,531	85,531	U

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201	0207277F	ISR Innovations	07				U
202	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	07	60,062		60,062	U
203	0207410F	Air & Space Operations Center (AOC)	07	106,102		106,102	U
204	0207412F	Control and Reporting Center (CRC)	07	6,413		6,413	U
205	0207417F	Airborne Warning and Control System (AWACS)	07	120,664		120,664	U
206	0207418F	Tactical Airborne Control Systems	07	2,659		2,659	U
208	0207431F	Combat Air Intelligence System Activities	07	10,316		10,316	U
209	0207444F	Tactical Air Control Party-Mod	07	6,149		6,149	U
210	0207448F	C2ISR Tactical Data Link	07	1,738		1,738	U
211	0207452F	DCAPES	07	13,297		13,297	U
212	0207573F	National Technical Nuclear Forensics	07	1,788		1,788	U
213	0207581F	Joint Surveillance/Target Attack Radar System (JSTARS)	07	14,888		14,888	U
214	0207590F	Seek Eagle	07	24,699		24,699	U
215	0207601F	USAF Modeling and Simulation	07	17,078		17,078	U
216	0207605F	Wargaming and Simulation Centers	07	6,141		6,141	U
217	0207610F	Battlefield Abn Comm Node (BACN)	07		42,349	42,349	U

218	0207697F	Distributed Training and Exercises	07	4,225		4,225	U
219	0208006F	Mission Planning Systems	07	63,653		63,653	U

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220	0208007F	Tactical Deception	07		3,761	3,761			U
221	0208087F	AF Offensive Cyberspace Operations	07	24,109	35,693	35,693	4,000	4,000	U
222	0208088F	AF Defensive Cyberspace Operations	07	38,035	20,964	20,964			U
223	0208097F	Joint Cyber Command and Control (JCC2)	07						U
224	0208099F	Unified Platform (UP)	07						U
228	0208288F	Intel Data Applications	07						U
229	0301017F	Global Sensor Integrated on Network (GSIN)	07	3,296	3,549	3,549			U
230	0301112F	Nuclear Planning and Execution System (NPES)	07	3,926	4,371	4,371			U
236	0301400F	Space Superiority Intelligence	07	12,380					U
237	0301401F	Air Force Space and Cyber Non-Traditional ISR for Battlespace Awareness	07		3,721	3,721			U
238	0302015F	E-4B National Airborne Operations Center (NAOC)	07	25,104	35,467	35,467			U
239	0303001F	Family of Advanced BLoS Terminals (FAB-T)	07	50,071					U
240	0303131F	Minimum Essential Emergency Communications Network (MEECN)	07	40,099	48,841	48,841			U
241	0303133F	High Frequency Radio Systems	07						U

242	0303140F	Information Systems Security Program	07	36,074	42,973	42,973			U
243	0303141F	Global Combat Support System	07	50	105	105			U

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220	0208007F	Tactical Deception	07				3,761		3,761	U
221	0208087F	AF Offensive Cyberspace Operations	07				39,693		39,693	U
222	0208088F	AF Defensive Cyberspace Operations	07				20,964		20,964	U
223	0208097F	Joint Cyber Command and Control (JCC2)	07							U
224	0208099F	Unified Platform (UP)	07							U
228	0208288F	Intel Data Applications	07							U
229	0301017F	Global Sensor Integrated on Network (GSIN)	07				3,549		3,549	U
230	0301112F	Nuclear Planning and Execution System (NPES)	07				4,371		4,371	U
236	0301400F	Space Superiority Intelligence	07							U
237	0301401F	Air Force Space and Cyber Non-Traditional ISR for Battlespace Awareness	07				3,721		3,721	U
238	0302015F	E-4B National Airborne Operations Center (NAOC)	07				35,467		35,467	U
239	0303001F	Family of Advanced BLoS Terminals (FAB-T)	07							U
240	0303131F	Minimum Essential Emergency Communications Network (MEECN)	07				48,841		48,841	U
241	0303133F	High Frequency Radio Systems	07							U

242	0303140F	Information Systems Security Program	07		42,973	42,973	U
243	0303141F	Global Combat Support System	07		105	105	U

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220	0208007F	Tactical Deception	07	6,949		6,949	U
221	0208087F	AF Offensive Cyberspace Operations	07	40,526		40,526	U
222	0208088F	AF Defensive Cyberspace Operations	07	24,166		24,166	U
223	0208097F	Joint Cyber Command and Control (JCC2)	07	13,000		13,000	U
224	0208099F	Unified Platform (UP)	07	28,759		28,759	U
228	0208288F	Intel Data Applications	07		1,200	1,200	U
229	0301017F	Global Sensor Integrated on Network (GSIN)	07	3,579		3,579	U
230	0301112F	Nuclear Planning and Execution System (NPES)	07	29,620		29,620	U
236	0301400F	Space Superiority Intelligence	07				U
237	0301401F	Air Force Space and Cyber Non-Traditional ISR for Battlespace Awareness	07	6,633		6,633	U
238	0302015F	E-4B National Airborne Operations Center (NAOC)	07	57,758		57,758	U
239	0303001F	Family of Advanced BLoS Terminals (FAB-T)	07				U
240	0303131F	Minimum Essential Emergency Communications Network (MEECN)	07	99,088		99,088	U
241	0303133F	High Frequency Radio Systems	07	51,612		51,612	U

242	0303140F	Information Systems Security Program	07	34,612			34,612	U
243	0303141F	Global Combat Support System	07					U

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244	0303142F	Global Force Management - Data Initiative	07	1,851	2,147	2,147			U
246	0304260F	Airborne SIGINT Enterprise	07	95,284	121,948	121,948			U
247	0304310F	Commercial Economic Analysis	07		3,544	3,544			U
250	0305015F	C2 Air Operations Suite - C2 Info Services	07						U
251	0305020F	CCMD Intelligence Information Technology	07	1,507	1,542	1,542			U
252	0305099F	Global Air Traffic Management (GATM)	07	4,219	4,453	4,453			U
253	0305110F	Satellite Control Network (SPACE)	07	14,099					U
254	0305111F	Weather Service	07	24,193	26,654	26,654			U
255	0305114F	Air Traffic Control, Approach, and Landing System (ATCALS)	07	17,732	6,306	6,306			U
256	0305116F	Aerial Targets	07	2,981	21,295	21,295			U
259	0305128F	Security and Investigative Activities	07	405	415	415			U
260	0305145F	Arms Control Implementation	07	4,667					U
261	0305146F	Defense Joint Counterintelligence Activities	07	339	3,867	3,867			U
264	0305173F	Space and Missile Test and Evaluation Center	07	4,250					U
265	0305174F	Space Innovation, Integration and	07	6,233					U

Rapid Technology Development

266 0305179F Integrated Broadcast Service (IBS) 07 8,833 U

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Line No	Program Element Number	Item	Act	FY 2018 Emergency Requests** Emergency	FY 2018 Less Enacted Div B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req Emergency	FY 2018 Total PB Requests* with CR Adj Base + OCO + Emergency**	FY 2018 Less Enacted DIV B P.L.115-96*** MDDE + Ship Repairs	FY 2018 Remaining Req with CR Adj Base + OCO + Emergency	Sec
244	0303142F	Global Force Management - Data Initiative	07				2,147		2,147	U
246	0304260F	Airborne SIGINT Enterprise	07				121,948		121,948	U
247	0304310F	Commercial Economic Analysis	07				3,544		3,544	U
250	0305015F	C2 Air Operations Suite - C2 Info Services	07							U
251	0305020F	CCMD Intelligence Information Technology	07				1,542		1,542	U
252	0305099F	Global Air Traffic Management (GATM)	07				4,453		4,453	U
253	0305110F	Satellite Control Network (SPACE)	07							U
254	0305111F	Weather Service	07				26,654		26,654	U
255	0305114F	Air Traffic Control, Approach, and Landing System (ATCALS)	07				6,306		6,306	U
256	0305116F	Aerial Targets	07				21,295		21,295	U
259	0305128F	Security and Investigative Activities	07				415		415	U
260	0305145F	Arms Control Implementation	07							U
261	0305146F	Defense Joint Counterintelligence Activities	07				3,867		3,867	U
264	0305173F	Space and Missile Test and Evaluation Center	07							U
265	0305174F	Space Innovation, Integration and	07							U

Rapid Technology Development

266 0305179F Integrated Broadcast Service (IBS) 07 U

R-119PB: FY 2019 President's Budget (Published Version), as of February 1, 2018 at 12:30:16

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Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
244	0303142F	Global Force Management - Data Initiative	07	2,170		2,170	U
246	0304260F	Airborne SIGINT Enterprise	07	106,873		106,873	U
247	0304310F	Commercial Economic Analysis	07	3,472		3,472	U
250	0305015F	C2 Air Operations Suite - C2 Info Services	07	8,608		8,608	U
251	0305020F	CCMD Intelligence Information Technology	07	1,586		1,586	U
252	0305099F	Global Air Traffic Management (GATM)	07	4,492		4,492	U
253	0305110F	Satellite Control Network (SPACE)	07				U
254	0305111F	Weather Service	07	26,942	3,000	29,942	U
255	0305114F	Air Traffic Control, Approach, and Landing System (ATCALS)	07	6,271		6,271	U
256	0305116F	Aerial Targets	07	8,383		8,383	U
259	0305128F	Security and Investigative Activities	07	418		418	U
260	0305145F	Arms Control Implementation	07				U
261	0305146F	Defense Joint Counterintelligence Activities	07	3,845		3,845	U
264	0305173F	Space and Missile Test and Evaluation Center	07				U
265	0305174F	Space Innovation, Integration and	07				U

Rapid Technology Development

266 0305179F Integrated Broadcast Service (IBS) 07 U

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267	0305182F	Spacelift Range System (SPACE)	07	21,082					U
268	0305202F	Dragon U-2	07	37,217	34,486	34,486			U
269	0305205F	Endurance Unmanned Aerial Vehicles	07	50,000					U
270	0305206F	Airborne Reconnaissance Systems	07	13,465	4,450	4,450			U
271	0305207F	Manned Reconnaissance Systems	07	20,975	14,269	14,269			U
272	0305208F	Distributed Common Ground/Surface Systems	07	18,898	27,501	27,501			U
273	0305220F	RQ-4 UAV	07	244,807	214,849	214,849			U
274	0305221F	Network-Centric Collaborative Targeting	07	18,088	18,842	18,842			U
275	0305238F	NATO AGS	07	38,904	44,729	44,729			U
276	0305240F	Support to DCGS Enterprise	07	23,084	26,349	26,349			U
277	0305265F	GPS III Space Segment	07	165,794					U
278	0305600F	International Intelligence Technology and Architectures	07	2,360	3,491	3,491			U
279	0305614F	JSPOC Mission System	07	76,467					U
280	0305881F	Rapid Cyber Acquisition	07	4,123	4,899	4,899			U
281	0305906F	NCMC - TW/AA System	07	4,951					U
282	0305913F	NUDET Detection System (SPACE)	07	21,093					U
283	0305940F	Space Situation Awareness Operations	07	92,482					U

284	0305984F	Personnel Recovery Command & Ctrl (PRC2)	07		2,445	2,445		U

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267	0305182F	Spacelift Range System (SPACE)	07							U
268	0305202F	Dragon U-2	07				34,486		34,486	U
269	0305205F	Endurance Unmanned Aerial Vehicles	07							U
270	0305206F	Airborne Reconnaissance Systems	07				4,450		4,450	U
271	0305207F	Manned Reconnaissance Systems	07				14,269		14,269	U
272	0305208F	Distributed Common Ground/Surface Systems	07				27,501		27,501	U
273	0305220F	RQ-4 UAV	07				214,849		214,849	U
274	0305221F	Network-Centric Collaborative Targeting	07				18,842		18,842	U
275	0305238F	NATO AGS	07				44,729		44,729	U
276	0305240F	Support to DCGS Enterprise	07				26,349		26,349	U
277	0305265F	GPS III Space Segment	07							U
278	0305600F	International Intelligence Technology and Architectures	07				3,491		3,491	U
279	0305614F	JSPOC Mission System	07							U
280	0305881F	Rapid Cyber Acquisition	07				4,899		4,899	U
281	0305906F	NCMC - TW/AA System	07							U
282	0305913F	NUDET Detection System (SPACE)	07							U
283	0305940F	Space Situation Awareness Operations	07							U

284	0305984F	Personnel Recovery Command & Ctrl (PRC2)	07		2,445	2,445	U

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267	0305182F	Spacelift Range System (SPACE)	07				U
268	0305202F	Dragon U-2	07	48,518	22,100	70,618	U
269	0305205F	Endurance Unmanned Aerial Vehicles	07				U
270	0305206F	Airborne Reconnaissance Systems	07	175,334		175,334	U
271	0305207F	Manned Reconnaissance Systems	07	14,223		14,223	U
272	0305208F	Distributed Common Ground/Surface Systems	07	24,554	29,500	54,054	U
273	0305220F	RQ-4 UAV	07	221,690		221,690	U
274	0305221F	Network-Centric Collaborative Targeting	07	14,288		14,288	U
275	0305238F	NATO AGS	07	51,527		51,527	U
276	0305240F	Support to DCGS Enterprise	07	26,579		26,579	U
277	0305265F	GPS III Space Segment	07				U
278	0305600F	International Intelligence Technology and Architectures	07	8,464		8,464	U
279	0305614F	JSPOC Mission System	07				U
280	0305881F	Rapid Cyber Acquisition	07	4,303		4,303	U
281	0305906F	NCMC - TW/AA System	07				U
282	0305913F	NUDET Detection System (SPACE)	07				U
283	0305940F	Space Situation Awareness Operations	07				U

284	0305984F	Personnel Recovery Command & Ctrl (PRC2)	07	2,466		2,466	U

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285	0307577F	Intelligence Mission Data (IMD)	07		8,684	8,684			U
286	0308699F	Shared Early Warning (SEW)	07	6,154					U
287	0401115F	C-130 Airlift Squadron	07	15,599	10,219	10,219			U
288	0401119F	C-5 Airlift Squadrons (IF)	07	65,057	22,758	22,758			U
289	0401130F	C-17 Aircraft (IF)	07	12,021	34,287	34,287			U
290	0401132F	C-130J Program	07	16,199	26,821	26,821			U
291	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	07	5,011	5,283	5,283			U
292	0401218F	KC-135s	07		9,942	9,942			U
293	0401219F	KC-10s	07	3,500	7,933	7,933			U
294	0401314F	Operational Support Airlift	07	13,332	6,681	6,681			U
295	0401318F	CV-22	07	27,704	22,519	22,519			U
296	0401840F	AMC Command and Control System	07		3,510	3,510			U
297	0408011F	Special Tactics / Combat Control	07	6,902	8,090	8,090			U
298	0702207F	Depot Maintenance (Non-IF)	07	1,507	1,528	1,528			U
299	0708055F	Maintenance, Repair & Overhaul System	07		31,677	31,677			U
300	0708610F	Logistics Information Technology (LOGIT)	07	53,369	33,344	33,344			U
301	0708611F	Support Systems Development	07	10,552	9,362	9,362			U

302	0804743F	Other Flight Training	07	1,841	2,074	2,074		U

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285	0307577F	Intelligence Mission Data (IMD)	07				8,684		8,684	U
286	0308699F	Shared Early Warning (SEW)	07							U
287	0401115F	C-130 Airlift Squadron	07				10,219		10,219	U
288	0401119F	C-5 Airlift Squadrons (IF)	07				22,758		22,758	U
289	0401130F	C-17 Aircraft (IF)	07				34,287		34,287	U
290	0401132F	C-130J Program	07				26,821		26,821	U
291	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	07				5,283		5,283	U
292	0401218F	KC-135s	07				9,942		9,942	U
293	0401219F	KC-10s	07				7,933		7,933	U
294	0401314F	Operational Support Airlift	07				6,681		6,681	U
295	0401318F	CV-22	07				22,519		22,519	U
296	0401840F	AMC Command and Control System	07				3,510		3,510	U
297	0408011F	Special Tactics / Combat Control	07				8,090		8,090	U
298	0702207F	Depot Maintenance (Non-IF)	07				1,528		1,528	U
299	0708055F	Maintenance, Repair & Overhaul System	07				31,677		31,677	U
300	0708610F	Logistics Information Technology (LOGIT)	07				33,344		33,344	U
301	0708611F	Support Systems Development	07				9,362		9,362	U

302	0804743F	Other Flight Training	07		2,074	2,074	U

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285	0307577F	Intelligence Mission Data (IMD)	07	4,117		4,117	U
286	0308699F	Shared Early Warning (SEW)	07				U
287	0401115F	C-130 Airlift Squadron	07	105,988		105,988	U
288	0401119F	C-5 Airlift Squadrons (IF)	07	25,071		25,071	U
289	0401130F	C-17 Aircraft (IF)	07	48,299		48,299	U
290	0401132F	C-130J Program	07	15,409		15,409	U
291	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	07	4,334		4,334	U
292	0401218F	KC-135s	07	3,493		3,493	U
293	0401219F	KC-10s	07	6,569		6,569	U
294	0401314F	Operational Support Airlift	07	3,172		3,172	U
295	0401318F	CV-22	07	18,502		18,502	U
296	0401840F	AMC Command and Control System	07	1,688		1,688	U
297	0408011F	Special Tactics / Combat Control	07	2,541		2,541	U
298	0702207F	Depot Maintenance (Non-IF)	07	1,897		1,897	U
299	0708055F	Maintenance, Repair & Overhaul System	07	50,933		50,933	U
300	0708610F	Logistics Information Technology (LOGIT)	07	13,787		13,787	U
301	0708611F	Support Systems Development	07	4,497		4,497	U

302	0804743F	Other Flight Training	07	2,022		2,022	U

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303	0808716F	Other Personnel Activities	07	57	107	107			U
304	0901202F	Joint Personnel Recovery Agency	07	3,556	2,006	2,006			U
305	0901218F	Civilian Compensation Program	07	2,878	3,780	3,780			U
306	0901220F	Personnel Administration	07	4,968	7,472	7,472			U
307	0901226F	Air Force Studies and Analysis Agency	07	1,415	1,563	1,563			U
308	0901538F	Financial Management Information Systems Development	07	10,478	91,211	91,211			U
309	1201921F	Service Support to STRATCOM - Space Activities	07		14,255	14,255			U
310	1202247F	AF TENCAP	07		31,914	31,914			U
311	1203001F	Family of Advanced BLoS Terminals (FAB-T)	07		32,426	32,426			U
312	1203110F	Satellite Control Network (SPACE)	07		18,808	18,808			U
314	1203165F	NAVSTAR Global Positioning System (Space and Control Segments)	07		10,029	10,029			U
315	1203173F	Space and Missile Test and Evaluation Center	07		25,051	25,051			U
316	1203174F	Space Innovation, Integration and Rapid Technology Development	07		11,390	11,390			U
317	1203179F	Integrated Broadcast Service (IBS)	07		8,747	8,747			U
318	1203182F	Spacelift Range System (SPACE)	07		10,549	10,549			U

319	1203265F	GPS III Space Segment	07		243,435	243,435		U

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303	0808716F	Other Personnel Activities	07				107		107	U
304	0901202F	Joint Personnel Recovery Agency	07				2,006		2,006	U
305	0901218F	Civilian Compensation Program	07				3,780		3,780	U
306	0901220F	Personnel Administration	07				7,472		7,472	U
307	0901226F	Air Force Studies and Analysis Agency	07				1,563		1,563	U
308	0901538F	Financial Management Information Systems Development	07				91,211		91,211	U
309	1201921F	Service Support to STRATCOM - Space Activities	07				14,255		14,255	U
310	1202247F	AF TENCAP	07				31,914		31,914	U
311	1203001F	Family of Advanced BLoS Terminals (FAB-T)	07				32,426		32,426	U
312	1203110F	Satellite Control Network (SPACE)	07				18,808		18,808	U
314	1203165F	NAVSTAR Global Positioning System (Space and Control Segments)	07				10,029		10,029	U
315	1203173F	Space and Missile Test and Evaluation Center	07				25,051		25,051	U
316	1203174F	Space Innovation, Integration and Rapid Technology Development	07				11,390		11,390	U
317	1203179F	Integrated Broadcast Service (IBS)	07				8,747		8,747	U
318	1203182F	Spacelift Range System (SPACE)	07				10,549		10,549	U

319	1203265F	GPS III Space Segment	07		243,435	243,435	U

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Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
303	0808716F	Other Personnel Activities	07	108		108	U
304	0901202F	Joint Personnel Recovery Agency	07	2,023		2,023	U
305	0901218F	Civilian Compensation Program	07	3,772		3,772	U
306	0901220F	Personnel Administration	07	6,358		6,358	U
307	0901226F	Air Force Studies and Analysis Agency	07	1,418		1,418	U
308	0901538F	Financial Management Information Systems Development	07	99,734		99,734	U
309	1201921F	Service Support to STRATCOM - Space Activities	07	14,161		14,161	U
310	1202247F	AF TENCAP	07	26,986	5,000	31,986	U
311	1203001F	Family of Advanced BLoS Terminals (FAB-T)	07	80,168		80,168	U
312	1203110F	Satellite Control Network (SPACE)	07	17,808		17,808	U
314	1203165F	NAVSTAR Global Positioning System (Space and Control Segments)	07	8,937		8,937	U
315	1203173F	Space and Missile Test and Evaluation Center	07	59,935		59,935	U
316	1203174F	Space Innovation, Integration and Rapid Technology Development	07	21,019		21,019	U
317	1203179F	Integrated Broadcast Service (IBS)	07	8,568		8,568	U
318	1203182F	Spacelift Range System (SPACE)	07	10,641		10,641	U

319	1203265F	GPS III Space Segment	07	144,543		144,543	U	

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320	1203400F	Space Superiority Intelligence	07		12,691	12,691			U
321	1203614F	JSpOC Mission System	07		99,455	99,455			U
322	1203620F	National Space Defense Center	07		18,052	18,052			U
323	1203699F	Shared Early Warning (SEW)	07		1,373	1,373			U
324	1203906F	NCMC - TW/AA System	07		5,000	5,000			U
325	1203913F	NUDET Detection System (SPACE)	07		31,508	31,508			U
326	1203940F	Space Situation Awareness Operations	07		99,984	99,984			U
327	1206423F	Global Positioning System III - Operational Control Segment	07		510,938	510,938			U
9999	9999999999	Classified Programs		12,971,689	14,938,002	14,938,002	112,408	112,408	U
		Operational Systems Development		17,256,679	20,585,302	20,585,302	122,158	122,158	
328	0901560F	Continuing Resolution Programs	20		-7,336,882	-7,336,882	229,847	229,847	U
		Undistributed			-7,336,882	-7,336,882	229,847	229,847	
Total Research, Development, Test & Eval, AF				28,381,681	27,577,477	27,577,477	365,205	365,205	

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320	1203400F	Space Superiority Intelligence	07				12,691		12,691	U
321	1203614F	JSpOC Mission System	07				99,455		99,455	U
322	1203620F	National Space Defense Center	07				18,052		18,052	U
323	1203699F	Shared Early Warning (SEW)	07				1,373		1,373	U
324	1203906F	NCMC - TW/AA System	07				5,000		5,000	U
325	1203913F	NUDET Detection System (SPACE)	07				31,508		31,508	U
326	1203940F	Space Situation Awareness Operations	07				99,984		99,984	U
327	1206423F	Global Positioning System III - Operational Control Segment	07				510,938		510,938	U
9999	9999999999	Classified Programs		165,244	-165,244		15,215,654	-165,244	15,050,410	U
		Operational Systems Development					20,872,704		20,707,460	
328	0901560F	Continuing Resolution Programs	20				-7,107,035		-7,107,035	U
		Undistributed					-7,107,035		-7,107,035	
Total Research, Development, Test & Eval, AF				255,744	-255,744		28,198,426	-255,744	27,942,682	

UNCLASSIFIED

Department of the Air Force
FY 2019 President's Budget
Exhibit R-1 FY 2019 President's Budget
Total Obligational Authority
(Dollars in Thousands)

01 Feb 2018

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

Line No	Program Element Number	Item	Act	FY 2019 Base	FY 2019 OCO	FY 2019 Total	Sec
320	1203400F	Space Superiority Intelligence	07	16,278		16,278	U
321	1203614F	JSpOC Mission System	07	72,256		72,256	U
322	1203620F	National Space Defense Center	07	42,209		42,209	U
323	1203699F	Shared Early Warning (SEW)	07				U
324	1203906F	NCMC - TW/AA System	07				U
325	1203913F	NUDET Detection System (SPACE)	07	19,778		19,778	U
326	1203940F	Space Situation Awareness Operations	07	19,572		19,572	U
327	1206423F	Global Positioning System III - Operational Control Segment	07	513,235		513,235	U
9999	9999999999	Classified Programs		16,247,930	474,321	16,722,251	U
		Operational Systems Development		22,605,546	586,970	23,192,516	
328	0901560F	Continuing Resolution Programs	20				U
		Undistributed					
Total Research, Development, Test & Eval, AF				39,892,149	600,465	40,492,614	

Master Program Element Table of Contents (by Budget Activity then Line Item Number)

Appropriation 3600: Research, Development, Test & Evaluation, Air Force

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Master Program Element Table of Contents (Alphabetically by Program Element Title)

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The following Program Elements are not providing RDT&E exhibits due to classification:

0101815F	ADVANCED STRATEGIC PROGRAM
0207424F	EVALUATION AND ANALYSIS PROGRAM
0208161F	SPECIAL EVALUATION SYSTEM
0208162F	ADVANCED TECHNOLOGY PROGRAM
0301310F	NATIONAL AIR INTELLIGENCE CENTER
0301314F	COBRA BALL
0301315F	MISSILE AND SPACE TECHICAL COLLECTION
0301324F	FOREST GREEN
0301386F	GDIP COLLECTION MANAGEMENT
0304111F	SPECIAL ACTIVITES
0304311F	SELECTED ACTIVITIES
0304348F	ADVANCED GEOSPATIAL INTELLIGENCE (AGI)
0305124F	SPECIAL APPLICATIONS PROGRAM
0305127F	FOREIGN COUNTERINTELLIGENCE ACTIVITES
0305159F	DEFENSE RECONNAISSANCE SUPPORT ACTIVITIES
0305172F	COMBINED ADVANCED APPLICATIONS
0604446F	WIDE AREA SURVEILLANCE - SP
0605798F	ANALYSIS SUPPORT GROUP

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102F / *Defense Research Sciences*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	370.595	342.919	348.322	0.000	348.322	354.360	361.369	368.686	376.162	Continuing	Continuing
613001: *Physics and Electronics*	-	109.053	100.693	102.504	0.000	102.504	104.054	106.111	108.259	110.457	Continuing	Continuing
613002: *Aerospace, Chemical and Material Sciences*	-	116.284	106.172	107.763	0.000	107.763	109.712	111.883	114.149	116.464	Continuing	Continuing
613003: *Mathematics, Information and Life Sciences*	-	110.158	101.920	103.438	0.000	103.438	105.318	107.402	109.577	111.798	Continuing	Continuing
613004: *Education and Outreach*	-	35.100	34.134	34.617	0.000	34.617	35.276	35.973	36.701	37.443	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.

In FY 2018, a portion of HQ AFRL S&T civilian manpower in PE 0601102F, Defense Research Sciences, was transferred to PE 0602298F, Science and Technology Management - Major Headquarters Activities, to provide increased transparency to Congress on personnel in Major Headquarters Activities (MHA).

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, and 602298F."

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	340.812	342.919	348.323	0.000	348.323
Current President's Budget	370.595	342.919	348.322	0.000	348.322
Total Adjustments	29.783	0.000	-0.001	0.000	-0.001
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	40.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-10.217	0.000			
• Other Adjustments	0.000	0.000	-0.001	0.000	-0.001

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 613001: *Physics and Electronics*		
Congressional Add: *Program Increase - Basic Research*	14.260	0.000
Congressional Add Subtotals for Project: 613001	14.260	0.000
Project: 613002: *Aerospace, Chemical and Material Sciences*		
Congressional Add: *Program Increase - Basic Research*	14.241	0.000
Congressional Add Subtotals for Project: 613002	14.241	0.000
Project: 613003: *Mathematics, Information and Life Sciences*		
Congressional Add: *Program Increase - Basic Research*	7.401	0.000
Congressional Add Subtotals for Project: 613003	7.401	0.000
Project: 613004: *Education and Outreach*		
Congressional Add: *Program Increase - Basic Research*	2.613	0.000
Congressional Add Subtotals for Project: 613004	2.613	0.000
Congressional Add Totals for all Projects	38.515	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / *Defense Research Sciences*	Project (Number/Name) 613001 / *Physics and Electronics*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
613001: *Physics and Electronics*	-	109.053	100.693	102.504	0.000	102.504	104.054	106.111	108.259	110.457	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 2017	FY 2018	FY 2019
Title: Complex Electronics and Fundamental Quantum Processes	38.357	40.756	41.489
Description: Scientific focus areas are atomic and molecular physics, photonics, quantum electronic solids, gigahertz-terahertz electronics and material, semiconductor and electromagnetic materials, and optoelectronics. ***FY 2018 Plans:*** Explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, meta-materials, 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 photons and ultracold atoms and molecules. ***FY 2019 Plans:*** Continue to explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, meta-materials, 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 photons and ultracold atoms and molecules. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.733 million. Justification for this increase is described in plans above.			
Title: Plasma Physics and High Energy Density Non-Equilibrium Processes	19.757	20.993	21.371
Description: Scientific focus areas are plasma, electro-energetic physics and space sciences. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613001 / *Physics and Electronics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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, RF propagation, RF-plasma interaction, and high-power, beam-driven microwave devices. ***FY 2019 Plans:*** 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, RF propagation, RF-plasma interaction, and high-power, beam-driven microwave devices. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.378 million. Justification for this increase is described in plans above.			
Title: Lasers and Optics, Electromagnetics, Communication and Signal Processing ***Description:*** Scientific focus areas are physical mathematics and applied analysis, novel computational methods, dynamics sensing capability, electromagnetics, remote sensing and imaging physics, and surveillance and navigation. ***FY 2018 Plans:*** 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. ***FY 2019 Plans:*** 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.700 million. Justification for this increase is described in plans above.	36.679	38.944	39.644
Accomplishments/Planned Programs Subtotals	94.793	100.693	102.504

	FY 2017	FY 2018
Congressional Add: Program Increase - Basic Research	14.260	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613001 / *Physics and Electronics*

	FY 2017	FY 2018
FY 2017 Accomplishments: Conducted Congressionally directed effort. ***FY 2018 Plans:*** N/A		
Congressional Adds Subtotals	14.260	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / *Defense Research Sciences*	Project (Number/Name) 613002 / *Aerospace, Chemical and Material Sciences*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
613002: *Aerospace, Chemical and Material Sciences*	-	116.284	106.172	107.763	0.000	107.763	109.712	111.883	114.149	116.464	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. Major efforts being investigated in this project are aero-structure interactions and control; energy, power, and propulsion; and complex materials and structures. Although the major effort descriptions that follow are specific sub-areas of focus within this 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 2017	FY 2018	FY 2019
Title: Aero Structure Interactions and Control	30.090	31.295	31.763
Description: Scientific focus areas are high temperature aerospace materials, hypersonics, aerothermodynamics and turbulence, and flow interactions and control. ***FY 2018 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 2019 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. 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 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.468 million. Justification for this increase is described in plans above.			
Title: Energy, Power, and Propulsion	32.420	33.763	34.269
Description: Scientific focus areas are thermal control, theoretical chemistry, molecular dynamics, space power and propulsion, and combustion and diagnostics.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613002 / *Aerospace, Chemical and Material Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hybrid simulation, and structures. 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 and optimizing combustion processes. ***FY 2019 Plans:*** Continue to exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hybrid simulation, and structures. 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 and optimizing combustion processes. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.506 million. Justification for this increase is described in plans above.			
Title: Complex Materials and Structures ***Description:*** Scientific focus areas are mechanics of multifunctional materials and microsystems, multi-scale mechanics and prognosis, low density materials, and polymer chemistry. ***FY 2018 Plans:*** Investigate multifunctional materials and structures composed of different classes of materials, both organic and inorganic, that may be able to change functionality or performance characteristics to enhance the mission versatility of future air and space systems, with a key goal of increasing functionality while decreasing weight and volume. 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. ***FY 2019 Plans:*** Continue to investigate multifunctional materials and structures composed of different classes of materials, both organic and inorganic, that may be able to change functionality or performance characteristics to enhance the mission versatility of future air and space systems, with a key goal of increasing functionality while decreasing weight and volume. Explore materials, microsystems, and structures that incorporate hierarchical design and functionality from the nano-scale through the meso-scale, ultimately leading to controlled, well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	39.533	41.114	41.731

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613002 / *Aerospace, Chemical and Material Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 increased compared to FY 2018 by $0.617 million. Justification for this increase is described in plans above.			
Accomplishments/Planned Programs Subtotals	102.043	106.172	107.763

	FY 2017	FY 2018
Congressional Add: Program Increase - Basic Research ***FY 2017 Accomplishments:*** Conducted Congressionally directed effort. ***FY 2018 Plans:*** N/A	14.241	0.000
Congressional Adds Subtotals	14.241	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / *Defense Research Sciences*	Project (Number/Name) 613003 / *Mathematics, Information and Life Sciences*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
613003: *Mathematics, Information and Life Sciences*	-	110.158	101.920	103.438	0.000	103.438	105.318	107.402	109.577	111.798	Continuing	Continuing

A. Mission Description and Budget Item Justification

Basic research in the Mathematics, Information, and Life 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. Major areas being investigated in this project are information and complex networks, 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 projects within this program.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Information and Complex Networks	26.207	25.982	26.369
Description: Scientific focus areas are systems and software, information operations and security, information fusion, and complex networks. ***FY 2018 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, software engineering, and reliable systems, but the emphasis is on the underlying mathematics of secure-by-design architectures of networked communications and neural information processing. Sub-areas include system and network performance prediction, design and analysis, and modeling of human-machine systems. ***FY 2019 Plans:*** Continue to design and analyze techniques to enable reliable and secure exchange of information and predictable operation of networks and systems. This includes traditional aspects of information assurance, software engineering, and reliable systems, but the emphasis is on the underlying mathematics of secure-by-design architectures of networked communications and neural information processing. Sub-areas include system and network performance prediction, design and analysis, and modeling of human-machine systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.387 million. Justification for this increase is described in plans above.			
Title: Decision Making	20.438	20.263	20.565

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613003 / *Mathematics, Information and Life Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Scientific focus areas are mathematical modeling of cognition and decision making, trust between humans and autonomous agents, mixed human-machine decision making, and computational social science. ***FY 2018 Plans:*** Investigate new mathematical laws, scientific principles, and robust algorithms that underlie intelligent, mixed human-machine decision making to achieve accurate real-time projection of expertise and knowledge into and out of the battlespace. This includes efforts to advance the critical knowledge base in information sciences and information fusion, and to model individual and group cognitive processing and decision making. ***FY 2019 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 projection of expertise and knowledge into and out of the battlespace. This includes efforts to advance the critical knowledge base in information sciences and information fusion, and to model individual and group cognitive processing and decision making. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.302 million. Justification for this increase is described in plans above.			
Title: Dynamical Systems, Optimization, and Control ***Description:*** Scientific focus areas are computational mathematics, dynamics and control, and optimization and discrete mathematics. ***FY 2018 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. ***FY 2019 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. This includes developing novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	26.969	26.782	27.180

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613003 / *Mathematics, Information and Life Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 increased compared to FY 2018 by $0.398 million. Justification for this increase is described in plans above.			
Title: Natural Materials and Systems ***Description:*** Scientific focus areas are natural materials and nature inspired systems, human performance and biosystems, cognitive neuroscience and biophysics ***FY 2018 Plans:*** Investigate multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems accomplish their required tasks. Study how to adapt and mimic existing natural sensory systems and add existing capabilities to these organisms with the intent to gain more precise control over their material production. ***FY 2019 Plans:*** Continue to investigate multi-disciplinary approaches for studying the ways natural systems accomplish their required tasks. Study how to adapt and mimic existing natural sensory systems and add existing capabilities to these organisms with the intent to gain more precise control over their material production. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.431 million. Justification for this increase is described in plans above.	29.143	28.893	29.324
Accomplishments/Planned Programs Subtotals	102.757	101.920	103.438

	FY 2017	FY 2018
Congressional Add: Program Increase - Basic Research ***FY 2017 Accomplishments:*** Conducted Congressionally directed effort. ***FY 2018 Plans:*** N/A	7.401	0.000
Congressional Adds Subtotals	7.401	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613003 / *Mathematics, Information and Life Sciences*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
613004: *Education and Outreach*	-	35.100	34.134	34.617	0.000	34.617	35.276	35.973	36.701	37.443	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 2017	FY 2018	FY 2019
Title: Outreach to International S&T Community	11.444	12.019	12.189
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 2018 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 S&T delegations, and provide primary interface to coordinate international S&T participation among DoD organizations. ***FY 2019 Plans:*** Continue to 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 S&T delegations, and provide primary interface to coordinate international S&T participation among DoD organizations. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.170 million. Justification for this increase is described in plans above.			
Title: Outreach to U.S. S&T Workforce	21.043	22.115	22.428
Description: Strengthen science, mathematics, and engineering research and infrastructure in the U.S., thereby strengthening current and future Air Force S&T capabilities.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613004 / *Education and Outreach*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Increase awareness of Air Force research needs and opportunities throughout the civilian scientific community, while simultaneously identifying, recruiting, and increasing opportunities for new young investigators to participate in critical Air Force research. Support science, mathematics, and engineering research, and educational outreach programs including Historically Black Colleges and Universities, Hispanic serving institutions, and other minority institutions. ***FY 2019 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. 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 (STEM) fields. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.313 million. Justification for this increase is described in plans above.			
Accomplishments/Planned Programs Subtotals	32.487	34.134	34.617

	FY 2017	FY 2018
Congressional Add: Program Increase - Basic Research ***FY 2017 Accomplishments:*** Conducted Congressionally directed effort. ***FY 2018 Plans:*** N/A	2.613	0.000
Congressional Adds Subtotals	2.613	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601103F / *University Research Initiatives*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	137.775	147.923	154.991	0.000	154.991	158.859	161.914	165.083	168.302	Continuing	Continuing
615094: *University Research Initiatives*	-	137.775	147.923	154.991	0.000	154.991	158.859	161.914	165.083	168.302	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, intelligence information fusion, smart materials and structures, 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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, and 602298F.

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103F / *University Research Initiatives*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	145.044	147.923	150.158	0.000	150.158
Current President's Budget	137.775	147.923	154.991	0.000	154.991
Total Adjustments	-7.269	0.000	4.833	0.000	4.833
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	5.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-6.888	0.000			
• SBIR/STTR Transfer	-5.381	0.000			
• Other Adjustments	0.000	0.000	4.833	0.000	4.833

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 615094: *University Research Initiatives*		
Congressional Add: *Program Increase*	4.821	0.000
Congressional Add Subtotals for Project: 615094	4.821	0.000
Congressional Add Totals for all Projects	4.821	0.000

Change Summary Explanation

Decrease in FY 2017 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Increase in FY 2019 for the National Defense Science and Engineering Graduate (NDSEG) program.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Multidisciplinary University Research Initiative	75.355	83.839	84.445
Description: Promote fundamental, multi- and interdisciplinary science and engineering research projects involving multiple principle investigators.			
FY 2018 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			

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103F / *University Research Initiatives*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
recognize superior academic researchers in the early stages of their careers through the Presidential Early Career Award for Scientists and Engineers (PECASE) program. Continue funding of multi-disciplinary programs initially awarded in prior years. ***FY 2019 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. Support and recognize superior academic researchers in the early stages of their careers through the PECASE program. Continue funding of multi-disciplinary programs initially awarded in prior years. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.606 million. Justification for this increase is described in plans above.			
Title: Science and Engineering Education ***Description:*** Support post-graduate, graduate, and undergraduate education in science and engineering disciplines at U.S. universities. ***FY 2018 Plans:*** Award highly competitive National Defense Science and Engineering Graduate (NDSEG) fellowships. Support competitive awards for graduate and undergraduate research experiences, including those established under the Awards to Stimulate and Support Undergraduate Research Experiences (ASSURE) program. Continue funding for awards initiated under prior year DoD programs. ***FY 2019 Plans:*** Continue to award highly competitive NDSEG fellowships. Continue to support competitive awards for graduate and undergraduate research experiences, including those established under the ASSURE program. Continue funding for awards initiated under prior year DoD programs. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $6.356 million due to increase in National Defense Science and Engineering Graduate Fellowship (NDSEG) program.	44.308	49.296	55.652
Title: Research Instrumentation ***Description:*** Enhance scientific and engineering research through advanced education infrastructure and instrumentation at U.S. universities. ***FY 2018 Plans:***	13.291	14.788	14.894

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103F / *University Research Initiatives*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Award grants on a competitive basis under the Defense University Research Instrumentation Program (DURIP) to U.S. universities to acquire state-of-the-art, high technology instrumentation and infrastructure to enhance research and educational capabilities. ***FY 2019 Plans:*** Continue to award grants on a competitive basis under the DURIP to U.S. universities to acquire state-of-the-art, high technology instrumentation and infrastructure to enhance research and educational capabilities. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.106 million. Justification for this increase is described in plans above.			
Accomplishments/Planned Programs Subtotals	132.954	147.923	154.991

	FY 2017	FY 2018
Congressional Add: Program Increase ***FY 2017 Accomplishments:*** Conducted Congressionally directed effort. ***FY 2018 Plans:*** N/A	4.821	0.000
Congressional Adds Subtotals	4.821	0.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601108F / *High Energy Laser Research Initiatives*

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
Total Program Element	-	13.224	14.417	14.506	0.000	14.506	14.795	15.090	15.397	15.708	Continuing	Continuing
615097: *High Energy Laser Research Initiatves*	-	13.224	14.417	14.506	0.000	14.506	14.795	15.090	15.397	15.708	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 high energy laser systems through the Joint Directed Energy Transition Office. This program funds multi-disciplinary research institutes to conduct research on laser and beam control technologies. In addition, this program supports educational grants to stimulate student interest in high energy lasers and encourage graduate research in topics related to high energy lasers. 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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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.

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	14.168	14.417	14.615	0.000	14.615
Current President's Budget	13.224	14.417	14.506	0.000	14.506
Total Adjustments	-0.944	0.000	-0.109	0.000	-0.109
• 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	-0.425	0.000			
• SBIR/STTR Transfer	-0.519	0.000			
• Other Adjustments	0.000	0.000	-0.109	0.000	-0.109

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: High Energy Laser Sources and Devices	6.228	6.717	6.711

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601108F / *High Energy Laser Research Initiatives*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Improve the fundamental understanding of high energy laser sources and devices, to include solid state, fiber, and gas laser technologies. ***FY 2018 Plans:*** Investigate innovative laser technologies in diode-pumped alkali lasers, short-pulse, fiber, and solid state laser technologies. Continue overseas efforts to leverage international technology advancements. ***FY 2019 Plans:*** Continue investigations into innovative laser technologies in diode-pumped alkali lasers, short-pulse, fiber, and solid state laser technologies. Continue overseas efforts to leverage international technology advancements. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Fiscal year (FY) 2019 decreased compared to FY 2018 by $0.006 million. Justification for this increase is described in plans above.			
Title: High Energy Laser Beam Control ***Description:*** Improve the fundamental understanding of beam control technologies as they relate to High Energy Laser applications. Conduct research in atmospheric characterization, metrology, control systems, algorithms and beam control component technology. ***FY 2018 Plans:*** Continue research on innovative beam control architectures. Continue overseas efforts to leverage international technology advancements. ***FY 2019 Plans:*** Continue research on innovative beam control architectures. Continue overseas involvement to leverage research developments and technology advancements. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.045 million. Justification for this increase is described in plans above.	5.796	6.500	6.545
Title: High Energy Laser Education ***Description:*** Fund educational grants to stimulate student interest in high energy lasers. ***FY 2018 Plans:***	1.200	1.200	1.250

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601108F / *High Energy Laser Research Initiatives*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Provide scholarships and internships to support college students studying in fields related to high energy lasers. Provide grants to Service Academies to stimulate studies related to high energy lasers among military cadets. Fund publication of journals and support continuing education for professionals in the high energy laser field. ***FY 2019 Plans:*** Continue to provide scholarships and internships to support college students studying in fields related to high energy lasers. Provide grants to Service Academies to stimulate studies related to high energy lasers among military cadets. Fund publication of journals and support continuing education for professionals in the high energy laser field. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Fiscal year (FY) 2019 increased compared to FY 2018 by $0.050 million. Justification for this increase is described in plans above.			
Accomplishments/Planned Programs Subtotals	13.224	14.417	14.506

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602102F / *Materials*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	158.243	124.264	125.373	0.000	125.373	136.526	135.741	140.244	133.091	Continuing	Continuing
624347: *Materials for Structures, Propulsion, and Subsystems*	-	57.300	45.059	47.375	0.000	47.375	51.539	49.212	50.877	48.283	Continuing	Continuing
624348: *Materials for Electronics, Optics, and Survivability*	-	50.353	31.523	32.475	0.000	32.475	36.066	36.839	38.358	36.401	Continuing	Continuing
624349: *Materials Technology for Sustainment*	-	50.590	47.682	45.523	0.000	45.523	48.921	49.690	51.009	48.407	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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	126.152	124.264	124.561	0.000	124.561
Current President's Budget	158.243	124.264	125.373	0.000	125.373
Total Adjustments	32.091	0.000	0.812	0.000	0.812
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	33.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	1.631	0.000			
• SBIR/STTR Transfer	-2.540	0.000			
• Other Adjustments	0.000	0.000	0.812	0.000	0.812

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 624347: *Materials for Structures, Propulsion, and Subsystems*		
Congressional Add: *Program increase - Structures, propulsion, subsystems*	4.916	-
Congressional Add: *Program increase - Certification of advanced materials*	5.899	-
Congressional Add Subtotals for Project: 624347	10.815	-
Project: 624348: *Materials for Electronics, Optics, and Survivability*		
Congressional Add: *Program increase - Electronics, optics, and survivability*	7.865	-
Congressional Add: *Program Increase - Air Force Education and Outreach program*	9.832	-
Congressional Add Subtotals for Project: 624348	17.697	-
Project: 624349: *Materials Technology for Sustainment*		
Congressional Add: *Program increase - Coatings Technology*	3.933	-
Congressional Add Subtotals for Project: 624349	3.933	-
Congressional Add Totals for all Projects	32.445	-

Change Summary Explanation

Increase in FY 2017 reflects reprogramming to support Research and Development projects, 10 U.S.C. Section 2358.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / *Materials*	Project (Number/Name) 624347 / *Materials for Structures, Propulsion, and Subsystems*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
624347: *Materials for Structures, Propulsion, and Subsystems*	-	57.300	45.059	47.375	0.000	47.375	51.539	49.212	50.877	48.283	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 double the turbine engine thrust-to-weight ratio. 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. Materials for thermal management including coolants, adaptive thermally conductive materials, coatings, friction and wear-resistant materials, and other pervasive nonstructural materials technologies are being developed for directed energy, propulsion, and subsystems on aircraft, spacecraft, and missiles. The project concurrently develops advanced processing methods to enable adaptive processing of aerospace materials.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Ceramics and Composites	27.443	26.585	27.771
Description: Develop ceramic, ceramic matrix composite, and hybrid materials technologies for performance and supportability improvement in propulsion systems and high temperature aerospace structures. ***FY 2018 Plans:*** Continue the validation of repeatability of new advanced processing methods, coating technologies, and behavioral life prediction for higher temperature capable organic and ceramic matrix composites. Demonstrate severe environment durability of advanced composite systems via mechanical testing. Explore 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 an effort to accelerate the development and certification of advanced composite materials. Verify and validate damage progression models on increasingly complex polymer matrix composite structural applications. Develop composite damage progression models for application in an engineering environment. ***FY 2019 Plans:*** Demonstrate and mature new advanced processing methods, coating technologies, and behavioral life prediction for higher temperature capable organic and ceramic matrix composites. Continue to analyze severe environment durability of advanced composite systems via mechanical testing. Continue development of new ceramic and polymer matrix composite materials and			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624347 / *Materials for Structures, Propulsion, and Subsystems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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 an effort to 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 development of composite damage progression models for application in an engineering environment. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.186 million. Justification for this increase is increased emphasis in ceramic and composite materials.			
Title: Metals ***Description:*** Develop lightweight and high temperature metallics, life prediction, and metals processing technologies for increased affordability, durability, and reliability. ***FY 2018 Plans:*** Implement of advanced computation methods to support material development and characterization modeling. Demonstrate quantitative, predictive models for performance of metallic based thermal management systems. Analyze relationships between microstructure, processing, properties, and performance of metallic, hybrid, nanoscale, and gradient metallic materials. Validate and continue development of affordable integrated material/manufacturing and component analysis for life management and development of affordable structural materials innovative research. Continue to advance development of next generation turbine engine disk and reliable affordable metallic structural components through computational methods. Demonstrate the value of integrated analytical tools in the optimization of design and certification of additively manufactured metallic components. Initiate the development of integrated spatial registration capability addressing accuracy, precision, and durability for all intended state awareness applications. ***FY 2019 Plans:*** Continue demonstration and implementation of advanced computation methods to support material development and characterization modeling. Continue to validate quantitative, predictive models for performance of metallic based thermal management systems through coupon specimen testing. Continue to analyze relationships between microstructure, processing, properties, and performance of metallic, hybrid, nanoscale, and gradient metallic materials. Validate and continue development of affordable integrated material/manufacturing and component analysis for life management and development of affordable structural materials innovative research. Continue to advance development of next generation turbine engine disk and reliable affordable metallic structural components through computational methods. Validate the value of integrated analytical tools in the	14.398	13.968	14.822

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624347 / *Materials for Structures, Propulsion, and Subsystems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
optimization of design and certification of additively manufactured metallic components. Continue development and refine low cost processing methods for low cost, attritable propulsion systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.854 million. Justification for this increase is described in the plans above.			
Title: Thermal Protection Materials ***Description:*** Develop and evaluate lightweight, active, adaptive, multifunctional, high temperature, and durable material systems for extreme environments and hypersonic applications. ***FY 2018 Plans:*** Validate and refine processing methods for fabricating materials required for expendable hypersonic applications. Continue to refine and develop unique experimental techniques to assess mechanical properties and time-dependent behavior. Validate and demonstrate material properties and performance to meet design needs for control surfaces, leading edges and acreage. Validate computational models to assess environmental degradation of materials in a hypersonic environment. ***FY 2019 Plans:*** Mature processing methods for fabricating materials required for expendable hypersonic applications. Continue to validate, and 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 and acreage. Continue to develop computational models to assess environmental degradation of materials in a hypersonic environment. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.276 million. Justification for this increase is described in the plans above.	4.644	4.506	4.782
Accomplishments/Planned Programs Subtotals	46.485	45.059	47.375

	FY 2017	FY 2018
Congressional Add: Program increase - Structures, propulsion, subsystems ***FY 2017 Accomplishments:*** Conducted congressionally directed effort.	4.916	-
Congressional Add: Program increase - Certification of advanced materials ***FY 2017 Accomplishments:*** Conducted congressionally directed effort.	5.899	-
Congressional Adds Subtotals	10.815	-

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624347 / *Materials for Structures, Propulsion, and Subsystems*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / *Materials*	Project (Number/Name) 624348 / *Materials for Electronics, Optics, and Survivability*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
624348: *Materials for Electronics, Optics, and Survivability*	-	50.353	31.523	32.475	0.000	32.475	36.066	36.839	38.358	36.401	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, 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 2017	FY 2018	FY 2019
Title: Infrared Detector and Electromagnetic Device Materials	10.846	10.403	10.792
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 2018 Plans: Develop and demonstrate materials and processes for control and detection of electromagnetic radiation for ISR technologies. Develop and demonstrate materials for use in high resolution imaging by electromagnetic radiation. Demonstrate nanoscale materials, meta materials, and models for use in producing detectors. Utilize computational materials science to improve performance prediction and reliability models. Demonstrate quantum materials for aerospace applications. Develop and demonstrate Short wave infrared (SWIR) detector materials and hyper-spectral Long wave infrared (LWIR) materials. Validate materials and processes for integration of radio frequency and optical signals as well as concepts for novel optical devices and components. Validate and continue development of photonics for air vehicle applications. Demonstrate nanostructured materials for components to enable agile radio frequency capability.			
FY 2019 Plans: Continue to develop and demonstrate materials and processes for control and detection of electromagnetic radiation for ISR technologies. Continue to develop and demonstrate materials for use in high resolution imaging by electromagnetic radiation.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624348 / *Materials for Electronics, Optics, and Survivability*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue to demonstrate nanoscale materials, meta materials, and models for use in producing detectors. Continue to utilize computational materials science to improve performance prediction and reliability models. Continue to analyze quantum materials for aerospace applications. Continue to develop and demonstrate Short wave infrared (SWIR) detector materials and hyper-spectral Long wave infrared (LWIR) materials. Continue to validate materials and processes for integration of radio frequency and optical signals as well as concepts for novel optical devices and components. Validate and continue development of photonics for air vehicle applications. Continue to demonstrate nanostructured materials for components to enable agile radio frequency capability. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increase compared to FY 2018 by $0.389 million. Justification for the increase is described in the plans above.			
Title: Directed Energy Hardened Materials ***Description:*** Develop and demonstrate technologies to enhance the safety, survivability, and mission effectiveness of aircrews, sensors, viewing systems, and related assets. ***FY 2018 Plans:*** Validate and demonstrate a plethora of materials and technologies to protect against directed energy threats. Demonstrate advanced optical limiter materials for damage protection, enhanced hybrid materials for advanced applications in airborne, space, and personnel systems. Assess response of new materials for high-energy laser interactions. Develop approaches for integration of multi-modal hardening into structures and devices. Validate repeatability and continue to utilize computational materials science to enhance multi-scale modeling for design of robust, reliable integrated protection. ***FY 2019 Plans:*** Analyze and validate a plethora of materials and technologies to protect against directed energy threats. Develop, validate, and demonstrate advanced optical limiter materials for damage protection, enhanced hybrid materials for advanced applications in airborne, space, and personnel systems. Continue to assess response of new materials for high-energy laser interactions. Continue to develop approaches for integration of multi-modal hardening into structures and devices. Continue to validate repeatability and continue to utilize computational materials science to enhance multi-scale modeling for design of robust, reliable integrated protection. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.220 million. Justification for the increase is described in the plans above.	12.279	11.979	12.199
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).	1.315	1.261	1.308

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624348 / *Materials for Electronics, Optics, and Survivability*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Validate materials and process technologies to control and generate directed electromagnetic energy for survivability and other applications. Demonstrate and model materials processes for controlling laser beam direction and focus with optical components. Demonstrate materials for frequency conversion, optical coatings, mirrors and high power microwave sources for directed energy sources. ***FY 2019 Plans:*** Validate materials and process technologies to control and generate directed electromagnetic energy for survivability and other applications. Continue to demonstrate and model materials processes for controlling laser beam direction and focus with optical components. Continue to develop materials for frequency conversion, high power optical isolators, Mid Wave Infrared (MWIR) Laser Sources and high power microwave sources for directed energy sources. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.047 million. Justification for the increase is described in the plans above.			
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 2018 Plans:*** Validate engineering, scientific and processing methods for nano and biological materials to address unique requirements for Air Force man-machine integration, and electronic components. Explore biotechnology to assess the impact of microbes and fungi on Air Force systems. Study reliable materials and processes to optimize components for compact, flexible, stretchable multi-functional devices. Validate materials and process for functional additive manufacturing of electronic components. Demonstrate methods to assess reliability of nano and bio materials and processes. Continue to support Flexible Hybrid Electronics Institute for Manufacturing Innovation and the NanoBio Manufacturing Consortium. ***FY 2019 Plans:*** Continue to validate 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 reliable materials and processes to optimize components for compact, flexible, stretchable multi-functional devices. Continue to validate materials and process for functional additive manufacturing of electronic components. Continue to demonstrate methods to assess reliability of nano and bio materials and	8.216	7.880	8.176

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624348 / *Materials for Electronics, Optics, and Survivability*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
processes. Continue to support Flexible Hybrid Electronics Institute for Manufacturing Innovation and the NanoBio Manufacturing Consortium. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.296 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	32.656	31.523	32.475

	FY 2017	FY 2018
Congressional Add: Program increase - Electronics, optics, and survivability ***FY 2017 Accomplishments:*** Conducted congressionally directed effort.	7.865	-
Congressional Add: Program Increase - Air Force Education and Outreach program ***FY 2017 Accomplishments:*** Conducted congressionally directed effort.	9.832	-
Congressional Adds Subtotals	17.697	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / *Materials*	Project (Number/Name) 624349 / *Materials Technology for Sustainment*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
624349: *Materials Technology for Sustainment*	-	50.590	47.682	45.523	0.000	45.523	48.921	49.690	51.009	48.407	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 2017	FY 2018	FY 2019
Title: Material State Awareness	16.395	16.689	15.309
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. Effort changed from "Sensing Technologies" ***FY 2018 Plans:*** Validate and continue to demonstrate non-destructive evaluation modeling capabilities and use these competencies to drive improvements in capability to detect and characterize damage in realistic aerospace structures and engine components. Develop approaches to address the variability inherent in aerospace systems and materials and begin to quantify the impact of that variability on non-destructive inspection capability and reliability. Demonstrate 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. ***FY 2019 Plans:*** Continue to validate and demonstrate non-destructive evaluation modeling capabilities and use these competencies to drive improvements in capability to detect and characterize damage in realistic aerospace structures and engine components. Continue			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624349 / *Materials Technology for Sustainment*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
to analyze approaches to address the variability inherent in aerospace systems and materials and begin to quantify the impact of that variability on non-destructive 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.380 million. Justification for the decrease is decreased emphasis in material state awareness.			
Title: Production and Repair Technologies	12.179	12.397	11.685
Description: Develop support capabilities, information, and processes to resolve problems with materials in the production and repair of systems components and structures. ***FY 2018 Plans:*** Substantiate repeatability and demonstrate advanced materials and processes technology to repair and extend the life of Air Force legacy systems. Further refine through demonstration the understanding of failure 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. Improve the continued assessment 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 low observable affordability technologies and processes to reduce maintenance costs of these materials. ***FY 2019 Plans:*** Continue to substantiate repeatability and demonstrate advanced materials and processes technology to repair and extend the life of Air Force systems. Continue to 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. 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. Continue to further advance specialty material affordability technologies and processes to reduce maintenance costs of these materials. ***FY 2018 to FY 2019 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624349 / *Materials Technology for Sustainment*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $0.712 million. Justification for the decrease is described in the plans above.			
Title: Failure Analysis Technologies	18.083	18.596	18.529
Description: Develop support capabilities, information, and processes to resolve materials problems and provide electronic and structural failure analysis of components. ***FY 2018 Plans:*** Perform and increase efficiency of quick response failure analyses and materials investigations. Continue to develop and investigate improved analysis techniques to determine root cause materials failure/degradation. Develop and provide advanced materials solutions to ensure warfighter system availability and safety of flight. Develop functional materials failure analysis capabilities. Analyze and validate advanced electrostatic discharge protection technologies and procedures for emerging avionics subsystems. Continue to transition advanced test 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 for Air Force weapon systems. Research and develop to provide advanced materials to improve systems sustainment. ***FY 2019 Plans:*** Continue to perform and increase efficiency of quick response failure analyses and materials investigations. Continue to develop 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. Continue to 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 for Air Force weapon systems. Continue research, development and characterization of advanced materials. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.067 million. Justification for the decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	46.657	47.682	45.523

	FY 2017	FY 2018
Congressional Add: Program increase - Coatings Technology ***FY 2017 Accomplishments:*** Conducted congressionally directed effort.	3.933	-
Congressional Adds Subtotals	3.933	-

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624349 / *Materials Technology for Sustainment*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
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*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	130.923	124.678	130.547	0.000	130.547	140.859	143.896	152.559	144.767	Continuing	Continuing
622401: *Structures*	-	40.397	42.925	43.501	0.000	43.501	46.953	50.062	52.003	49.349	Continuing	Continuing
622403: *Flight Controls and Pilot-Vehicle Interface*	-	28.216	30.130	31.402	0.000	31.402	32.411	33.225	38.610	36.638	Continuing	Continuing
622404: *Aeromechanics and Integration*	-	34.006	29.557	30.932	0.000	30.932	31.110	32.507	33.356	31.650	Continuing	Continuing
622405: *High Speed Systems Technology*	-	28.304	22.066	24.712	0.000	24.712	30.385	28.102	28.590	27.130	Continuing	Continuing

A. Mission Description and Budget Item Justification

This effort investigates, develops, and analyzes aerospace vehicle technologies in the three primary areas of structures, controls, and aerodynamics for legacy and future aerospace vehicles. Advanced structures concepts are explored and developed to exploit new materials, fabrication processes, and design techniques. Vehicle, inter-vehicle, and intra-vehicle control technologies are developed and simulated for aerospace vehicles. Advanced aerodynamic vehicle configurations are developed and analyzed through simulations, experiments, and multi-disciplinary analyses. Resulting technologies improve performance of existing and future manned and remotely piloted air vehicles, sustained high speed, and space access vehicles. Improvements include, but are not limited to, reduced energy use by efficient air platform designs, use of lightweight composite structures, and improved sustainment methods based on the condition of the platform and sub-systems. Projects in this effort 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, 0602202F, 0602203F, 0602204F, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, and 0602298F.

This effort 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
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*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	122.831	124.678	128.303	0.000	128.303
Current President's Budget	130.923	124.678	130.547	0.000	130.547
Total Adjustments	8.092	0.000	2.244	0.000	2.244
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	10.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.908	0.000			
• Other Adjustments	0.000	0.000	2.244	0.000	2.244

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 622405: *High Speed Systems Technology*		
Congressional Add: *Program Increase-Hypersonic vehicle structures*	9.846	0.000
Congressional Add Subtotals for Project: 622405	9.846	0.000
Congressional Add Totals for all Projects	9.846	0.000

Change Summary Explanation

Increase in FY 2019 due to Department of Defense (DoD) civilian pay repricing adjustment.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622401 / *Structures*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622401: *Structures*	-	40.397	42.925	43.501	0.000	43.501	46.953	50.062	52.003	49.349	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 incorporating subsystem hardware items and adaptive mechanisms into the aerospace structures and/or skin of the platform.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Aircraft Service Life Technologies	21.063	22.381	22.681
Description: Develop an economic service life analysis capability comprised of analysis tools, methodologies, and structural health monitoring technologies. ***FY 2018 Plans:*** Complete development of engineered residual stress methods for airframe life extension. Initiate methods for achieving lifing credit in advanced & enhanced metallic airframe components to extend structural life. Complete efforts in certification of advanced composite for aircraft structures. Complete efforts in Airframe Digital Twin to develop an integrated system of data, models, and analysis tools that enable better decisions regarding fleet lifecycle management and sustainment. Initiate demonstration of Aircraft Digital Twin models and tools on legacy fleet aircraft. ***FY 2019 Plans:*** Continue 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. Initiate development of impact damage analysis criteria and methods for advanced composite structures. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.300 million. Justification for the increase is described in the plans above.			
Title: Vehicle Design Technologies	11.840	12.581	12.750
Description: Develop methodologies to reduce the cost and time involved from design to full-scale testing of structural concepts and aircraft systems. ***FY 2018 Plans:*** Continue the development of advanced high fidelity aircraft design analysis tools. Continue parametric modeling methods for integrated multidiscipline collaborative design. Continue the development of design methods for low cost attritable aircraft			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622401 / *Structures*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
concepts. Continue evaluation of control effector concepts for supersonic tailless aircraft. Initiate the development of integrating cost, mission effectiveness, and affordable manufacturing methods into the aircraft design analysis tools. ***FY 2019 Plans:*** Continue the development of advanced high fidelity aircraft design analysis tools. Complete parametric modeling methods for integrated multi-discipline collaborative design. Complete the development of design methods for low cost attritable aircraft concepts. Complete the evaluation of control effector concepts for supersonic tailless aircraft. Continue the development of integrating cost, mission effectiveness, and affordable manufacturing methods into the aircraft design analysis tools. Initiate the development of control effector designs for supersonic tailless aircraft. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.169 million. Justification for the increase is described in the plans above.			
Title: Structural Concepts ***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. ***FY 2018 Plans:*** Continue innovative energy efficient conformal load bearing antenna structural concepts. Continue development and verification of low cost attritable airframe concepts and manufacturing methods. Continue development of lightweight aircraft structural concepts to support Air Superiority 2030 requirements. ***FY 2019 Plans:*** Complete innovative energy efficient conformal load bearing antenna structural concepts. Continue development and verification of low cost attritable airframe concepts and manufacturing methods. Continue development of lightweight aircraft structural concepts to support Air Superiority 2030 and Advanced Mobility requirements. Initiate development of innovative structural design methods to dramatically reduce weight and complexity of aircraft structures. Initiate the development of fail-safe technologies for bonded unitized composite structures applicable to Mobility aircraft. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.107 million. Justification for the increase is described in the plans above.	7.494	7.963	8.070
Accomplishments/Planned Programs Subtotals	40.397	42.925	43.501

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622401 / *Structures*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622403: *Flight Controls and Pilot-Vehicle Interface*	-	28.216	30.130	31.402	0.000	31.402	32.411	33.225	38.610	36.638	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 remotely piloted air vehicles, hypersonic aircraft, and extended-life legacy aircraft.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Flight Controls Technologies	11.535	6.905	7.196
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 and remotely piloted aircraft. ***FY 2018 Plans:*** Continue 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 survivable and health-adaptive control system architecture. Continue the development of advanced automation capabilities for mobility aircraft, including air drop and air refueling automation technologies. Initiate development of trusted autonomy approach, integrating certification processes and autonomy development. ***FY 2019 Plans:*** Continue 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 survivable and health-adaptive control system architecture. Complete the development of advanced automation capabilities for mobility aircraft and transition to advanced development. Continue the development of trusted autonomy approach, integrating certification processes and autonomy development. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.291 million. Justification for the increase is described in the plans above.			
Title: Manned and Unmanned Teaming Technologies	9.921	17.941	18.699
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..			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 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. Initiate development of autonomous behaviors for safe, loyal wingman. ***FY 2019 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 UAS operations in a terminal airspace environment. Continue the development of autonomous behaviors for safe, loyal wingman. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.758 million. Justification for the increase is described in the plans above.			
Title: Flight Controls Technologies Modeling and Simulation ***Description:*** Develop tools and methods for capitalizing on simulation-based research and development of future aerospace vehicles. ***FY 2018 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. Continue analyses of automated unmanned air systems and manned-unmanned teams in controlled airspace and airbase operations, as well as in adversarial mission environments. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Continue manned-unmanned teaming evaluations. Continue development of autonomy for tactical aircraft operations. ***FY 2019 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. Continue analyses of automated unmanned air systems and manned-unmanned teams in controlled airspace and airbase operations, as well as in adversarial mission environments. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Continue manned-unmanned teaming evaluations. Continue development of autonomy for tactical aircraft operations. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	6.760	5.284	5.507

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 increased compared to FY 2018 by $0.223 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	28.216	30.130	31.402

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622404 / *Aeromechanics and Integration*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622404: *Aeromechanics and Integration*	-	34.006	29.557	30.932	0.000	30.932	31.110	32.507	33.356	31.650	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Aerodynamic Systems Technologies	8.994	7.818	8.181
Description: Develop aerodynamic assessment prediction methods centered on expanding the design capabilities of future air vehicles. ***FY 2018 Plans:*** Complete development and assessment of aerodynamic technologies that enable future revolutionary manned and unmanned air vehicles. Continue development and assessment of low cost attritable Unmanned Aircraft Vehicle (UAV) concepts. Continue assessment of efficient airfoil flow control and distributed propulsion concepts. Initiate design assessments of distributed propulsion concepts for next generation Mobility. ***FY 2019 Plans:*** Continue development and assessment of low cost attritable UAV concepts. Complete assessment of efficient airfoil flow control and distributed propulsion concepts. Continue design assessments of distributed propulsion concepts for next generation Mobility. Initiate the development of a high fidelity aerodynamic analysis tool for the design of lasers turrets applicable to Air Superiority 2030 requirements. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.363 million. Justification for the increase is described in the plans above.			
Title: Next Generation Aerodynamic Technologies	10.840	9.422	9.860
Description: Develop and assess technologies for the next generation of multi-role large aircraft. ***FY 2018 Plans:*** Continue development of high fidelity aerodynamic analysis and method development for future Air Superiority 2030. Continue development of practical laminar flow technologies for highly swept wings. Continue next generation tanker maturation and assess			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622404 / *Aeromechanics and Integration*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
promising configurations in high and low speed wind tunnels. Complete wind tunnel test of natural laminar flow for Mobility hybrid wing body configuration. Initiate distributed embedded propulsion wind tunnel test. ***FY 2019 Plans:*** Complete development of high fidelity aerodynamic analysis and method development for future Air Superiority 2030. Complete development of practical laminar flow technologies for highly swept wings. Continue next generation tanker maturation and assess promising configurations in high and low speed wind tunnels. Complete distributed embedded propulsion wind tunnel test. Initiate wind tunnel tests of practical laminar flow treatments and coatings for highly swept wings applicable to Mobility applications. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.438 million. Justification for the increase is described in the plans above.			
Title: Aircraft Integration Technologies ***Description:*** Develop enabling technologies to allow efficient and effective integration of propulsion, weapons, and subsystems into current and future air vehicles. ***FY 2018 Plans:*** Complete the development of aerodynamic and propulsion integration technologies that enable future mobility and fighter aircraft. Complete advanced inlet and exhaust systems subscale tests for future air superiority. Continue development of advanced kinetic and directed energy weapons integration technologies for future air superiority. Continue the design of an integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility. ***FY 2019 Plans:*** Continue development of advanced kinetic and directed energy weapons integration technologies for future air superiority. Complete the design of an integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility. Initiate integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility. Initiate propulsion integrations component wind tunnels tests for Air Superiority 2030 requirements. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.574 million. Justification for the increase is described in the plans above.	14.172	12.317	12.891
Accomplishments/Planned Programs Subtotals	34.006	29.557	30.932

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622404 / *Aeromechanics and Integration*

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622405 / *High Speed Systems Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622405: *High Speed Systems Technology*	-	28.304	22.066	24.712	0.000	24.712	30.385	28.102	28.590	27.130	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: High Speed/Hypersonics Structures	10.641	12.828	14.366

Description: Develop high speed, high temperature structural analysis methods and technologies for extreme operating conditions in current and future air vehicles.

FY 2018 Plans:

Continue development 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.

FY 2019 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

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622405 / *High Speed Systems Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
development of structural life prediction methodology for extreme environment structures and thermal protection systems. Initiate development on novel designs and demonstration of integrated hot structures for hypersonic reusable air platforms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.538 million. Justification for the increase is increased emphasis in hypersonic structures.			
Title: High Speed Vehicle Aeromechanics and Integration	7.817	9.238	10.346
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. ***FY 2018 Plans:*** Complete Critical Design Review (CDR) for Hypersonic International Flight Research Experimentation (HIFiRE) 5c, begin manufacturing of flight vehicle hardware. Evaluate interactions between air flow and structural deformations for a complex built-up hypersonic inlet. 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 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. As part of international collaborative effort, complete flight testing of Mach 6 adaptive guidance and control flight experiment and initiate boundary layer transition flight experiment program. 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. ***FY 2019 Plans:*** Complete the manufacturing of flight vehicle hardware for HIFiRE 5c. 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 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			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622405 / *High Speed Systems Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.108 million. Justification for the increase is increased emphasis in high speed vehicle aerodynamics.			
Accomplishments/Planned Programs Subtotals	18.458	22.066	24.712

	FY 2017	FY 2018
Congressional Add: Program Increase-Hypersonic vehicle structures	9.846	0.000
FY 2017 Accomplishments: Conducted Congressionally-directed efforts.		
FY 2018 Plans: N/A		
Congressional Adds Subtotals	9.846	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

N/A

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	110.012	108.784	112.518	0.000	112.518	122.392	124.055	129.338	122.740	Continuing	Continuing
621123: *Learning and Operational Readiness*	0.000	22.899	23.840	22.440	0.000	22.440	24.292	23.660	24.725	23.464	Continuing	Continuing
625328: *Human Dynamics Evaluation*	0.000	25.864	24.338	24.568	0.000	24.568	27.259	28.056	29.104	27.619	Continuing	Continuing
625329: *Sensory Evaluation and Decision Science*	0.000	31.257	29.476	31.687	0.000	31.687	33.288	34.241	35.517	33.707	Continuing	Continuing
627757: *Bioeffects*	0.000	29.992	31.130	33.823	0.000	33.823	37.553	38.098	39.992	37.950	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 measure, accelerate, and expand the cognitive skills necessary to improve airmen training and mission performance. The Human Dynamics Evaluation project conducts research to advance machine intelligence and operator-aiding technologies by developing and applying airman-focused research for advanced intelligence, surveillance, and reconnaissance (ISR) capabilities and detecting and exploiting human signatures. The Sensory Evaluation and Decision Science project conducts research to revolutionize the manner in which airmen optimize the capabilities of Air Force systems, including remotely piloted aircraft (RPA) and adaptive teams of airmen and machines. The Bioeffects project conducts research on the effects of human exposure to potentially toxic, operational and advanced chemicals and materials (including nanomaterials), electromagnetic (EM) energy (radio frequency to optical), scalable directed energy weapons, and non-lethal weapons. 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, 0602203F, 0602204F, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force					Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*			R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*		
B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	111.647	108.784	111.326	0.000	111.326
Current President's Budget	110.012	108.784	112.518	0.000	112.518
Total Adjustments	-1.635	0.000	1.192	0.000	1.192
• 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	-1.635	0.000			
• Other Adjustments	0.000	0.000	1.192	0.000	1.192

Change Summary Explanation

Increase in FY 2019 due to Department of Defense (DoD) civilian pay reprice adjustment.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 621123 / *Learning and Operational Readiness*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
621123: *Learning and Operational Readiness*	0.000	22.899	23.840	22.440	0.000	22.440	24.292	23.660	24.725	23.464	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts applied research to measure, accelerate, and expand the cognitive skills necessary to improve airmen training and mission performance. Research is conducted in two focus areas: continuous learning and cognitive modeling. The continuous learning effort creates live, virtual, and constructive (LVC) environments for use in developing revolutionary simulation technologies to increase training capabilities and enhance training effectiveness and efficiency by using learning theory to improve military training and mission performance. Cognitive modeling creates realistic models and simulations of human behavior to advance the understanding of how airmen perform complex tasks.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Continuous Learning	20.713	19.708	13.733
Description: Research enhances distributed mission operations (DMO) and LVC environments and identifies technology requirements for training in live and immersive environments. Continuous learning strategies improve mission training, command and control (C2), ISR, and cyber missions. ***FY 2018 Plans:*** Transition scenarios and performance tracking techniques to operationally relevant testbeds. Develop cross domain solution ruleset for fifth generation LVC operations. Execute training readiness evaluations to integrate real-time performance tracking to develop and validate personalized team adaptive training. Continue to develop designs for out-year studies to execute fourth to fifth generation realistic, secure training and rehearsal events. Conduct evaluations of identified training gaps and potential solutions to gaps for the integration of the fifth generation aircraft into a close air support environment.Design experimentation, studies, and evaluation for challenges for multi-domain operations. ***FY 2019 Plans:*** Grow persistent readiness assessment and tracking capabilities for optimized airman machine teaming. Establish objective training performance metrics. Continue to develop 5th Gen Cross Domain solution prototypes. Investigate integrated simulations of, secure adaptive environments for, and execute training research studies within multi-domain command and control. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $5.975 million. Justification for the decrease is decreased emphasis in continuous learning.			
Title: Cognitive Modeling	2.186	4.132	8.707

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 621123 / *Learning and Operational Readiness*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Research explores application of cognitive science for performance improvement by enhancing training in mission-relevant environments (e.g., flight simulators). ***FY 2018 Plans:*** Conduct studies in autonomous operations in mission-relevant simulations. Validate autonomous training agent learning-through-reading capability in mission-relevant context. Continue to validate complex cognitive models through in computing architectures. Initiate studies in multi-level models for performance assessment. Continue development of personalized learning through scheduling of learning events in intelligent tutors. Continue work in computational analysis for agent training and assessment. ***FY 2019 Plans:*** Transition fatigue models for mobility operations. Demonstrate time-savings for mission planning using model-based processes. Integrate retention-based scheduling system for training into operational learning management system. Demonstrate prototype trainable agent for multi-domain operations. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $4.575 million. Justification for the increase is increased emphasis in cognitive learning.			
Accomplishments/Planned Programs Subtotals	22.899	23.840	22.440

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 625328 / *Human Dynamics Evaluation*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625328: *Human Dynamics Evaluation*	0.000	25.864	24.338	24.568	0.000	24.568	27.259	28.056	29.104	27.619	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts applied research to advance machine intelligence, information operations, and operator-aiding technologies for advanced ISR capabilities. Research is focused in the following areas: human analyst augmentation, human trust and interaction, and human signatures. The human analyst augmentation area develops, integrates, and evaluates human-centric analyst technology to develop cognitive systems engineering solutions for airman data overload, work integration, and mission performance, enhancing operationally effective ISR for the Air Force. The human trust and interaction area seeks to advance human language technologies to benefit military linguists and analysts as well as to understand, quantify, and calibrate trust factors influencing airman interaction with autonomous systems that can be applied to airman-machine teaming in future weapon systems. The human signatures area develops and applies S&T to detect and exploit a variety of human-centered signatures, including behavioral and anthropometric aspects of existing and emerging adversaries as well as nano, bio, and molecular signatures of airman performance.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Human Analyst Augmentation	10.147	9.339	9.572
Description: Conduct research to enhance human components of 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. ***FY 2018 Plans:*** Develop methodologies and techniques for enabling individual analysts to exploit multiple intelligence sources. Investigate verbal communication with semiautonomous analysis agents for aiding intelligence analysts. ***FY 2019 Plans:*** Further investigate cognitive mechanisms that underlie analyst's sense making capabilities and develop methodologies to use autonomous agents to assist in the process. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.233 million. Justification for the increase is described in the plans above.			
Title: Human Trust and Interaction	8.091	8.063	8.845
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			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625328 / *Human Dynamics Evaluation*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
knows an autonomous or semiautonomous system is safe to use and whether the system, data, conclusions, and decision recommendations can be trusted. ***FY 2018 Plans:*** Evaluate trust for robotics and automated systems in degraded visual environments and develop trust guidelines for Line In-The-Sky Auto Ground Collision Avoidance System. Study multilingual deep neural networks for automatic speech recognition and adapt Asian languages machine translation models for information search and retrieval. ***FY 2019 Plans:*** Develop initial transparency and trust guidelines for application to semiautonomous vehicles and autonomous agents for analysts. Investigate techniques for translating text to images and images to text. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.782 million. Justification for the increase is described in the plans above.			
Title: Human Signatures ***Description:*** Develop databases of human motion and features collected from air/space platforms. Identify human threat signatures across diverse populations for ISR and force protection applications. Develop nano, bio, and molecular signatures of airman performance. ***FY 2018 Plans:*** Develop methodologies for integrating near real-time performance assessment algorithms using physiological and non-invasive biomarkers and individualized learning algorithms. Continue development of durable algorithm to provide persistent human detection and tracking throughout a single full motion video mission. ***FY 2019 Plans:*** Develop methodologies for air quality and physiological monitoring of personnel using machine learning techniques. Develop algorithms to characterize human detections from air based sensors. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.785 million. Justification for the decrease is described in the plans above.	7.626	6.936	6.151
Accomplishments/Planned Programs Subtotals	25.864	24.338	24.568

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625328 / *Human Dynamics Evaluation*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 625329 / *Sensory Evaluation and Decision Science*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625329: *Sensory Evaluation and Decision Science*	0.000	31.257	29.476	31.687	0.000	31.687	33.288	34.241	35.517	33.707	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts applied research to revolutionize the manner in which airmen optimize the capabilities of Air Force systems, including remotely piloted aircraft (RPA) and adaptive teams of airmen and machines. Research optimizes airman situational awareness and cognitive performance, improves the airman-machine interface, and seamlessly integrates warfighters with their weapon systems across air, space, and cyber domains. Research is conducted in four focus areas: applied neuroscience; human role in semiautonomous systems; battlespace visualization; and battlespace acoustics. The applied neuroscience area develops technologies to enhance airman-airman and airman-machine collaborations and system interactions in distributed decision-making environments. The human role in semiautonomous systems area develops new control/display concepts and technologies to optimize Air Force platform capabilities. The battlespace visualization area advances the science and technology (S&T) associated with collecting, optimizing, displaying, and assimilating sensory information to enhance warfighter decision-making. The battlespace acoustics area researches human-human and human-machine communications to exploit the use of voice and acoustic data in collaborative, net-centric environments while accounting for the effects of acoustic propagation.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Applied Neuroscience	15.502	12.719	14.634
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 2018 Plans:*** Refine real-time sensing and assessment technologies for enhanced Airman performance in operationally-relevant environments. Explore human-machine teaming constructs relevant to Airman mission success. Continue assessing the applicability of biomarker sensor technologies use in operational environments. Refine, validate, and implement augmentation techniques (including non-invasive brain stimulation) for physical and cognitive performance optimization and stress resilience. Explore novel data analytic techniques to develop capabilities that predict Airman performance over time and in any environment. Explore utility of non-invasive peripheral nerve stimulation techniques and closed-loop stimulation techniques to enhance cognitive performance. Complete development of human response models to mitigate injury risks. Continue development of the next generation aircraft injury exposure criteria for improved aircrew protection. Continue investigation of on-board oxygen generating system performance vulnerabilities affecting oxygen production. Continue development of an on-board oxygen generating system contamination database and susceptibility model. ***FY 2019 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue to investigate and refine sensing and assessment technologies/capabilities for sustained and enhanced Airman performance in multiple operationally relevant environments including Airman-Machine Teaming scenarios and multi-domain operations. Validate applicability of biomarker sensor technologies use in operational environments. Continue to investigate augmentation techniques for physical and cognitive performance optimization and stress resilience and apply those techniques in operationally-relevant environments. Continue to explore utility of non-invasive peripheral nerve stimulation and closed-loop stimulation techniques to enhance cognitive performance. Complete development of the next generation aircraft injury exposure criteria for improved aircrew protection. Investigate multi-axis spinal injury modeling during aircraft ejection. Complete investigation of on-board oxygen generating system performance vulnerabilities affecting oxygen production. Complete the development for on-board oxygen generating system contamination database and susceptibility model. Research the development of the next generation of oxygen monitoring system. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.915 million. Justification for the increase is increased emphasis in applied neuroscience.			
Title: Human Role in Semiautonomous Systems	3.152	5.837	6.224
Description: Research new control/display concepts and technologies (e.g., information portrayal, control devices, decision aiding algorithms) for adaptive human-machine interaction and teamwork. ***FY 2018 Plans:*** Demonstrate distributed control methods for unmanned system concepts in limited communication environments. Continue research and development of predictive, look-ahead tools for effects-based mission planning and execution. Continue research in advanced airman workload measurement technologies integrated with real-time adaptive airman-machine teaming and task allocation methods. Research and develop human-machine interface methods to for real time machine reasoning and negotiating processes. ***FY 2019 Plans:*** Refine airman-system cooperative decision aids and interfaces that support distributed unmanned system control concepts in limited communication environments. Continue research and development of predictive, look-ahead tools for effects-based mission planning and execution. Continue research on real-time adaptive human-machine teaming/task allocation that includes examining workload and shared situation awareness metrics and the influence of machine aids on airmen problem solving, attention management and task prioritization. Continue research and development of airman-machine interface methods for real-time machine reasoning and negotiating processes. ***FY 2018 to FY 2019 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 increased compared to FY 2018 by $0.387 million. Justification for the increase is described in the plans above.			
Title: Battlespace Visualization ***Description:*** Research the visualization, interaction and understanding of complex information to enhance warfighter decision making. ***FY 2018 Plans:*** Continue exploration of analytic strategies with machine learning techniques to achieve next-generation, automated, data exploitation capability. Continue data analytics research focused on human visualization of complex data. Evaluate cyber operator system interfaces for integrated defensive and offensive operations. Develop models to predict visibility of objects viewed by humans under both unaided and aided conditions. Integrate visualizations of threats and their priority, tasks, targets, and courses of action for C2 environments across the space and cyberspace domains. ***FY 2019 Plans:*** Continue exploration of analytic strategies with machine learning techniques to achieve next-generation, automated, data exploitation capability, and develop visual interfaces to enhance decision making. Continue data analytics research focused on human visualization of complex data. Evaluate multi-domain operator system interfaces for integrated defensive and offensive operations. Refine models to predict visibility of objects viewed by humans under both unaided and aided conditions and explore multi-modal model integration. Continue to integrate visualizations of events and their influence on objectives and courses of action for C2 environments across the air, space and cyberspace domains. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.590 million. Justification for the increase is described in the plans above.	8.398	6.867	7.457
Title: Battlespace Acoustics ***Description:*** Conducts research on advanced auditory and communication technologies that mitigate effects of noise and enhance performance in operational environments. ***FY 2018 Plans:*** Conduct research on auditory processing of complex, multi-source acoustic scenes and develop context-aware auditory displays for optimal delivery of real-time information from synthetic teammates, including verbal communication, spatial location and system state. Develop electro-acoustic characterization techniques for the prediction of auditory protection and performance requirements. Examine techniques for real-time augmentation of auditory reality. Develop and evaluate new biomimic acoustic detection models that employ representations of domain-specific listening environments. ***FY 2019 Plans:***	4.205	4.053	3.372

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue to conduct research on auditory processing of complex, multi-source acoustic scenes and develop context-aware auditory displays for optimal delivery of real-time information from synthetic teammates, including verbal communication, spatial location and system state. Develop enhanced electro-acoustic characterization techniques for the prediction of auditory protection and performance requirements. Examine and implement techniques for real-time augmentation of auditory reality. Enhance and refine biologically-inspired models of acoustic detection for special operations aviation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.681 million. Justification for the decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	31.257	29.476	31.687

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 627757 / *Bioeffects*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
627757: *Bioeffects*	0.000	29.992	31.130	33.823	0.000	33.823	37.553	38.098	39.992	37.950	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts applied research on the effects of human exposure to potentially toxic chemicals in the operational environment, advanced materials (including nanomaterials), electromagnetic (EM) energy (radio frequency to optical), scalable directed energy weapons, and non-lethal weapons. This research addresses fundamental physical principles, as well as the psychophysical interaction between directed energy and the individual or groups of individuals. Research is divided into three core focus areas: optical radiation bioeffects; radio frequency radiation (RFR) bioeffects; and molecular bioeffects. Optical radiation bioeffects research enhances combat survivability and systems effectiveness through technologies that enable deployed forces to counter optical threats and exploit optical systems for offensive applications. The RFR bioeffects research investigates basic biological mechanisms of RFR, conducts theoretical and empirical dosimetry, conducts research of bioeffects from short and long-term exposures, develops methods to counter RFR threats, and performs research for exploitation of directed energy systems for offensive capabilities. Molecular bioeffects research is conducted to protect Airmen from the effects of toxic chemicals and materials to include nanomaterials and other advanced development products and to discover novel biomarkers and molecular mechanisms to support personalized training, performance and protection of Airman cognitive and physical performance using advanced sense, assess and augment technologies.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Optical Radiation Bioeffects	8.811	11.695	14.247
Description: Conduct laboratory experiments and field research on laser bioeffects, enabling military exploitation of laser technology while providing countermeasures for optical hazards/threats.			
FY 2018 Plans: Initiate assessment of alternate wavelength bioeffects for use in high-energy lasers. Complete assessment of effectiveness of novel glare device bioeffects. Continue pulse laser damage bioeffects assessment to help in evaluation of collateral hazards of high energy laser systems. Initiate investigations of suprathreshold laser damage to allow future probabilistic assessment of full range of bioeffects from collateral exposures. Validate developing scalable effects simulation tool and dose-response methodologies to assure science-based assessment of high-energy lasers weapons or developing visual glare devices. Continue development of models reflecting the performance impact of laser exposures and develop mitigation strategies.			
FY 2019 Plans: Complete initial studies of alternate laser wavelength bioeffects for use in high-energy lasers. Incorporate glare vision effect models in national and DoD standards for definition of protective requirements and glare device effectiveness. Transition risk-based model components for hazard evaluations of laser and broad-band optical systems. Mature generalized dose-response			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 627757 / *Bioeffects*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
component models for future analysis of emerging laser technologies such as fiber and Diode Pumped Alkali Laser (DPAL) systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $2.552 million. Justification for the increase is increased emphasis in optical radiation bioeffects.			
Title: Radio Frequency Bioeffects ***Description:*** Conduct laboratory experiments and field research to enable safe exploitation of directed energy technologies for communication, target identification, and weapons development. ***FY 2018 Plans:*** Parameterize fast thermal gradient bioeffects for whole body application. Validate targeted energy deposition models. Explore smart waveform mixing for deep-targeted energy deposition. Advance whole body molecular beacon technology for advanced radio frequency (RF) dosimetry and computer effects model validation. ***FY 2019 Plans:*** Focus on molecular signatures of RF overexposure to assess acute and chronic bioeffects of RF overexposures in operational situations. Complete scalability matrix for fast thermal gradients exposures for transition from contact to free field application. Continued advancements in fast thermal gradient research. Investigating damage effects of high average power exposures. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.821 million. Justification for the increase is increased emphasis in radio frequency bioeffects.	9.928	9.052	10.873
Title: Molecular Bioeffects ***Description:*** Protect Airmen from toxic chemicals and materials and enhance performance capability under demanding training and mission activities through molecular bioscience research. ***FY 2018 Plans:*** Initiate toxicological analysis of several relevant aerospace fluids, such as coolants and jet fuels, that may negatively affect high performance aircraft operators. Initiate developmental studies to create an organ on chip technology that enables rapid and accurate assessment of potentially toxic aerospace materials, with special emphasis on advanced acquisition materials that includes nanoparticles. Conduct characterization and toxicity evaluation of particle aerosol in post-detonated areas to define exposure limits for the warfighter. Complete definitive analysis of chromium VI toxicity to best protect maintenance Airmen exposed to the surface coating on many current aircraft containing this chemical. Identify an easily measureable biomarker in	11.253	10.383	8.703

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 627757 / *Bioeffects*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Airmen that become hypoxic, to rapidly identify a degraded performance state. Examine molecular mechanism of cognitive performance in physically or mentally intensive operational environments for the development of effective and safe strategies to protect, optimize and augment Airmen performance. ***FY 2019 Plans:*** Complete toxicological analysis of several relevant aerospace fluids, such as hydraulics, coolants, lubricants and jet fuels that may negatively affect high performance aircraft operators. Begin development of an Air Force Specific In Vitro Screen (AFSIVS) to enable rapid and accurate assessment of potentially toxic chemicals and materials including nanoparticles. Conduct studies to develop safe and effective fatigue counter measures to improve Airmen performance in physically or mentally intensive operational environments. Complete initial characterization and toxicity evaluation of particle aerosol in post-detonated areas to define exposure limits for the warfighter. Conduct developmental studies to create an organ on chip technology that enables rapid and accurate assessment of potentially toxic aerospace materials, with special emphasis on advanced acquisition materials that includes nanoparticles. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.680 million. Justification for the decrease is decreased emphasis in molecular bioeffects.			
Accomplishments/Planned Programs Subtotals	29.992	31.130	33.823

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	192.583	192.695	190.919	0.000	190.919	214.984	213.042	216.885	205.822	Continuing	Continuing
623012: *Advanced Propulsion Technology*	-	26.750	28.612	26.813	0.000	26.813	32.250	28.628	30.791	29.221	Continuing	Continuing
623048: *Combustion and Mechanical Systems*	-	10.502	10.833	10.691	0.000	10.691	11.983	12.199	12.414	11.778	Continuing	Continuing
623066: *Turbine Engine Technology*	-	50.776	55.304	52.429	0.000	52.429	60.891	62.308	63.405	60.167	Continuing	Continuing
623145: *Aerospace Power Technology*	-	44.703	34.736	39.102	0.000	39.102	40.327	38.861	37.996	36.056	Continuing	Continuing
624847: *Rocket Propulsion Technology*	-	55.384	58.594	57.340	0.000	57.340	64.432	65.848	66.988	63.575	Continuing	Continuing
625330: *Aerospace Fuel Technology*	-	4.468	4.616	4.544	0.000	4.544	5.101	5.198	5.291	5.025	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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*

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, 0602204F, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, and 0602298F.

This effort 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	185.671	192.695	193.579	0.000	193.579
Current President's Budget	192.583	192.695	190.919	0.000	190.919
Total Adjustments	6.912	0.000	-2.660	0.000	-2.660
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	10.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.486	0.000			
• SBIR/STTR Transfer	-3.574	0.000			
• Other Adjustments	0.000	0.000	-2.660	0.000	-2.660

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 623145: *Aerospace Power Technology*		
Congressional Add: *Program Increase*	4.912	0.000
Congressional Add: *Program Increase - aerospace power technology*	4.912	0.000
Congressional Add Subtotals for Project: 623145	9.824	0.000
Congressional Add Totals for all Projects	9.824	0.000

Change Summary Explanation

Decrease in FY 2019 due to Department of Defense (DoD) non-pay deflation and civilian pay repricing adjustment.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
623012: *Advanced Propulsion Technology*	-	26.750	28.612	26.813	0.000	26.813	32.250	28.628	30.791	29.221	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Title: Hypersonic Scramjet Technologies	26.750	28.612	26.813	0.000	26.813
Description: Develop robust hydrocarbon fueled scramjet engine components and technologies to improve performance, operability, durability, and scalability for future platforms.					
FY 2018 Plans: Complete scramjet engine controls development as part of the high speed strike weapon technology maturation program. Complete mapping of scramjet isolator operability for distorted in-flow conditions. Continue to develop advanced engine components to improve scramjet operating margin and to refine scramjet scaling laws for reusable applications. Continue to develop techniques to decrease scramjet take-over from Mach 4.5 to Mach 3.5 to provide robust options for Combined Cycle Engines (CCEs). Continue to develop low internal drag flame stabilization devices and flight test engine components.					
FY 2019 Base 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 techniques to decrease scramjet take-over from Mach 4.5 to Mach 3.5 to provide robust options for CCEs. Continue to develop low internal drag flame stabilization devices and flight test engine components.					
FY 2019 OCO Plans: N/A					
FY 2018 to FY 2019 Increase/Decrease Statement:					

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623012 / *Advanced Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
FY 2019 decreased compared to FY 2018 by $1.799 million. Justification for the decrease is civilian pay deflation and the acceleration of hypersonics technology maturation effort.					
Accomplishments/Planned Programs Subtotals	26.750	28.612	26.813	0.000	26.813

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 623048 / *Combustion and Mechanical Systems*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
623048: *Combustion and Mechanical Systems*	-	10.502	10.833	10.691	0.000	10.691	11.983	12.199	12.414	11.778	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Title: Combustion Technologies	4.372	4.510	4.451	0.000	4.451
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 2018 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).					
FY 2019 Base Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623048 / *Combustion and Mechanical Systems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
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 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). ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.059 million. Justification for the decrease is described in the plans above.					
Title: Diagnostic Technologies ***Description:*** Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary propulsion technologies. ***FY 2018 Plans:*** Continue development and demonstration of diagnostic systems for high-bandwidth kHz-MHz measurements of combustion chemistry and physics. Efforts seek to increase time scales of interest, size of regions explored, and increasing the number of species and their concentrations. Diagnostics techniques should 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. Continue to provide sufficient data to support computational fluid dynamics (CFD) combustion model development. Specific efforts include 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. Further development of diagnostic tools/methods will provide robust measurement	0.695	0.717	0.708	0.000	0.708

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623048 / *Combustion and Mechanical Systems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
capability in engine test cells and full-annular ground-test environments. Developing systems to provide portable measurement capability throughout engine development and testing. ***FY 2019 Base Plans:*** Continue development and demonstration of diagnostic systems for high-bandwidth kHz-MHz measurements of combustion chemistry and physics. Continue to seek to increase time scales of interest, size of regions explored, and increasing the number of species and their concentrations. 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. Continue to provide sufficient data to support 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. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.009 million. Justification for the decrease is described in the plans above.					
Title: Lubricant Technologies ***Description:*** Develop, test, and qualify advanced turbine engine lubricants. Generate and maintain military specifications for aviation engine lubricants. ***FY 2018 Plans:*** Continue developing innovative fluids (i.e., ionic fluids/additives) as potential high temperature lubricants for high-Mach and future high performance engines. Demonstrate Enhanced Ester (EE) oils in rig testing and design studies of turbine engines. Continue transitioning EE oil to F-35 and F-22 fleet. Continue developing on-line mechanical system health monitoring technologies. Continue implementation of new lubricant traction models into updated bearing design codes. Continue supporting the warfighter on field-related mechanical system issues. ***FY 2019 Base Plans:***	2.683	2.767	2.731	0.000	2.731

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623048 / *Combustion and Mechanical Systems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Continue developing innovative fluids (i.e., ionic fluids/additives) as potential high temperature lubricants for high-Mach and future high performance engines. Demonstrate Enhanced Ester (EE) oils in rig testing and design studies of turbine engines. Continue transitioning EE oil to F-35 and F-22 fleet. Continue developing on-line mechanical system health monitoring technologies. Continue the implementation of new lubricant traction models into updated bearing design codes. Continue supporting the warfighter on field-related mechanical system issues. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.036 million. Justification for the decrease is described in the plans above.					
Title: Bearing Technologies ***Description:*** Develop and test advanced bearing material technology and bearing concepts for small, intermediate, and large-scale turbine engine applications. ***FY 2018 Plans:*** Continue developing physics-based bearing life model based on bearing alloy fatigue & microstructural investigations, including bearing life factors for advanced bearing materials. Continue work on small magnetic bearings & oil-free bearings for small & medium scale unmanned aircraft system (UAS), hi-Mach cruise missile and low-cost engines. Initiate the integration of new bearing modeling simulation tools into full-engine design models. Continue development of active thrust-balance/prognostic health management (PHM) system for large man-rated and medium-scale propulsion. ***FY 2019 Base Plans:*** Continue developing physics-based bearing life model based on bearing alloy fatigue & microstructural investigations, including bearing life factors for advanced bearing materials. Continue work on small magnetic bearings & oil-free bearings for small & medium scale UAS, hi-Mach cruise missile and low-cost engines. Continue the integration of new bearing modeling simulation tools into full-engine design models. Continue development of active thrust-balance/PHM system for large man-rated and medium-scale propulsion. ***FY 2019 OCO Plans:***	2.752	2.839	2.801	0.000	2.801

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623048 / *Combustion and Mechanical Systems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.038 million. Justification for the decrease is described in the plans above.					
Accomplishments/Planned Programs Subtotals	10.502	10.833	10.691	0.000	10.691

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 623066 / *Turbine Engine Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
623066: *Turbine Engine Technology*	-	50.776	55.304	52.429	0.000	52.429	60.891	62.308	63.405	60.167	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 DoD, 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).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Title: Turbofan/Turbojet Engine Core Technologies	22.742	24.770	23.482	0.000	23.482
Description: Develop core turbofan/turbojet engine components (i.e., compressors, combustors, and turbines) for fighters, bombers, sustained supersonic/hypersonic cruise vehicles, and transports. ***FY 2018 Plans:*** Develop and validate modeling and simulation tools for the design and analysis of advanced turbine components with improved durability for adaptive cycle engines. Continue development of improved compressor aerodynamic design tools and analysis methods to extend engine operability and efficiency. ***FY 2019 Base Plans:*** Develop and validate modeling and simulation tools for the design and analysis of advanced turbine components with improved durability for adaptive cycle engines. Continue development of improved compressor aerodynamic design tools and analysis methods to extend engine operability and efficiency. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.288 million. Justification for the decrease is civilian pay deflation and the acceleration of hypersonics technology maturation effort.					
Title: Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies	22.807	24.840	23.550	0.000	23.550

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
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. ***FY 2018 Plans:*** Continue development of modeling and simulation tools, including methods to predict behavior of serpentine inlets and nozzles. Continue development and validation of 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. Initiate the identification of control technology elements applicable to integrated propulsion/power/thermal solutions. Initiate the definition of actionable indicators and assess interface control gaps to enable decision-based informed lifecycle tools. ***FY 2019 Base Plans:*** Continue development of modeling and simulation tools, including methods to predict behavior of serpentine inlets and nozzles. 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. Define actionable indicators and assess interface control gaps to enable decision-based informed life cycle tools ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.290 million. Justification for the decrease is civilian pay deflation and acceleration of the hypersonics technology maturation effort.					
Title: Missile and Remotely Piloted Aircraft Engine Technologies ***Description:*** Develop limited life engine components for missile and remotely piloted aircraft (RPA) applications, including long-range supersonic and hypersonic vehicles. ***FY 2018 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. Initiate the development and validation of parameter,	4.277	4.659	4.417	0.000	4.417

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
process, and performance modeling for components manufactured through additive technologies. Initiate the development and validation of rules and tools to enable flexible design for targeted life. ***FY 2019 Base 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. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.242 million. Justification for the decrease is described in the plans above.					
Title: Turboshaft/Turboprop and Small Turbofan Engine Technologies	0.950	1.035	0.980	0.000	0.980
Description: Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. ***FY 2018 Plans:*** Continue development and validation of modeling and simulation tools to achieve very high levels of loading for advanced low pressure turbine components. Initiate the exploration of advanced integrated engine controls with potential for synergistic airframe system level benefits. ***FY 2019 Base 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. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
FY 2019 decreased compared to FY 2018 by $0.055 million. Justification for the decrease is described in the plans above.					
Accomplishments/Planned Programs Subtotals	50.776	55.304	52.429	0.000	52.429

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 623145 / *Aerospace Power Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
623145: *Aerospace Power Technology*	-	44.703	34.736	39.102	0.000	39.102	40.327	38.861	37.996	36.056	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Title: High Power System Technologies	34.879	34.736	39.102	0.000	39.102
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 2018 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. Initiate development of advanced power options for small unmanned aircraft. ***FY 2019 Base 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					

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623145 / *Aerospace Power Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
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 the development of advanced power options for small unmanned aircraft. Initiate weapon system contractor support for platform integration of advanced power and thermal system architectures. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $4.366 million. Justification for the acceleration of the hypersonics technology maturation effort.					
Accomplishments/Planned Programs Subtotals	34.879	34.736	39.102	0.000	39.102

	FY 2017	FY 2018
Congressional Add: Program Increase ***FY 2017 Accomplishments:*** Conducted Congressionally-directed efforts ***FY 2018 Plans:*** N/A	4.912	0.000
Congressional Add: Program Increase - aerospace power technology ***FY 2017 Accomplishments:*** Conducted Congressionally-directed efforts ***FY 2018 Plans:*** N/A	4.912	0.000
Congressional Adds Subtotals	9.824	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623145 / *Aerospace Power Technology*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 624847 / *Rocket Propulsion Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
624847: *Rocket Propulsion Technology*	-	55.384	58.594	57.340	0.000	57.340	64.432	65.848	66.988	63.575	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 thrusts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire 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 achieve RP21 Goals.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Title: Fuel Technologies	6.745	7.136	10.791	0.000	10.791
Description: Develop, characterize, and test advanced hydrocarbons, energetics, solid propellants, and monopropellants to increase space launch payload capability and refine new synthesis methods. ***FY 2018 Plans:*** Continue developing solid rocket propellant binder systems for intended use across a variety operationally relevant conditions. Initiate conception, synthesis, 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. Initiate transfer of knowledge for making green monopropellants to the United States industrial base. Initiate the formulation, scale-up, and evaluate formulations of solid and liquid rocket propellants. Initiate the identification, evaluation, and adaption of 21st century material processing equipment to enable more rapid and agile development and more precise products. Continue support for NASA's Green Propellant Infusion mission to demonstrate a non-toxic ionic liquid based propulsion system in space. Continue research in high-temperature resins, insulators, and composite case					

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
fabrication techniques to enable high mass-fraction rocket motor cases. Initiate high-performance bi-propellant synthesis and formulation. ***FY 2019 Base 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. Continue support for NASAs Green Propellant Infusion mission to demonstrate a non-toxic ionic liquid based propulsion system in space. Continue 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. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $3.655 million. Justification for the increase is increased emphasis in fuel technologies.					
Title: Liquid Engine Combustion Technologies	6.728	7.118	8.601	0.000	8.601
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. ***FY 2018 Plans:*** Complete the testing plan for the program to assess the potential payoff of, and technical barriers to, Rotating Detonation Engines as a reliable and lower-cost advanced propulsion approach for both launch and in-space applications. Continue evaluation of methane multi-injector designs in hot-fire conditions. Complete the delivery of high-fidelity injector simulations that complement experimental data. Continue hot fire tests in combustion stability rig. Continue combustion stability modeling critical 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 in to methane fuels and other cryogenic cooling. Continue the					

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
employment 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. Initiate 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 DoD and industry for next-generation engines (including use of liquid oxygen and higher pressures and thrust). ***FY 2019 Base 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 future hydrocarbon fueled liquid rocket engines. Continue the delivery 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 in to 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 DoD and industry for next-generation engines (including use of liquid oxygen and higher pressures and thrust). ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.483 million. Justification for the increase is increased emphasis in liquid engine combustion technologies.					
Title: Advanced Liquid Engine Technologies ***Description:*** Develop advanced liquid engine technologies for improved performance, while increasing life and reliability needs for engine uses in expendable and reusable launch vehicles. ***FY 2018 Plans:*** Complete architecture and cost-benefit study for next generation liquid propulsion, with efforts focused on modularity and cost reduction. Continue to develop enabling Hydrocarbon Boost (HCB) technology for future spacelift concepts and continue risk reduction activities for the development of HCB technologies. Continue exploring engine concepts for next generation, beyond 2035, launch vehicles and concepts to effect cost	17.623	18.644	12.615	0.000	12.615

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
reductions. Initiate sub-scale risk mitigation and technology maturation activities to transition to next generation engine concepts. ***FY 2019 Base Plans:*** Continue to develop enabling HCB technology for future spacelift concepts and continue risk reduction activities for the development of HCB technologies. Continue exploring engine concepts for next generation, beyond 2035, launch vehicles and concepts to effect cost reductions. Initiate sub-scale risk mitigation and technology maturation activities to transition to next generation engine concepts. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decrease compared to FY 2018 by $6.029 million. Justification for the decrease is decreased emphasis in advanced liquid combustion technologies.					
Title: On-Orbit Propulsion Technologies ***Description:*** Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for station-keeping, repositioning, and orbit transfer for satellites and satellite constellations. ***FY 2018 Plans:*** Continue scale-up research of advanced chemical propellants with particular focus on transition of numerical tools and experimental methodologies for advanced monopropellants 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 (EP) thruster models, to industry partners. Continue to explore advanced EP and chemical thruster concepts and assess new spacecraft propulsion requirements. ***FY 2019 Base 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	12.980	13.732	13.865	0.000	13.865

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
support thruster-spacecraft integration. Continue transition and support of thruster/plume modeling framework to spacecraft industry, with addition of advanced electric propulsion (EP) thruster models, to industry partners. Continue to explore advanced EP and chemical thruster concepts and assess new spacecraft propulsion requirements. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.133 million. Justification for the increase is described in the plans above.					
Title: Space Access and Strike Applications ***Description:*** Develop missile propulsion and boost technologies for space access and strike applications. ***FY 2018 Plans:*** Continue to develop advanced tactical propulsion. Continue development and evaluation of next generation of updated, physics-based modeling, simulation, and analysis tools for missile propulsion components and applications. Complete the use of tools in missile propulsion demonstration. Continue to develop advanced component technologies for missile propulsion applications for strategic and strike systems helping to ensure their long-term sustainment, to include an altitude hot fire. Continue 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. ***FY 2019 Base Plans:*** Continue to develop advanced tactical propulsion. 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. Continue 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. ***FY 2019 OCO Plans:***	7.032	7.440	6.307	0.000	6.307

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.133 million. Justification for the decrease is decreased emphasis in space access and strike applications.					
Title: Ballistic Missile Technologies ***Description:*** Develop missile propulsion technologies and aging and surveillance technologies for ballistic missiles. ***FY 2018 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. Initiate 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. ***FY 2019 Base 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. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.637 million. Justification for the increase is described in the plans above.	4.276	4.524	5.161	0.000	5.161
Accomplishments/Planned Programs Subtotals	55.384	58.594	57.340	0.000	57.340

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 625330 / *Aerospace Fuel Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625330: *Aerospace Fuel Technology*	-	4.468	4.616	4.544	0.000	4.544	5.101	5.198	5.291	5.025	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Title: Alternative Fuels ***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 2018 Plans:*** Initiate evaluation of fully-synthetic jet fuels produced from alcohol and triglyceride feedstocks. ***FY 2019 Base Plans:*** Continue evaluation of fully-synthetic jet fuels produced from alcohol and triglyceride feedstocks. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.002 million. Justification for the decrease is described in the plans above.	0.099	0.102	0.100	0.000	0.100
Title: Integrated Thermal and Energy Management ***Description:*** Develop and demonstrate advanced components and conduct performance assessments of advanced aircraft integrated thermal and energy management systems for engines and aircraft. ***FY 2018 Plans:***	1.390	1.437	1.415	0.000	1.415

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 625330 / *Aerospace Fuel Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Continue the evaluation of advanced additives, catalysts, and fuel composition approaches to minimize endothermic fuel coking. ***FY 2019 Base Plans:*** Continue the evaluation of advanced additives, catalysts, and fuel composition approaches to minimize endothermic fuel coking. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.022 million. Justification for the decrease is described in the plans above.					
Title: Fuel Logistics ***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. ***FY 2018 Plans:*** Initiate the development of fuel temperature limits for full-life fuel systems as part of integrated power and thermal management systems ***FY 2019 Base Plans:*** Continue the development of fuel temperature limits for full-life fuel systems as part of integrated power and thermal management systems. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.022 million. Justification for the decrease is described in the plans above.	1.390	1.437	1.415	0.000	1.415
Title: Combustion Emissions and Performance ***Description:*** Develop and test advanced emissions diagnostic techniques for airbreathing propulsion systems. Conduct evaluations of the combustion and emissions characteristics of aviation fuels. ***FY 2018 Plans:***	1.589	1.640	1.614	0.000	1.614

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 625330 / *Aerospace Fuel Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Initiate the development of Aerospace Recommended Practice (ARP) for particulate emissions measurements for engine certification, joint with Federal Aviation Administration (FAA), NASA, and industry. ***FY 2019 Base Plans:*** Complete the development of Aerospace Recommended Practice (ARP) for particulate emissions measurements for engine certification, joint with Federal Aviation Administration (FAA), NASA, and industry. ***FY 2019 OCO Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.026 million. Justification for the decrease is described in the plans above.					
Accomplishments/Planned Programs Subtotals	4.468	4.616	4.544	0.000	4.544

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	160.339	152.782	166.534	0.000	166.534	174.632	180.724	185.126	177.980	Continuing	Continuing
622002: *Electronic Component Technology*	-	44.522	38.522	43.633	0.000	43.633	44.486	47.742	48.991	47.749	Continuing	Continuing
622003: *EO Sensors & Countermeasures Tech*	-	21.451	24.473	28.820	0.000	28.820	31.600	32.175	32.737	31.275	Continuing	Continuing
622005: *Cyber Technology*	-	10.120	6.428	6.196	0.000	6.196	6.394	6.497	6.605	6.218	Continuing	Continuing
626095: *Sensor Fusion Technology*	-	34.807	32.370	32.281	0.000	32.281	33.824	34.400	37.290	35.289	Continuing	Continuing
627622: *RF Sensors and Countermeasures Tech*	-	49.439	50.989	55.604	0.000	55.604	58.328	59.910	59.503	57.449	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) RF antennas and associated electronics for airborne and space surveillance, together with active and passive EO/IR 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 RF sensors and electronic combat systems; and 6) technologies that aid in the discovery and mitigation of cyber vulnerabilities in avionics 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 program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*	

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	155.174	152.782	151.000	0.000	151.000
Current President's Budget	160.339	152.782	166.534	0.000	166.534
Total Adjustments	5.165	0.000	15.534	0.000	15.534
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	7.500	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-0.647	0.000			
• SBIR/STTR Transfer	-1.688	0.000			
• Other Adjustments	0.000	0.000	15.534	0.000	15.534

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 622002: *Electronic Component Technology*		
Congressional Add: *Program Increase - electronic component technology*	3.949	0.000
Congressional Add Subtotals for Project: 622002	3.949	0.000
Project: 627622: *RF Sensors and Countermeasures Tech*		
Congressional Add: *Program Increase - Spectrum Monitoring*	3.455	0.000
Congressional Add Subtotals for Project: 627622	3.455	0.000
Congressional Add Totals for all Projects	7.404	0.000

Change Summary Explanation

Increase in FY 2019 due to Department of Defense civilian pay repricing adjustment and realignment of Sensors Science and Technology (S&T) Advanced Technology Development activities to Sensors S&T Applied Research.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*	Project (Number/Name) 622002 / *Electronic Component Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622002: *Electronic Component Technology*	-	44.522	38.522	43.633	0.000	43.633	44.486	47.742	48.991	47.749	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, EW, 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 aims to demonstrate 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, EW, navigation, and smart weapons.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Sensor Subsystems	9.779	9.284	10.033
Description: Develop, analyze, demonstrate, and perform engineering trade studies for technologies for compact, affordable, multi-function subsystems for aerospace sensors. This effort is being renamed from Multifunction Sensor Subsystems to better align project and thrusts with funding in functional areas. ***FY 2018 Plans:*** Complete first demonstration of affordable, miniature multifunction prototype. Continue to refine models and simulations through updated technology and microsystem/subsystem performance and cost models. Initiate digital beamforming demonstration using Arrays at Commercial Timescales modules. Initiate development of subsystem prototypes for attritable platforms. ***FY 2019 Plans:*** Complete demonstration of models and simulations for low-cost, multi-function radio frequency subsystems. Complete digital beamforming demonstration. Continue the development of subsystem prototypes for attritable platforms. Initiate demonstration of low-cost on-board sensor processing subsystem. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.749 million. Justification for this increase is described in plans above.			
Title: Electronic Devices	10.778	10.242	7.738

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622002 / *Electronic Component Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Assess, research, develop, demonstrate and transition revolutionary and evolutionary electronic devices and their associate technologies. This effort is being renamed from Microelectronic/Optoelectronic Technologies to better align project and thrusts with funding in functional areas. ***FY 2018 Plans:*** Continue to refine tools and methods to design, build, and analyze game changing component technologies. Continue evaluation of emerging component technologies against device concept baseline for multi-use applications. Initiate development of prototypes from identified emerging device concepts. Continue wide-bandgap device technology development for power generation and management. Continue demonstration of models for high-performance, high-frequency, millimeter-wave device technologies for power amplification. Continue commercialization of Air Force foundry process to industry. Continue wide-bandgap device technology development for power generation and management. ***FY 2019 Plans:*** Continue to refine tools and methods to design, build, and analyze game changing component technologies. Continue evaluation of emerging component technologies against device concept baseline for multi-use applications and continue development of prototypes from identified emerging device concepts. Continue wide-bandgap device technology development for power generation and management. Complete demonstration of models for high-performance, high-frequency, millimeter-wave device technologies for power amplification. Complete commercialization of Air Force foundry process to industry. Continue wide-bandgap device technology development for power generation and management. Initiate high-voltage L and S-Band power amplifier demonstration. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $2.504 million. Decrease is due to the renaming/realignment of the thrusts in Project 622002, Electronic Component Technology.			
Title: Electro-Optical/Infrared (EO/IR) Components	5.750	5.454	9.271
Description: Research, develop, demonstrate and transition EO/IR components for next generation intelligence, surveillance, reconnaissance (ISR) and countermeasures. This effort is being renamed from Apertures to better align project and thrusts with funding in functional areas. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622002 / *Electronic Component Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Complete gimbal-less beamsteering prototype. Continue to explore and evaluate innovative materials and devices for tunability, increased bandwidth and multi-wavelength operation. Initiate compact, tunable, laser source prototype. ***FY 2019 Plans:*** Continue to explore and evaluate innovative materials and devices for tunability, increased bandwidth and multi-wavelength operation. Continue compact, tunable, laser source prototype. Complete demonstration of first generation reconfigurable focal plane array. Continue to develop a semiconductor optomechanical oscillator. Initiate demonstration of high pulse power midwave IR laser source. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $3.817 million. Increase is due to the renaming/realignment of the thrusts in Project 622002, Electronic Component Technology as well as the realignment of Electronic Combat Technology and Advanced Aerospace Sensors Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors S&T Applied Research.			
Title: Trusted Electronics for Intelligence, Surveillance, Reconnaissance and Avionics Systems	6.569	6.232	9.797
Description: Investigate and develop designs of trusted electronic and optoelectronic systems when integrating commercially available solutions commercial-off-the-shelf 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. This effort is being renamed from Trusted Systems for intelligence, surveillance, reconnaissance to better align project and thrusts with funding in functional areas. ***FY 2018 Plans:*** Continue to refine demonstration of trust in design and trust in fabrication. Continue modeling and simulation architecture development to inform and predict mission assurance for highly integrated microsystems, devices and materials. Initiate development of prototype trustworthiness assessment capability. ***FY 2019 Plans:*** Complete initial demonstration of trust in design and trust in fabrication. Complete baseline modeling and simulation architecture development to inform and predict mission assurance for highly integrated microsystems, devices and materials. Continue development of prototype trustworthiness assessment capability. Initiate reliability assessments of advanced heterogeneously integrated microsystems. ***FY 2018 to FY 2019 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622002 / *Electronic Component Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 increased compared to FY 2018 by $3.565 million. Increase is due to the renaming/realignment of the thrusts in Project 622002, Electronic Component Technology as well as the realignment of Electronic Combat Technology and Advanced Aerospace Sensors Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors S&T Applied Research.			
Title: Advanced Highly Integrated Microsystems for Intelligence, Surveillance, Reconnaissance and Electronic Warfare ***Description:*** Develop, mature, and demonstrate critical electronic technologies to enable revolutionary electronic warfare subsystems. This effort is being renamed from Advanced Components for Electronic Warfare to better align project and thrusts with funding in functional areas. ***FY 2018 Plans:*** Complete reconfigurable and agile radio frequency front end prototype. Continue development of highly-reconfigurable microsystem prototype. Continue investigation and development of integrated photonic circuit prototype. Initiate assessment of commercial microsystem fabrication techniques to militarily-relevant electronics and optoelectronics. ***FY 2019 Plans:*** Complete demonstration of highly-reconfigurable microsystem prototype. Complete baseline demonstration of militarily relevant integrated photonic circuit prototype. Complete assessment of microsystem fabrication techniques to militarily-relevant electronics and optoelectronics. Initiate development and demonstration of integrated wideband and adaptable transceiver microsystem. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.516 million. Justification for this decrease is described in plans above.	7.697	7.310	6.794
Accomplishments/Planned Programs Subtotals	40.573	38.522	43.633

	FY 2017	FY 2018
Congressional Add: Program Increase - electronic component technology ***FY 2017 Accomplishments:*** Conducted congressionally directed effort. ***FY 2018 Plans:*** Not Applicable	3.949	0.000
Congressional Adds Subtotals	3.949	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622002 / *Electronic Component Technology*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*	Project (Number/Name) 622003 / *EO Sensors & Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622003: *EO Sensors & Countermeasures Tech*	-	21.451	24.473	28.820	0.000	28.820	31.600	32.175	32.737	31.275	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project determines the technical feasibility of advanced electro-optical (EO) 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 main goals is to improve EO 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 EO threat warning and countermeasures.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Passive Electro-Optical/Infrared Sensing in Contested Environments	7.150	8.157	13.674

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 2018 Plans:

Continue to evaluate, via component and subsystem laboratory testing, innovative sensor concepts to increase long range image quality for high altitude passive electro-optical and infrared reconnaissance sensors. Continue and advance demonstrations of the effectiveness of computational image restoration and noise reduction. Assess non-traditional sensor architectures for improving image quality and the operational range of passive imagers for potential prototyping and laboratory test. Demonstrate technologies and components supporting longwave infrared hyperspectral imaging. Select promising technology options for hyperspectral imaging on small unmanned aircraft systems and advance their technology readiness level. Continue next generation infrared search and track architecture and component development to improve system performance in clutter. Test these component prototypes in a laboratory environment.

Improve passive sensing models to support infrared search and track technology trade analyses. Examine potential new capabilities resulting from a systems engineering strategy on cross domain electro-optical sensing for Air Force relevant missions. Initiate incorporation of sensor-specific modeling and simulation results into larger engagement level and campaign level simulations to explore new concepts.

FY 2019 Plans:

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622003 / *EO Sensors & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Develop an enhanced midwave infrared imaging upgrade to a fielded reconnaissance sensor. Show performance improvements using appropriate sensor and component technology models. Fabricate and test in a laboratory environment, an electro-optical sensor fore-optic based on novel concepts in optical engineering. Develop and implement the necessary optical metrology capability to support laboratory testing of the novel optics. Continue development of novel computational techniques for image restoration and noise reduction. Demonstrate the most promising candidates in a virtual environment. Complete and test in a laboratory environment, a pathfinder for small size, weight and power hyperspectral imaging for a small unmanned aircraft system. Generate appropriate sensor models to adequately explore performance in a virtual environment. Explore and develop signal processing and data processing algorithms needed to enhance the capabilities of the novel sensor hardware. Refine passive sensing computer models to support infrared search and track technology trade analyses. Generate models for new sensor architectures and examine potential new capabilities resulting from a systems engineering strategy on cross domain electro-optical sensing for Air Force relevant missions using broad capability computer simulations, including engagement level and campaign level simulations. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $5.517 million. Increase is due to realignment of Electronic Combat Technology and Advanced Aerospace Sensors Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors Applied Research.			
Title: Laser Radar Sensing in Contested Environments	14.301	16.316	15.146
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 2018 Plans:*** Complete testing of next generation long range holographic aperture laser radar imaging testbed focused on progression to platform compatible configurations. Complete laboratory testing of initial foundry runs of focal planes optimized for holographic imaging. Continue research on components needed for improving synthetic aperture laser radar system capabilities to provide target identification at standoff. Test in laboratory integrated direct detection ladar prototype and advance its technology readiness level. Conduct laboratory tests of candidate holographic aperture ladar techniques for enhancing spatial resolution beyond the diffraction limit of conventional optics while promoting platform-compatible architectures in a laboratory environment. Continue tests of prototype remote laser vibrometry and range-Doppler sensing technology to aid in target identification. Enhance emphasis of vibrometry signal processing refinement and on the development of automated signal recognition. Initiate investigation of advanced system architectures and evaluate candidates. This additional emphasis will involve both direction			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622003 / *EO Sensors & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
and synthetic aperture ladar approaches. Continue assessment of technology options for laser radar based three-dimensional imaging on small unmanned aircraft system for Air Force relevant missions. ***FY 2019 Plans:*** Test, in a laboratory environment, a distributed aperture laser radar system for imaging at long ranges, beyond the diffraction limit of the available individual apertures. Assess the architecture's limitations and its potential for implementation on current Air Force sensor pods and aircraft internal integration. Demonstrate the use of a holographic laser radar sensor for wavefront sensing and examine its potential for applications where wavefront sensing is a limitation. Continue development of a reduced size, weight and power laser amplifier suitable for laser radar applications such as synthetic aperture ladar and unmanned aircraft systems based active sensing. Enhance efforts to develop an end-to-end laser system computer model. Integrate the software with other system-level models. Continue component development for low cost, low size, weight and power laser radar suited for implementation on an unmanned aircraft system. Analyze potential system improvements brought about by enhanced components through computer modeling and laboratory test. Continue tests of prototype remote laser vibrometry and range-Doppler sensing technology to aid in target identification. Examine utility of candidate automated signal recognition software. Continue investigation of advanced system architectures and evaluate candidates. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.170 million. Decrease is due to realignment of Electronic Combat Technology and Advanced Aerospace Sensors Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors Applied Research.			
Accomplishments/Planned Programs Subtotals	21.451	24.473	28.820

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*	Project (Number/Name) 622005 / *Cyber Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622005: *Cyber Technology*	-	10.120	6.428	6.196	0.000	6.196	6.394	6.497	6.605	6.218	Continuing	Continuing

A. Mission Description and Budget Item Justification

Work from this effort was previously performed under Project 627622, RF Sensors and Countermeasures Tech.

This project focuses on technologies for cyber security and resilience of Air Force weapon systems. First, this project improves our understanding of avionics cyber vulnerabilities by investigating the fundamental nature of avionics 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. Second, this project aims to develop 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. Lastly, this project investigates open architecture concepts and technologies to deliver capability flexibility to Air Force avionics and weapon systems. These technologies are matured via integrated capability demonstrations.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Vulnerability Mitigation	4.418	2.806	2.704
Description: Apply knowledge from computer vulnerability discovery and computer security to investigate capabilities for identifying and mitigating vulnerabilities in United States avionics 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 2018 Plans: Based on classes of vulnerabilities identified in FY 2017 efforts and the characterized hardware: Investigate means to automate and make scalable vulnerability assessment tools and techniques. Investigate systematic methodologies to achieve repeatable and reliable cyber test to expand our understanding of root causes of avionics vulnerabilities. Investigate and apply our insights to evaluate feasibility of new capability concepts on next generation avionics architectures designed from a secure foundation.			
FY 2019 Plans: Continue to investigate means to automate and make scalable vulnerability assessment tools and techniques. Continue to investigate systematic methodologies to achieve repeatable and reliable cyber test to expand our understanding of root causes of avionics vulnerabilities. Investigate and apply our insights to evaluate feasibility of new capability concepts on next generation avionics architectures designed from a secure foundation. Begin transition from hands-on legacy platform assessment and tool development to developing guidelines, methodologies, and technologies for cyber hardening and resilience.			
FY 2018 to FY 2019 Increase/Decrease Statement: FY 2019 decreased compared to FY 2018 by $0.102 million. Justification for this decrease is described in plans above.			
Title: Adaptive Cyber Protections	5.702	3.622	3.492

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622005 / *Cyber Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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. ***FY 2018 Plans:*** Continue avionics protections research into real-time software/hardware monitoring tools. Apply these techniques to next-generation intelligence, surveillance and reconnaissance and avionics system architectures to investigate avionics malware detection and response protection system. ***FY 2019 Plans:*** Continue investigations into platform-independent malware feature selection capability. Investigate automation and optimization of malware detection and classification work using machine learning techniques. Investigate adaptable cyber protections and technologies to achieve cyber resilience in avionics systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.130 million. Justification for this decrease is described in plans above.			
Accomplishments/Planned Programs Subtotals	10.120	6.428	6.196

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
626095: *Sensor Fusion Technology*	-	34.807	32.370	32.281	0.000	32.281	33.824	34.400	37.290	35.289	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops the technologies required to perform management and fusion of sensor information for timely, comprehensive situational awareness, automatic target recognition, integrated fire control, and bomb damage assessment. This project determines the feasibility of technologies and concepts for fire control that help to precisely locate, identify, and target airborne and surface targets. The project emphasizes finding reduced signature targets and targets of opportunity. It will enable new covert tactics for successful air-to-air and air-to-surface strikes. This project also develops the technologies required to create trusted autonomic, distributed, collaborative, and self-organizing sensor systems that provide anticipatory intelligence, surveillance and reconnaissance, situational awareness, and decision support for multi-layered sensing. This program provides the technologies for: 1) trusted sensors and trusted sensor systems that will deter reverse engineering and exploitation of our critical hardware and software technology and impede unwanted technology transfer, alteration of system capability, and prevent the development of countermeasures to United States systems; 2) collaborative tasking of our own distributed heterogeneous sensor networks across a region and co-opted tasking of both traditional and non-traditional adversary sensors; 3) secure sensor web backbone technologies, sensor web physical topologies, and related protocols to assure reliable trusted sensor interactions; and 4) defining architectures for distributed trusted collaborative heterogeneous sensor systems and semantic sensor networks, developing new methodologies for system of systems sensor engineering and analysis, and new techniques for sensor network situation awareness and predictive analytics.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Target Signature Modeling	4.847	4.508	4.496
Description: Develop, evaluate, and demonstrate target signature models to support sensor exploitation algorithm development and testing for reconnaissance and strike mission applications. ***FY 2018 Plans:*** Develop space-time alignment with synthetic multi-sensor target primitive data. Initiate development of multi-sensor feature level fusion for stationary target identification. ***FY 2019 Plans:*** Continue development and initiate experimentation for multi-sensor feature level fusion for stationary target identification. Demonstrate space-time alignment with measured multi-sensor target primitive data with in-house multi-sensor test bench. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.012 million. Justification for this decrease is described in plans above.			
Title: Sensor Exploitation Technologies	7.395	6.877	6.858
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.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 626095 / *Sensor Fusion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Continue development of adaptive deep learning synthetic aperture radar target identification algorithms with more challenging conditions, including decoy rejection. Develop decision level fusion methodology conditioned on operating conditions and feature dependencies. ***FY 2019 Plans:*** Develop optimized high performance computing-based deep learning synthetic aperture radar and electro-optical/infrared algorithm training process. Continue development of a closed-loop sensor mode controller for adaptive transmit and receive. Initiate development of methodology for feature level fusion within a single modality. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.019 million. Justification for this decrease is described in plans above.			
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 2018 Plans:*** Conduct an initial multi-domain intelligence, surveillance and reconnaissance processing, exploitation and dissemination analysis. Conduct live demonstration of decentralized asset management with real and synthetic unmanned aerial vehicles to include target identification, passive geolocation, and context-sensitive target prioritization. Develop modeling and simulation space and remote sensing toolbox. Develop initial adaptive representation algorithm to test in simulation. ***FY 2019 Plans:*** Conduct enhanced multi-domain intelligence, surveillance and reconnaissance processing, exploitation and dissemination analysis. Develop electronic warfare/cyber effects toolbox. Demonstrate in simulation reasoning and replanner selection using multiple replanners and architectures. Initiate development of adaptive representation algorithms for high level information sharing. Initiate development a general framework for joint inference and control with arbitrary sensors. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.046 million. Justification for this decrease is described in plans above.	17.649	16.413	16.367
Title: Distributed Sensing for Automatic Target Recognition	4.916	4.572	4.560

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 626095 / *Sensor Fusion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Develop techniques and metrics for adaptive, penetrating, distributed radio frequency exploitation in contested environments. ***FY 2018 Plans:*** Continue to develop bi-static phenomenology models. Demonstrate new waveforms to exploit bi-static radio frequency phenomenology. Continue to develop a systems theory for incorporating identification uncertainty in automatic target recognition algorithms. Demonstrate distributed exploitation algorithms on prior data collections. Continue to design a closed-loop sensor mode controller for adaptive transmit and receive. ***FY 2019 Plans:*** Investigate transition opportunities for real-time processing of bistatic air-to-ground moving target indication algorithms. Investigate transition opportunities for algorithms for imaging and identifying moving targets using geometric invariance. Continue to develop alternative algorithms for non-template-based synthetic aperture radar automatic target recognition exploitation. Plan bistatic X-band data collection with a moving receiver to demonstrate algorithms to exploit bistatic synthetic aperture radar data with unknown parameters in non-cooperative environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.012 million. Justification for this decrease is described in plans above.			
Accomplishments/Planned Programs Subtotals	34.807	32.370	32.281

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*	Project (Number/Name) 627622 / *RF Sensors and Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
627622: *RF Sensors and Countermeasures Tech*	-	49.439	50.989	55.604	0.000	55.604	58.328	59.910	59.503	57.449	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 ISR 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 position navigation and timing integrity, accuracy, and resiliency.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Hybrid Sensor Technologies	10.151	11.256	13.069
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 2018 Plans: Conduct research to provide optimal frameworks for hybrid navigation sensor integration and modeling and simulation. Continue research regarding alternative navigation and timing technologies. Explore technologies to support precise time and time transfer with airborne platforms. Continue bandwidth efficient communication protocol research to support collaborative state estimation techniques to enable common model referencing for position, navigation and timing in Global Positioning System denied environments. Continue modeling and simulation studies to address the multispectrum threat. Continue integration of passive radar illumination selection manager hardware and software and conduct data collection on a finite number of radio frequency emitters (cooperative/non-cooperative) and assess the utility of correlated multi-mode (for example synthetic aperture radar, moving target indication and signals intelligence) operation.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 627622 / *RF Sensors and Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue research to provide optimal frameworks for hybrid navigation sensor integration and modeling and simulation. Continue alternative navigation and timing technologies research. Continue exploring technologies to support precise time and time transfer with airborne platforms. Continue bandwidth efficient communication protocol research to support collaborative state estimation techniques to enable common model referencing for position, navigation and timing in Global Positioning System denied environments. Continue modeling and simulation studies to address the multispectrum threat. Continue passive radar illumination selection manager hardware and software development and assess the utility of correlated multi-mode (for example synthetic aperture radar, moving target indication and signals intelligence) operation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.813 million. Increase is due to realignment of Electronic Combat Technology and Advanced Aerospace Sensors Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors Applied Research.			
Title: Radio Frequency Sensor Technologies ***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. ***FY 2018 Plans:*** Develop passive radar illumination selection manager electronic support hardware and electromagnetic environment forensics software. Conduct system engineering analysis to provide test criteria for critical experiment. ***FY 2019 Plans:*** The radio frequency countermeasures technology work performed in fiscal year 2018 in this effort, was moved in fiscal year 2019 to Project 627622, Radio Frequency Sensors and Countermeasures Technology, Radio Frequency Countermeasures Technology effort. Integrate passive radar illumination selection manager hardware and software and conduct data collection on a finite number of radio frequency emitters (cooperative/non-cooperative) and assess the utility of correlated multi-mode (synthetic aperture radar/moving target indicator/signals intelligence) operation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $6.750 million. Decrease is due to realignment of Electronic Combat Technology and Advanced Aerospace Sensors Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors Applied Research.	13.419	14.878	8.128
Title: Multi-Band/Multi-Beam Technologies	9.181	10.181	11.315

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 627622 / *RF Sensors and Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Develop multi-band and multi-beam forming technologies. Address technologies for antenna array operations in dynamic sensor networks. ***FY 2018 Plans:*** Integrate conformal/planar multi-band (C- and Ka Bands) radio frequency antenna proof-of-concepts with select multi-beam technologies for multi-spectral sensing capability. Employ adaptive, reconfigurable and tunable detection methods and techniques as effective optional countermeasures on sensing blue force platforms. ***FY 2019 Plans:*** Validate through radio frequency range testing simultaneous multibeam, conformal antenna with integrated radar/communication and multi-spectral signal processing functions on representative low-cost, size, weight and power constrained platforms (for example, Miniature Air-Launched Decoy). Continue to employ adaptive, reconfigurable and tunable detection methods and techniques as effective optional countermeasures on sensing blue force platforms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.134 million. Increase is due to realignment of Electronic Combat Technology and Advanced Aerospace Sensors Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors Applied Research.			
Title: Sensor Resource Management ***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. ***FY 2018 Plans:*** Continue demonstration of robust modeling and simulation capability to study the efficiency versus effectiveness of distributed electronic warfare assets including electronic support and electronic attack capabilities. Continue research into effective management of electronic warfare assets in operational environments focusing on a multi-ship strike package employment. Validate single and multi-ship sensor resource management under high fidelity modeling and simulation conditions, and under the construct of an open mission systems architecture. Continue to develop additional functional disciplines (radar, electro-optical/ infrared, high energy laser) in the service oriented architecture and sensor resource optimization. Continue bandwidth efficient communication protocol research to support collaborative state estimation techniques to enable common model referencing for position, navigation and timing in Global Positioning System denied environments. ***FY 2019 Plans:***	13.233	14.674	9.411

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 627622 / *RF Sensors and Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
The radio frequency countermeasures technology work performed in fiscal year 2018 in this effort, was moved in fiscal year 2019 to Project 627622, RF Sensors and Countermeasures Tech, Radio Frequency Countermeasures Technology effort. Assess fidelity of sensor resource manager Air Force Simulation models with leveraged flight test data (radar, electro-optical/infrared) collected under Defense Advanced Research Projects Agency's System of Systems Integration Technology and Experimentation Program. Complete single ship sensor resource management effort resulting in radio frequency multi-function/multi-mode use cases for size, weight and power constrained platforms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $5.263M. Decrease is due to realignment of Electronic Combat Technology and Advanced Aerospace Sensors Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors Applied Research.			
Title: Radio Frequency Countermeasure Technologies ***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. ***FY 2018 Plans:*** For FY 2018, this work is performed in PE 0602204F, Project 627622, RF Sensors and Countermeasures Tech, under the efforts Radio Frequency Sensor Technologies and Sensor Resource Management. ***FY 2019 Plans:*** Conduct 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. Extend research to address dynamic planning for collaborative autonomous electronic warfare systems. Demonstrate robust modeling and simulation capability to study the efficiency versus effectiveness of distributed electronic warfare assets including electronic support and electronic attack capabilities. Continue research into effective management of electronic warfare assets in operational environments focusing on a multi-ship strike package employment. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $13.681 million. Increase is due to the realignment of Radio Frequency Sensor Technologies and Sensor Resource Management efforts within Project 627622, RF Sensors and Countermeasures Tech. Additionally, the increase was impacted by the realignment of Electronic Combat Technology and Advanced Aerospace Sensors Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors Applied Research.	-	0.000	13.681
Accomplishments/Planned Programs Subtotals	45.984	50.989	55.604

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 627622 / *RF Sensors and Countermeasures Tech*

	FY 2017	FY 2018
Congressional Add: Program Increase - Spectrum Monitoring ***FY 2017 Accomplishments:*** Conducted congressionally directed effort. ***FY 2018 Plans:*** N/A.	3.455	0.000
Congressional Adds Subtotals	3.455	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602298F / *Science and Technology Management - Major Headquarters Activities*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	0.000	8.353	8.288	0.000	8.288	8.302	8.454	8.615	8.796	Continuing	Continuing
622520: *Science and Technology Management - Major HQ*	-	0.000	8.353	8.288	0.000	8.288	8.302	8.454	8.615	8.796	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.

In FY 2018, PE 0602298F, Science and Technology Management - Major Headquarters Activities, Project 622520, Science and Technology Management - Major HQ, was established to provide increased transparency to Congress on personnel in Major Headquarters Activities (MHA). A portion of HQ AFRL civilian manpower was transferred into this PE from the following Air Force S&T RDT&E PEs: 0601102F, Basic Research; 0602102F, Materials; 0602201F, Aerospace Vehicle Technologies; 0602203F, Aerospace Propulsion; 0602204F, Aerospace Sensors; 0602601F, Space Technology; 0602602F, Conventional Munitions; 0602605F, Directed Energy Technology; and 0602788F, Dominant Information Sciences and Methods. This was an administrative realignment and not a new start. Prior year funding in this exhibit was previously budgeted in the Air Force S&T RDT&E PEs listed above.

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, 0602601F, 0602602F, 0602605F, 0602788F, and 1206601F.

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force					Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*		R-1 Program Element (Number/Name) PE 0602298F / *Science and Technology Management - Major Headquarters Activities*			
B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	0.000	8.353	8.314	0.000	8.314
Current President's Budget	0.000	8.353	8.288	0.000	8.288
Total Adjustments	0.000	0.000	-0.026	0.000	-0.026
• 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	-0.026	0.000	-0.026

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602298F / *Science and Technology Management - Major Headquarters Activities*	**Project (Number/Name)** 622520 / *Science and Technology Management - Major HQ*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622520: *Science and Technology Management - Major HQ*	-	0.000	8.353	8.288	0.000	8.288	8.302	8.454	8.615	8.796	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.

In FY 2018, PE 0602298F, Science and Technology Management - Major Headquarters Activities, project 622520, Science and Technology Management - Major HQ, was established to provide increased transparency to Congress on personnel in Major Headquarters Activities (MHA). A portion of HQ AFRL civilian manpower was transferred into this PE from the following Air Force S&T RDT&E PEs: 0601102F, Basic Research; 0602102F, Materials; 0602201F, Aerospace Vehicle Technologies; 0602203F, Aerospace Propulsion; 0602204F, Aerospace Sensors; 0602601F, Space Technology; 0602602F, Conventional Munitions; 0602605F, Directed Energy Technology; and 0602788F, Dominant Information Sciences and Methods. This was an administrative realignment and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: AFRL - Major Headquarters Activities	0.000	8.353	8.288
Description: Provide professional government civilian workforce in support of all AFRL programs and activities. ***FY 2018 Plans:*** Provide professional government civilian workforce in support of all AFRL programs and activities. ***FY 2019 Plans:*** Provide professional government civilian workforce in support of all AFRL programs and activities. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by 0.065 million due to Department of Defense (DoD) deflation factors.			
Accomplishments/Planned Programs Subtotals	0.000	8.353	8.288

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602298F / *Science and Technology Management - Major Headquarters Activities*	**Project (Number/Name)** 622520 / *Science and Technology Management - Major HQ*

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	119.670	116.503	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
621010: *Space Survivability & Surveillance*	-	39.864	39.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
624846: *Spacecraft Payload Technologies*	-	15.758	15.841	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
625018: *Spacecraft Protection Technology*	-	19.507	21.720	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
628809: *Spacecraft Vehicle Technologies*	-	44.541	39.842	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 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.

In FY 2019, the entirety of PE 0602601F, Space Technology, will transfer to PE 1206601F, Space Technology, to provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment.

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, 1206601F, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force					Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*			R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*		
B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	117.915	116.503	114.683	0.000	114.683
Current President's Budget	119.670	116.503	0.000	0.000	0.000
Total Adjustments	1.755	0.000	-114.683	0.000	-114.683
• 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	3.610	0.000			
• SBIR/STTR Transfer	-1.855	0.000			
• Other Adjustments	0.000	0.000	-114.683	0.000	-114.683

Change Summary Explanation

Increase in FY 2017 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Decrease in FY 2019 due to the transfer of the entire PE 0602601F, Space Technology, to PE 1206601F, Space Technology.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*	Project (Number/Name) 621010 / *Space Survivability & Surveillance*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
621010: *Space Survivability & Surveillance*	-	39.864	39.100	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 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.

For FY 2019 and beyond, the entirety of the Project 621010, Space Survivability and Surveillance, will be reported under PE 1206601F, Space Technology, Project 621010, Space Survivability and Surveillance. This administrative transfer will provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Space Environment Research	13.606	13.460	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 2018 Plans: Begin evaluation of next-generation solar particle event models for operational suitability. Develop suitable trapped energetic particle specification model for inclusion in rapid anomaly resolution tool. Begin chemical analysis of aged spacecraft materials for electrical and optical property changes. Begin exploitation of unique internal charging sensor with respect to space material aging. Continue analyzing and exploiting data from on-orbit assets. Continue to assess impacts of the arctic ionosphere on sensor systems. Continue to evaluate and refine Global Positioning System radio frequency exploitation algorithms for global scintillation specification. Continue improvements of state-of-the-art solar magnetic flux transport model for more reliable forecast of solar radio and extreme ultraviolet flux levels. Validate the advanced ionosphere-thermosphere model. Continue work on hybrid hypersonic solvers.			
FY 2019 Plans: For FY 2019, this work will be performed under the Space Environment Research effort in PE 1206601F, Space Technology, Project 621010, Space Survivability & Surveillance.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $13.460 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Surveillance Technologies ***Description:*** Develop advanced target detection techniques, spectral signature libraries, and decision aids for space-based sensors and surveillance systems. ***FY 2018 Plans:*** Complete assessment of target detection methodologies for hypertemporal imaging-based, missile warning concepts. Continue evaluation of computational methods for reducing time-critical downlink of missile warning and surveillance data through state-of-the-art data compression capabilities. Analyze missile-like events observed by hypertemporal imaging-dedicated space experiment to continue evaluation of hypertemporal imaging concept for early warning of theater ballistic missile launches. Initiate study of analytic approaches to space-based sensing of new and emerging ballistic and non-ballistic threats in denied areas. ***FY 2019 Plans:*** For FY 2019, this work will be performed under the Surveillance Technologies effort in PE 1206601F, Space Technology, Project 621010, Space Survivability & Surveillance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $8.202 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.	7.990	8.202	0.000
Title: Radiation Remediation Research ***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. ***FY 2018 Plans:*** Complete reduction and exploitation of science data from the space experiments to finalize the validation of the end-to-end model. Complete study to determine technical feasibility of a fielded ground or space-based system using the final validated end-to-end model. ***FY 2019 Plans:*** For FY 2019, this work will be performed under the Radiation Remediation Research effort in PE 1206601F, Space Technology, Project 621010, Space Survivability & Surveillance. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	3.946	2.625	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $2.625 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Seismic Technologies ***Description:*** 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. ***FY 2018 Plans:*** Implement high performance computing capabilities to automate the detection, location, and discrimination of seismic events. Test and provide high-performance computing modeling and simulation codes to model full seismic waveforms for operational expert analysis of difficult-to-discriminate earthquakes and explosions. Provide improved understanding of the behavior of discriminants for local and regional seismic events. Explore the application of big-data heuristics to more quickly characterize seismic events. ***FY 2019 Plans:*** For FY 2019, this work is performed the under the Seismic Technologies effort in PE 1206601F, Space Technology, Project 621010, Space Survivability & Surveillance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $6.281 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.	6.565	6.281	0.000
Title: Alternative Navigation Technologies ***Description:*** 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. ***FY 2018 Plans:*** Begin testing of advanced compact atomic clocks with improved accuracy and stability to replace legacy atomic clocks. Complete testing of advanced clock from National Institute of Standards and Technology. Package system for flight on experimental satellite system. Begin testing of free-space, cold atom 3-axis gyroscope/accelerometer that will enable Global Positioning System-free precision navigation. Begin planning for packaging of system for test on aircraft flight experiment or other suitable platform. ***FY 2019 Plans:*** For FY 2019, this work is performed under Alternative Navigation Technologies effort in PE 1206601F, Space Technology, Project 621010, Space Survivability & Surveillance. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	7.757	8.532	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $8.532 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Accomplishments/Planned Programs Subtotals	39.864	39.100	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*	Project (Number/Name) 624846 / *Spacecraft Payload Technologies*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
624846: *Spacecraft Payload Technologies*	-	15.758	15.841	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 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.

In FY 2019, the entirety of Project 624846, Spacecraft Payload Technologies will be reported under PE 1206601F, Space Technology, Project 624846, Spacecraft Payload Technologies. This administrative transfer will provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Space-Based Detector Technologies	3.341	3.290	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 2018 Plans:*** Focus on growing larger infrared detectors with emphasis on noise-equivalent operability reflective of space-based launch detection missile warning applications with derivative benefits for tactical applications. Characterize detectors in a representative space environment to include surface charging, latch-up, and displacement damage. Iterate upon design to ensure suitability for space operation. ***FY 2019 Plans:*** For FY 2019, this work is performed under the Space-Based Detector Technologies effort in PE 1206601F, Space Technology, Project 624846, Spacecraft Payload Technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $3.290 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Space Electronics Research	2.723	2.715	0.000
Description: Develop technologies for space-based payload components such as radiation-hardened electronic devices, micro-electro-mechanical system devices, and advanced electronics packaging.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 624846 / *Spacecraft Payload Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Continue development of trusted electronics path as it applies to space technology tools and fabrication. Continue development of three-dimensional electronics to extend technology node density. Investigate alternative memory approaches for high density memory. Continue advanced transistor efforts transitioning techniques to mainstream manufacturing. Finalize Gallium Nitride transistor radiation mitigation results and techniques to the electronics manufacturing community. Continue to transition benchmarking results to user for selection of technology path while updating capability to keep pace with state-of-the-art. ***FY 2019 Plans:*** For FY 2019, this work is performed under the Space Electronics Research effort in PE 1206601F, Space Technology, Project 624846, Spacecraft Payload Technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $2.715 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Modeling and Simulation Tools for Space Applications ***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. ***FY 2018 Plans:*** Define mission-level military utility analyses of various space sensing, satellite navigation and communication architecture approaches. Refine guidelines and checkpoints to evaluate maturity and applicability of emerging space technologies to support various Air Force Research Laboratory technical programs, Department of Defense customers and wargame events. Continue development of models and mission simulations enabling analysis of contested space environment and space enterprise capabilities. ***FY 2019 Plans:*** For FY 2019, this work is performed under the Modeling and Simulation Tools for Space Applications effort in PE 1206601F, Space Technology, Project 624846, Spacecraft Payload Technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $5.306 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.	5.054	5.306	0.000
Title: Alternative Positioning, Navigation, and Timing Technology ***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	4.640	4.530	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 624846 / *Spacecraft Payload Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
current capabilities. Develop technologies to meet identified Air Force Space Command/Space and Missile Systems Center positioning, navigation, and timing space payload technology needs. ***FY 2018 Plans:*** Complete in-house laboratory feasibility experiments on an advanced digital payload for future Global Positioning System application. Conduct in-house experiment to prove the ability of at least two advanced signal concepts to overcome adversarial countermeasures. Continue studies to identify alternative and innovative technologies that are viable for positioning, navigation, and timing payloads and to investigate advanced signal concepts. ***FY 2019 Plans:*** For FY 2019, this work is performed under the Alternative Positioning, Navigation, and Timing Technology effort in PE 1206601F, Space Technology, Project 624846, Spacecraft Payload Technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $4.530 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Accomplishments/Planned Programs Subtotals	15.758	15.841	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*	Project (Number/Name) 625018 / *Spacecraft Protection Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625018: *Spacecraft Protection Technology*	-	19.507	21.720	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 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 developing technologies to mitigate the effects of both intentional and unintentional threats.

In FY 2019, the entirety of Project 625018, Spacecraft Protection Technology will be reported under PE 1206601F, Space Technology, Project 625018, Spacecraft Protection Technology. This administrative transfer will provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Threat Warning Research	19.507	21.720	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 2018 Plans: Begin satellite protection techniques to continued development of advanced algorithms for sensor data fusion and satellite threat detection, assessment, and response. Expand space situational awareness-focused data analysis methods including physics-based sensor model development for use in data filtering. Develop additional advanced filtering techniques accommodating nonlinear dynamics and non-normal random variable distributions. Mature concepts of new electro-optical and radio frequency sensors for space object identification and characterization. Incorporate customer feedback into closed loop sensor tasking concept for space surveillance combining commercial and government sensor assets. Continue assessment and development of commercial remote sensing data and information to fill gaps in coverage for monitoring and tracking ground and space objects. Continue engagements with commercial space data providers for testing new enabling technologies on commercial satellites. Operate ground test facility to evaluate performance of integrated technology solutions in contested space, cyber, and radio frequency environment. Conduct red-teaming to evaluate effectiveness of specific space cyber resiliency technologies. Develop and refine bare-metal hypervisor and associated security modules and expand to multiple computer architectures. Continue development of hosted payload options for enhanced satellite survivability and mission assurance in contested environments.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 625018 / *Spacecraft Protection Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
For FY 2019, this work is performed under the Threat Warning Research effort in PE 1206601F, Space Technology, Project 625018, Spacecraft Protection Technology. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $21.720 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Accomplishments/Planned Programs Subtotals	19.507	21.720	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*	Project (Number/Name) 628809 / *Spacecraft Vehicle Technologies*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
628809: *Spacecraft Vehicle Technologies*	-	44.541	39.842	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 focuses on spacecraft platforms (for example, structures, power, and thermal management); satellite control (such as, signal processing and control); and space experiments of maturing technologies for space qualification.

In FY 2019, the entirety of Project 628809, Spacecraft Vehicle Technologies, will be reported under PE 1206601F, Space Technology, Project 628809, Spacecraft Vehicle Technologies. This administrative transfer will provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Space Power/Thermal Research	4.933	4.547	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 2018 Plans:*** Continue research into approaches for greater than 40% solar cell efficiency. Complete initial investigation of photon management approaches for increased end-of-life performance. Continue development of advanced array technologies to meet 70-80 kilowatt per cubic meter array performance. ***FY 2019 Plans:*** For FY 2019, this work is performed under the Space Power/Thermal Research effort in PE 1206601F, Space Technology, Project 628809, Spacecraft Vehicle Technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $4.547 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Space Structures and Controls Research	11.437	8.527	0.000
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. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 628809 / *Spacecraft Vehicle Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue collaborative autonomous multi-spacecraft control algorithms in laboratory and high-fidelity simulations/hardware test boards including embedded processor implementations. Continue reactive maneuver strategies for spacecraft resiliency in laboratory simulation and initiate high-fidelity simulations/hardware test boards. Continue research in verification and validation techniques for autonomous spacecraft flight software. Initiate improved estimation algorithms for on-orbit navigation software. Complete development of energy responsive technologies to control electromagnetic interactions of spacecraft structures and antennas. Continue development of United States space asset protection technologies including deployable structures enabling affordable protection concepts, thermal technologies for threat identification and mitigation, and local area sensing concepts. Continue development of advanced, agile manufacturing and assembly technologies for satellite production to improve system performance and affordability. Initiate research in affordable, high-performance phased arrays and electrically steerable antennas for tactical communication and radar concepts. ***FY 2019 Plans:*** For FY 2019, this work is performed under the Space Structures and Controls Research effort in PE 1206601F, Space Technology, Project 628809, Spacecraft Vehicle Technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $8.527 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Space Experiments ***Description:*** Develop flight experiments to improve the capabilities of existing operational space systems and to enable new transformational space capabilities. ***FY 2018 Plans:*** Complete on-orbit early checkout for radiation remediation proof-of-concept experiment and complete one year of experimental activities. Initiate on-orbit testing and verification of a fourth generation geosynchronous orbit based missile warning payload to demonstrate hypertemporal imaging capabilities to detect missile launches under sun-lit clouds, potentially enabling all weather early missile detection. Begin on-orbit testing and verification of an integrated, on-board sensing, assessment, and autonomy technology demonstration payload at geosynchronous orbit, demonstrating geosynchronous orbit asset resiliency to a specific set of on-orbit events enabling system mission assurance in a degraded space environment. Continue development and testing of next-generation small satellite space experiment. Continue development of on-orbit experiment plan and mission objectives/ data requirements for space based integrated demonstration of an advanced Global Positioning System payload for contested environments. ***FY 2019 Plans:***	18.829	18.435	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 628809 / *Spacecraft Vehicle Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
For FY 2019, this work is performed under the Space Experiments effort in PE 1206601F, Space Technology, Project 628809, Spacecraft Vehicle Technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $18.435 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
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 2018 Plans:*** Support integration and test of the W and V frequency band flight instrument onto the host spacecraft. Fabricate, test, and deploy the last three operational, remotely controlled W and V frequency band ground terminals and shelter units. Establish and test network connections to remote ground terminals. Establish W and V frequency band flight experiment operations center, prepare staff, and test data analysis tools. Establish interface to host mission operations center for receiving telemetry. Conduct initial design and hardware test board testing of the W and V frequency band follow-on project. Continue to support development of critical space and ground terminal technology, such as multi-beam antenna, high power amplifiers, low noise amplifiers, reconfigurable radios, and wideband modem and signal processing technology. ***FY 2019 Plans:*** For FY 2019, this work is performed under the Space Communication Technologies effort in PE 1206601F, Space Technology, Project 628809, Spacecraft Vehicle Technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $8.333 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.	9.342	8.333	0.000
Accomplishments/Planned Programs Subtotals	44.541	39.842	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 628809 / *Spacecraft Vehicle Technologies*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602602F / *Conventional Munitions*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	110.074	112.195	112.841	0.000	112.841	129.393	137.159	146.218	139.010	Continuing	Continuing
622068: *Advanced Guidance Technology*	-	53.158	55.925	57.513	0.000	57.513	65.023	68.807	72.176	68.758	Continuing	Continuing
622502: *Ordnance Technology*	-	56.916	56.270	55.328	0.000	55.328	64.370	68.352	74.042	70.252	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 is in Budget Activity 2, Applied Research, and projects 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, 0602601F, 0602605F, 0602788F, 1206601F, 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	109.649	112.195	113.831	0.000	113.831
Current President's Budget	110.074	112.195	112.841	0.000	112.841
Total Adjustments	0.425	0.000	-0.990	0.000	-0.990
• 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	2.271	0.000			
• SBIR/STTR Transfer	-1.846	0.000			
• Other Adjustments	0.000	0.000	-0.990	0.000	-0.990

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*

Change Summary Explanation

Increase in FY 2017 reflects reprogramming to support Research and Development Projects, 10 U.S.C Section 2358.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / *Conventional Munitions*	Project (Number/Name) 622068 / *Advanced Guidance Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622068: *Advanced Guidance Technology*	-	53.158	55.925	57.513	0.000	57.513	65.023	68.807	72.176	68.758	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-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)	FY 2017	FY 2018	FY 2019
Title: Seeker Technologies	10.529	9.495	10.480

Description: Develops seeker technologies for air-delivered munitions to provide high-confidence target discrimination and classification, precise target location, and robust terminal tracking.

FY 2018 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 and mathematical approaches to integrate weapons into the kill chain and enable distributive, flexible seeker imaging targeting with or without an operator in the loop. Continue to explore terminal seeker technologies that enable innovative air-to-air engagements for fifth-generation aircraft and beyond. Continue to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker subsystems. Continue to develop distributed, low-cost seeker technology hardware. Continue to explore specific techniques for seeker cost reduction with performance improvement; novel technical approaches such as sparse sensing and compressive sensing will be investigated. Continue to conduct research on integrated processing techniques to enable networked systems. Initiate small, air-to-air, self-defense munitions research effort.

FY 2019 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 and mathematical approaches to integrate weapons into the kill chain and 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 and beyond. Continue to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker subsystems. Continue to develop distributed, low-cost seeker technology hardware. Continue to explore specific techniques for seeker cost reduction with

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622068 / *Advanced Guidance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
performance improvement; novel technical approaches such as sparse sensing and compressive sensing will be investigated. Continue to conduct research on integrated processing techniques to enable networked systems. Continue development and early testing of small, air-to-air, self-defense munitions seeker technology including initial captive flight testing and hardware in the loop testing. Continue to develop open seeker architecture software in the loop integration laboratory. Initiate the investigation of the technical challenges of cooperative radio frequency functions including coherent on transmit and coherent on receive operation. Initiate software development kit for Open Seeker Architecture to enable rapid technology insertion into software-defined, multi-function seekers. Initiate the development of tools for evaluation of deep-learning networks to evaluate feasibility for weapon seekers. Initiate exploration of Open Architecture systems' cyber vulnerabilities and formulate software resilient techniques. Initiate data collection experiments to support cooperative radio frequency systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.985 million. Justification for increase is described in the plans above.			
Title: Aerodynamics, Navigation, and Control Technologies	29.569	28.178	28.716
Description: Develops weapon aerodynamic, control, navigation, and networking technologies for air-delivered munitions to provide precise, agile flight, networked effects, and immunity to countermeasures. ***FY 2018 Plans:*** Continue to mature linked aero-structural-thermal computational tools to predict flight performance of hypersonic weapons and tools to develop prototype concepts for further analysis. Continue to mature algorithms for guidance and control of advanced weapons concepts in a contested electromagnetic environment. Continue to develop technologies that achieve precision navigation under Global Positioning System-degraded and Global Positioning System-denied conditions. Continue development of weapon platform interfaces, including advanced high capacity carriage and release technology. Continue to integrate algorithms to support distributed, multi-strategy weapon concept-of-operations to defeat enemy defenses. Continue to develop airframe and control technologies that enable innovative air-to-air engagements. Continue conducting flight demonstrations of precision navigation of weapons without Global Positioning System experiments to characterize innovative air-to-air high off-bore sight missile maneuverability and hit-to-kill agility. Continue conducting experiments to demonstrate precision navigation using celestial aiding for long-range flights at high and low altitudes. Continue conducting experiments to demonstrate algorithms implementing cooperation and collaboration between multiple surrogate weapon platforms. Continue the development and demonstration of component modular and service-oriented weapon architectures for seeker navigation, and data services that use reconfigurable weapon sensors. Continue conducting flight innovative air-to-air high off-bore sight missile maneuverability and hit-to kill agility. Continue conducting ground tests of rocket motor component technologies to evaluate their ability to increase weapon range and reduce size and weight. Initiate small, air-to-air, self-defense munitions research effort. ***FY 2019 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622068 / *Advanced Guidance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue the maturation of linked aero-structural-thermal computational tools to predict flight performance of hypersonic weapons and tools to develop prototype concepts for further analysis. Initiate the transition of linked aero-structural-thermal computational tools to the hypersonic weapons program office. Initiate assistance of program office to assess contractor concepts. Continue to refine and demonstrate via captive and surrogate flight test, a precision navigation method that does not rely on Global Positioning System. Initiate the demonstration via captive and surrogate flight test, of a precision navigation method that does not rely on Global Positioning System. Initiate the transition M-Code compliant anti-jam Global Positioning System chip set. Continue development of weapon platform interfaces. Initiate a weapon demonstration concept and showing an increase of load-out by double. Complete the integration of algorithms to support distributed, multi-strategy weapon concept-of-operations to defeat enemy defenses. Initiate development of flight test algorithms for multi-agent navigation aiding that uses data link information to bound drift of a swarm of weapons on small, large-scale airframes. Continue ground testing of advanced guidance laws and actuators that enable innovative air-to-air engagements and hyper agility including hit-to-kill. Continue conducting experiments to demonstrate precision navigation using celestial aiding for long-range flights at high and low altitudes. Continue small, air-to-air, self-defense munitions research effort. Initiate demonstration, via flight test, cooperation, and collaboration of a swarm of small cruise missiles flying into an operationally relevant threat environment having the ability to find, locate, and overwhelm targets. Initiate 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, design the ingress method to include packaging multi rotor aircraft into common launch tubes. Complete conducting ground tests of rocket motor component technologies to evaluate their ability to increase weapon range and reduce size and weight. Initiate the development of defensive cyber algorithms for autopilot and navigation functions, including swarms. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.538 million. Justification for increase is described in the plans above.			
Title: Guidance Technologies	13.060	18.252	18.317
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. ***FY 2018 Plans:*** Continue to support flight demonstrations of critical behaviors for Distributed, Cooperative, Collaborative strategies. Continue to develop improved simulation technologies that evaluate innovative air-to-air engagements. 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. Continue to develop simulation technologies that evaluate cooperative, flexible munition target engagements. Continue to develop a modular radio frequency hardware-in-the-loop capability to support munitions concepts with high speed			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622068 / *Advanced Guidance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
target engagement. Continue to develop new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems. ***FY 2019 Plans:*** Continue to support flight demonstrations of critical behaviors for Distributed, Cooperative, Collaborative strategies and other advanced guidance capabilities by improving constructive and virtual analysis tools for design, development, and analysis of advanced weapon concepts in representative environments. Continue to perform constructive and virtual analysis on numerous weapon concepts providing design, performance, and trade space analysis to the program offices. Continue to develop improved simulation technologies that evaluate innovative air-to-air engagements to include guidance 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. Continue to develop simulation technologies that evaluate cooperative, flexible monition target engagements. Continue to transition our engineering models to Air Force mission level simulation for analysis. Initiate constructive and virtual analysis on numerous weapon concepts to provide design, performance, and trade space analysis to the program offices. Continue to develop a modular radio frequency Hardware-in-the-loop capability to support munitions concepts with high speed target engagement. Continue to improve capabilities of our reconfigurable radio frequency hardware-in-the-loop chamber to handle faster and more complex scenes. Continue to develop new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems. Initiate and complete the startup of a Modeling and Simulation center at multi-level security enabling cross-domain, distributed, multi-level security Modeling and Simulation activities. Initiate a help desk and configuration control of higher fidelity simulation codes for mission level analysis. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.065 million. Justification for increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	53.158	55.925	57.513

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / *Conventional Munitions*	Project (Number/Name) 622502 / *Ordnance Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622502: *Ordnance Technology*	-	56.916	56.270	55.328	0.000	55.328	64.370	68.352	74.042	70.252	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 2017	FY 2018	FY 2019
Title: Energetic Materials Technology	10.098	9.981	9.744
Description: Investigates and develops energetic materials and technology that safely and securely optimize survivability, cost, and weapon lethality for air-delivered munitions.			
FY 2018 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.			
FY 2019 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.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622502 / *Ordnance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $0.237 million. Justification for decrease is described in the plans above.			
Title: Fuze Technologies ***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 2018 Plans:*** Continue to develop testing capabilities for munitions penetration scenarios and increase Modeling and Simulation capabilities to reduce research and development costs and time lines. 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 munition 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. ***FY 2019 Plans:*** Continue to develop testing capabilities for munitions penetration scenarios and increase Modeling and Simulation capabilities to reduce research and development costs and time lines. 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.326 million. Justification for decrease is described in the plans above.	10.697	9.756	9.430
Title: Warhead Technologies ***Description:*** Investigate and develop innovative warhead kill mechanisms for air-delivered weapons that maximize weapon lethality for all engagement scenarios. ***FY 2018 Plans:*** 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	20.123	19.657	19.375

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622502 / *Ordnance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
particle interactions. Begin integration of warhead research with related activities planned for the advanced/integrated ordnance subsystems research capability. ***FY 2019 Plans:*** 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. Begin integration of warhead research with related activities planned for the advanced/integrated ordnance subsystems research capability. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.282 million. Justification for decrease is described in the plans above.			
Title: Ordnance Technologies ***Description:*** 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. ***FY 2018 Plans:*** 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. Continue to implement cost-effective and rapid transition war-head technologies for inventory penetrators. 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 Modeling and Simulation tools and analysis techniques to understand energy partitioning in order to optimize lethality with a focus on blast wave interactions, cumulative and collaborative damage, and distributed blast. ***FY 2019 Plans:*** 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. Continue to implement cost-effective and rapid transition war-head technologies for inventory penetrators. Continue to conduct Modeling and Simulation that explores the ordnance technology trade space for low-cost, long-range munition concepts. Continue	15.998	16.876	16.779

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622502 / *Ordnance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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. Complete the development of Modeling and Simulation tools and analysis techniques to understand energy partitioning in order to optimize lethality with a focus on blast wave interactions, cumulative and collaborative damage, and distributed blast. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.097 million. Justification for decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	56.916	56.270	55.328

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602605F / *Directed Energy Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	127.365	132.993	141.898	0.000	141.898	133.106	134.172	136.237	129.251	Continuing	Continuing
624866: *Lasers & Imaging Technology*	-	92.797	99.946	108.392	0.000	108.392	96.403	96.141	96.241	91.294	Continuing	Continuing
624867: *Advanced Weapons & Survivability Technology*	-	34.568	33.047	33.506	0.000	33.506	36.703	38.031	39.996	37.957	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program covers research in directed energy weapon technologies, primarily high energy lasers; including laser devices, optical beam control; integration; target lethality/vulnerability assessments; ground-based optical space situational awareness; and high power microwaves. Laser research includes moderate to high power laser devices that are applicable to a wide range of applications, optical technologies to propagate lasers beams through the atmosphere, and integration of these technologies into demonstration packages. In space situational awareness, this research uses the Starfire Optical Range and the Maui Space Surveillance System 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 weapon vulnerability/lethality assessments; develops protection technologies versus directed energy weapons; 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, 0602601F, 0602602F, 0602788F, 1206601F, and 0602298F."

This program is in Budget Activity 2, Applied Research because it 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

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force					Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*			R-1 Program Element (Number/Name) PE 0602605F / *Directed Energy Technology*		
B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	127.163	132.993	128.039	0.000	128.039
Current President's Budget	127.365	132.993	141.898	0.000	141.898
Total Adjustments	0.202	0.000	13.859	0.000	13.859
• 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	2.762	0.000			
• SBIR/STTR Transfer	-2.560	0.000			
• Other Adjustments	0.000	0.000	13.859	0.000	13.859

Change Summary Explanation

Increase in FY 2017 reflect reprogramming to support Research and Development Projects, 10 U.S.C., Section 2358.

Increase in FY 2019 due to realignment of funds to focus on Directed Energy Game Changer efforts.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / *Directed Energy Technology*	Project (Number/Name) 624866 / *Lasers & Imaging Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
624866: *Lasers & Imaging Technology*	-	92.797	99.946	108.392	0.000	108.392	96.403	96.141	96.241	91.294	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 weapon and non-directed energy weapon concept development and assessment tools to determine which technology solutions to pursue. This project conducts research supporting ground-based optical space situational awareness.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: High Energy Laser Technologies and Directed Energy Assessments	65.408	66.657	79.824

Description: Develop and demonstrate high energy laser device technologies for Air Force applications. Develop and demonstrate optical 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 directed energy weapon concepts and tradeoffs between directed energy weapon and non-directed energy weapon solutions. Integrate optical beam control technologies with laser device technologies and demonstrate the combined technologies. Develop and use technologies to better understand the vulnerability of weapon systems to high energy lasers.

FY 2018 Plans:

Develop beam control technologies including aero-effects mitigation techniques. Power scale monolithic fiber amplifiers using advanced fibers. Conduct effects testing to establish system requirements and validate models. Integrate beam control and low power laser subsystems for fiscal year (FY) 2021 pod-mounted moderate power airborne laser demonstration vs representative targets. Transition the Integrated Weapons Environment for Analysis Build 2 to external users and transition Integrated Weapons Environment for Analysis into an advanced framework to support Air Force Research Laboratory-wide Modeling, Simulation & Analysis environment. Assess directed energy weapon and/or synergistic directed energy weapon/kinetic energy weapon capabilities to help users plan weapon investments. Model and characterize foreign high energy laser threats, and provide information to develop mitigation techniques to protect blue assets.

FY 2019 Plans:

Continue to develop beam control technologies including aero-effects mitigation techniques. Continue to power scale monolithic fiber amplifiers using advanced fibers. Continue with effects testing to establish system requirements and validate models. Finish integration of beam control and low power laser subsystems for FY 2021 pod-mounted moderate power airborne laser demonstration vs representative targets. Demonstrate Phase I low power laser system. Begin integration of moderate power

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624866 / *Lasers & Imaging Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
system into a pod for Phase 2 aircraft self-protect demonstration including ground support and aircraft interface. Continue to support and enhance Integrated Weapons Environment for Analysis for internal and external users and utilize Integrated Weapons Environment for Analysis 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increase compared to FY 2018 by $13.167 million. Justification for this increase is to accelerate high energy laser technology development and transition.			
Title: Optical Space Situational Awareness and Satellite Vulnerability	27.389	33.289	28.568
Description: Develop advanced, long-range, electro-optical technologies that enable ground-based optical 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 to conduct research meeting internal and customer requirements. ***FY 2018 Plans:*** Complete the dynamic telescope subsystems that maintain custody of high-priority threat objects in deep space, re-identify from night-to-night near-geosynchronous satellites, and search or dim objects lurking in objects in vicinity around high-value blue satellites. Report on the maturity of three sensor technologies for detection of geosynchronous satellites allowing custody through daytime hours when satellites cannot normally be detected by our ground-based optical systems. Mature component technologies for 24/7 real-time optical imaging of near-earth satellites enabling characterization on tactical timelines. Provide recommendations to Air Force programs on potential transitions of maturing technologies for space situational awareness and satellite modeling. Shift emphasis of laser-enabled space situational awareness research to full-dark imaging using laser illumination. Investigate through modeling and simulation the susceptibility of satellite optical systems 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 long-range secure optical communications technologies leveraging quantum science for free space laser-communication channels. Continue to maintain Starfire Optical Range facility and experimental equipment in a mission-ready state. ***FY 2019 Plans:*** Begin 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 geo-belt. 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 satellites enabling characterization on tactical timelines. Continue investigation through modeling and simulation the susceptibility			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624866 / *Lasers & Imaging Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
of satellite optical systems to laser threats to inform practical designs for protection equipment and for tactically-rapid course-of-action decision-making enabling protection methods. Continue maturing laser-enabled space situational awareness research focused on full-dark imaging using laser illumination. Investigate laser-enabled options for both ranging to and imaging to enable range-profiling of geosynchronous satellites from apertures smaller than three meters. smaller apertures, allowing rapid orbit determination from a broader range of electro-optical assets. Continue development of long-range secure optical communications technologies leveraging quantum science for free space laser-communication channels. Continue to maintain Starfire Optical Range facility and experimental equipment in a mission-ready state. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $4.721 million. Justification for this is to accelerate high energy laser technology development and transition.			
Accomplishments/Planned Programs Subtotals	92.797	99.946	108.392

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / *Directed Energy Technology*	Project (Number/Name) 624867 / *Advanced Weapons & Survivability Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
624867: *Advanced Weapons & Survivability Technology*	-	34.568	33.047	33.506	0.000	33.506	36.703	38.031	39.996	37.957	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 weapon and non-directed energy weapon 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 2017	FY 2018	FY 2019
Title: High Power Microwave and Unconventional Weapon Technologies	4.920	7.956	8.038
Description: Investigate technologies for high power microwave and unconventional weapon technology 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 2018 Plans:*** Begin ultra-short pulsed laser atmospheric propagation studies in a density gradient. Conduct effects studies on electronics based on the assessments from fiscal year (FY) 2016 and FY 2017 to support a joint high power microwave program with the Navy. Complete compact 50 kilovolt solid state switch for a militarily relevant platform. Initiate design of smaller, higher power, source technology for the joint Air Force - Navy high power microwave demonstration. ***FY 2019 Plans:*** Complete ultra-short pulsed laser atmospheric propagation studies in a density gradient. Complete effects studies on electronics based on the assessments from FY 2016 and FY 2017 to support a joint high power microwave program with the Navy. Design and develop high power microwave components for ground and aerial high power microwave demonstrators. Design and develop smaller, higher power, source technology for the joint Air Force-Navy high power microwave demonstration. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 compared to FY 2018 increased by $0.082 million. Justification for this increase is described in plans above.			
Title: High Power Microwave Effects and Mitigation Research	29.648	25.091	25.468

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624867 / *Advanced Weapons & Survivability Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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 microwave. ***FY 2018 Plans:*** Test and validate Phase 3 of directed energy High Performance Computing Software Applications Institute software, which allows modeling of directed energy sources and propagation that involves plasmas and laser directed energy weapons. Assess potential improvements to blue weapons systems from employing high power microwave weapons technologies for platform protection and target prosecution. Continue assessments of high power microwave and synergistic/kinetic energy weapon concept capabilities to help users plan weapons investments. Transition modeling, simulation and analysis tools to the broader modeling, simulation and analysis community. Transition Integrated Weapons Environment for Analysis Build 2 to external users and complete Integrated Weapons Environment for Analysis transition into an advanced framework to support Air Force Research laboratory wide modeling, simulation and analysis environment. ***FY 2019 Plans:*** Iteratively improve upon software applications that are hosted in the directed energy High Performance Computing Software Applications Institute for a broad spectrum directed energy sources. Develop end-to-end modeling and weapon utility assessments to incorporate high power microwave weapon technology into various platforms for multiple target prosecutions. Build 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 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.377 million. Justification for this increase is described in plans above.			
Accomplishments/Planned Programs Subtotals	34.568	33.047	33.506

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624867 / *Advanced Weapons & Survivability Technology*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	165.517	167.818	162.420	0.000	162.420	173.761	177.163	183.401	174.984	Continuing	Continuing
625315: *Connectivity and Protection Tech*	-	30.429	30.914	32.482	0.000	32.482	32.309	32.700	35.777	33.951	Continuing	Continuing
625316: *Info Mgt and Computational Tech*	-	12.868	10.720	12.089	0.000	12.089	13.252	12.978	14.007	13.291	Continuing	Continuing
625317: *Information Decision Making Tech*	-	14.747	28.349	16.719	0.000	16.719	17.501	18.500	18.693	17.737	Continuing	Continuing
625318: *Operational Awareness Tech*	-	21.217	21.514	22.338	0.000	22.338	24.893	25.727	26.164	24.828	Continuing	Continuing
625319: *Cyberspace Dominance Technology*	-	64.528	55.801	57.742	0.000	57.742	64.281	65.144	66.255	62.876	Continuing	Continuing
62OMMS: *Research Site Support*	-	21.728	20.520	21.050	0.000	21.050	21.525	22.114	22.505	22.301	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 Cyberspace Dominance Technology project develops 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 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*

The Air Force Future Operating Concept established a science and technology challenge 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 by 2035. 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 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.

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, 0602601F, 0602602F, 0602605F, 1206601F, 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	161.650	167.818	162.216	0.000	162.216
Current President's Budget	165.517	167.818	162.420	0.000	162.420
Total Adjustments	3.867	0.000	0.204	0.000	0.204
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	5.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	1.179	0.000			
• SBIR/STTR Transfer	-2.312	0.000			
• Other Adjustments	0.000	0.000	0.204	0.000	0.204

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 625319: *Cyberspace Dominance Technology*		
Congressional Add: *Program Increase*	4.934	0.000
Congressional Add Subtotals for Project: 625319	4.934	0.000
Congressional Add Totals for all Projects	4.934	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*

Change Summary Explanation

Increase in FY 2017 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 625315 / *Connectivity and Protection Tech*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625315: *Connectivity and Protection Tech*	-	30.429	30.914	32.482	0.000	32.482	32.309	32.700	35.777	33.951	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force requires technologies that enable assured, worldwide communications among all elements of the force. These communication technologies will provide en-route and deployed reach-back communications for distributed, collaborative military operations. 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Connectivity Technologies	30.429	30.914	32.482
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.			
FY 2018 Plans: Advance the development of Aerial Layer Network Components to develop and prototype technologies for robust, adaptive Mission Aware airborne networks. Continue the investigation and research into high frequency pathways (i.e. V and W band of the electromagnetic spectrum) to support aerial and space-based beyond line of sight communications. Continue dynamic map-to-mission software for operations continuity and agile info management technology for secure message exchange. Continue the investigation of the optimal use of autonomy on small unmanned aircraft system platforms to support semi-autonomous distributed cooperative airborne tactics using airborne networks. Progress on the development of advanced hardware with embedded cyber protection for multi-mission agile radio frequency capability.			
FY 2019 Plans: Continue the research and development of Aerial Layer Network Components and prototype technologies for robust, adaptive, and mission aware airborne networks. Advance the research and investigation of high frequency pathways (e.g. the V and W band of the electromagnetic spectrum) to support aerial and space-based beyond line of sight communications. Expand the research and development of dynamic map-to-mission for secure message exchange operations continuity and agile info management. Develop a waveform testbed and flight test a new multi-waveform radio. Conduct research and development to measure propagation at millimeter wave frequencies to validate previously developed models and enable future definition of			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625315 / *Connectivity and Protection Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
military satellite communications systems. Complete autonomic network model and simulation. Complete low overhead network monitoring and management protocol. Continue ionospheric research, propagation modeling and simulation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.568 million. Justification for this increase is due to additional research and development in multi-waveform radio and new models for military satellite communications.			
Accomplishments/Planned Programs Subtotals	30.429	30.914	32.482

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 625316 / *Info Mgt and Computational Tech*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625316: *Info Mgt and Computational Tech*	-	12.868	10.720	12.089	0.000	12.089	13.252	12.978	14.007	13.291	Continuing	Continuing

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 Air Force Future Operating Concept established a science and technology challenge 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 by 2035. 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Dissemination Technologies	12.868	10.720	12.089
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 2018 Plans: Initiate research and development that will enable multiple echelons of a battlefield command to adapt operations to changing situations and dynamically select from the best set of mission options. Continue the development and demonstration of a set of embedded information management software services and adaptable user interfaces that will automate sensor tasking based on sensor availability and multiple consumer information needs. Continue to develop highly scalable mission-oriented middleware that semantically characterizes and contextualizes information to automatically identify and deliver mission relevant information to consumers in federated environments.			
FY 2019 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625316 / *Info Mgt and Computational Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue research that will enable multiple echelons of a battlefield command to adapt operations to changing situations and dynamically select from the best set of mission options. Advance the research of highly scalable mission oriented middleware that semantically characterizes and contextualizes information to automatically identify and deliver mission relevant information to consumers in federated environments. Focus research in the area of Multi-Domain Command and Control. Continue development of integrated and field tested tactical-to-enterprise information management services. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.369 million. Justification for this increase is due to additional investment in multi-domain command and control and increased focus on tactical to enterprise information management services.			
Accomplishments/Planned Programs Subtotals	12.868	10.720	12.089

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 625317 / *Information Decision Making Tech*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625317: *Information Decision Making Tech*	-	14.747	28.349	16.719	0.000	16.719	17.501	18.500	18.693	17.737	Continuing	Continuing

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 Air Force Future Operating Concept established a science and technology challenge 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 by 2035. 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Campaign Planning Technologies	9.930	5.405	9.888
Description: Develop advanced monitoring, planning, and assessment technologies enabling aerospace commanders to develop effects-based campaigns.			
FY 2018 Plans: Initiate development of software algorithms and architecture showing that an autonomous system can execute a tactical mission, in responding to commands and changing operational and environmental conditions, in a manner consistent with mission-planned contracts. Continue to develop and deliver combat planning and tactical assessment software services supporting distributed command and control capabilities.			
FY 2019 Plans: Continue to research combat planning and tactical assessment software services and increase applied research in the area of multi-domain command and control for campaign planning and battlefield management. Continue research for identifying and implementing state-of-the-art learning models. Develop algorithms for data-efficient leaning and integrate with a machine learning framework. Develop algorithms that will dynamically adapt to varying situations based on situational awareness.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625317 / *Information Decision Making Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 increased compared to FY 2018 by $4.483 million. Justification for this increase is due to larger emphasis on artificial intelligence and machine learning for situational awaremenss.			
Title: Command and Control System Technologies ***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. ***FY 2018 Plans:*** Continue development of assessment services allowing the ability to recognize plan deviations and determine the need for replanning across a degraded operational environment. Continue development of the application of group-sourcing methods, and advanced visualization capabilities, for Space Command and Control. Leverage the Defense Advanced Research Projects Agency Future Command and Control program activities and initiate $13 million effort to support Air Force Science and Technology need to develop solutions for a classified Air Combat Command capability gap. ***FY 2019 Plans:*** 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. Initiate research and development of command and control system technologies in the area of multi-domain command and control. Initiate research for applying machine learning techniques to enhance and optimize space operations. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $16.113 million. Justification for this decrease is due to completion of Defense Advanced Research Projects Agency future Command and Control program activities toward Air Combat Command capability gap.	4.817	22.944	6.831
Accomplishments/Planned Programs Subtotals	14.747	28.349	16.719

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625317 / *Information Decision Making Tech*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 625318 / *Operational Awareness Tech*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625318: *Operational Awareness Tech*	-	21.217	21.514	22.338	0.000	22.338	24.893	25.727	26.164	24.828	Continuing	Continuing

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Multi-Source Fusion Technologies	9.744	11.902	10.117
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 2018 Plans: Continue the research and development of technologies to achieve large data alignment, and to improve indexing and search on textual data, for large-scale, disparate data sources, both structured and unstructured, by employing various ontologies and machine learning techniques. Continue to develop multiple sourced intelligence techniques using context-based, pattern of life analysis for permissive and contested environments. Continue development of techniques for information extraction from network analysis. Continue to develop a distributed multi-sources intelligence processing, exploitation, and dissemination software framework. Incorporate automated or operator-assist product generation to expedite analyst workflow, and provide analytics with based on input from the analyst.			
FY 2019 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). Advance research and development for cloud-based data and information sharing environment for optimized processing and automated association capability.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625318 / *Operational Awareness Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $1.785 million. Justification for this decrease is due to de-emphasis on certain types of information/text extraction mechanisms.			
Title: Exploitation Technologies ***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. ***FY 2018 Plans:*** Continue to develop topological algorithm analytics to exploit features for anomaly and/or pattern detection. Continue signals intelligence characterization algorithm development and refine methods based on operator feedback. Develop specialized signals intelligence alerting and change detection. ***FY 2019 Plans:*** Focus signals intelligence characterization on audio and other electronic signals. Initiate 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $2.617 million. Justification for this increase is due to initiated research in machine learning techniques applied to audio/language processing.	8.724	8.353	10.970
Title: Next Generation Command Technologies ***Description:*** Develop modeling and simulation technologies for the next generation of planning, assessment, and execution environments. ***FY 2018 Plans:*** Continue research and development of capabilities to support battle damage assessment and situational awareness based on available data. Continue to conduct research and development of capabilities that semi-automatically extracts and visualizes relationships, automatically prioritize/rank entities based on identified relationships, semi-automatically updates understanding of each entity based on the situation analysis when new information is available. ***FY 2019 Plans:*** Continue research and development of capabilities to support situational awareness. Conduct extended user evaluations at designated operational sites to advance applied research for full spectrum targeting semantic capabilities and provide a cross-organization workflow. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	2.749	1.259	1.251

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625318 / *Operational Awareness Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $0.008 million. Justification for this decrease is described in plans above.			
Accomplishments/Planned Programs Subtotals	21.217	21.514	22.338

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 625319 / *Cyberspace Dominance Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625319: *Cyberspace Dominance Technology*	-	64.528	55.801	57.742	0.000	57.742	64.281	65.144	66.255	62.876	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 2017	FY 2018	FY 2019
Title: Cyber Defense Technologies	15.311	17.850	18.768
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 2018 Plans: Continue research and development to implement new, or improve existing, cyber security and mission assurance capabilities for Air Force systems and networks. Continue development of validation techniques that assess qualitative effects of mission awareness analytics and system command and control system cyber resiliency. Continue development of a secure foundation for mission models that cross Department of Defense network domains while maintaining robustness, awareness capabilities, and engage assurance technologies. Demonstrate live autonomous systems and integration of the Stockbridge facility into cyber exercise structure. Continue to address gaps identified in the initial research and development, expand upon the results obtained from previous research and development, and explore additional capabilities.			
FY 2019 Plans: Continue research in the area of autonomous integrated cyber operations. Initiate applied research in the area of biologically resilient cyber technologies, mission-specific blockchain capabilities, and the alignment of cyber resilient services and dynamic management tailored towards unmanned aerial systems.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625319 / *Cyberspace Dominance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 increased compared to FY 2018 by $0.918 million. Justification for this increase is described in plans above.			
Title: Cyber Offense Technologies ***Description:*** Develop offensive cyber operations technologies to access, maintain presence on, and deliver effects to adversary systems. ***FY 2018 Plans:*** Continue to research and develop dynamic waveform techniques and cyberspace capabilities in order to detect, identify, locate and attack in anti-access, area-denial environments. Continue to develop technologies to accommodate new waveforms and signals that emerge. Continue to conduct research and development of new, leading-edge technologies that are "game changing" for cyber offensive operations. ***FY 2019 Plans:*** Continue to conduct research and development of new, leading-edge technologies that are game changing and employ dominant power for cyber offensive operations. Increase activity in capabilities for multi-function, non-kinetic cyber effects against adversarial systems. Demonstrate ground-based and airborne delivery of disrupt, deny, degrade, destroy, or deceive effects that are both cyber and physical/kinetic. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $4.672 million. Justification for this increase is due to added emphasis in multi-function, non-kinetic cyber effect capabilities.	15.975	6.079	10.751
Title: Advanced Architectural Technologies ***Description:*** Develop the architectural mechanisms that form the basis for predictable software and high assurance systems. ***FY 2018 Plans:*** Continue research and development of a cyber hardened processor for embedded weapon systems. Develop a runtime environment that can monitor and maintain a trusted and resilient envelope of operation. Continue research and development on neuromorphic processing technologies to assess the feasibility of autonomy on mobile and power-constrained platforms. ***FY 2019 Plans:*** Continue research and validation of a cyber hardened (robust, secure) processor for embedded weapon systems. Continue 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 research and development of the neuromorphic	8.786	12.165	10.105

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625319 / *Cyberspace Dominance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
processor and validate capabilities for dynamic learning on mobile and power-constrained platforms. Initiate development of software using evolutionary approaches to make embedded systems tolerant to unexpected and unforeseen situations. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $2.060 million. Justification for this decrease is due to de-emphasis on runtime environments.			
Title: Processing Technologies ***Description:*** Develop automatic and dynamically reconfigurable, scalable, affordable distributed peta-flop processing technologies for real-time global information systems. ***FY 2018 Plans:*** Research and develop a novel neuromorphic system for visual object detection using Google's open source deep learning framework, TensorFlow. Continue research and development 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 with the existing freespace optical link between the Air Force Research Laboratory, Information Directorate laboratory facility in Rome and the Stockbridge remote test site. ***FY 2019 Plans:*** Continue to research the application of novel neuromorphic systems for robust machine learning. 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. Test 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $2.000 million. Justification for this increase is due to added emphasis on quantum research.	7.775	6.938	8.938
Title: Survivability Technologies ***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. ***FY 2018 Plans:***	4.214	3.599	2.072

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625319 / *Cyberspace Dominance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue to research concepts and capabilities for automated and autonomous processes addressing cyber survivability using an operational system laboratory to host modular research, development, test and evaluation. Continue to integrate autonomous machine learning functions into defensive cyber operations systems. ***FY 2019 Plans:*** Continue to research concepts and capabilities for cyber survivability techniques and algorithms for counter-unmanned aerial systems. Design and develop a counter-unmanned aerial systems open architecture to enable interoperability. Continue to evolve autonomous machine learning functions. Validate and demonstrate automated workflows into defensive cyber operations systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.527 million. Justification for this decrease is due to additional support for cross domain research.			
Title: Cross-Domain Technologies ***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. ***FY 2018 Plans:*** Continue research and development on cross-domain change detection, cross-domain machine to machine mediation layer, and multiple levels of security mobile secure foundation technologies. ***FY 2019 Plans:*** Continue 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. Continue research and development for machine to machine interfaces. Develop cross-domain solution command and control capabilities to manage cross-domain solution risk based upon changes in mission and threat. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $2.799 million. Justification for this increase is due to added emphasis on dynamic content filtering techniques in cross-domain management.	3.744	3.663	6.462
Title: Cyber Technologies for Spectrum Warfare ***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. ***FY 2018 Plans:***	3.789	5.507	0.646

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625319 / *Cyberspace Dominance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue development of active and passive methods to locate, acquire, and process data and signals of interest. ***FY 2019 Plans:*** Continue development of active and passive methods to locate, acquire, and process data and signals of interest. Advance research in systems to perform blind data discovery associated with the Internet of Things. Identify items of interest associated with the Internet of Things. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $4.861 million. Justification for this decrease is due to additional investment in offensive cyber technologies.			
Accomplishments/Planned Programs Subtotals	59.594	55.801	57.742

	FY 2017	FY 2018
Congressional Add: Program Increase	4.934	0.000
FY 2017 Accomplishments: Conducted Congressionally direct effort.		
FY 2018 Plans: N/A		
Congressional Adds Subtotals	4.934	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 62OMMS / *Research Site Support*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
62OMMS: *Research Site Support*	-	21.728	20.520	21.050	0.000	21.050	21.525	22.114	22.505	22.301	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 2017	FY 2018	FY 2019
Title: Rome Research Infrastructure	21.728	20.520	21.050
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 2018 Plans: Provide civilian payroll and non-pay costs for installation operations in support of the Rome Research Site property and all onsite personnel. 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. Provide Real Property Management & 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. Provide basic			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 62OMMS / *Research Site Support*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
installation communication services, including long haul trunk and telecommunications services. Provide site vehicle lease under General Service Administration for logistics, security, and mission support. ***FY 2019 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 under GSA for logistics, security, and mission support. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.530 million. Justification for this increase is described in plans above.			
Accomplishments/Planned Programs Subtotals	21.728	20.520	21.050

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602890F / *High Energy Laser Research*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	39.545	43.049	43.359	0.000	43.359	44.221	45.103	46.019	46.948	Continuing	Continuing
625096: *High Energy Laser Research*	-	39.545	43.049	43.359	0.000	43.359	44.221	45.103	46.019	46.948	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program funds Department of Defense high energy laser applied research through the Joint Directed Energy Transition Office. This program is part of an overall Department of Defense high energy laser Science and Technology program. High energy laser weapon systems have many potential advantages including speed-of-light delivery, precision target engagement, significant magazine depth, low-cost per kill, and reduced logistics requirements. High energy lasers have the potential to perform a wide variety of military missions including high value asset and base protection, precision strike and platform self-protection vs. a wide variety of missile, rocket, artillery, mortar and air platforms. Efforts funded under this program are generally chosen for their potential to have an impact on multiple high energy laser systems and multiple Service missions while complementing Service/Agency programs that are directed at specific Service needs. A broad range of technologies are addressed in key areas such as laser sources, laser beam control, modeling and simulation, and laser lethality mechanisms. 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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602890F / *High Energy Laser Research*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	42.300	43.049	43.685	0.000	43.685
Current President's Budget	39.545	43.049	43.359	0.000	43.359
Total Adjustments	-2.755	0.000	-0.326	0.000	-0.326
• 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	-1.269	0.000			
• SBIR/STTR Transfer	-1.486	0.000			
• Other Adjustments	0.000	0.000	-0.326	0.000	-0.326

Change Summary Explanation

Decrease in FY 2017 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Solid State Laser Technologies	7.650	7.650	9.185
Description: Mature technologies that will provide system level performance commensurate with fieldable laser devices. ***FY 2018 Plans:*** 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 high power fiber technologies. Reduce technical risk in solid state lasers for inclusion in future laser weapon systems. Conduct trade space analysis to understand performance, fielding, robustness and integration issues for military platforms. ***FY 2019 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. Investigate 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.535 million. Justification for this increase is increased emphasis in solid state laser technologies.			
Title: Advanced High Energy Laser Technologies	6.210	6.210	6.100

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602890F / *High Energy Laser Research*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Investigate new technologies that have revolutionary potential for high energy lasers. ***FY 2018 Plans:*** Explore advanced concepts for laser technologies that will improve efficiency and decrease mass and volume for future laser weapon systems. Evaluate materials for high energy laser applications. Improve understanding of short-pulse laser technologies to include material interaction and propagation. Scale electrically-pumped alkali vapor 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 high energy laser test ranges. Collaborate with the international laser development community. Validate predictive models through analysis of atmospheric propagation data and measurements. ***FY 2019 Plans:*** Continue to explore advanced concepts for laser technologies that will improve efficiency and decrease mass and volume for future laser weapon systems. Continue to evaluate materials for high energy laser applications. Continue to improve understanding of short-pulse laser technologies to include material interaction and propagation. Continue to scale electrically-pumped alkali vapor 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 high energy laser test ranges. Continue to collaborate with the international laser development community. Validate predictive models through analysis of atmospheric propagation data and measurements. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decrease compared to FY 2018 by $0.110 million. Justification for this decrease is described in plans above.			
Title: Laser Beam Control Technologies ***Description:*** Develop technology to support high performance beam control systems and integrated demonstrations. ***FY 2018 Plans:*** Develop beam control technologies for laser weapon use on multiple platforms (aircraft, ground vehicles and shipboard systems) in stressing environments. Develop predictive avoidance fire control systems for use on multiple platforms. Develop kill assessment technologies. Develop hardware and technologies to improve throughput efficiency through the beam director, decrease component weight, and improve tracking and compensation through the atmosphere for joint beam control. Select additional programs for service-specific applications. ***FY 2019 Plans:***	18.325	21.080	22.174

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602890F / *High Energy Laser Research*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue development of beam control technologies for laser weapon use on multiple platforms (aircraft, ground vehicles and shipboard systems) in stressing environments. Continue development of a predictive avoidance fire control system for use on multiple platforms. Continue execution of a program for kill assessment technologies. Continue joint beam control efforts to develop hardware and technologies to improve throughput efficiency through the beam director, decrease component weight, and improve tracking and compensation through the atmosphere. Select additional programs for service-specific applications. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increase compared to FY 2018 by $1.094 million. Justification for this increase is increased emphasis laser bean control technologies.			
Title: High Energy Laser Lethality Research ***Description:*** Conduct laser vulnerability experiments on materials, components, and targets. Develop a lethality database, and integrate into a systems-level architecture plan and lethality models. ***FY 2018 Plans:*** Integrate lethality data into campaign-level high energy laser system models. Conduct laser vulnerability experiments on materials, components, and targets. Develop a suite of directed energy weapon tools to be used in a database from which the warfighter can assess target vulnerabilities and mission utility for given directed energy weapon platform and engagement. Develop warfighter tools employing service and agencies metrics and criteria such as the Joint Munitions Effectiveness Standards. ***FY 2019 Plans:*** Continue to integrate lethality data into campaign-level high energy laser system models. Continue to conduct laser vulnerability experiments on materials, components, and targets. Continue to develop a suite of directed energy weapon tools to be used in a database from which the warfighter can assess target vulnerabilities and mission utility for given directed energy weapon platform and engagement. Continue to develop warfighter tools employing service and agencies metrics and criteria such as the Joint Munitions Effectiveness Standards. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.595 million. Justification for this decrease is described in plans above.	3.720	4.095	3.500
Title: High Energy Laser Modeling ***Description:*** Maintain and evaluate high-fidelity engineering models for high energy laser system scenario evaluation and incorporation into the high energy laser toolkit. Provide atmospheric propagation and high energy laser system modeling for mission-level war-gaming activities.	3.640	4.014	2.400

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602890F / *High Energy Laser Research*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Provide maintenance, verification, validation, and accreditation for updated system level atmospheric propagation and high energy laser 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. ***FY 2019 Plans:*** Continue to provide maintenance, verification, validation, and accreditation for updated system level atmospheric propagation and high energy laser 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.614 million. Justification for this decrease is decreased emphasis in high energy laser modeling.			
Accomplishments/Planned Programs Subtotals	39.545	43.049	43.359

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 1206601F / *Space Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	0.000	0.000	117.645	0.000	117.645	135.795	138.264	142.076	135.105	Continuing	Continuing
621010: *Space Survivability & Surveillance*	-	0.000	0.000	40.234	0.000	40.234	40.857	41.197	43.045	41.042	Continuing	Continuing
624846: *Spacecraft Payload Technologies*	-	0.000	0.000	15.981	0.000	15.981	17.540	17.946	18.348	17.475	Continuing	Continuing
625018: *Spacecraft Protection Technology*	-	0.000	0.000	18.591	0.000	18.591	22.486	23.153	24.047	22.665	Continuing	Continuing
628809: *Spacecraft Vehicle Technologies*	-	0.000	0.000	42.839	0.000	42.839	54.912	55.968	56.636	53.923	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

In FY 2019, the entirety of PE 0602601F, Space Technology, will transfer to 1206601F, Space Technology, to provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment. This is an administrative only adjustment 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, 0602298F, 0602601F, 0602602F, 0602605F, and 0602788F.

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force					Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*			R-1 Program Element (Number/Name) PE 1206601F / *Space Technology*		
B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	117.645	0.000	117.645
Total Adjustments	0.000	0.000	117.645	0.000	117.645
• 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	117.645	0.000	117.645

Change Summary Explanation

Increase in FY 2019 due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / *Space Technology*	Project (Number/Name) 621010 / *Space Survivability & Surveillance*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
621010: *Space Survivability & Surveillance*	-	0.000	0.000	40.234	0.000	40.234	40.857	41.197	43.045	41.042	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

Prior to FY 2019, the entirety of Project 621010, Space Survivability and Surveillance was reported under PE 0602601F, Space Technology, Project 621010, Space Survivability and Surveillance. For FY 2019 and beyond, this project will be reported under PE 1206601F, Space Technology, to provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment. This is an administrative only change and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Space Environment Research	0.000	0.000	14.695
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 2018 Plans: For FY 2018 and FY 2017, this work is performed under the Space Environment Research effort in PE 0602601F, Space Technology, Project 621010, Space Survivability & Surveillance.			
FY 2019 Plans: Exploit data from aged electrical and optical property changes to enhance predictive material property model and inform development of improved spacecraft materials. Select next-generation solar particle event model for development towards operational demonstration. Select next-generation electron specification model for development towards operational demonstration. Evaluate space environment sensor and anomaly attribution tool demonstration to identify key areas for future model improvements. Assess the performance of oblique ionosonde auto scaling technologies as applied to real-time characterization of over-the-horizon-radar performance. Assess and validate advanced regional and global assimilative ionospheric models for integration into next-generation operational support. Continue to assess impacts of the arctic ionosphere on defense radar system availability. Validate integrated version of space environment impact on space-ground radio frequency links attribution tool meeting space operations requirements for scintillation and solar impacts on satellite communications,			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
command, and control systems. Use data from the new weather satellite constellation to evaluate and refine Global Positioning System radio frequency exploitation algorithms for global scintillation specification. Continue improvements of state-of-the-art solar magnetic flux transport model for more reliable forecast of solar radio and extreme ultraviolet flux levels, key parameters for Air Force space weather models and forecasts. Validate the advanced assimilative ionosphere-thermosphere model using these parameters. Continue work on hybrid supersonic solver code development and validation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $14.695 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Surveillance Technologies ***Description:*** Develop advanced target detection techniques, spectral signature libraries, and decision aids for space-based sensors and surveillance systems. ***FY 2018 Plans:*** For FY 2018 and FY 2017, this work is performed under the Surveillance Technologies effort in PE 0602601F Space Technology, Project 621010, Space Survivability & Surveillance. ***FY 2019 Plans:*** Initiate technology development for missile warning prototyping, including target signatures, background phenomenology, satellite constellation architecture analyses, 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. Complete testing and transition innovative computational methods to missile warning System Program Office to significantly decrease satellite down-link bandwidth while maintaining high fidelity of missile warning data. Continue mission of demonstration satellite for prototyping advanced sensor and analytic methods of innovative hypertemporal imaging early missile warning concept, including the collection and analysis of missile and missile like data. Provide assessment of prototyping satellite's capabilities for detecting and tracking low signature targets with complex trajectories. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $10.880 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.	0.000	0.000	10.880
Title: Radiation Remediation Research ***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. ***FY 2018 Plans:***	0.000	0.000	0.100

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
For FY 2018 and FY 2017, this work is performed under the Radiation Remediation Research effort in PE 0602601F Space Technology, Project 621010, Space Survivability & Surveillance. ***FY 2019 Plans:*** Complete space experiment operations, reduction and science data exploitation to finalize the validation of the end-to-end model for space-based remediation systems. Conduct assessment of feasibility and system requirements for space-based and combined ground and space-based remediation systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.100 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Seismic Technologies ***Description:*** 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. ***FY 2018 Plans:*** For FY 2018 and FY 2017, this work is performed under the Seismic Technologies effort in PE 0602601F, Space Technology, Project 621010, Space Survivability & Surveillance. ***FY 2019 Plans:*** Test new algorithms on high performance computing capabilities to improve automation of the detection, location, and discrimination of seismic events. Assess earth models for use in high-performance computing modeling and simulation codes for operational expert analysis of difficult-to-discriminate earthquakes and explosions. Test specific algorithms for application of big data heuristics to more quickly characterize seismic events. Explore new statistical approaches to the behavior of discriminants for local (less than 200 kilometers) and regional (less than 2,000 kilometers) seismic events. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $5.972 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.	0.000	0.000	5.972
Title: Alternative Navigation Technologies ***Description:*** 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. ***FY 2018 Plans:***	0.000	0.000	8.587

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
For FY 2018 and FY 2017, this work is performed under the Alternative Navigation Technologies effort in PE 0602601F, Space Technology, Project 621010, Space Survivability & Surveillance. ***FY 2019 Plans:*** Complete testing of advanced compact atomic clocks with improved accuracy and stability to replace legacy atomic clocks. Complete packaging of system for flight on experimental satellite system. Continue transition of advanced compact atomic clocks to industry. Begin testing of free-space, cold atom 3-axis gyroscope/accelerometer that will enable Global Positioning System free precision navigation. Start packaging of system for test on aircraft flight experiment or other suitable platform. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $8.587 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	40.234

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / *Space Technology*	Project (Number/Name) 624846 / *Spacecraft Payload Technologies*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
624846: *Spacecraft Payload Technologies*	-	0.000	0.000	15.981	0.000	15.981	17.540	17.946	18.348	17.475	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

Prior to FY 2019, the entirety of Project 624846, Spacecraft Payload Technologies, was reported under PE 0602601F, Space Technology, Project 624846, Spacecraft Payload Technologies. For FY 2019 and beyond, this project will be reported under PE 1206601F, Space Technology, to provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment. This is an administrative only change and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Space-Based Detector Technologies	0.000	0.000	3.230
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 2018 Plans:*** For FY 2018 and FY 2017, this work is performed under the Space-Based Detector Technologies effort in PE 0602601F, Space Technology, Project 624846, Spacecraft Payload Technologies. ***FY 2019 Plans:*** Delivery of an 8000 x 8000, 10 micrometer pitch focal plane arrays that will be hardened to the natural space environment as well as focused photons. Upon delivery of said hardware it will be characterized in representative environment to verify functionality and if any shortfalls arise they will be addressed with iterative development. This will enable whole earth starring for the Launch Detection and Missile Warning mission. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $3.230 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Space Electronics Research	0.000	0.000	2.764

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 624846 / *Spacecraft Payload Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Develop technologies for space-based payload components such as radiation-hardened electronic devices, microelectro-mechanical system devices, and advanced electronics packaging. ***FY 2018 Plans:*** For FY 2018 and FY 2017, this work is performed under the Space Electronics Research effort in PE 0602601F, Space Technology, Project 624846, Spacecraft Payload Technologies. ***FY 2019 Plans:*** Continue leadership role in Deputy Assistant Secretary of Defense Systems Engineering risk reduction strategy by development of trusted manufacturing techniques that reduce risk to National Security Strategy systems. Continue to benchmark advanced algorithms on state-of-the-art electronics and transition results to acquisition community to enable data-informed architecture design decisions. Expanding capability to include assessments of classified requirements. Continue planning qualification efforts for next generation space processor. Continue research and development on ultra-low power and neuromorphic processing architectures to enable game-changing capabilities in future National Security Strategy systems. Continue development of alternative memory approaches for high density memory for use in space-based systems. Continue advanced transistor development, and transitioning techniques to mainstream manufacturing. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $2.764 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Modeling and Simulation Tools for Space Applications ***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. ***FY 2018 Plans:*** For FY 2018 and FY 2017, this work is performed under the Modeling and Simulation Tools for Space Applications effort in PE 0602601F, Space Technology, Project 624846, Spacecraft Payload Technologies. ***FY 2019 Plans:*** Conduct mission-level military utility analyses of various space sensing, satellite navigation, space control, and communication architecture approaches. Refine guidelines and checkpoints to evaluate maturity and applicability of emerging space technologies to support various Air Force Research Laboratory technical programs, Department of Defense customers and wargame events. Continue development of models and mission simulations enabling analysis of contested space environment and space enterprise	0.000	0.000	5.403

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 624846 / *Spacecraft Payload Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
capabilities. Progress the development of baseline modeling and simulation capabilities to support quick-turn analysis and trade studies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $5.403 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Alternative Positioning, Navigation, and Timing Technology ***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. ***FY 2018 Plans:*** For FY 2018 and FY 2017, this work is performed under the Alternative Positioning, Navigation, and Timing Technology effort in PE 0602601F, Space Technology, Project 624846, Spacecraft Payload Technologies. ***FY 2019 Plans:*** Begin characterization of amplifiers, multiplexers and digital waveform generators being developed under Small Business Innovation Research Phase II contracts. Continue studies to identify alternative and innovative technologies that are viable for positioning, navigation, and timing payloads and ground systems and to investigate advanced signal and system concepts. Begin integration of positioning, navigation, and timing payload components developed under various contracts into positioning, navigation, and timing payloads to explore the concept of positioning, navigation, and timing payload modularity. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $4.584 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.	0.000	0.000	4.584
Accomplishments/Planned Programs Subtotals	0.000	0.000	15.981

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 624846 / *Spacecraft Payload Technologies*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / *Space Technology*	Project (Number/Name) 625018 / *Spacecraft Protection Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
625018: *Spacecraft Protection Technology*	-	0.000	0.000	18.591	0.000	18.591	22.486	23.153	24.047	22.665	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

Prior to FY 2019, the entirety of Project 625018, Spacecraft Protection Technology, was reported under PE 0602601F, Space Technology, Project 625018, Spacecraft Protection Technology. For FY 2019 and beyond, this project will be reported under PE 1206601F, Space Technology, to provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment. This is an administrative only change and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Threat Warning Research	0.000	0.000	18.591
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 2018 Plans: For FY 2018 and FY 2017, this work is performed under the Threat Warning Research effort in PE 0602601F, Space Technology, Project 625018, Spacecraft Protection Technology.			
FY 2019 Plans: Develop techniques to detect, track, identify, and characterize satellites using multi-phenomenology to address gaps in knowledge for space situational awareness. Consider the tasking, collection, processing, exploitation and dissemination needs. Assess timeliness and persistence of space situational awareness capability and develop techniques that address the growing number of objects that must be monitored. Develop techniques to mitigate the growing population of objects that need to be monitored, from newly launched objects to debris. Assess utilizing commercial and international space situational awareness sources. Continue maturation of the space resiliency testbed to enhance ability to conduct full-spectrum space control RED-vs-BLUE experimentation with ops, network, command and control, and hardware in the loop. Conduct space cyber experimentation using on-orbit science satellite. Initiate research into advanced methods for net-centric space command and control architectures, to include cloud-based paradigms and other advanced computational methods across the full scope of the ground and space-based enterprise. Continue development of advanced algorithms for sensor data fusion and satellite threat detections, assessment,			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 625018 / *Spacecraft Protection Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
response and protection. Complete space situational awareness-focused data analysis methods including physics-based sensor model development for data filtering and space command and control architectures. Complete advancing filtering techniques accommodating nonlinear dynamics and non-normal random variable distributions. Mature concepts of new electro-optical and radio frequency sensors for space object identification and characterization. Continue incorporating customer feedback of closed loop sensor tasking concept for space surveillance, combining commercial and government sensor assets. Continue assessment and development of commercial remote sensing data and information to fill gaps in coverage for monitoring and tracking ground and space objects. Continue engagements and methods development with commercial space data providers for testing new enabling technologies on commercial satellites. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $18.591 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	18.591

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 1206601F / *Space Technology*	Project (Number/Name) 628809 / *Spacecraft Vehicle Technologies*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
628809: *Spacecraft Vehicle Technologies*	-	0.000	0.000	42.839	0.000	42.839	54.912	55.968	56.636	53.923	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

Prior to FY 2019, the entirety of Project 628809, Spacecraft Vehicle Technologies, was reported under PE 0602601F, Space Technology, Project 628809, Spacecraft Vehicle Technologies. For FY 2019 and beyond, this project will be reported under PE 1206601F, Space Technology, to provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment. This is an administrative only change and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Space Power/Thermal Research	0.000	0.000	4.804
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 2018 Plans:*** For FY 2018 and FY 2017, this work is performed under the Space Power/Thermal Research effort in PE 0602601F, Space Technology, Project 628809, Spacecraft Vehicle Technologies. ***FY 2019 Plans:*** Continue research into approaches for greater than 40% solar cell efficiency. Begin evaluation of approaches for high radiation orbit optimized solar cells. Continue development of advanced array technologies to meet 70-80 kilowatt per cubic meter array performance. Initiate research incorporating photon management schemes into III-V devices for increased efficiency and end of-life. Initiate cell level resiliency research efforts. Develop panel level resilient approaches. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $4.804 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Space Structures and Controls Research	0.000	0.000	9.007
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.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 628809 / *Spacecraft Vehicle Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: For FY 2018 and FY 2017, this work is performed under the Space Structures and Controls Research effort in PE 0602601F, Space Technology, Project 628809, Spacecraft Vehicle Technologies. ***FY 2019 Plans:*** Continue reactive maneuver strategies for spacecraft resiliency in laboratory simulation and initiate high-fidelity simulations/ breadboards. Continue research in verification and validation techniques for autonomous spacecraft flight software. Continue improved estimation algorithms for on-orbit navigation software. Initiate laboratory and high-fidelity simulations/breadboard implementation for navigation algorithms with hardware-in-the-loop. Transition development of United States space asset protection, threat identification, and mitigation technologies including deployable structures, structural sensing, and thermal technologies to advanced development and flight experimentation. Perform test bed develop and integrated proof-of-concept experiments for advanced, agile manufacturing and assembly technologies for satellite production to improve performance and affordability. Continue 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. Initiate research in functionalized structures using multi-material additive manufacturing. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $9.007 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
Title: Space Experiments	0.000	0.000	21.705
Description: Develop flight experiments to improve the capabilities of existing operational space systems and to enable new transformational space capabilities. ***FY 2018 Plans:*** Previous work for the Space Experiments effort was accomplished under Space Experiments effort, under 0602601F Space Technology, Spacecraft Vehicle Technologies project 628809. In FY 2019, the entirety of the Space Experiments effort will move to Space Experiments effort under 1206601F Space Technology, Spacecraft Vehicle Technologies project 628809. This transfer will provide increased transparency to the Office of the Secretary of Defense and Congress regarding Space Science and Technology Major Force Program 12 Space investment. ***FY 2019 Plans:*** Continue and complete one year of experimental satellite on-orbit operations. Complete program and close-out. Conclude on-orbit testing and verification of a fourth geosynchronous orbit based missile warning payload to demonstrate hypertemporal imaging capabilities to detect missile launches under sun-lit clouds, potentially enabling all weather early missile detection. Conclude on-orbit testing and verification of an integrated, on-board sensing, assessment, and autonomy technology demonstration payload at			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 628809 / *Spacecraft Vehicle Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
geosynchronous orbit, demonstrating geosynchronous orbit asset resiliency to a specific set of on-orbit events enabling system mission assurance in a degraded space environment. On-orbit demonstration of the first geosynchronous orbit CubeSat providing enhanced capability to the space enterprise. On-orbit demonstration of three formation flying satellites for near autonomous formation control. Refine on-orbit experiment plan and mission objectives to align with payload development progress, and continue developing data requirements and risk management plan for space-based integrated demonstration of an advanced Global Positioning System payload for contested environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $21.705 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.			
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 2018 Plans:*** For FY 2018 and FY 2017, this work is performed under the Space Communication Technologies effort, in PE 0602601F, Space Technology, Project 628809, Spacecraft Vehicle Technologies project. ***FY 2019 Plans:*** Support launch of W and V frequency band flight instrument. Support execution of a W and V band propagation experiment. Conduct research and development 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 technology. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $7.323 million due to the transfer of the entire PE 0602601F, Space Technology, to 1206601F, Space Technology.	0.000	0.000	7.323
Accomplishments/Planned Programs Subtotals	0.000	0.000	42.839

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 1206601F / *Space Technology*	**Project (Number/Name)** 628809 / *Spacecraft Vehicle Technologies*

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603112F / *Advanced Materials for Weapon Systems*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	54.095	37.856	34.426	0.000	34.426	36.584	37.567	39.021	39.813	Continuing	Continuing
632100: *Laser Hardened Materials*	-	17.230	14.948	14.786	0.000	14.786	15.806	16.124	16.450	16.784	Continuing	Continuing
633153: *Non-Destructive Inspection Development*	-	5.900	6.331	6.375	0.000	6.375	6.500	6.632	6.765	6.904	Continuing	Continuing
633946: *Materials Transition*	-	30.965	16.577	13.265	0.000	13.265	14.278	14.811	15.806	16.125	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program 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 are also developed and demonstrated to enhance protection for Air Force sensors and systems to ensure safety, survivability, and operability in threat environments.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	35.137	37.856	35.139	0.000	35.139
Current President's Budget	54.095	37.856	34.426	0.000	34.426
Total Adjustments	18.958	0.000	-0.713	0.000	-0.713
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	18.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	2.300	0.000			
• SBIR/STTR Transfer	-1.342	0.000			
• Other Adjustments	0.000	0.000	-0.713	0.000	-0.713

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 633946: *Materials Transition*		
Congressional Add: *Program increase - Protective Equipment*	0.974	-
Congressional Add: *Program increase - Metals Affordability Research*	16.558	-
Congressional Add Subtotals for Project: 633946	17.532	-
Congressional Add Totals for all Projects	17.532	-

Change Summary Explanation

Increase in FY 2017 due to reprogramming for Hypersonics Science and Technology activities.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / *Advanced Materials for Weapon Systems*	Project (Number/Name) 632100 / *Laser Hardened Materials*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
632100: *Laser Hardened Materials*	-	17.230	14.948	14.786	0.000	14.786	15.806	16.124	16.450	16.784	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 are also developed and demonstrated to enhance protection for Air Force sensors and systems to ensure safety, survivability, and operability in threat environments.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Aerospace Systems Protection	9.030	7.026	7.015

Description: Develop and demonstrate materials technologies that enhance hardening for sensors, avionics, and components to increase survivability and mission effectiveness of aerospace systems.

FY 2018 Plans:

Validate and continue to develop protection materials for visual/Near-Infrared (NIR)Space Intelligence, Surveillance Reconnaissance (ISR) sensors. Assess the demonstrated results and pursue the use of protection technologies for future sensor designs and strategies to mitigate directed energy damage for visual/NIR, Short Wave Infrared (SWIR), and Mid Wave Infrared (MWIR) detectors. Apply gained technologies and integrate the developments into survivable electro-optic sensors that provide full spectrum protection for missile warning. Analyze the performance impact of damage-limiting semiconductor materials designed to harden electro-optic imaging sensors. Initiate transition of 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. Technology stimulation and maturation to develop defensive capability for air systems airframe and anti-access munitions hardening assessments and solutions.

FY 2019 Plans:

Continue to validate and continue to develop protection materials for visual/NIR ISR sensors. Assess the demonstrated results and pursue the use of protection technologies for future sensor designs and strategies to mitigate directed energy damage for visual/NIR, SWIR, and MWIR detectors. Apply gained technologies and integrate the developments into survivable electro-optic sensors that provide full spectrum protection for missile warning. Continue analyzing the performance impact of damage-limiting semiconductor materials designed to harden electro-optic imaging sensors. Continue transition of 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

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 632100 / *Laser Hardened Materials*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
time of coatings development for use in sensor hardening. Continue technology stimulation and maturation to develop defensive capability for air systems airframe and anti-access munitions hardening assessments and solutions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.011 million. Justification for this decrease is described in the plans above.			
Title: Aircrew Protection ***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. ***FY 2018 Plans:*** Develop, validate, and demonstrate laser protection materials and technologies for personnel protection. Validate and develop helmet-mounted sensor hardening materials focusing on next-generation nighttime sensors. Advance development of visor based aircrew protection materials with agile protection. Evaluate advances in characterization and demonstration of eye protection technologies using computational materials science tools. Validate, mature, and test improvements to functionality and performance of personnel protection technologies in expected operational conditions. ***FY 2019 Plans:*** Continue to develop, validate, and demonstrate laser protection materials and technologies for personnel protection. Continue to validate and develop helmet-mounted sensor hardening materials focusing on next-generation nighttime sensors. Continue to advance development of visor based aircrew protection materials with agile protection. Continue to evaluate advances in characterization and demonstration of eye protection technologies using computational materials science tools. Continue to validate, mature, and test improvements to functionality and performance of personnel protection technologies in expected operational conditions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.151 million. Justification for this decrease is described in the plans above.	8.200	7.922	7.771
Accomplishments/Planned Programs Subtotals	17.230	14.948	14.786

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 632100 / *Laser Hardened Materials*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / *Advanced Materials for Weapon Systems*	Project (Number/Name) 633153 / *Non-Destructive Inspection Development*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
633153: *Non-Destructive Inspection Development*	-	5.900	6.331	6.375	0.000	6.375	6.500	6.632	6.765	6.904	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced nondestructive inspection and evaluation (NDI/E) technologies to monitor performance integrity and to detect failure causing conditions in weapon systems components and materials. NDI/E 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Engine Inspection Technologies	1.563	1.558	1.581
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 2018 Plans:*** Validate repeatability of NDI/E (nondestructive inspection/evaluation) approaches 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. Assess model prediction, accuracy, and effectiveness of digital nondestructive inspection technologies and demonstrate tool automation for high confidence repeatable results. ***FY 2019 Plans:*** Continue to develop nondestructive inspection/evaluation approaches 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 assess model prediction, accuracy, and effectiveness of digital nondestructive inspection technologies and demonstrate tool automation for high confidence repeatable results. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.023 million. Justification for the increase is described in the plans above.			
Title: Special Material Inspection Technologies (formerly known as "Low-Observable Inspection Technologies")	1.186	1.182	1.199
Description: Develop and demonstrate advanced inspection technologies supporting low-observable (LO) systems to enhance affordability and ensure full performance and survivability. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 633153 / *Non-Destructive Inspection Development*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Transition 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 signature assessment. Develop tools to improve characterization of specialty multilayer coatings. Continue to develop hand-held and robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization. ***FY 2019 Plans:*** Continue to transition 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 of specialty multilayer coatings. Continue to develop robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.017 million. Justification for the increase is described in the plans above.			
Title: Advanced System Monitoring Technologies	3.151	3.591	3.595
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. ***FY 2018 Plans:*** Validate analytical methods to assess the location of damage in multi-layered structure base on nondestructive inspection data and results. Transition robotic nondestructive inspection methods to minimize disassembly and reduced maintenance burden to perform inspections of aircraft structures. Develop novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. Continue enhanced methods for collecting and analyzing digital Non-Destructive Inspection/Evaluation (NDI/E) data necessary for improved damage detection and characterization. Integrate computational materials science tools with life prediction methods to enable risk-based life management. Comprehensive development of physical and digital nondestructive evaluation tools to support and provide concept approach of Damage State Awareness of materials. ***FY 2019 Plans:*** Continue demonstrating analytical methods to assess the location of damage in multi-layered structure base on nondestructive inspection data and results. Continue to transition robotic nondestructive inspection methods to minimize disassembly and reduced maintenance burden to perform inspections of aircraft structures. Continue development of novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. Continue enhanced methods for collecting and analyzing digital Non-Destructive Inspection/Evaluation (NDI/E) data necessary for improved damage detection			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 633153 / *Non-Destructive Inspection Development*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
and characterization. Continue the integration of computational materials science tools with life prediction methods to enable risk-based life management. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.004 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	5.900	6.331	6.375

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / *Advanced Materials for Weapon Systems*	Project (Number/Name) 633946 / *Materials Transition*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
633946: *Materials Transition*	-	30.965	16.577	13.265	0.000	13.265	14.278	14.811	15.806	16.125	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Air Vehicle Materials Technologies	11.436	14.090	11.228
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 2018 Plans:*** Transition magnetoresistive sensing and materials and processes to increase special materials affordability. Develop of advanced directed energy protection technologies. Develop of technologies for electromagnetic hardening acquisition and field support. Develop of technologies for organic engine lifing analysis for enhanced engine component risk management capability. ***FY 2019 Plans:*** Transition magnetoresistive sensing and materials and processes to increase special materials affordability. Continue development of advanced directed energy protection technologies. Continue development of technologies for electromagnetic hardening acquisition and field support. Continue development of technologies for organic engine lifing analysis for enhanced engine component risk management capability. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $2.862 million. Justification for the decrease is decreased emphasis in air vehicles materials technologies.			
Title: High Temperature Material Technologies	1.997	2.487	2.037
Description: Develop and demonstrate affordable, novel high temperature materials/structures and thermal management concepts to enable future defense capabilities for prompt global strike concepts. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 633946 / *Materials Transition*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Validate repeatability of multimaterial structures to 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. Demonstrate and model 2700-degree Fahrenheit ceramic matrix composites for turbine hot section components. Develop high performance and affordable metals for next-generation turbine engine disks and low cost propulsion, aerostructure and munitions components. ***FY 2019 Plans:*** Continue 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. 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.450 million. Justification for the decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	13.433	16.577	13.265

	FY 2017	FY 2018
Congressional Add: Program increase - Protective Equipment ***FY 2017 Accomplishments:*** Conducted congressionally directed effort.	0.974	-
Congressional Add: Program increase - Metals Affordability Research ***FY 2017 Accomplishments:*** Conducted congressionally directed effort.	16.558	-
Congressional Adds Subtotals	17.532	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 633946 / *Materials Transition*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603199F / *Sustainment Science and Technology (S&T)*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	19.994	22.811	15.150	0.000	15.150	16.249	16.938	17.731	18.324	Continuing	Continuing
635351: *Technology Sustainment*	-	19.994	22.811	15.150	0.000	15.150	16.249	16.938	17.731	18.324	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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603199F / *Sustainment Science and Technology (S&T)*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	20.636	22.811	23.217	0.000	23.217
Current President's Budget	19.994	22.811	15.150	0.000	15.150
Total Adjustments	-0.642	0.000	-8.067	0.000	-8.067
• 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	-0.642	0.000			
• Other Adjustments	0.000	0.000	-8.067	0.000	-8.067

Change Summary Explanation

Decrease in FY 2019 due to realignment of composite certification work from PE 0603199F, Sustainment Science and Technology (S&T), Project 635351, Technology Sustainment, to PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Tech Integration.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: System Health Management/Assessment Technologies	4.798	5.325	5.171

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 bi-annual, competitive process.

FY 2018 Plans:

Complete demonstration of aircraft electrical systems maintenance testing capability. Continue health assessment capability development for fielded air/space/cyber systems and components. Continue development of diagnostic system to assess aircraft wiring and avionics subsystems. Continue development and demonstration of diagnostic technology to monitor/assess health of airframe/engine, launch vehicle, spacecraft, intercontinental ballistic missiles (ICBMs), and components. These efforts are in Air Force Air, Space, and Cyber mission areas. Initiate the following effort based on competitive selection in FY 2017: development of system to reduce maintenance requirements of F-35 carbon monoxide detection system.

FY 2019 Plans:

Complete development of automated software release capability to assess and maintain system health. Continue development of diagnostic system to assess aircraft wiring and avionics subsystems. Continue 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 to monitor/assess health of

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603199F / *Sustainment Science and Technology (S&T)*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
airframe/engine, launch vehicle, spacecraft, intercontinental ballistic missiles (ICBMs), and components. These efforts are in Air Force Air, Space, and Cyber mission areas. Continue development of testing systems to assess aircraft electrical subsystems. Initiate new efforts based on competitive selection processes in FY 2018. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $ 0.154 million. Justification for the decrease is described in the plans above.			
Title: Prevention/Enhanced Maintainability Technologies	4.868	5.325	5.171
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 bi-annual, competitive process. ***FY 2018 Plans:*** Complete advanced monopropellant material replacement for space propulsion systems. Complete transition of two full sized B-2 Radomes for functional ground testing and flight service evaluation. Continue Advanced Canopy Technology development. Initiate Rapid Repair Requirements materials development for aircraft battle damage repair of advanced fighter aircraft. Continue efforts to develop an adaptive maintainer training capability to improve maintainer performance, and an improved method for removal of biofilms from in ground fuel storage systems. 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 sustainment technologies to improve component design, maintenance, repair, replacement, and concepts for maintainer training, extending part life and reduced maintenance burden spanning Air Force Air, Space, and Cyber mission areas. Initiate the following effort based on competitive selection in FY 2017: development of materials and processes to reduce maintenance burden on low observable systems. ***FY 2019 Plans:*** Complete thermal spray coating process development for engine components. Complete development of an improved method for removal of biofilms from in ground fuel storage systems. Complete improved durability conductive tape and enhanced edge treatment repair development for transition to the B-2. Continue Rapid Repair Requirements materials development for aircraft battle damage repair of advanced fighter aircraftContinue Advanced Canopy Technology development. Initiate total body non-destructive 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			

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603199F / *Sustainment Science and Technology (S&T)*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
concepts for maintainer training, extending part life, and reduced maintenance burden spanning Air Force Air, Space, and Cyber mission areas. Initiate new efforts based on competitive selection processes in FY 2018. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $ 0.154 million. Justification for the decrease is described in the plans above.			
Title: Management/Improved Reliability Technologies ***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 bi-annual, competitive process. ***FY 2018 Plans:*** Complete corrosion data management and prediction tool demonstration and development of replacement honeycomb structures for C-5. Continue data mining software development to determine asset availability. Continue effort to assess and accurately determine B-2 exhaust liner thermal profile and structural environment, and demonstrate performance of exhaust structures coatings. Continue software development to increase speed and accuracy of solid rocket motor inspections to reduce sustainment costs and improve reliability. 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 Air, Space, and Cyber mission areas. Initiate the following effort based on competitive selection in FY 2017: analysis techniques to extend engine component service life. ***FY 2019 Plans:*** Complete data mining software development to determine asset availability. Continue effort to assess and accurately determine B-2 exhaust liner thermal profile and structural environment, and demonstrate performance of exhaust structures coatings. Continue software development to increase speed and accuracy of solid rocket motor inspections to reduce sustainment costs and improve reliability. Continue development of 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 Air, Space, and Cyber mission areas. Initiate new efforts based on competitive selection processes in FY 2018. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $ 0.120 million. Justification for the decrease is described in the plans above.	4.504	4.144	4.024
Title: Composite Certification	5.824	8.017	0.784

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603199F / *Sustainment Science and Technology (S&T)*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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. ***FY 2018 Plans:*** Complete demonstration of manufacturing processes and manufacturing process control of composite primary structures. Complete demonstration of the feasibility and benefits of a robust process for predicting and addressing the risk elements for safe and affordable certification of composite structures. Complete demonstration of life extension of a composite primary structure beyond that of the original certified service life. Initiate a service life extension demonstration on a legacy fleet aircraft composite part. ***FY 2019 Plans:*** Continue service life extension demonstration on a legacy fleet aircraft composite part. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $7.233 million. Justification for this decrease is due to realignment of composite certification work from Program Element 0603199F to Program Element 0603211F, Project 634920, Advanced Aerospace Structures Technologies effort.			
Accomplishments/Planned Programs Subtotals	19.994	22.811	15.150

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603203F / *Advanced Aerospace Sensors*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	39.854	40.978	39.968	0.000	39.968	41.662	42.039	43.547	43.515	Continuing	Continuing
63665A: *Advanced Aerospace Sensors Technology*	-	16.711	19.734	19.992	0.000	19.992	21.277	21.324	21.750	21.970	Continuing	Continuing
6369DF: *Target Attack and Recognition Technology*	-	23.143	21.244	19.976	0.000	19.976	20.385	20.715	21.797	21.545	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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	40.945	40.978	43.010	0.000	43.010
Current President's Budget	39.854	40.978	39.968	0.000	39.968
Total Adjustments	-1.091	0.000	-3.042	0.000	-3.042
• 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	-0.027	0.000			
• SBIR/STTR Transfer	-1.064	0.000			
• Other Adjustments	0.000	0.000	-3.042	0.000	-3.042

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*

Change Summary Explanation

Decrease in FY 2019 due to realignment of Sensors Science & Technology (S&T) Advanced Technology Development activities to Sensors S&T Applied Research.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / *Advanced Aerospace Sensors*	Project (Number/Name) 63665A / *Advanced Aerospace Sensors Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
63665A: *Advanced Aerospace Sensors Technology*	-	16.711	19.734	19.992	0.000	19.992	21.277	21.324	21.750	21.970	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Persistent Sensing in Contested Environment Technologies	2.016	2.381	2.412
Description: Develop active radio frequency sensor solutions to use against difficult-to-detect targets in challenging environments, and advanced RF architectures for open and reconfigurable systems. Enable persistent intelligence, surveillance and reconnaissance over wide areas, and detect advanced air and ground targets.			
FY 2018 Plans: Develop multichannel transmit and receive hardware for distributed multiple input multiple output applications. Explore methodologies for coherent signal processing modes supporting electronic support and passive radar receivers.			
FY 2019 Plans: Conduct controlled environment ground-based data collections to validate distributed coherent radar proof-of-concept at X and S-bands for synthetic aperture radar.			
FY 2018 to FY 2019 Increase/Decrease Statement: FY 2019 increased compared to FY 2018 by $0.031 million. Justification for this increase is described in plans above.			
Title: Passive Radio Frequency Sensing Technologies	3.780	4.464	4.523
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.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 63665A / *Advanced Aerospace Sensors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Conduct system engineering analysis to provide architectural trades and test criteria for multi-function passive radio frequency sensors at frequencies above 18 gigahertz (millimeter-wave) requiring increased sensitivity. ***FY 2019 Plans:*** Integrate millimeter-wave hardware and software radio frequency sensor suite for proof-of-concept to intercept, collect, locate and track evolving adversary air and ground sensor systems with evolving agile radio frequency signals of interest. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.059 million. Justification for this increase is described in plans above.			
Title: Long Range Sensing Technologies ***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. ***FY 2018 Plans:*** Extend open architecture constructs to incorporate electronic warfare and communication functions. Continue to develop radar systems and algorithms for multi-static cooperative radar to address the challenges of long stand-off radio frequency sensing in air and space domains. Collect multi-static data with cooperative targets to test algorithms. ***FY 2019 Plans:*** Integrate Passive Radar Illumination Selection Manager hardware and software and conduct data collection on a finite number of radio frequency emitters (cooperative/non-cooperative) and assess the utility of correlated multi-mode operation. Evaluate data collected from experiments that coordinate air and space radio frequency sensors for detection and location of air and ground radio frequency emitters. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.029 million. Justification for this increase is described in plans above.	1.891	2.233	2.262
Title: Passive Electro-Optical Sensing for Surveillance and Reconnaissance Technologies ***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. ***FY 2018 Plans:*** Complete construction of infrared search and track brassboard system and test under laboratory conditions. Modify as appropriate to meet performance goals. Refine and integrate advanced subsystem technology for infrared search and track systems. Test in a laboratory environment to enhance system and subsystem technology readiness level. Advance refinement	5.795	6.843	6.933

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 63665A / *Advanced Aerospace Sensors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
of prototypes for low cost and low size, weight and power hyperspectral imaging to achieve operationally useful radiometric sensitivity, detection performance, and area coverage rates. Continue improvements in algorithms and software required for target detection and tracking and clutter suppression. Advance and refine engineering trades and system optimization for this novel approach, through modeling and simulation. Initiate refinement and prototyping of novel software/hardware combined sensing strategy for turbulence mitigation in passive electro-optical/infrared reconnaissance systems to improve the useful range beyond the current state of the art. Initiate examination of approaches and technologies to reduce size, weight and power of an infrared search and track system while maintaining operationally relevant performance. ***FY 2019 Plans:*** Complete focal plane and other component technologies to enhance performance of a staring infrared search and track architecture. Prepare for a flight test of a staring infrared search and track architecture. Continue examination of approaches and technologies to reduce size, weight and power of an infrared search and track system while maintaining operationally relevant performance. Continue improvements in algorithms and software required for target detection and tracking and clutter suppression. Test candidate systems and subsystems in a laboratory environment. Advance and refine engineering trades and system optimization for this novel approach, through modeling and simulation. Continue refinement and prototyping of novel software/hardware combined sensing strategy for turbulence mitigation in passive electro-optical/infrared reconnaissance systems to improve the useful range beyond the current state of the art. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.090 million. Justification for this increase is described in plans above.			
Title: Laser Radar for Non-Cooperative Identification ***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. ***FY 2018 Plans:*** Complete further flight testing on a synthetic aperture laser radar system with component upgrades under more challenging atmospheric and target conditions. Continue atmospheric characterization, processing, and analysis of synthetic aperture ladar performance based on flight test data and model comparison. Refine and test synthetic aperture laser radar technology under development based on modeling and simulation to enhance spatial resolution beyond the diffraction limit of equivalent optical apertures. Fabricate, modify, and test critical components and subsystems for a synthetic aperture laser radar demonstration in a laboratory environment. Continue research on components needed for improving system capabilities to provide high confidence identification at standoff ranges. Integrate these technologies into a prototype architecture if judged sufficiently mature. Advance sensor automatic target recognition software by applying previous phenomenology research and advanced mathematical	3.229	3.813	3.862

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 63665A / *Advanced Aerospace Sensors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
concepts to simulated and measured data. Continue emphasizing long range air-to-air laser radar concepts through modeling and simulation to support system design and analysis of alternatives. Prepare for future technology demonstrations to advance system, subsystem, and component technology readiness levels. ***FY 2019 Plans:*** Establish predictive synthetic aperture laser radar performance model based on measured data and theoretical modeling. Continue development and integration of enhanced components and subsystems. Demonstrate the associated improvement in performance in a laboratory environment. Refine and test holographic aperture laser radar technology under development based on modeling and simulation to enhance spatial resolution beyond the diffraction limit of individual optical apertures. Fabricate, modify, and test critical components and subsystems for a holographic aperture laser radar demonstration in a laboratory environment. Continue sensor automatic target recognition software by applying previous phenomenology research and advanced mathematical concepts. Continue emphasizing long range air-to-air laser radar concepts through modeling and simulation to support system design and analysis of alternatives. Prepare for future technology demonstrations to advance system, subsystem, and component technology readiness levels. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.049 million. Justification for this increase is described in plans above.			
Accomplishments/Planned Programs Subtotals	16.711	19.734	19.992

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / *Advanced Aerospace Sensors*	Project (Number/Name) 6369DF / *Target Attack and Recognition Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
6369DF: *Target Attack and Recognition Technology*	-	23.143	21.244	19.976	0.000	19.976	20.385	20.715	21.797	21.545	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project area develops and demonstrates advanced technologies for attack management, fire control, and target identification and recognition. This includes developing and demonstrating integrated and cooperative fire control techniques to provide for adverse-weather precision air strikes against multiple targets per pass and at maximum weapon launch ranges. Specific fire control technologies under development include attack management, sensor fusion, automated decision aids, advanced tracking for low radar cross section threats, and targeting using both on-board and off-board sensor information. This project area also evaluates targeting techniques to support theater missile defense efforts in surveillance and attack. These fire control technologies will provide force multiplication and reduce warfighter exposure to hostile fire. This project area also develops and demonstrates target identification and recognition technologies for positive, high confidence cueing, recognition, and identification of airborne and ground-based, high-value, time-critical targets at longer ranges than are currently possible. The goal is to apply these technologies to tactical air-to-air and air-to-surface weapon systems so they are able to operate in all weather conditions, during day or night, and in high-threat, multiple target environments. Model-based vision algorithms and target signature development techniques are the key to target identification and recognition. This project is maturing these technologies in partnership with the Defense Advanced Research Projects Agency and evaluating the techniques to support theater missile defense efforts in surveillance and attack. Fire control and recognition technologies developed and demonstrated in this project area are high leverage efforts, providing for significant advancements in operational capabilities largely through software improvements readily transitionable to new and existing weapon systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Integrated Sensor Targeting Technologies	4.283	3.932	3.697
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 2018 Plans: Continue developing multi-intelligence detection for single named area of interest incorporating multiple weapons systems. Demonstrate closed loop sensor exploitation using deep reinforcement learning.			
FY 2019 Plans: Extend development of multi-intelligence detection for multiple named areas of interest in multiple areas of regard. Conduct laboratory test of task flexibility with payload management and knowledge reasoning with electronic support measure and intelligence, surveillance and reconnaissance. Initiate development of multi-platform resource management aggregate planning capability.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 6369DF / *Target Attack and Recognition Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $0.235 million. Justification for this decrease is described in plans above.			
Title: Multi-Sensor Target Recognition ***Description:*** Develop and assess multi-sensor automatic target recognition for intelligence, surveillance, reconnaissance, strike, and weapon systems. ***FY 2018 Plans:*** Develop template based electro-optical full motion video automatic target recognition reference implementation. Initiate development of multi-sensor decision level fusion for stationary targets. ***FY 2019 Plans:*** Demonstrate flyable, real-time deep learning-based synthetic aperture radar target identification. Conduct large electro-optical data collection/characterization and assessment in conjunction with the National Geospatial-Intelligence Agency. Develop performance model for deep learning synthetic aperture radar target recognition. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.521 million. Justification for this decrease is described in plans above.	9.518	8.737	8.216
Title: Wide-Angle Continuously-Staring Technologies ***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. ***FY 2018 Plans:*** Continue development of stand-off (air and space) and episodic stand-in sensing capabilities for contested and denied environments. Demonstrate tracking, change detection, and image processing capabilities for data representative of contested and denied environments. Collect, process, and catalogue data from advanced wide-angle sensor. Develop feature aided tracking methods for wide angle radio frequency sensors. ***FY 2019 Plans:*** Continue development of stand-off (air and space) and episodic stand-in sensing capabilities for contested and denied environments. Continue to demonstrate tracking, change detection, and image processing capabilities for data representative of contested and denied environments. Collect, process, and catalogue data from advanced wide-angle sensor. Develop feature aided tracking methods for wide angle radio frequency sensors. Initiate multi-target tracking, improvement to three-dimensional radar products, and surrogate radar sensing capability. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	9.342	8.575	8.063

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 6369DF / *Target Attack and Recognition Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $0.512 million. Justification for this decrease is described in plans above.			
Accomplishments/Planned Programs Subtotals	23.143	21.244	19.976

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603211F / *Aerospace Technology Dev/Demo*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	128.358	115.966	121.002	0.000	121.002	105.411	79.995	84.997	86.479	Continuing	Continuing
634920: *Flight Vehicle Tech Integration*	-	31.448	19.734	26.679	0.000	26.679	32.325	33.619	34.844	35.311	Continuing	Continuing
634926: *High Speed/Hypersonic Intgr and Demo*	-	82.097	78.762	78.324	0.000	78.324	48.959	21.592	22.031	22.476	Continuing	Continuing
634927: *Flight Systems Control*	-	14.813	17.470	15.999	0.000	15.999	24.127	24.784	28.122	28.692	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program supports Department of Defense (DoD) priorities for demonstrations in hypersonics and 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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force					Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*			R-1 Program Element (Number/Name) PE 0603211F / *Aerospace Technology Dev/Demo*		
B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	130.950	115.966	115.861	0.000	115.861
Current President's Budget	128.358	115.966	121.002	0.000	121.002
Total Adjustments	-2.592	0.000	5.141	0.000	5.141
• 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	0.906	0.000			
• SBIR/STTR Transfer	-3.498	0.000			
• Other Adjustments	0.000	0.000	5.141	0.000	5.141

Change Summary Explanation

Increase in FY 2019 due to realignment of composite certification work from PE 0603199F, Sustainment Science and Technology (S&T), Project 635351, Technology Sustainment, to PE 0603211F, Aerospace Technology Dev/Demo, Project 634920, Flight Vehicle Tech Integration.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
634920: *Flight Vehicle Tech Integration*	-	31.448	19.734	26.679	0.000	26.679	32.325	33.619	34.844	35.311	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Aerospace Vehicle Technology Integration	16.527	10.371	10.342
Description: Develop, simulate, and demonstrate integrated technologies to improve the performance of aerospace platform capabilities. ***FY 2018 Plans:*** Complete risk reduction of exhaust systems component demonstration for future air superiority. Initiate next generation mobility vehicle technology experiments. ***FY 2019 Plans:*** Continue next generation mobility vehicle technology experiments. Initiate integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility. Initiate the flight demonstration of a low cost unmanned aerospace systems (UAS) capable of interoperations with different UAS assets. Initiate propulsion integrations component validation tests for Air Superiority 2030 requirements. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.029 million. Justification for this decrease is described in the plans above.			
Title: Advanced Aerospace Structure Technologies	14.921	9.363	16.337
Description: Develop and demonstrate affordable, lightweight, adaptive, and multifunctional structural concepts integrated into aerospace systems. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue low cost airframe design and manufacturing demonstrations. Continue low cost attritable aircraft flight demonstration analysis and support. Complete an electronic warfare and passive radar flight demonstration of an integrated antenna into load-bearing structures for small remotely piloted aircraft. ***FY 2019 Plans:*** Continue low cost airframe design and manufacturing demonstrations. Continue low cost attritable aircraft flight demonstration analysis and support. Initiate structural life extension demonstration of legacy fleet metallic structures. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increase compared to FY 2018 by $6.974 million. Justification for this increase is due to realignment of composite certification work from Program Element 0603199F to Program Element 0603211F, Project 634920.			
Accomplishments/Planned Programs Subtotals	31.448	19.734	26.679

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / *Aerospace Technology Dev/ Demo*	Project (Number/Name) 634926 / *High Speed/Hypersonic Intgr and Demo*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
634926: *High Speed/Hypersonic Intgr and Demo*	-	82.097	78.762	78.324	0.000	78.324	48.959	21.592	22.031	22.476	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: High Speed/Hypersonic Vehicle Technologies	82.097	78.762	78.324
Description: Develop, simulate, and demonstrate integrated vehicle technologies to enable and improve the performance of future high-speed and hypersonic systems. ***FY 2018 Plans:*** Initiate and complete critical design review for Hypersonic Air-breathing Weapon Concept (HAWC) and Tactical Boost Glide (TBG) demonstrations. Continue accelerated development and demonstration of tactically-relevant long-range high-speed strike technologies including ground and flight demonstrations needed for potential follow-on acquisition program. Continue advancement of high temperature materials and structures for hypersonic vehicles. ***FY 2019 Plans:*** Continue accelerated development and demonstration of tactically-relevant long-range high-speed strike technologies including ground and flight demonstrations needed. Initiate and complete HAWC and TBG integration, assembly, test, and checkout. Initiate flight test activities for both HAWC and TBG. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decrease compared to FY 2018 by $0.483 million. Justification for this decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	82.097	78.762	78.324

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603211F / *Aerospace Technology Dev/ Demo*	**Project (Number/Name)** 634926 / *High Speed/Hypersonic Intgr and Demo*

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / *Aerospace Technology Dev/ Demo*	Project (Number/Name) 634927 / *Flight Systems Control*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
634927: *Flight Systems Control*	-	14.813	17.470	15.999	0.000	15.999	24.127	24.784	28.122	28.692	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Autonomous Systems Control	14.813	17.470	15.999

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 2018 Plans:

Continue development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems and manned platforms. Continue demonstration of autonomous and safe airspace interoperability for manned and remotely piloted aircraft systems. Continue development and demonstration of airborne control of teams of unmanned aircraft. Continue development of small UAS for air-launch and off-board sensing in tactical environments. Initiate development and demonstration of reduced crew operations of future mobility aircraft. Initiate development of technologies to reduce risk for transition of collision avoidance technologies to 4th and 5th-gen aircraft. Initiate development of unmanned sense-and-avoid technologies for ground and air operations. Initiate development of foundational autonomy for unmanned systems and spiral demonstrations of capability.

FY 2019 Plans:

Continue development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems and manned platforms. Continue demonstration of autonomous and safe airspace interoperability for manned and remotely piloted aircraft systems. Continue development and demonstration of airborne control of teams of unmanned aircraft. Continue development and demonstration of reduced crew operations of future mobility aircraft. Continue development of unmanned sense-and-avoid technologies for ground and air operations. 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.

FY 2018 to FY 2019 Increase/Decrease Statement:

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603211F / *Aerospace Technology Dev/ Demo*	**Project (Number/Name)** 634927 / *Flight Systems Control*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $1.471 million. Justification for this decrease is due to due to Department of Defense deflation.			
Accomplishments/Planned Programs Subtotals	14.813	17.470	15.999

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	104.695	104.499	115.462	0.000	115.462	115.610	117.682	115.734	118.075	Continuing	Continuing
632480: *Aerospace Fuels*	-	2.054	2.302	2.340	0.000	2.340	2.386	2.434	2.483	2.532	Continuing	Continuing
633035: *Aerospace Power Technology*	-	21.229	13.934	23.954	0.000	23.954	22.170	22.375	18.492	18.866	Continuing	Continuing
634921: *Aircraft Propulsion Subsystems Int*	-	17.896	17.902	18.058	0.000	18.058	18.400	18.767	19.147	19.537	Continuing	Continuing
634922: *Space & Missile Rocket Propulsion*	-	26.313	28.799	29.264	0.000	29.264	29.847	30.443	31.062	31.690	Continuing	Continuing
635098: *Advanced Aerospace Propulsion*	-	22.622	28.797	20.194	0.000	20.194	20.595	21.009	21.435	21.867	Continuing	Continuing
63681B: *Advanced Turbine Engine Gas Generator*	-	14.581	12.765	21.652	0.000	21.652	22.212	22.654	23.115	23.583	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 (ASPI) 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, ASPI, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, and 0602298F.

This effort is in Budget Activity 3, Advanced Technology Development, because this budget activity includes development of subsystems, 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	94.594	104.499	112.332	0.000	112.332
Current President's Budget	104.695	104.499	115.462	0.000	115.462
Total Adjustments	10.101	0.000	3.130	0.000	3.130
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	15.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-1.254	0.000			
• SBIR/STTR Transfer	-3.645	0.000			
• Other Adjustments	0.000	0.000	3.130	0.000	3.130

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 633035: *Aerospace Power Technology*		
Congressional Add: *Silicon Carbide Research*	14.506	0.000
Congressional Add Subtotals for Project: 633035	14.506	0.000
Congressional Add Totals for all Projects	14.506	0.000

Change Summary Explanation

Increase in FY 2019 due to realignment of funds for High-Speed Strike Weapon (HSSW).

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 632480 / *Aerospace Fuels*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
632480: *Aerospace Fuels*	-	2.054	2.302	2.340	0.000	2.340	2.386	2.434	2.483	2.532	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Fuel-Related Thermal Management	0.601	0.674	0.685
Description: Demonstrate thermally stable fuels and fuel system hardware concepts to enhance cooling capacity (performance), minimize fuel coking, and reduce fuel system maintenance. ***FY 2018 Plans:*** Continue investigation of fuel heat sink approaches for thermal management of adaptive engines, including on-board fuel deoxygenation. ***FY 2019 Plans:*** Continue investigation of fuel heat sink approaches for thermal management of adaptive engines, including on-board fuel deoxygenation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.011 million. Justification for the increase is described in the plans above.			
Title: Gas Turbine Combustion, Emissions, and Performance	0.545	0.611	0.621
Description: Develop and demonstrate efficacy of low-cost, environmentally friendly fuel approaches to assess and reduce soot/ particulate emissions from gas turbine engines. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 632480 / *Aerospace Fuels*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Initiate development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions. ***FY 2019 Plans:*** Contnue development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.010 million. Justification for the increase is described in the plans above.			
Title: Fuel Logistics ***Description:*** Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Air Force. ***FY 2018 Plans:*** Complete evaluation of advanced additives for water sequestration and mitigation of biological growth. ***FY 2019 Plans:*** Initiate development of fuel composition in-situ sensors to ensure thermal stability throughout platform mission. Initiate development of fuel sensors and mitigation products to detect and mitigate fuel bio-contamination. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.014 million. Justification for the increase is described in the plans above.	0.726	0.813	0.827
Title: Alternative Jet Fuels ***Description:*** Characterize and demonstrate the use of alternative hydrocarbon jet fuel to comply with Air Force certifications and standards for jet fuels. ***FY 2018 Plans:*** Continue development of generic alternative fuel specification annexes for commercial jet fuels used by Air Force. ***FY 2019 Plans:*** Continue development of generic alternative fuel specification annexes for commercial jet fuels used by Air Force. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.003 million. Justification for the increase is described in the plans above.	0.182	0.204	0.207
Accomplishments/Planned Programs Subtotals	2.054	2.302	2.340

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 632480 / *Aerospace Fuels*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 633035 / *Aerospace Power Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
633035: *Aerospace Power Technology*	-	21.229	13.934	23.954	0.000	23.954	22.170	22.375	18.492	18.866	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 as well as to enable 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: High Power Aircraft Subsystem Technologies	6.723	13.934	23.954
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 2018 Plans: Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Continue 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. Initiate development and demonstration of megawatt class architecture, controls and integration. Initiate development and demonstration of robust electrical power systems for megawatt applications. Initiate development and demonstration of thermal management systems for megawatt applications. Initiate development and demonstration of solid state electrical distribution technology for megawatt applications.			
FY 2019 Plans: Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Continue 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.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 633035 / *Aerospace Power Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $10.020 million. Justification for the increase is due to increased emphasis in high power aircraft subsystems.			
Accomplishments/Planned Programs Subtotals	6.723	13.934	23.954

	FY 2017	FY 2018
Congressional Add: Silicon Carbide Research ***FY 2017 Accomplishments:*** Conducted Congressionally directed efforts. ***FY 2018 Plans:*** N/A	14.506	0.000
Congressional Adds Subtotals	14.506	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 634921 / *Aircraft Propulsion Subsystems Int*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
634921: *Aircraft Propulsion Subsystems Int*	-	17.896	17.902	18.058	0.000	18.058	18.400	18.767	19.147	19.537	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 Advanced Turbine Engine Gas Generator (ATEGG) 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 APSI 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Missile/Remotely Piloted Aircraft Engine Performance	10.650	10.653	10.746
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 2018 Plans: Complete supersonic turbojet engine altitude testing. Complete Preliminary Design Review (PDR) of medium-scale efficient core demonstrator. Initiate detailed design of medium-scale efficient core demonstrator. Continue risk reduction testing of components for 200lb thrust and 650lb thrust engines. Complete PDR of 200lb thrust engine and Critical Design Review (CDR) of 650lb thrust engine. Complete PDR of durability test utilizing small scale cruise missile engine to validate advanced design and life prediction tools for medium and large engine applications. Continue the development of derivative supersonic turbojet engines for missile			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634921 / *Aircraft Propulsion Subsystems Int*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
and high speed accelerators. Initiate design of advanced turbine based accelerator with reusable hypersonics applications. Continue the assessment of Air Force Research Laboratory (AFRL) vehicle and propulsion system integration efforts. ***FY 2019 Plans:*** Complete detailed design of and CDR of a medium-scale efficient core demonstrator. Initiate risk reduction component testing of a medium-scale efficient core demonstrator. Continue risk reduction testing of components for 200lb thrust and 650lb thrust engines. Complete CDR of 200lb thrust engine. Completion of testing of 650lb engine. Complete CDR of durability test utilizing small scale cruise missile engine to validate advanced design and life prediction tools for medium and large engine applications. Continue the development of derivative supersonic turbojet engines for missile and high speed accelerators. Continue design of advanced turbine based accelerator with reusable hypersonics applications. Continue the assessment of AFRL vehicle and propulsion system integration efforts. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.093 million. Justification for this increase is described in the plans above.			
Title: Adaptive Turbine Engine Technologies ***Description:*** Design, fabricate, and demonstrate performance, durability, and operability technologies to mature adaptive turbine engine technologies. ***FY 2018 Plans:*** Complete ground testing of experimental adaptive turbine engine core. Initiate and complete the assessment of the acquired and processed data from the ground testing of experimental adaptive turbine engine core and comparison to analytical prediction tools to validate reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. Continue to provide subject matter expert support to Adaptive Engine Transition Program (AETP) to ensure knowledge transition and successful incorporation of test results into AETP design. Initiate and complete design for integrated power and thermal management engine demonstrator to facilitate investigation and mapping of off-design operations for integrated propulsion, power and thermal management. Initiate hardware fabrication for an adaptive engine for utilization as an integrated power and thermal management engine demonstrator. ***FY 2019 Plans:*** Continue to provide subject matter expert support to AETP. Complete fabrication of components for integrated power and thermal management engine demonstrator. Continue hardware fabrication for an adaptive engine for utilization as an integrated power and thermal management engine demonstrator. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.063 million. Justification for this increase is described in the plans above.	7.246	7.249	7.312
Accomplishments/Planned Programs Subtotals	17.896	17.902	18.058

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634921 / *Aircraft Propulsion Subsystems Int*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 634922 / *Space & Missile Rocket Propulsion*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
634922: *Space & Missile Rocket Propulsion*	-	26.313	28.799	29.264	0.000	29.264	29.847	30.443	31.062	31.690	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 thrusts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire DoD and National Aeronautics and Space Administration (NASA). The thrusts in this project are part of the Rocket Propulsion 21 (RP21) program. The thrusts 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Liquid Rocket Propulsion Technologies	19.837	20.923	19.314
Description: Develop liquid rocket propulsion technology for current and future space launch vehicles.			
FY 2018 Plans: Complete development of hydrocarbon engine components and initiate preparation for integrated testing. Complete testing of the full-scale preburner. Continue fabrication of the Turbopump. Initiate study for next generation liquid propulsion technology demonstration effort focused on modularity and cost reduction.			
FY 2019 Plans: Complete preparation for integrated testing. Complete fabrication of the Turbopump. Continue study for next generation liquid propulsion technology demonstration effort focused on modularity and cost reduction. Initiate integrated testing of hydrocarbon engines components			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634922 / *Space & Missile Rocket Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $1.609 million. Justification for the decrease is due to a decreased emphasis in liquid rocket propulsion technology.			
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 2018 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. Initiate the extension of the capability to study next generation of hypergolic fuels, including propellant characterization, drop-in testing, and lab-scale thruster demonstration. Continue analysis and development of multimode propulsion opportunities to combine high efficiency and high thrust capabilities on a common propellant. ***FY 2019 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. Initiate thrust scale-up effort for advanced non-toxic mono-propellant thrusters. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.107 million. Justification for the increase is described in the plans above.	0.464	1.649	1.756
Title: Ballistic Missile Technologies ***Description:*** Develop and demonstrate missile propulsion and post-boost control systems technologies for ballistic missiles. ***FY 2018 Plans:*** Continue technology demonstration effort on advanced missile case, insulation, and nozzle technologies and validation of physics-based modeling, simulation, and analysis tools for ballistic and tactical missile solid rocket motors. Continue technology maturation and demonstration efforts for post-boost technologies and tactical missile technologies. ***FY 2019 Plans:***	4.792	2.664	4.682

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634922 / *Space & Missile Rocket Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Complete technology demonstration effort on advanced missile case, insulation, and nozzle technologies and validation of physics-based modeling, simulation, and analysis tools for ballistic and tactical missile solid rocket motors. Continue technology maturation and demonstration efforts for post-boost technologies and tactical missile technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $2.018 million. Justification for the increase is an increased emphasis in ballistic missile technologies.			
Title: Strategic System Motor Surveillance ***Description:*** Develop and demonstrate aging and surveillance technologies for strategic systems to reduce lifetime prediction uncertainty for individual motors, enabling motor replacement for cause. ***FY 2018 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 the support of 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. Initiate 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. ***FY 2019 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:***	1.220	3.563	3.512

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634922 / *Space & Missile Rocket Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $0.051 million. Justification for the decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	26.313	28.799	29.264

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 635098 / *Advanced Aerospace Propulsion*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635098: *Advanced Aerospace Propulsion*	-	22.622	28.797	20.194	0.000	20.194	20.595	21.009	21.435	21.867	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. Thrusts 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Scramjet Technologies	22.622	28.797	20.194
Description: Develop and demonstrate technologies for a hydrocarbon-fueled scramjet with robust operation up to Mach 7.			
FY 2018 Plans: Initiate the design and analyze flight weight, medium scale high-speed propulsion systems in preparation for future ground test. Continue development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and engine controls. Initiate direct-connect test of tactically compliant cold start system in flight weight hardware. Continue development of scramjet technologies to enhance operability including robust operation during maneuvers. Complete direct connect testing of medium scale engine components at the Aerodynamic and Propulsion Test Unit (APTU) in support of reusable air platform technology development.			
FY 2019 Plans: Initiate scramjet combustor maturation efforts for flight-compliant designs based on results from direct connect testing of medium scale engine components at APTU. Continue development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and engine controls. Continue development of scramjet technologies to enhance operability including robust operation during maneuvers. Continued 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 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 635098 / *Advanced Aerospace Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $8.603 million. Justification for the decrease is due to realignment for hypersonics and laser technology.			
Accomplishments/Planned Programs Subtotals	22.622	28.797	20.194

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 63681B / *Advanced Turbine Engine Gas Generator*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
63681B: *Advanced Turbine Engine Gas Generator*	-	14.581	12.765	21.652	0.000	21.652	22.212	22.654	23.115	23.583	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 APSI 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Core Engine Technologies	6.241	5.463	9.268
Description: Design, fabricate, and demonstrate performance predictions in core engines, using innovative engine cycles and advanced materials for turbofan and for turbojet engines. ***FY 2018 Plans:*** Complete Preliminary Design Review (PDR) of medium-scale efficient core demonstrator. Initiate detailed design of medium-scale efficient core demonstrator. Initiate design of large-scale adaptive core concepts. Complete green run and baseline testing of a small cruise missile size engines for use as future sustainment demonstrator. Initiate detailed design of bladed disks and bearing systems components for small cruise missile size engine. Initiate development of small cruise missile engine demonstrator test plans to improve life prediction capability. ***FY 2019 Plans:*** Complete design and Critical Design Review (CDR) of medium-scale efficient core demonstrator. Initiate risk reduction component tests for medium-scale engine advanced fan and core. Initiate build of medium-scale engine. Complete design and CDR of large-scale adaptive core concepts. Complete development of small cruise missile engine demonstrator test plans to			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 63681B / *Advanced Turbine Engine Gas Generator*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
improve life prediction capability for bladed disks and bearing systems. Complete design and CDR of bladed disks and bearing systems components for small cruise missile size engine. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $3.805 million. Justification for the increase is due to an increased emphasis engine technologies.			
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 2018 Plans:*** Continue risk reduction testing of components for 200lb thrust and 650lb thrust engines. Complete Preliminary Design Review (PDR) of 200lb thrust engine and Critical Design Review (CDR) of 650lb thrust engine. Complete fabrication of advanced concept additive manufacturing heat exchanger for small core engines. Complete design and CDR of recouperator for demonstration of increased core efficiency in small core engines. ***FY 2019 Plans:*** Complete risk reduction testing of components for 200lb thrust and 650lb thrust engines. Complete CDR of 200lb thrust engine. Initiate assembly of advanced concept additive manufacturing heat exchanger for small core engines. Initiate fabrication of recouperator for demonstration of increased core efficiency in small core engines. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.380 million. Justification for the increase is due to an increased emphasis in engine technology.	2.264	1.982	3.362
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 2018 Plans:*** Complete final ground testing of final Adaptive Engine Technology Demonstrator core demonstrator. Complete data reduction to validate predictions and provided technical information/lessons learned to Adaptive Engine Technology Program to ensure successful design. Continue design and initiate long lead procurement for advanced air dominance adaptive core demonstrator and risk reduction rigs. Complete the selection of technologies to be incorporated into adaptive engine demonstrator design. Initiate the evaluation of application of high temperature Polymer Matrix Composite (PMC) and Ceramic Matrix Composites	6.076	5.320	9.022

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 63681B / *Advanced Turbine Engine Gas Generator*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
(CMCs) to reduce system weight and improve cycle efficiency. Initiate analyses of adaptive engine technologies operational mission impact. ***FY 2019 Plans:*** Complete Preliminary Design Review and procurement of long lead hardware for advanced air dominance adaptive core demonstrator and risk reduction rigs. Initiate detailed design advanced air dominance adaptive core demonstrator. Initiate component tests of advanced variable turbine and innovative compression rear block designed to accept flow variations caused by variable turbine operation. Complete the evaluation of application of high temperature PMC and CMCs to reduce system weight and improve cycle efficiency. Complete analyses of adaptive engine technologies operational mission impact. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $3.702 million. Justification for the increase is due to an increased emphasis in engine technology.			
Accomplishments/Planned Programs Subtotals	14.581	12.765	21.652

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	64.591	60.551	55.319	0.000	55.319	57.501	58.359	58.123	58.580	Continuing	Continuing
633720: *EW Quick Reaction Capabilities*	-	36.742	31.254	30.821	0.000	30.821	34.444	36.392	33.652	33.854	Continuing	Continuing
63431G: *RF Warning & Countermeasures Tech*	-	16.671	18.284	14.441	0.000	14.441	13.568	12.255	12.648	12.730	Continuing	Continuing
634335: *Cyber Concepts*	-	4.095	6.087	5.832	0.000	5.832	5.129	5.261	7.236	7.382	Continuing	Continuing
63691X: *EO/IR Warning & Countermeasures Tech*	-	7.083	4.926	4.225	0.000	4.225	4.360	4.451	4.587	4.614	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 combat, 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 RF 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 identify and mitigate avionics system cyber vulnerabilities as well as protects avionics and other critical technologies. 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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force					Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*			R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*		
B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	58.250	60.551	61.945	0.000	61.945
Current President's Budget	64.591	60.551	55.319	0.000	55.319
Total Adjustments	6.341	0.000	-6.626	0.000	-6.626
• 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	7.900	0.000			
• SBIR/STTR Transfer	-1.559	0.000			
• Other Adjustments	0.000	0.000	-6.626	0.000	-6.626

Change Summary Explanation

Decrease in FY 2019 due to realignment of Electronic Combat Technology Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors S&T Applied Research.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 633720 / *EW Quick Reaction Capabilities*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
633720: *EW Quick Reaction Capabilities*	-	36.742	31.254	30.821	0.000	30.821	34.444	36.392	33.652	33.854	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 (EW-threat interactions) in a congested/ contested electromagnetic spectrum, system-of-systems (SoS) environment of the future. It develops disruptive EW 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 EW systems engineering methodology. It develops a core analytic function, supported by simulation-based wargaming and interactive engineering modeling capabilities to evaluate advanced countermeasures concepts.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Radio Frequency Electronic Warfare	13.055	13.943	9.600

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).

This effort is being renamed from Disruptive Electronic Warfare and Countermeasure Technologies to better align project and thrusts with functional areas.

FY 2018 Plans:
Conduct sense, learn, and adapt demonstrations illustrating advancements in electromagnetic spectrum awareness, reasoning, and collaborative effects. Demonstrate advanced counter satellite position, navigation and timing techniques in an operational environment. Begin the development and demonstration efforts to prove the concepts for "full spectrum" countermeasures capabilities.

FY 2019 Plans:
Continue expansion of simulations to accommodate advanced electronic warfare systems, and to emulate the radio frequency threats and signal environments for which they're designed. Develop 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. Continue the development and demonstration efforts to prove the concepts for "full spectrum"

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 633720 / *EW Quick Reaction Capabilities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
countermeasures capabilities. In select situations, develop threat seeker surrogates with which to test emerging electronic warfare technologies. Expand software-in-the-loop and hardware-in-the-loop environments to achieve closed-loop system performance. Previous to FY 2019, Position, navigation and timing technology development was performed in Project 633720, Electronic Warfare Capabilities, Position, Navigation and Timing for Contested/Denied Environments Effort. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $4.343 million. Justification for the decrease is due to realignment of Electronic Combat Technology Science and Technology (S&T) Advanced Technology Development to Aerospace Sensors S&T Applied Research.			
Title: Position, Navigation and Timing for Contested/Denied Environments	15.052	8.089	16.425
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; 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. This effort is being renamed from Threat-to-Countermeasure SoS Methods to better align project and thrusts with functional areas. ***FY 2018 Plans:*** Demonstrate robust distributed time transfer in a Global Positioning System jamming environment. Develop / evolve position, navigation and timing open architecture standards to enable resiliency to position, navigation and timing threats. Demonstrate effects of a coordinated electronic attack capability. ***FY 2019 Plans:*** Research techniques to securely certify Global Navigation Satellite System software defined radio technology and methods to trust Global Navigation Satellite System. Develop complementary 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 complementary 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 an resilient embedded Global Positioning System inertial government reference architecture.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 633720 / *EW Quick Reaction Capabilities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Previous to FY 2019, some of this work was performed in Project 633720, Electronic Warfare Capability, efforts Radio Frequency Electronic Warfare and Electro-Optical and Infrared (EO/IR) Threat Warning and Countermeasures. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $8.336 million. Justification for the increase is due to realignment of work from Radio Frequency Electronic Warfare and Electro-Optical and Infrared (EO/IR) Threat Warning and Countermeasures efforts.			
Title: Electro-Optical/Infrared Threat Warning and Countermeasures	8.635	9.222	4.796
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. This effort is being renamed from Evaluation of Advanced Countermeasure Concepts to better align project and thrusts with funding in functional areas. ***FY 2018 Plans:*** Continue data collection on advanced imaging sensor defeat mechanisms and conduct requirements trades for system transition architectures. Continue the development of advanced missile warning technologies for long-range detection. Demonstrate adaptable threat emulation capability to simulate modern and expected future electronic warfare threats. Demonstrate trusted use of foreign satellite position, navigation and timing signals through signal authentication techniques, constellation signal monitoring and data dissemination, and jamming countermeasure techniques. Address size, weight and power requirements for application to the whole range of Air Force platforms. Begin the incorporation of the proactive situational awareness and countermeasures capabilities into engagement models. ***FY 2019 Plans:*** Continue test planning and field and flight tests of a proactive infrared countermeasure capability to detect ground based electro-optical/infrared threats. Continue the integration of joint radio frequency and electro-optical/infrared engagement modeling and simulation capabilities to support countering multispectrum (for example, radio frequency and electro-optical/infrared combined) threats. Continue designs and begin field test demonstration of capabilities against multispectral threats. Refine the countermeasure techniques and sources for countermeasures against advanced imaging multispectral sensors to include tower testing against surrogates and representative threats hardware.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 633720 / *EW Quick Reaction Capabilities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Previous to FY 2019, Position, navigation and timing technology development was performed in Project 633720, EW Capabilities, Position, Navigation and Timing for Contested/Denied Environments Effort. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $4.426 million. Justification for the decrease is due to realignment of Electronic Combat Technology Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors S&T Applied Research.			
Accomplishments/Planned Programs Subtotals	36.742	31.254	30.821

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 63431G / *RF Warning & Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
63431G: *RF Warning & Countermeasures Tech*	-	16.671	18.284	14.441	0.000	14.441	13.568	12.255	12.648	12.730	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Electronic Attack	16.671	18.284	14.441
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 2018 Plans: Continue efforts in advanced electronic warfare receiver algorithms and architectures, as well as machine learning ("cognitive") algorithms. Continue research into innovative electronic attack concepts/techniques including use of closed loop, cooperatively controlled, distributed unmanned aerial vehicles and their performance against integrated air defense networks and adaptable techniques for use against any threats. Fabricate and demonstrate an advanced capability electronic attack pod against emerging, high priority threats. Develop, integrate and demonstrate distributed electronic attack concepts and their required position, navigation, timing and datalink technologies. Demonstrate integration of position, navigation and timing signals of opportunity and vision aiding into a resilient embedded Global Positioning System inertial system prototype.			
FY 2019 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, underserviced 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. Initiate the study, research and/or development of merged autonomy and electronic warfare technologies. Continue			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 63431G / *RF Warning & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
expansion of modeling, simulation and laboratory assessment environments commensurate with technologies being researched, developed and tested. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $3.843 million. Justification for the decrease is due to realignment of Electronic Combat Technology Science and Technology (S&T) Advanced Technology Development activities to Aerospace Sensors S&T Applied Research.			
Accomplishments/Planned Programs Subtotals	16.671	18.284	14.441

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 634335 / *Cyber Concepts*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
634335: *Cyber Concepts*	-	4.095	6.087	5.832	0.000	5.832	5.129	5.261	7.236	7.382	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Avionics Cyber Vulnerabilities	2.275	3.382	3.241
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 2018 Plans: Continue vulnerability investigations with the intent to provide a standardized methodology for discovery and set of tools for performing a thorough cyber vulnerability assessment of a weapon system. Transition assessment tools to Department of Defense test communities. Continue to develop and transition mitigation technologies.			
FY 2019 Plans: Complete transition of assessment tools and continue to develop and transition mitigation technologies. Investigate and advance architectural concepts that enable cost-effective and rapid integration of revolutionary sensor capabilities. This allows system flexibility required for future operations. Architecture includes features to make it cyber secure.			
FY 2018 to FY 2019 Increase/Decrease Statement: FY 2019 decreased compared to FY 2018 by $0.141 million. Justification for the decrease is described in the plans above.			
Title: Avionics Cyber Protections	1.820	2.705	2.591
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.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 634335 / *Cyber Concepts*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Continue to extend research on a suite of protection tools with focus on their application to unmanned aircraft system platforms. Prototype and demonstrate a platform independent malware feature selection capability. Investigate automation and optimization of malware detection and classification work using machine learning techniques. ***FY 2019 Plans:*** Continue to extend research on a suite of protection tools with focus on their application to unmanned aircraft system platforms. Continue to investigate automation and optimization of malware detection and classification work using machine learning techniques. Develop a patterns database that detects and classifies benign and malicious behaviors, and validate proof-of-concept for x86 computer architectures. Investigate and create architecture specific translators to provide input to behaviors database to further validate the concept. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.114 million. Justification for the decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	4.095	6.087	5.832

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 63691X / *EO/IR Warning & Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
63691X: *EO/IR Warning & Countermeasures Tech*	-	7.083	4.926	4.225	0.000	4.225	4.360	4.451	4.587	4.614	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Electro-Optical/Infrared Warning and Countermeasure Technologies	7.083	4.926	4.225

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 2018 Plans:

Continue characterization and exploitation of newly acquired advanced threats. Standup new lab space to perform characterization and countermeasure development of these new threats. Refine the imaging threat surrogates based on data collected from countermeasures flight tests and update the Modeling System for Advanced Investigation of Countermeasures engagement model with new surrogate information. Continue working with the Guided Weapons Evaluation Facility to develop high fidelity jam codes and to correlate the modeling and simulation with hardware-in-the-loop and live fire results. Finalize the Modeling System for Advanced Investigation of Countermeasures verification, validation, & accreditation activities to support programs of record. Begin to insert proactive capabilities into Modeling System for Advanced Investigation of Countermeasures. Continue the fabrication of the low cost missile system and plan for flight and live fire test. Begin analysis on options for next generation long range missile warning sensor for future capabilities. Conduct an analysis of alternatives for laser warning for air and space platforms and plan for field and flight tests. Continue to refine the tower proactive testbed by evaluating additional high sensitivity focal plane array options. Begin plans for proactive critical field tests that incorporates information from mid-infrared situational awareness and the tower testbed. Begin planning for a multifunction proactive countermeasure critical experiment

FY 2019 Plans:

Continue countermeasure development and field testing of new threats to include new jam codes and countermeasure techniques. Continue to incorporate proactive infrared countermeasures capabilities into Modeling System for Advanced Investigation of Countermeasures. Flight test the low cost missile warning capabilities and refine design alternative and

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 63691X / *EO/IR Warning & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
conduct critical experiments for long range missile warning. Stand up the High altitude threat warning capabilities and begin characterization testing for advanced laser warning options. Start design and tradeoff phase for the proactive critical experiment. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.701 million. Justification for the decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	7.083	4.926	4.225

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	69.338	58.910	54.895	0.000	54.895	53.979	55.891	58.966	60.113	Continuing	Continuing
632181: *Spacecraft Payloads*	-	13.034	15.767	15.093	0.000	15.093	15.078	15.886	17.114	17.493	Continuing	Continuing
633834: *Integrated Space Technology Demonstrations*	-	33.978	21.424	16.523	0.000	16.523	16.511	16.712	18.210	18.582	Continuing	Continuing
634400: *Space Systems Protection*	-	7.228	7.964	8.419	0.000	8.419	8.509	9.021	9.184	9.349	Continuing	Continuing
635021: *Space Systems Survivability*	-	2.474	1.820	1.571	0.000	1.571	1.581	1.610	1.644	1.674	Continuing	Continuing
63682J: *Spacecraft Vehicles*	-	12.624	11.935	13.289	0.000	13.289	12.300	12.662	12.814	13.015	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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	61.593	58.910	57.237	0.000	57.237
Current President's Budget	69.338	58.910	54.895	0.000	54.895
Total Adjustments	7.745	0.000	-2.342	0.000	-2.342
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	10.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-2.255	0.000			
• Other Adjustments	0.000	0.000	-2.342	0.000	-2.342

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 633834: *Integrated Space Technology Demonstrations*		
Congressional Add: *Program Increase*	9.685	0.000
Congressional Add Subtotals for Project: 633834	9.685	0.000
Congressional Add Totals for all Projects	9.685	0.000

Change Summary Explanation

Decrease in FY 2019 due to realignment of Space Science and Technology Advanced Technology Development activities to Space Science and Technology Applied Research.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 632181 / *Spacecraft Payloads*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
632181: *Spacecraft Payloads*	-	13.034	15.767	15.093	0.000	15.093	15.078	15.886	17.114	17.493	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Space Electronics	3.125	4.156	3.669
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 2018 Plans:*** Continue development of advanced electronic circuit components. Verify split-fabrication as trusted method. Complete first stage of electron-beam lithography transition and begin productization. Continue as lead for Field-Programmable Gate Array development. Oversee qualification of processing and memory technology developments. Continue development of high-efficiency power conversion devices. Begin development of analog to digital and digital to analog technologies. ***FY 2019 Plans:*** Complete verification of split-fabrication as trusted method. Continue second (productization) stage of electron-beam manufacturing capability. Continue to lead trusted Field-Programmable Gate Array development. Continue development of next generation memory technologies for space. Oversee qualification of processing and memory technology developments. Continue assessments of tolerance of advanced electronic circuit components to space radiation environmental conditions. Continue development of novel payload processor technologies and necessary memory to support it. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.487 million. Justification for this decrease is described in the plans above.			
Title: Advanced Space Modeling and Simulation Tools	1.004	1.192	0.851

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 632181 / *Spacecraft Payloads*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Develop modeling, simulation, and analysis tools for space-based surveillance systems, space capability protection technologies, access/mobility technologies, and flight experiments. ***FY 2018 Plans:*** Apply and analyze models for cross-platform modeling, simulation, and analysis support of multi-mission geosynchronous space flight demonstration. Continue trade studies and utility analysis for concept development of emerging space technologies, future space flight experiments and associated software algorithms, including advanced positioning, navigation, and timing technologies. ***FY 2019 Plans:*** Apply and analyze models for cross-platform modeling, simulation, and analysis support of multi-mission geosynchronous space flight demonstration. Continue trade studies and utility analysis for concept development of emerging space technologies, future space flight experiments (with associated software algorithms), and commercial space applications. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.341 million. Justification for this decrease is described in the plans above.			
Title: Advanced Space Sensors ***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. ***FY 2018 Plans:*** Deliver a scanning Focal Plane Array for missile warning capability demonstration during laser impingement. Characterize performance of scanning Focal Plane Array in representative space environment to include natural and man-made radiation including focused photons. ***FY 2019 Plans:*** Deliver a scanning Focal Plane Array for missile warning capability demonstration during laser impingement. Characterize performance of scanning Focal Plane Array in representative space environment to include natural and man-made radiation including focused photons will take place to identify any shortfalls that may be present and resolve if necessary. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.206 million. Justification for this increase is described in the plans above.	2.162	2.316	2.522
Title: Positioning, Navigation, and Timing Space Payload Technologies ***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	6.743	8.103	8.051

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 632181 / *Spacecraft Payloads*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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 2018 Plans:*** Complete designs of on-orbit reprogrammable digital waveform generator for positioning, navigation, and timing / Global Positioning System and deliver engineering development units. Initiate development of broadband amplifier for Global Positioning System application. ***FY 2019 Plans:*** Conduct preliminary and critical design activities for multiple modular/hostable positioning, navigation, and timing payloads/ payload technologies for future Global Positioning System and Global Positioning System augmentation satellites. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.052 million. Justification for this increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	13.034	15.767	15.093

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 633834 / *Integrated Space Technology Demonstrations*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
633834: *Integrated Space Technology Demonstrations*	-	33.978	21.424	16.523	0.000	16.523	16.511	16.712	18.210	18.582	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Integrated Satellite Demonstrations	24.293	21.424	16.523
Description: Develop satellite technologies for integrated, robust, and flexible satellite demonstrations building on previous work and leveraging investments by other organizations. ***FY 2018 Plans:*** Complete launch vehicle integration for geosynchronous spaceflight demonstration. Support launch operations. Begin on-orbit operations; conduct experimental flight operations of Hypertemporal Imaging sensor, integrated on-board sensing, threat assessment and autonomy payload, and increase autonomy and safety of advanced proximity operations. Continue space and ground segment design and build of advanced space-based integrated Global Positioning System demonstration for contested environments-target launch of FY 2021-2023. ***FY 2019 Plans:*** Conclude on-orbit operations; complete experimental flight operations of hypertemporal imaging sensor, integrated on-board sensing, threat assessment and autonomy payload, and increase autonomy and safety of advanced proximity operations. Begin transition of spacecraft operations to Air Force Space Command. Continue refining space and ground segments architecture and initial prototype hardware/software for an advanced Global Positioning System space-based integrated demonstration for contested environments with a target launch of FY 2021-2023. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $4.901 million. Justification for this decrease is due to a re-baseline of flight experiment program.			
Accomplishments/Planned Programs Subtotals	24.293	21.424	16.523

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 633834 / *Integrated Space Technology Demonstrations*

	FY 2017	FY 2018
Congressional Add: Program Increase	9.685	0.000
FY 2017 Accomplishments: Conducted Congressionally directed efforts.		
FY 2018 Plans: N/A		
Congressional Adds Subtotals	9.685	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 634400 / *Space Systems Protection*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
634400: *Space Systems Protection*	-	7.228	7.964	8.419	0.000	8.419	8.509	9.021	9.184	9.349	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. Technologies are developed and demonstrated to support balanced satellite protection strategies for detecting and avoiding threats and operating in a hostile space environment.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Space Situational Awareness Capability Development ***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. ***FY 2018 Plans:*** Complete all on-orbital-regime integrated tracking filter and transition to operational community. Continue maturing sensors with reduced solar exclusion angle for improved space situational awareness. Continue maturation of radio frequency sensing modalities. Complete processing chain showing end-to-end tracking and characterization capabilities incorporating real data. ***FY 2019 Plans:*** 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. Initiate development of prototypes utilizing multi-phenomenology based on the observables indicating a potential threat. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.348 million. Justification for this decrease is described in the plans above.	1.778	1.846	2.194
Title: Space Indicators and Warning Research ***Description:*** Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites. ***FY 2018 Plans:*** Integrate space cyber resilience indications and warning concepts into ground and flight experiments for verification and validation of efficacy in contested environments. Prepare and conduct ground experimentation in support of indications and warning	2.268	2.014	2.651

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 634400 / *Space Systems Protection*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
technology development. Conduct experiments to evaluate integration of resilience technologies and concepts into programs of record and high value assets; document and disseminate best practices and lessons learned. Continue maturing resilient spacecraft concepts. Conduct evaluation of on-orbit data from geosynchronous spaceflight demonstration and other flight experiment and operational test opportunities. ***FY 2019 Plans:*** Conduct RED-vs-BLUE space cyber indications and warning experimentation utilizing the on-orbit research satellite. Evaluate the efficacy of multi-spectrum indications and warning technology within the space resiliency testbed. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.637 million. Justification for this increase is described the in plans above.			
Title: Spacecraft Threat Detection ***Description:*** Develop active satellite local space awareness technologies and exploitation tools for satellite systems. ***FY 2018 Plans:*** Continue to advance technology in 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. ***FY 2019 Plans:*** Complete advanced technology in 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. Initiate advanced autonomy demonstrations to prove advanced concepts in multidomain real-time command and control. Expand our threat warning and response portfolio, including further maturation of both on board and off board threat sensor suites and supporting computing / comm systems. Demonstrate and experiment with prototype threat warning and response systems within the space resiliency lab. Integrate response options into the Air Force Research Laboratory's space resiliency lab in order to conduct end-to-end multi-spectral threat and response scenarios. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.530 million. Justification for this decrease is described in the plans above.	3.182	4.104	3.574
Accomplishments/Planned Programs Subtotals	7.228	7.964	8.419

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 634400 / *Space Systems Protection*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 635021 / *Space Systems Survivability*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635021: *Space Systems Survivability*	-	2.474	1.820	1.571	0.000	1.571	1.581	1.610	1.644	1.674	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Spacecraft Survivability/Reliability	2.474	1.820	1.571
Description: Develop technologies to provide improved space radiation and ionospheric hazard specification and forecasting. ***FY 2018 Plans:*** Continue spiral one anomaly attribution tool demonstration and transition to operational use with common ground system. Continue spiral two development for anomaly attribution tool and begin transition to operational demonstration. Complete assembly and calibration of energetic particle sensor for use in contested space. Continue development of automated exploitation tool for on-orbit data for rapid detection and characterization of space environment impacts. Begin exploiting data from on-orbit radiation remediation mission for inclusion in standard radiation belt model for satellite design. Continue investigation and improvement of the forecasting of solar radio events that impact Air Force operational systems. ***FY 2019 Plans:*** Continue exploitation of data from on-orbit radiation remediation mission for inclusion in standard radiation belt model for satellite design. Transition updated radiation model to industry with modular architecture, additional data sources, and improved usability. Select concept to proceed to detailed design phase for next-generation highly-miniaturized energetic particle sensor for use in contested space. Begin anomaly attribution tool spiral two demonstration and transition to operational use with common ground system. Continue investigation and improvement of the forecasting of solar radio events that impact Air Force operational systems. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.249 million. Justification for this increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	2.474	1.820	1.571

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 635021 / *Space Systems Survivability*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 63682J / *Spacecraft Vehicles*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
63682J: *Spacecraft Vehicles*	-	12.624	11.935	13.289	0.000	13.289	12.300	12.662	12.814	13.015	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Space Power Technologies	0.990	1.110	1.063
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. ***FY 2018 Plans:*** Complete end-of-life optimization of solar cell architectures approaching 35%. Continue development of mitigation approaches for thermal excursion in resilient arrays. Initiate on-orbit flight experiment of resilient array technologies. ***FY 2019 Plans:*** Continue development of mitigation approaches for thermal excursion in resilient arrays. Continue on-orbit flight experiment development for resilient array technologies. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.047 million. Justification for this decrease is described in the plans above.			
Title: Spacecraft Structures Technologies	0.992	1.109	1.061
Description: Develop, integrate, and demonstrate composite spacecraft structures and thermal technologies for deployable structures, antennas, electronics cooling, and structural sensing. ***FY 2018 Plans:*** Complete spaceflight experiment to test structurally-integrated sensing technologies for on-orbit impact detection and situational awareness of potential threats. Continue flight experiment to test affordable deployable antennas for denied area communication and high-gain, anti-jam Global Positioning System applications. Initiate integrated experiment concepts testing structures and thermal technologies for high energy density, full spectrum radio frequency reconfigurabilty, adaptability, and protection. ***FY 2019 Plans:*** Complete ground experimentation to test affordable deployable antennas for denied area communication and high-gain, anti-jam Global Positioning System applications. Continue integrated experiment concepts testing structures and thermal technologies			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 63682J / *Spacecraft Vehicles*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
for high energy density, full spectrum radio frequency reconfigurabilty, adaptability, and protection. Initiate integrated ground experiment or flight experiment for extremely thin, multi-mission, radio frequency antennas for ensured capability in highly contested environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.048 Million. Justification for this decrease is described in plans above.			
Title: On-Orbit Satellite Controls ***Description:*** Develop technologies for spacecraft controls and mechanisms for on-orbit applications. ***FY 2018 Plans:*** Continue development and testing of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions. ***FY 2019 Plans:*** Continue testing of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.018 Million. Justification for this decrease is described in plans above.	0.423	0.433	0.415
Title: Space Communication and Control Technologies ***Description:*** Develop technologies for next-generation space communications terminals and equipment, along with methods/ techniques to enable future space system operational command and control concepts. ***FY 2018 Plans:*** Support integration and test of the W and V frequency band flight instrument onto the host spacecraft. Support initial design and hardware test board testing of W and V frequency band follow-on project that would demonstrate W and V band satellite communications (bi-directional, modulated signals) and mitigate technology risks in order to facilitate transition to an operational system. Continue to support development of critical space and ground terminal technology, such as multi-beam antenna, high power amplifiers, low noise amplifiers, reconfigurable radios, and wideband modem and signal processing technology. ***FY 2019 Plans:*** Support launch of W and V frequency band flight instrument. Support execution of a W and V band propagation experiment. Conduct development and 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,	2.812	1.905	3.629

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 63682J / *Spacecraft Vehicles*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
reconfigurable satellite radios / transponders, and anti-jam signal processing technologies. Support development and demonstration of novel laser communications technology. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.724 Million. Justification for this increase is described in plans above.			
Title: Advanced Alternative Navigation Technologies ***Description:*** Develop new atomic clock technologies and transition these technologies to industry for potential application to future positioning, navigation, and timing space considerations. ***FY 2018 Plans:*** Continue transition of atomic clock technology to industry to build into flight experiment payload units for flight testing. Continue integration and testing of clock engineering models. Continue the development of radiation-hardened, ultra-stable laser needed for cold-atom atomic clocks, accelerometers, and gyroscopes operating in space or nuclear environments. Continue the development of technology to leverage communications links to provide positioning and time knowledge, and continue second spiral demonstration of performance on handheld military radios to inform technology development activity. ***FY 2019 Plans:*** Test industry-transitioned clock technology being built into flight experiment payload units for flight testing. Finalize integration and testing of clock engineering models. Start packaging of radiation-hardened, ultra-stable laser needed for cold-atom atomic clocks, accelerometers and gyroscopes operating in space or nuclear environments. Start testing of technology that leverages communications links to provide positioning and time knowledge, and continue second spiral demonstration of performance on hand held military radios to inform technology development activity. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.257 Million. Justification for this decrease is described in plans above.	7.407	7.378	7.121
Accomplishments/Planned Programs Subtotals	12.624	11.935	13.289

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 63682J / *Spacecraft Vehicles*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603444F / *Maui Space Surveillance System (MSSS)*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	11.493	10.433	10.674	0.000	10.674	11.878	12.094	12.319	11.553	Continuing	Continuing
634868: *Maui Space Surveillance System*	-	11.493	10.433	10.674	0.000	10.674	11.878	12.094	12.319	11.553	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program funds ground-based optical space situational awareness technology development and demonstration at the Maui Space Surveillance System 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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	11.681	10.433	11.912	0.000	11.912
Current President's Budget	11.493	10.433	10.674	0.000	10.674
Total Adjustments	-0.188	0.000	-1.238	0.000	-1.238
• 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	-0.188	0.000			
• Other Adjustments	0.000	0.000	-1.238	0.000	-1.238

Change Summary Explanation

Decrease in FY 2019 due to realignment of funds to focus on Directed Energy Game Changer efforts.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603444F / *Maui Space Surveillance System (MSSS)*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Operate and Upgrade Maui Space Surveillance System	9.083	9.454	10.674
Description: Operate and upgrade the Maui Space Surveillance System to support development, demonstration, and integration of ground-based optical space situational awareness technologies. ***FY 2018 Plans:*** 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. 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. Apply laser-guidestar system at Maui Space Surveillance System to geosynchronous satellite imaging demonstration. ***FY 2019 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. 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. Accept control of geosynchronous satellite imaging capability, collecting images as requested by stakeholders. Accept control of dynamic telescope system operations into Maui Space Surveillance System capability baseline. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $1.220 million. Justification for this increase is due to increased space situational awareness technology development.			
Title: Geosynchronous Object Sensor	2.410	0.979	0.000
Description: Develop and demonstrate dual-use integrated sensor technology for imaging of geosynchronous objects as well as other long-range applications. ***FY 2018 Plans:*** Conduct full-power demonstration of laser imaging of objects in geosynchronous orbit. Investigate options to scale technology to smaller apertures and enable range profiling of geosynchronous satellites for rapid orbit determination. ***FY 2019 Plans:*** Effort completed ***FY 2018 to FY 2019 Increase/Decrease Statement:***			

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603444F / *Maui Space Surveillance System (MSSS)*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $0.979 million. Justification for this decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	11.493	10.433	10.674

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	25.784	33.635	36.463	0.000	36.463	37.541	36.237	37.068	37.818	Continuing	Continuing
635323: *Directed Energy Bioeffects Parameters*	-	4.848	5.388	5.251	0.000	5.251	5.154	5.280	6.602	6.736	Continuing	Continuing
635324: *Human Dynamics and Terrain Demonstration*	-	6.115	5.432	5.408	0.000	5.408	5.886	6.001	7.446	7.597	Continuing	Continuing
635325: *Mission Effective Performance*	-	9.199	6.626	6.795	0.000	6.795	6.929	7.069	7.212	7.358	Continuing	Continuing
635327: *Warfighter Interfaces*	-	5.622	16.189	19.009	0.000	19.009	19.572	17.887	15.808	16.127	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 project develops, demonstrates, and transitions human-centric technologies to address processing, exploitation, and dissemination of intelligence, surveillance, and reconnaissance (ISR) capability needs. 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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force					Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*			R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*		
B. Program Change Summary ($ in Millions)	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**
Previous President's Budget	26.492	33.635	36.737	0.000	36.737
Current President's Budget	25.784	33.635	36.463	0.000	36.463
Total Adjustments	-0.708	0.000	-0.274	0.000	-0.274
• 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	-0.708	0.000			
• Other Adjustments	0.000	0.000	-0.274	0.000	-0.274

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*	Project (Number/Name) 635323 / *Directed Energy Bioeffects Parameters*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635323: *Directed Energy Bioeffects Parameters*	-	4.848	5.388	5.251	0.000	5.251	5.154	5.280	6.602	6.736	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 also 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. The optical radiation bioeffects thrust develops and demonstrates technologies that counter optical threats, while exploiting optical systems for directed energy weapons applications. The radio frequency (RF) radiation bioeffects thrust develops and demonstrates technologies to assess RF bioeffects and collateral hazards from high power RF directed energy systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Optical Radiation Bioeffects	3.506	4.324	4.247
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 2018 Plans: Support low-power ground testing as part of Self-Protect High Energy Laser Demonstrator (SHiELD) Advanced Technology Demonstration (ATD). The SHiELD ATD will be supported in order to assess concepts of operation risks from laser exposures and in order to ensure test safety. Activities will include the integration of simulation capabilities as well as validation of predictive laser bioeffects models. Develop probabilistic risk assessment tools to evaluate hazards and effectiveness of developing laser weapons. Continue campaign-level assessment of mission with simulations involving directed energy threat and concept assessment. Complete assessment of threshold level damage effects on physiological/behavioral responses using in-house models. Complete assessment of block 3 laser eye protection capability with prediction metrics for next spiral in acquisition.			
FY 2019 Plans: Mature integration of predictive models of bioeffects and protection in Air Force Research Laboratory (AFRL) level analysis architectures. Complete first end-to-end methodology for incorporation of probabilistic risk-based assessments for lasers in a collateral damage estimation toolset. Perform ground evaluation of prototype nuclear flash protection goggle to investigate technology compatibility with cockpit displays and airman performance requirements. Mature high-energy laser bioeffects and safety analysis tools through validation and verification and end-user evaluation for initial transition to major test range			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635323 / *Directed Energy Bioeffects Parameters*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
environments. Apply matured technologies to support of SHiELD Advanced Technology Demonstration and AFRL Laser Weapons System Program during ground and flight test safety planning. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.077 million. Justification for the decrease is described in the plans above.			
Title: Radio Frequency Bioeffects ***Description:*** Develop and demonstrate technologies to assess RF bioeffects and collateral hazards from high power RF directed energy systems. ***FY 2018 Plans:*** Complete validation of a high average power bio-heat dosimetry model. Continue verification and validation of thermal effects models for high average power systems. Initiate fast thermal gradient effects model, and validation of dosimetry model. Continue development of fire control algorithms for millimeter wave technology, and initiate development of system training software in preparation for distributed simulation events. ***FY 2019 Plans:*** Integrate high average power bio-heat dosimetry models into distributed simulation environments. Development of fast thermal gradient effects dosimetry validation models and continue effect model validation strategy. Further development/refinement of high average power models and validation through use of empirical comparisons moving into finer resolution to include internal structures. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.060 million. Justification for the decrease is described in the plans above.	1.342	1.064	1.004
Accomplishments/Planned Programs Subtotals	4.848	5.388	5.251

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*	Project (Number/Name) 635324 / *Human Dynamics and Terrain Demonstration*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635324: *Human Dynamics and Terrain Demonstration*	-	6.115	5.432	5.408	0.000	5.408	5.886	6.001	7.446	7.597	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, demonstrates, and transitions technologies to identify human threats within the air, space, and cyber domains. These technologies will enhance Air Force capabilities in ISR, layered sensing, autonomous and adaptive decision-making systems, decision aids for computer network attack/defense/support, ISR force development and training, cross-cultural communication, human-centric exploitation of measurement and signatures intelligence, and advanced molecular diagnostic methodologies to assess airman performance.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Human Analyst Augmentation	3.782	3.717	3.771
Description: Develop and demonstrate human-centered design processes and operational tools that optimize ISR information exploitation and analysis.			
FY 2018 Plans: Develop human-machine collaboration and automation technologies to improve work efficiency and product quality of ISR analysts. Preparing for transition speech-to-text technologies to the Air Force Distributed Common Ground Station architecture.			
FY 2019 Plans: Transition speech to text technologies to Distributed Ground System Special Operations Forces (DGS-SOF). Preparing for transition of multi-intelligence analysis tools and airman-machine collaboration technologies to Air Force Distributed Common Ground System (AF-DCGS).			
FY 2018 to FY 2019 Increase/Decrease Statement: FY 2019 increased compared to FY 2018 by $0.054 million. Justification for the increase is described in the plans above.			
Title: Human Trust and Interaction	1.874	1.715	1.637
Description: Develop and demonstrate machine translation and speech-to-text tools to support the span of Air Force mission areas including ISR and cyber operations.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635324 / *Human Dynamics and Terrain Demonstration*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Improve automatic speech recognition and machine translation results by incorporating context, including techniques for actively learning unknown words, and providing multilingual search capabilities to increase the task throughput of human operators performing intelligence, surveillance, and reconnaissance. ***FY 2019 Plans:*** Develop initial context awareness of deep neural networks for improving automatic speech recognition and machine translation algorithms for Intelligence Surveillance Reconnaissance (ISR) analyst applications. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.078 million. Justification for the decrease is described in the plans above.			
Title: Human Signatures ***Description:*** Develop automated and assisted methods to exploit human threat biosignatures to defeat terrorist activities and hidden person-borne threats. Provide improved models of virtual humans to deliver mission-ready training for ISR analysts and create more immersive, realistic experiences in joint and coalition exercises. ***FY 2018 Plans:*** Work Completed in FY 2017. No current plans as funding has been reallocated in FY18 to support AFRL Autonomy Initiative. ***FY 2019 Plans:*** Not applicable ***FY 2018 to FY 2019 Increase/Decrease Statement:*** Not applicable	0.459	0.000	0.000
Accomplishments/Planned Programs Subtotals	6.115	5.432	5.408

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*	Project (Number/Name) 635325 / *Mission Effective Performance*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635325: *Mission Effective Performance*	-	9.199	6.626	6.795	0.000	6.795	6.929	7.069	7.212	7.358	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Continuous Learning	9.199	6.626	6.795
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. This enables more efficient mission execution training in an LVC environment. ***FY 2018 Plans:*** Continue standards definition for sharable scenario content, data, models, and metrics across a range of military operations. Demonstrate learning management system in a series of LVC testbeds to enable transfer of training studies. Continue development of methods to create adaptive learning environments across multiple missions contexts. Execute evaluation studies on sharable scenario content models and metrics in LVC testbeds. ***FY 2019 Plans:*** Continue development and demonstration of sharable content across domain for airman machine team and multi-domain command and control. Establish warehouse for multiple domain performance data to enable proficiency-based training. Test and evaluate proficiency-based training at an operational unit. Increase after action review data visualization for real-time lessons learned and training effectiveness. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.169 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	9.199	6.626	6.795

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635325 / *Mission Effective Performance*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*	Project (Number/Name) 635327 / *Warfighter Interfaces*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635327: *Warfighter Interfaces*	-	5.622	16.189	19.009	0.000	19.009	19.572	17.887	15.808	16.127	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, demonstrates, and transitions 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 (3-D) audio to customize communications and enhance shared understanding across a diverse user community in air, space, and cyber for maximum situational awareness.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Battlespace Acoustics	3.689	4.071	4.722
Description: Demonstrate ability to forecast acoustic profiles for any atmospheric/terrain condition. Demonstrate technologies to enhance the battlefield Airman's situational awareness through wearable interfaces.			
FY 2018 Plans: Transition real-time acoustic mission planning capability to enhance training and optimize mission effectiveness. Develop advanced interfaces for real-time interaction with acoustic models of listening environments to enhance warfighter situational awareness and effectiveness. Employ advanced usability engineering methodologies for rapid prototyping, testing and seamless integration of innovative technologies into tactical ensembles supporting Battlefield Airmen and Pararescue operations. Transition enhanced, man-wearable communication systems, mobile interfaces, and physiological sensors to enhance situation awareness, improve training, and support real-time battlespace monitoring for dismounted operators.			
FY 2019 Plans: Continue 3D audibility modeling research for special operations aviation focusing on effects of atmospherics, terrain, and psychoacoustic performance, and continue development/refinement of advanced interfaces for real-time interaction with acoustic models of listening environments. Continue conducting usability testing and employing advanced engineering methodologies for rapid prototyping, testing and seamless integration of innovative technologies into tactical ensembles supporting Battlefield Airmen and Para-rescue operations. Continue to transition enhanced, man-wearable communication systems, mobile interfaces, and physiological sensors to enhance situation awareness, improve training, and support real-time battlespace monitoring for dismounted operators.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635327 / *Warfighter Interfaces*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 increased compared to FY 2018 by $0.651 million. Justification for the increase is described in the plans above.			
Title: Human Role in Semiautonomous Systems	1.933	12.118	14.287
Description: Develop and demonstrate an integrated human-centered interface to control multiple Remotely Piloted Aircraft (RPA) that have various levels of autonomy and that optimize net-centric information flow. Develop and demonstrate manned-unmanned interaction and team concepts for tactical environments. ***FY 2018 Plans:*** Develop human-machine interface (controls, displays, and decision support) to enable effective manned-unmanned tactical flight operations. Develop and demonstrate control techniques to direct maneuvers and tactics at manageable pilot workload levels. Develop and demonstrate architectures and interfaces to enable manned-machine teaming for the tactical air environment. Develop external contingency management methods for flight operations. Demonstrate pilot-vehicle interface capabilities in high-fidelity virtual simulation to assess pilot performance and mission effectiveness. ***FY 2019 Plans:*** Flight demonstrate airman-directed control and management of multiple unmanned tactical behaviors. Develop and integrate decision support and embedded intelligent agent capabilities to assess and reason about manned-unmanned team performance and overall mission effectiveness. Demonstrate adaptive human-machine interfaces and task allocation methods in virtual and live tests. Initiate m x n cooperative teams in networked simulation environments. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $2.169 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	5.622	16.189	19.009

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603601F / *Conventional Weapons Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	105.487	167.415	194.981	0.000	194.981	231.292	209.642	223.712	228.334	Continuing	Continuing
63670A: *Weapon Technology Development*	-	71.709	87.215	95.132	0.000	95.132	57.895	51.830	74.854	76.367	Continuing	Continuing
63670B: *Weapon Concept Development*	-	33.778	80.200	99.849	0.000	99.849	173.397	157.812	148.858	151.967	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program 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 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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	102.009	167.415	197.001	0.000	197.001
Current President's Budget	105.487	167.415	194.981	0.000	194.981
Total Adjustments	3.478	0.000	-2.020	0.000	-2.020
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	5.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.596	0.000			
• SBIR/STTR Transfer	-2.118	0.000			
• Other Adjustments	0.000	0.000	-2.020	0.000	-2.020

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603601F / *Conventional Weapons Technology*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 63670A: *Weapon Technology Development*		
Congressional Add: *Program increase*	4.898	0.000
Congressional Add Subtotals for Project: 63670A	4.898	0.000
Congressional Add Totals for all Projects	4.898	0.000

Change Summary Explanation

Decrease in FY 2019 due to Department of Defense (DoD) deflation adjustment.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / *Conventional Weapons Technology*	Project (Number/Name) 63670A / *Weapon Technology Development*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
63670A: *Weapon Technology Development*	-	71.709	87.215	95.132	0.000	95.132	57.895	51.830	74.854	76.367	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Ordnance Technologies	34.871	49.817	53.125
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 2018 Plans: Continue to demonstrate distributed, embedded fuzing concepts for close-controlled strike, area attack, and penetration applications (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 analysis tools to evaluate ordnance technologies in relevant environments. Continue to develop ordnance technologies/methodologies for high-speed impact and functional defeat. Continue research for distributed and multi-point fuzing concepts to reduce the logistics tail necessary for future and fielded munitions systems, as well as safe and arm functions. Continue research into armament systems for Special Operations applications. Continue to conduct lethality analyses for air-to-air weaponry. Continue to mature research on distributed, collaborative, cooperative effects munitions technologies.			
FY 2019 Plans: Continue to demonstrate distributed, embedded fuzing concepts for close-controlled strike, area attack, and penetration applications (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 weaponnering choices.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603601F / *Conventional Weapons Technology*	**Project (Number/Name)** 63670A / *Weapon Technology Development*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue to develop ordnance technologies/methodologies for high-speed impact and functional defeat. Continue research for distributed and multi-point fuzing concepts to reduce the logistics tail necessary for future and fielded munitions systems, as well as safe and arm functions. 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 meso-scale and micro-scale. Continue to mature research on distributed, collaborative, cooperative effects munitions technologies. Initiate the development high fidelity test capabilities and analysis tools to evaluate ordnance technologies in relevant environments. Initiate the incorporation of better material models and develop further joint kinetic/directed energy common target models. Initiate the incorporation of models for progressive collapse, multiple point initiation, secondary debris and others. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $3.308 million. Justification for this increase is due to an increased emphasis in ordnance technologies.			
Title: Guidance Technologies	31.940	37.398	42.007
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. ***FY 2018 Plans:*** Continue to conduct hardware-in-the-loop and software-in-the-loop to characterize air-to-air and air-to-ground guidance and control technologies. Continue increased emphasis on integrated hardware-in-the-loop, software-in-the-loop, and other Modeling and Simulation technologies for the demonstration of open architecture and modular weapon munition concepts. 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 design of Modeling and Simulation capability and initiate approval processes to permit simultaneous multi-level security Modeling and Simulation activities. Complete Modeling and Simulation center design and security approval processes to enable simultaneous, multi-level security Modeling and Simulation activities. ***FY 2019 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. Initiate the development of advanced modular and service oriented weapon architectures. Initiate the design and development of seeker			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603601F / *Conventional Weapons Technology*	**Project (Number/Name)** 63670A / *Weapon Technology Development*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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 to refine and complete fabrication of Modeling and Simulation center and initiate processes to enable simultaneous multi-level security Modeling and Simulation activities. Initiate launch to lethality analyses of in-house and Air Force weapon concepts. Initiate the design of hotter/faster Infrared panoramic projector for advanced seeker testing. Initiate the integration of higher fidelity constructive analysis tools with engagement and mission level Modeling and Simulation. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased as compared to FY 2018 by $4.609 million. Justification for this increase is due to an increased emphasis in guidance technologies.			
Accomplishments/Planned Programs Subtotals	66.811	87.215	95.132

	FY 2017	FY 2018
Congressional Add: Program increase	4.898	0.000
FY 2017 Accomplishments: Conducted Congressionally-directed efforts.		
FY 2018 Plans: N/A		
Congressional Adds Subtotals	4.898	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / *Conventional Weapons Technology*	Project (Number/Name) 63670B / *Weapon Concept Development*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
63670B: *Weapon Concept Development*	-	33.778	80.200	99.849	0.000	99.849	173.397	157.812	148.858	151.967	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Air-to-Air Concept Development	3.718	30.220	40.809
Description: Mature, integrate, and demonstrate air-to-air weapon components and systems (ordnance, guidance, and carriage and release technologies) to demonstrate war-fighter capability. ***FY 2018 Plans:*** Continue to demonstrate weapon integration concept for air target engagement. Continue planning and technology risk reduction for weapon concepts responsive to the 2030 time-frame threat environment (including air-to-air weapons for both offensive and defensive purposes). 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. Continue to test prototype propulsion systems to demonstrate attributes to meet next-generation air-to-air weapon requirements. Continue to conduct lethality studies to enable design of small form factor self-defense of an air platform. Continue to develop preliminary design of weapon concept for sixth generation platform. Continue to conduct wind-tunnel and limited flight experiments to characterize air-to-air maneuverability, range, and guidance and control for sixth generation weapon concept. Continue to conduct ground and arena tests of advanced weapons experimental-carriages for sixth generation weapon concept and prepare for flight worthiness testing. ***FY 2019 Plans:*** Continue to demonstrate weapon integration concept for air target engagement. Continue planning and technology risk reduction for weapon concepts responsive to the 2030 time-frame threat environment (including air-to-air weapons for both offensive and defensive purposes). Continue to test prototype propulsion systems to demonstrate attributes to meet next-generation air-to-air weapon requirements. Continue to conduct lethality studies to enable design of small form factor self-defense of an air platform. Continue to develop preliminary design of weapon concept for sixth generation platform. Continue to conduct wind-tunnel and limited flight experiments to characterize air-to-air maneuverability, range, and guidance and control for sixth generation weapon			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603601F / *Conventional Weapons Technology*	**Project (Number/Name)** 63670B / *Weapon Concept Development*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
concept. 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 energy weapons. Continue to incorporate higher fidelity methodologies into systems level analysis including joint weapons effectiveness. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $10.589 million. Justification for this increase is due to an increased emphasis in air-to-air concept development efforts.			
Title: Air-to-Ground Concept Development ***Description:*** Mature, integrate, and demonstrate air-to-ground weapon components and systems (ordnance, guidance, and carriage and release technologies) to demonstrate war-fighter capability. ***FY 2018 Plans:*** 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. 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 2030 time-frame 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 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 concepts for cooperative control of small weapons to produce scalable effects to increase the capacity and capability of fifth generation aircraft. Continue to refine competitive contractor processes to develop flying experimental concepts of the subsonic, standoff, low-cost cruise missile capability. Continue to develop kinetic/non-kinetic payloads, networking, seeker, fuze, and defense countermeasures technology for hypersonic applications. ***FY 2019 Plans:*** 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 monition demonstrator flight. Continue the development of monition concepts to incorporate technologies for carriage and terminal impact at high speed. Continue to investigate concepts for cooperative control of small weapons to produce scalable effects to increase the capacity and capability of fifth generation aircraft. Continue planning and technology risk reduction including demonstration and initial flight testing for weapons concepts responsive to the 2030 time-frame 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 incorporate higher fidelity methodologies into systems level analysis including joint weapons effectiveness and to apply	30.060	49.980	59.040

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603601F / *Conventional Weapons Technology*	**Project (Number/Name)** 63670B / *Weapon Concept Development*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
methodology to support future air dominance analysis. Continue to refine competitive contractor processes to develop flying experimental concepts of the subsonic, standoff, low cost cruise missile capability. Continue to develop kinetic/non-kinetic payloads, networking, seeker, fuze, and defense countermeasures technology for hypersonic applications. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $9.060 million. Justification for this increase is due to an increased emphasis in air-to-ground concept development efforts.			
Accomplishments/Planned Programs Subtotals	33.778	80.200	99.849

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603605F / *Advanced Weapons Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	47.358	45.502	43.368	0.000	43.368	37.467	31.258	32.386	42.771	Continuing	Continuing
633151: *High Power Solid State Laser Technology*	-	20.847	24.635	28.200	0.000	28.200	19.244	13.150	13.419	23.422	Continuing	Continuing
633152: *High Power Microwave Development and Integration*	-	26.511	20.867	15.168	0.000	15.168	18.223	18.108	18.967	19.349	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program provides for the development, integration, demonstration, and detailed assessment of directed energy weapon technologies for potential application on Air Force platforms. These include high energy laser, high power microwaves, 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. 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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	39.064	45.502	45.271	0.000	45.271
Current President's Budget	47.358	45.502	43.368	0.000	43.368
Total Adjustments	8.294	0.000	-1.903	0.000	-1.903
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	10.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.706	0.000			
• Other Adjustments	0.000	0.000	-1.903	0.000	-1.903

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603605F / *Advanced Weapons Technology*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 633152: *High Power Microwave Development and Integration*		
Congressional Add: *Program Increase*	9.652	0.000
Congressional Add Subtotals for Project: 633152	9.652	0.000
Congressional Add Totals for all Projects	9.652	0.000

Change Summary Explanation

Decrease in FY 2019 due to realignment of funds to focus on Directed Energy Game Changer efforts

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603605F / *Advanced Weapons Technology*	Project (Number/Name) 633151 / *High Power Solid State Laser Technology*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
633151: *High Power Solid State Laser Technology*	-	20.847	24.635	28.200	0.000	28.200	19.244	13.150	13.419	23.422	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: High Energy Laser/Beam Control	20.847	24.635	27.709
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 2018 Plans:*** Continue the integration of a low power laser system into a pod for Phase 1 aircraft self-protect demonstration. In addition to the laser source, continue with integration of the laser control subsystem for directing the laser onto the target for aircraft self-protect demonstration. Continue development of ground support and aircraft interface. ***FY 2019 Plans:*** Demonstrate the integration of a low power laser system into 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. Continue with integration of the laser control subsystem for directing the laser onto the target for aircraft self-protect demonstration. Continue development of the ground support and aircraft interface. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $3.074 million. Justification for this increase due to the increased emphasis of the high energy laser demonstration.			
Title: Optical Space Situational Awareness and Satellite Vulnerability	-	0.000	0.491
Description: Mature development of advanced, long-range, electro-optical technologies that support ground-based optical space situational awareness. 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.			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603605F / *Advanced Weapons Technology*	**Project (Number/Name)** 633151 / *High Power Solid State Laser Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: N/A ***FY 2019 Plans:*** Demonstrate 24/7 real-time optical imaging of near-earth satellites to allow characterization on tactical timelines. Continue development of full-dark imaging using laser illumination. Continue development of real-time daylight imaging of near-earth satellites. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.491 million. Justification for this increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	20.847	24.635	28.200

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603605F / *Advanced Weapons Technology*	Project (Number/Name) 633152 / *High Power Microwave Development and Integration*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
633152: *High Power Microwave Development and Integration*	-	26.511	20.867	15.168	0.000	15.168	18.223	18.108	18.967	19.349	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates high power microwave and other unconventional weapon generation and transmission technologies that 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 non-lethal antipersonnel weapon capabilities and inputs to the susceptibility, vulnerability, and lethality databases used across the Department of Defense to understand thresholds for scalable non-lethal effects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: HPM Technologies	16.859	20.867	15.168
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-lethal, anti-personnel weapon applications. ***FY 2018 Plans:*** Finalize design and evaluation of the utility of a class of reusable, multi-pulse, multi-target counter-electronics payloads capable of being hosted in various advanced platforms. Characterize, model, test and evaluate current and projected blue directed energy threats on red assets. Begin the joint high power microwave flight demonstration with the Navy. Verify enhancements to high power microwave missiles for aircraft compatibility testing during captive carry flight. ***FY 2019 Plans:*** Develop a class of reusable, multi-pulse, multi-target counter-electronics payloads capable of being hosted in various advanced platforms. Characterize, model, test and evaluate current and projected blue directed energy threats on current red assets. Design and develop the high power microwave payload for the joint flight demonstration with the Navy. Conduct captive carry flight testing of the high power microwave missiles. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $5.585 million. Justification for this decrease is due an increased emphasis in the speed-up of the high energy laser/beam control demonstrations in the high energy laser program.			
Accomplishments/Planned Programs Subtotals	16.859	20.867	15.168

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603605F / *Advanced Weapons Technology*	**Project (Number/Name)** 633152 / *High Power Microwave Development and Integration*

	FY 2017	FY 2018
Congressional Add: Program Increase	9.652	0.000
FY 2017 Accomplishments: Conducted congressionally directed effort.		
FY 2018 Plans: N/A		
Congressional Adds Subtotals	9.652	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603680F / *Manufacturing Technology Program*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	62.272	46.450	42.025	0.000	42.025	43.116	44.416	46.252	47.187	Continuing	Continuing
635280: *Manufacturing Technologies*	-	62.272	46.450	42.025	0.000	42.025	43.116	44.416	46.252	47.187	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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	46.344	46.450	42.953	0.000	42.953
Current President's Budget	62.272	46.450	42.025	0.000	42.025
Total Adjustments	15.928	0.000	-0.928	0.000	-0.928
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	16.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	1.600	0.000			
• SBIR/STTR Transfer	-1.672	0.000			
• Other Adjustments	0.000	0.000	-0.928	0.000	-0.928

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603680F / *Manufacturing Technology Program*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 635280: *Manufacturing Technologies*		
Congressional Add: *Program increase - Additive Manufacturing*	9.729	-
Congressional Add: *Program increase - Manufacturing Technology*	5.837	-
Congressional Add Subtotals for Project: 635280	15.566	-
Congressional Add Totals for all Projects	15.566	-

Change Summary Explanation

Increase in Fiscal Year 2017 is due to reprogramming for Hypersonics Science and Technology activities.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Sustainment Manufacturing Technologies	12.976	13.006	11.925
Description: Develop and transition pervasive affordability and producibility technologies for the sustainment of weapons systems and processes. ***FY 2018 Plans:*** Develops cost effective conventional production and special material repair technologies to enable affordable sustainment of aircraft systems. Continue agile sustainment and automation manufacturing technology development for depot maintenance. ***FY 2019 Plans:*** Continue development of cost effective conventional production and special material repair technologies to enable affordable sustainment of aircraft systems. Continue agile sustainment and automation manufacturing technology development for depot maintenance. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.081 million. Justification for the decrease is due to realignment of funds for directed energy game changer technologies.			
Title: Advanced Manufacturing Technologies	33.730	33.444	30.100
Description: Develop and transition affordable advanced manufacturing technologies for weapons systems. ***FY 2018 Plans:*** Develop and demonstrate agile manufacturing capabilities for more affordable advanced turbine engine propulsion technologies, Intelligence, Surveillance, and Reconnaissance (ISR) and communications technologies, transparent ceramics producibility, and the producibility of air armaments. Develop agile manufacturing applications and structures affordability with a focus on low cost			

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603680F / *Manufacturing Technology Program*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
attritable aircrafts and open pod architecture. Develop manufacturing capabilities for producibility and affordability of aerospace structures, precision guided munitions, and hypersonics. ***FY 2019 Plans:*** Continue development and demonstration of agile manufacturing capabilities for more affordable advanced turbine engine propulsion technologies, ISR and communications technologies, transparent ceramics producibility, and the producibility of air armaments. Continue development of agile manufacturing applications and structures affordability with a focus on low cost attritable aircrafts and open pod architecture. Continue to develop manufacturing capabilities for producibility and affordability of aerospace structures, and hypersonics. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $3.344 million. Justification for the decrease is due to realignment of funds for directed energy game changer technologies.			
Accomplishments/Planned Programs Subtotals	46.706	46.450	42.025

	FY 2017	FY 2018
Congressional Add: Program increase - Additive Manufacturing ***FY 2017 Accomplishments:*** Conducted congressionally directed efforts.	9.729	-
Congressional Add: Program increase - Manufacturing Technology ***FY 2017 Accomplishments:*** Conducted congressionally directed efforts.	5.837	-
Congressional Adds Subtotals	15.566	-

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	52.274	49.011	51.064	0.000	51.064	56.961	58.628	61.775	63.025	Continuing	Continuing
635319: *Anticipatory OPS Intent and Response*	-	4.000	3.602	6.099	0.000	6.099	6.221	6.344	6.473	6.603	Continuing	Continuing
635320: *Assured Worldwide Connectivity*	-	15.649	12.813	12.658	0.000	12.658	12.278	14.190	14.165	14.454	Continuing	Continuing
635321: *Global Battlespace Awareness*	-	9.600	11.017	11.242	0.000	11.242	14.507	14.156	15.096	15.401	Continuing	Continuing
635322: *Knowledge Management and Computing*	-	4.405	3.369	3.782	0.000	3.782	3.649	2.054	2.093	2.136	Continuing	Continuing
635329: *Cyber Battlespace Dev & Demo*	-	18.620	18.210	17.283	0.000	17.283	20.306	21.884	23.948	24.431	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 Air Force Future Operating Concept established a science and technology challenge 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 by 2035. 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 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.

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 program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, 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 prototypes fro field experiments and/or tests in a simulated environment.

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	58.110	49.011	52.995	0.000	52.995
Current President's Budget	52.274	49.011	51.064	0.000	51.064
Total Adjustments	-5.836	0.000	-1.931	0.000	-1.931
• 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	-3.900	0.000			
• SBIR/STTR Transfer	-1.936	0.000			
• Other Adjustments	0.000	0.000	-1.931	0.000	-1.931

Change Summary Explanation

Decrease in FY 2017 due to reprogramming for Hypersonics Science and Technology activities. Decrease in FY 2019 due realignment of funds to focus on Directed Energy Game Changer efforts.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*	Project (Number/Name) 635319 / *Anticipatory OPS Intent and Response*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635319: *Anticipatory OPS Intent and Response*	-	4.000	3.602	6.099	0.000	6.099	6.221	6.344	6.473	6.603	Continuing	Continuing

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 Air Force Future Operating Concept established a science and technology challenge 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 by 2035. 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Adaptive Planning and Decision Tools	2.366	2.520	1.739
Description: Develop and demonstrate the integration of planning tools and information-based intelligent agents for adaptive replanning and decision support tools. ***FY 2018 Plans:*** Continue to execute experiments, based on operational scenarios, which demonstrate technologies that allow operators at tactical nodes to have the ability to conduct combat planning and tactical assessments of operations during periods of reduced communications with operational level nodes. ***FY 2019 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. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.781 million. Justification for this decrease is described in the plans above.			
Title: Next Generation Planning and Assessment Tools	1.634	1.082	4.360

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635319 / *Anticipatory OPS Intent and Response*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
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. ***FY 2018 Plans:*** Continue to develop software capabilities that employ cyber, directed energy, and electronic warfare weaponry. Refine previously developed models that will give operators and analysts an increased understanding of the second and third order effects of a set of targeting actions. ***FY 2019 Plans:*** 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. Identify and implement state of the art learning models. Develop data-efficient learning. Integrate within the StreamlinedML framework. Develop end-to-end baseline learning capability. Develop model recommendation & user workflow capabilities. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $3.278 million. Justification for the increase is due to added emphasis in artificial intelligence and machine learning research to assist assessment and decision making in multiple domains.			
Accomplishments/Planned Programs Subtotals	4.000	3.602	6.099

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*	Project (Number/Name) 635320 / *Assured Worldwide Connectivity*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635320: *Assured Worldwide Connectivity*	-	15.649	12.813	12.658	0.000	12.658	12.278	14.190	14.165	14.454	Continuing	Continuing

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Connectivity Technologies	15.649	12.813	12.658
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 2018 Plans: Continue development and demonstration of a componentized building-block approach for a modular upgradable design for rapid waveform development of multi-mission radio frequency capability. Continue the development and demonstration of a large area multiple-input and multiple-output antenna capabilities.			
FY 2019 Plans: Continue development and demonstration for rapid waveform development of multi-mission radio frequency capability. Continue Wideband high frequency waveform development and testing. Investigate ionospheric research, propagation modeling and simulation. Perform beacon data collection on both the V and W frequency bands along with waveform development and simulation. Perform airborne testing of very low frequency software defined radio. Develop test platform for Common Very Low Frequency Receiver Increment Two. Demonstrate directional networking prototype. Demonstrate the Variable Rate - multiple-input and multiple-output clustered delay line technology and a targeting and force protection operational demonstration of integrated and field tested tactical-to-enterprise information management services.			
FY 2018 to FY 2019 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635320 / *Assured Worldwide Connectivity*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2019 decreased compared to FY 2018 by $0.155 million. Justification for this decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	15.649	12.813	12.658

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*	Project (Number/Name) 635321 / *Global Battlespace Awareness*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635321: *Global Battlespace Awareness*	-	9.600	11.017	11.242	0.000	11.242	14.507	14.156	15.096	15.401	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force must be able to process and exploit data and information from a variety of sources and domains to create a common operating picture of the battlespace to allow commanders to maintain information dominance. This project develops, integrates, and demonstrates advanced technologies to achieve comprehensive net-centric operations and Predictive Battlespace Awareness using information from all sources. Technology development includes: tasking information collectors, such as intelligence, surveillance, and reconnaissance (ISR) platforms, national intelligence sources, etc; correlating and geo-registering the collected data; exploiting the data to extract information of military significance; fusing information from multiple sources to create a digital-and-dimensional representation of the battlespace; assessing the situation; predicting adversary courses of action (COA); and archiving the results for ready use by decision-makers. This is a dynamic, complex process that involves technologies for information exploitation, fusion, processing, storage, and retrieval, as well as technologies for machine reasoning, pattern recognition, and timeline analysis.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Signal and Data Exploitation Technologies	3.424	1.049	5.168
Description: Demonstrate advanced signal and data exploitation technologies for detection, tracking, identification, and targeting of time-critical targets, and information extraction. ***FY 2018 Plans:*** Continue to refine and test technologies for ultra-wideband electronics intelligence signal detection and prosecution. Continue to develop and implement speaker similarity tagging to improve model generation, cohort detection methods, and prioritization methods based on acoustics, radio traffic, keywords, and metadata. ***FY 2019 Plans:*** Continue to refine and test technologies for ultra-wideband electronics intelligence signal detection and prosecution. Demonstrate enhanced emitter feature extraction capabilities. Demonstrate automated electronics intelligence analysis tool sets. Complete development, integrate, and demonstrate cyber-physical measurement and signature intelligence capabilities with the Twenty-Fifth Air Force and United States Special Operations Command as transition partners. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $4.119 million. Justification for the increase is due to additional work required for demonstration of capability in operational setting to Twenty-Fifth Air Force and Special Operations Command.			
Title: Advanced Data Handling, Visualization and Distributed Data Fusion	3.525	6.829	4.363

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635321 / *Global Battlespace Awareness*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Description: Develop and demonstrate advanced data handling, event visualization technologies, and distributed data fusion to enable a more effective utilization of data available. ***FY 2018 Plans:*** Continue development and demonstration of Activity Based Intelligence analysis capabilities from multiple intelligence sources for both near-real time and post mission. Continue to develop near-real time data mining and analysis capabilities by incorporating automated knowledge discovery, pattern learning, modeling and reasoning, and data fusion, exploitation, and processing. Continue to demonstrate the distributed multi-node multi-source intelligence processing, exploitation, and dissemination software framework capabilities compared to current methods for multi-source intelligence data mining, correlation, and fusion analytics. Initiate the automation of collected audio data for enhanced exploitation. ***FY 2019 Plans:*** 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. Demonstrate Seeded Language Modeling demonstration. Advance investigations of real-time deep learning algorithms. Perform service-based capability development. Complete cloud based data and information sharing environment. Continue with Object Based Production optimized processing and automated-association capability. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $2.466 million. Justification for the decrease is due to additional investment required within Advanced Signal and Data Exploitation demonstration.			
Title: Autonomous Text Exploitation	1.428	1.982	0.000
Description: Develop and demonstrate capabilities for reasoning and learning, text understanding, link and group discovery, and advanced analysis for situational awareness and understanding. ***FY 2018 Plans:*** Continue the development and demonstration of capabilities that enable automated text data extraction and exploitation. Continue development and demonstration of software tools and techniques that will fuse textual and non-textual information sources to increase semantic understanding. Continue research and development social media analytics tools and techniques for increased text understanding, as well as large scale, time dependent, network based analytics. ***FY 2019 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635321 / *Global Battlespace Awareness*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
For FY 2019 and beyond, work accomplished under this effort will be reported in Project 635321, Global Battlespace Awareness, under the Thrust "Advanced Signal and Data Exploitation Technologies". ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $1.982 million. Justification for the decrease is due to additional investment required within Advanced Signal and Data Exploitation demonstration.			
Title: Adversary Courses of Action ***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. ***FY 2018 Plans:*** Continue to develop and demonstrate kinetic and non-kinetic, full-spectrum targeting software tools that will semi-automatically extract and visualize relationships within target system; automatically prioritize/rank targets based on identified relationships; and semi-automatically update understanding of the target system analysis when new batches of reports arrive. ***FY 2019 Plans:*** Continue development and demonstration of full-spectrum targeting and intelligence software tools. Perform operational testing and experimentation on developed semantic capabilities and provide a cross-organization work-flow within intelligence and targeting software. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.554 million. Justification for this increase is described in the plans above.	1.223	1.157	1.711
Accomplishments/Planned Programs Subtotals	9.600	11.017	11.242

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*	Project (Number/Name) 635322 / *Knowledge Management and Computing*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635322: *Knowledge Management and Computing*	-	4.405	3.369	3.782	0.000	3.782	3.649	2.054	2.093	2.136	Continuing	Continuing

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 Air Force Future Operating Concept established a science and technology challenge 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 by 2035. 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Advanced Information Management	4.405	3.369	3.782
Description: Demonstrate how a publish, subscribe, and query information management paradigm can enable vertical and horizontal integration of Air Force information systems.			
FY 2018 Plans: Continue plans to develop, demonstrate and transition information management capabilities that securely bridge the gaps between enterprise and tactical domains for increased shared situational awareness across the theater of war for targeting and force protection operations. Focus will be on vulnerability assessments of the developed software, and, on field testing, technology integration, testing, and maturation. Continue the development, transition and delivery of new technologies in the form of plugins and include security for bulk data at rest to deliver full functionality for Air Force Special Operations Command Special Tactics mission sets so that special tactics operators can have superior situational awareness and communications.			
FY 2019 Plans: Continue plans to develop, demonstrate and transition information management capabilities that securely bridge the gaps between enterprise and tactical domains for increased shared situational awareness across the theater of war for targeting and force protection operations. Continue with capability enhancements and technology hardening based on operational			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635322 / *Knowledge Management and Computing*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
user assessments and collaboration. Execute a Technology Readiness Level 6 targeting and force protection operational demonstration of integrated and field tested tactical-to-enterprise information management services. Improve and update runway survey toolkit plug-in to aid aircraft runway surveys in austere locations. Spearhead geo-location capabilities in Global Positioning System denied environments using elevation, formations, and constellations. Ensure transition and hand-off special tactics plug-ins with Air Force Life Cycle Management Center support to the Battlefield Airman System Program Office. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.413 million. Justification for this increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	4.405	3.369	3.782

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force			Date: February 2018
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*	Project (Number/Name) 635329 / *Cyber Battlespace Dev & Demo*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
635329: *Cyber Battlespace Dev & Demo*	-	18.620	18.210	17.283	0.000	17.283	20.306	21.884	23.948	24.431	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 Air Force Future Operating Concept established a science and technology challenge 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 by 2035. 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.

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, 0602601F, 0602602F, 0602605F, 0602788F, 1206601F, and 602298F.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Cyber Offense	5.132	3.241	3.928
Description: Develop and demonstrate offensive cyber operations capabilities in a series of experimental technology demonstrations.			
FY 2018 Plans: Adapt and demonstrate technologies to remain current with new waveforms and signals. Continue development and demonstration of software that holds adversary threats at risk by exploiting the electromagnetic spectrum, and other signals of interest, for access and mission effects. Continue performing cyber vulnerability assessments to strengthen the security of the developed software.			
FY 2019 Plans: Continue to develop systems to identify items of interest associated with the Internet of Things. Facilitate the development of a counter small unmanned aerial system open architecture specification to enable interoperability between disparate protection			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635329 / *Cyber Battlespace Dev & Demo*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
systems. Demonstrate ground-based and airborne delivery of mitigation (disrupt, deny, degrade, destroy, or deceive) effects, both cyber and physical/kinetic. Integrate and transition multiple Air Force Research Laboratory and Air Force Lifecycle Management Center counter small unmanned aerial system capabilities. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.687 million. Justification for this increase is described in the plans above.			
Title: Effects-based Cyber Defense ***Description:*** Integrate technology to demonstrate an effects-based strategic approach to cyber defense that focuses on avoiding, deterring, and minimizing the threat, and rendering the adversary ineffective. ***FY 2018 Plans:*** Complete development and demonstration of technologies for the proactive control of cyber defenses that integrate with existing mission assurance framework(s) in a relevant environment. Complete the integration of cyber capabilities with existing intelligence, surveillance, and reconnaissance systems in a relevant environment. Demonstrate these technologies in relevant environments, such as the Cyber Experimentation Environment. This technology thrust completes its capability development in FY 2018. ***FY 2019 Plans:*** This technology thrust will have completed its capability development in FY 2018. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $4.084 million. Justification for the decrease is due to the completion of capability development within this Thrust in FY 2018.	5.029	4.084	0.000
Title: Resiliency ***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. ***FY 2018 Plans:*** Continue to develop and evolve software capabilities and Concept of Operations for active guidance and automated processes addressing cyber resiliency and survivability using a relevant system laboratory. Continue to develop effective red teaming techniques that sufficiently assess detection capabilities for mission-level critical events. Continue to develop and demonstrate ground vehicle protection prototype for automotive cyber-security. Continue development of mission monitoring components, analytics engine, and command and control technology integration. ***FY 2019 Plans:***	3.637	6.997	7.464

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635329 / *Cyber Battlespace Dev & Demo*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Continue to develop and evolve software capabilities and Concept of Operations for active guidance and automated processes addressing cyber resiliency and survivability using a relevant system laboratory. Continue capability migration to form factors which more readily align with operational systems. Demonstrate automated cyber survivability using integrated cyber technologies within the operational system laboratory in the context of risk management framework requirements. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $0.467 million. Justification for this increase is described in the plans above.			
Title: Game Changing Computing Power ***Description:*** Develop and demonstrate computer architectures with greater capacity and sophistication to enable game-changing computing power to the warfighter anywhere, anytime. ***FY 2018 Plans:*** Develop and demonstrate real-time neuromorphic computing architecture simulation framework. Conduct the first spiral demonstration of the inherently trusted and resilient architectures, mature for integration into a realistic operational environment. Continue development and demonstration of embedded computing pod in the field on a test platform with real-time processing and communication concepts. ***FY 2019 Plans:*** Continue the development of inherently trusted and resilient embedded computing. Improve software specifications using evolutionary approaches and make them inherently tolerant to the unexpected or unforeseen. As part of a trusted and resilient architecture, test and document the secure processor (T-CORE) cyber defenses and other features. Provide support to transition partners and application programmers or the T-CORE specification. Release T-CORE version 2. Continue with Robust Machine Learning upgrades and development. 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 that is used to support the mission and fight through zero day attacks that exploit these vulnerabilities to cause harm and/or failure to the mission. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 increased compared to FY 2018 by $2.116 million. Justification for the increase is due to additional development work required for the secure processor release and autonomous vehicle demonstration.	3.225	2.663	4.779
Title: Autonomous, Multi-level Access and Transfer ***Description:*** Develop autonomous, secure information access and sharing capabilities required by the Air Force net-centric information enterprise.	1.597	1.225	1.112

Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force		Date: February 2018
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635329 / *Cyber Battlespace Dev & Demo*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
FY 2018 Plans: Continue development and prototype development of advanced cross domain solutions. Refine interfaces and techniques to enforce cross-domain solutions compliance with machine to machine interface specifications to enable cross-domain enablement of machine to machine communications more robust and effective. Demonstrate and prototype multi-level security access solutions, including commercial-off-the-shelf mobile technologies as the basis for secure multi-level collaboration. ***FY 2019 Plans:*** Continue to develop and integrate a polyglot file identification filter to mitigate data exfiltration risk. Continue to develop a modularized filter store to maximize filter re-usability and increase the agility of cross-domain solutions to support new file types. Demonstrate a Commercial Solution for Classified compliant secure mobile solution that can enforce security policies beyond commercial solutions to satisfy unique Air Force requirements. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY 2019 decreased compared to FY 2018 by $0.113 million. Justification for this decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	18.620	18.210	17.283

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force											Date: February 2018	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0303467F / *SENSR Spectrum Pipeline SRF*							
COST ($ in Millions)	**Prior Years**	**FY 2017**	**FY 2018**	**FY 2019 Base**	**FY 2019 OCO**	**FY 2019 Total**	**FY 2020**	**FY 2021**	**FY 2022**	**FY 2023**	**Cost To Complete**	**Total Cost**
Total Program Element	-	6.904	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
632610: *Activities*	-	6.904	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.

On January 29, 2015, the Federal Communications Commission completed an auction of Advanced Wireless Service licenses in the 1695-1710 Megahertz (MHz), 1755-1780 MHz, and 2155-2180 MHz bands (collectively, the "AWS-3" bands). On June 23, 2015, the Office of Management and Budget (OMB) notified Congress of the forthcoming transfer of $5.030 billion to federal agencies with systems affected by the AWS-3 transition. Following the conclusion of the 30-day statutory waiting period, OMB transferred the funds to the federal agencies.

The Department of Defense (DoD) received $3.500 billion of the auction proceeds and created a $500 million Spectrum Access Research and Development Program (SAR&DP) to investigate new DoD technologies. The SAR&DP encompasses spectrum technology development that enables the DoD to perform its missions using spectrum-dependent systems in a manner that preferably enhances operational readiness and capability. Being able to operate in accordance with spectrum allocations resulting after the spectrum auction is a necessary, but not sufficient requirement for pursued technology solutions. DoD's transition out of or sharing of the auctioned bands can only be successful if the research and development solutions are sufficiently resilient (survivable and electronically protected) to operate 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.

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0303467F / *SENSR Spectrum Pipeline SRF*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	6.904	0.000	0.000	0.000	0.000
Total Adjustments	6.904	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	6.904	0.000	0.000	0.000	0.000

Change Summary Explanation

Other Adjustment of $6.904 million in FY 2017 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.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Air Force Spectrum Access Research & Development Program (SAR&DP)	6.904	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 2018 Plans:*** N/A ***FY 2019 Plans:*** N/A ***FY 2018 to FY 2019 Increase/Decrease Statement:*** No change from FY 2018 to FY 2019. Budget for Air Force portion of the Department of Defense Spectrum Access Research and Development Program is created from the auction of Advanced Wireless Service licenses.			
Accomplishments/Planned Programs Subtotals	6.904	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Air Force	Date: February 2018
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0303467F / *SENSR Spectrum Pipeline SRF*

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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