Department of Defense
Fiscal Year (FY) 2018 Budget Estimates

May 2017

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) 2018 Budget Estimates
RDT&E Descriptive Summaries
Scientific and Technology Budget Activities
May 2017

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 2018 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 2018 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 2018 President's Budget Request
Exhibit R-1 FY 2018 President's Budget Request
Total Obligational Authority
(Dollars in Thousands)

04 May 2017

Appropriation	FY 2016 Base + OCO	FY 2017 PB Request with CR Adj Base	FY 2017 Total PB Requests* with CR Adj Base	FY 2017 PB Request with CR Adj OCO	FY 2017 Total PB Requests* with CR Adj OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj OCO
Research, Development, Test & Eval, AF	25,243,981	25,146,562	25,988,644	17,100	89,900		89,900
Total Research, Development, Test & Evaluation	25,243,981	25,146,562	25,988,644	17,100	89,900		89,900

Department of Defense
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Appropriation	FY 2017 Total PB Requests** with CR Adj Base+OCO+SAA	FY 2017 Total PB Requests* with CR Adj Base + OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj Base + OCO	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Research, Development, Test & Eval, AF	25,163,662	26,078,544		26,078,544	34,914,359	135,358	35,049,717
Total Research, Development, Test & Evaluation	25,163,662	26,078,544		26,078,544	34,914,359	135,358	35,049,717

Department of Defense
FY 2018 President's Budget Request
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04 May 2017

Summary Recap of Budget Activities	FY 2016 Base + OCO	FY 2017 PB Request with CR Adj Base	FY 2017 Total PB Requests* with CR Adj Base	FY 2017 PB Request with CR Adj OCO	FY 2017 Total PB Requests* with CR Adj OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj OCO
Basic Research	510,673	500,024	500,024				
Applied Research	1,241,501	1,260,152	1,260,152				
Advanced Technology Development	675,737	725,805	725,805				
Advanced Component Development & Prototypes	1,555,274	2,847,833	3,047,833		4,700		4,700
System Development & Demonstration	3,832,399	4,075,804	4,135,704	425	11,425		11,425
Management Support	1,512,458	1,245,577	1,369,377				
Operational Systems Development	15,915,939	17,457,056	17,915,438	32,480	89,580		89,580
Undistributed		-2,965,689	-2,965,689	-15,805	-15,805		-15,805
Total Research, Development, Test & Evaluation	25,243,981	25,146,562	25,988,644	17,100	89,900		89,900

R-1C1F: FY 2018 President's Budget Request (Published Version), as of May 4, 2017 at 10:09:41

Department of Defense
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Summary Recap of Budget Activities	FY 2017 Total PB Requests** with CR Adj Base+OCO+SAA	FY 2017 Total PB Requests* with CR Adj Base + OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj Base + OCO	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Basic Research	500,024	500,024		500,024	505,259		505,259
Applied Research	1,260,152	1,260,152		1,260,152	1,284,114		1,284,114
Advanced Technology Development	725,805	725,805		725,805	794,017		794,017
Advanced Component Development & Prototypes	2,847,833	3,052,533		3,052,533	4,605,030	13,200	4,618,230
System Development & Demonstration	4,076,229	4,147,129		4,147,129	4,476,762		4,476,762
Management Support	1,245,577	1,369,377		1,369,377	2,663,875		2,663,875
Operational Systems Development	17,489,536	18,005,018		18,005,018	20,585,302	122,158	20,707,460
Undistributed	-2,981,494	-2,981,494		-2,981,494			
Total Research, Development, Test & Evaluation	25,163,662	26,078,544		26,078,544	34,914,359	135,358	35,049,717

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	FY 2016 Base + OCO	FY 2017 PB Request with CR Adj Base	FY 2017 Total PB Requests* with CR Adj Base	FY 2017 PB Request with CR Adj OCO	FY 2017 Total PB Requests* with CR Adj OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj OCO
Summary Recap of FYDP Programs							
Strategic Forces	551,805	636,723	646,723				
General Purpose Forces	1,608,073	2,203,903	2,382,603				
Intelligence and Communications	1,605,446	1,850,451	1,983,297	4,715	9,415		9,415
Mobility Forces	294,978	505,020	517,020				
Research and Development	8,916,417	9,680,261	10,036,961	425	11,425		11,425
Central Supply and Maintenance	98,763	105,997	105,997				
Training Medical and Other	3,155	3,114	3,114				
Administration and Associated Activities	110,405	-2,935,248	-2,935,248	-15,805	-15,805		-15,805
Support of Other Nations	2,315	4,784	4,784				
Space							
Classified Programs	12,052,624	13,091,557	13,243,393	27,765	84,865		84,865
Total Research, Development, Test & Evaluation	25,243,981	25,146,562	25,988,644	17,100	89,900		89,900

Department of Defense
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Summary Recap of FYDP Programs							
Strategic Forces	636,723	646,723		646,723	825,038		825,038
General Purpose Forces	2,203,903	2,382,603		2,382,603	2,962,365	9,750	2,972,115
Intelligence and Communications	1,855,166	1,992,712		1,992,712	1,466,925	5,400	1,472,325
Mobility Forces	505,020	517,020		517,020	602,629		602,629
Research and Development	9,680,686	10,048,386		10,048,386	10,713,989	7,800	10,721,789
Central Supply and Maintenance	105,997	105,997		105,997	109,419		109,419
Training Medical and Other	3,114	3,114		3,114	3,615		3,615
Administration and Associated Activities	-2,951,053	-2,951,053		-2,951,053	121,899		121,899
Support of Other Nations	4,784	4,784		4,784	4,569		4,569
Space					3,165,909		3,165,909
Classified Programs	13,119,322	13,328,258		13,328,258	14,938,002	112,408	15,050,410
Total Research, Development, Test & Evaluation	25,163,662	26,078,544		26,078,544	34,914,359	135,358	35,049,717

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Administration and Associated Activities	-2,951,053	-2,951,053		-2,951,053	121,899		121,899
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Department of the Air Force
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(Dollars in Thousands)

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

Line No	Program Element Number	Item	Act	FY 2016 Base + OCO	FY 2017 PB Request with CR Adj Base	FY 2017 Total PB Requests* with CR Adj Base	FY 2017 PB Request with CR Adj OCO	FY 2017 Total PB Requests* with CR Adj OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj OCO	Sec
1	0601102F	Defense Research Sciences	01	365,276	340,812	340,812					U
2	0601103F	University Research Initiatives	01	132,526	145,044	145,044					U
3	0601108F	High Energy Laser Research Initiatives	01	12,871	14,168	14,168					U
	Basic Research			510,673	500,024	500,024					
4	0602102F	Materials	02	132,768	126,152	126,152					U
5	0602201F	Aerospace Vehicle Technologies	02	118,263	122,831	122,831					U
6	0602202F	Human Effectiveness Applied Research	02	108,784	111,647	111,647					U
7	0602203F	Aerospace Propulsion	02	184,498	185,671	185,671					U
8	0602204F	Aerospace Sensors	02	151,264	155,174	155,174					U
9	0602298F	Science and Technology Management - Major Headquarters Activities	02								U
10	0602601F	Space Technology	02	107,442	117,915	117,915					U
11	0602602F	Conventional Munitions	02	105,296	109,649	109,649					U
12	0602605F	Directed Energy Technology	02	122,835	127,163	127,163					U
13	0602788F	Dominant Information Sciences and Methods	02	171,196	161,650	161,650					U
14	0602890F	High Energy Laser Research	02	39,155	42,300	42,300					U
	Applied Research			1,241,501	1,260,152	1,260,152					
15	0603112F	Advanced Materials for Weapon Systems	03	38,238	35,137	35,137					U
16	0603199F	Sustainment Science and Technology (S&T)	03	17,323	20,636	20,636					U

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1	0601102F	Defense Research Sciences	01	340,812	340,812		340,812	342,919		342,919	U
2	0601103F	University Research Initiatives	01	145,044	145,044		145,044	147,923		147,923	U
3	0601108F	High Energy Laser Research Initiatives	01	14,168	14,168		14,168	14,417		14,417	U
	Basic Research			500,024	500,024		500,024	505,259		505,259	
4	0602102F	Materials	02	126,152	126,152		126,152	124,264		124,264	U
5	0602201F	Aerospace Vehicle Technologies	02	122,831	122,831		122,831	124,678		124,678	U
6	0602202F	Human Effectiveness Applied Research	02	111,647	111,647		111,647	108,784		108,784	U
7	0602203F	Aerospace Propulsion	02	185,671	185,671		185,671	192,695		192,695	U
8	0602204F	Aerospace Sensors	02	155,174	155,174		155,174	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	117,915	117,915		117,915	116,503		116,503	U
11	0602602F	Conventional Munitions	02	109,649	109,649		109,649	112,195		112,195	U
12	0602605F	Directed Energy Technology	02	127,163	127,163		127,163	132,993		132,993	U
13	0602788F	Dominant Information Sciences and Methods	02	161,650	161,650		161,650	167,818		167,818	U
14	0602890F	High Energy Laser Research	02	42,300	42,300		42,300	43,049		43,049	U
	Applied Research			1,260,152	1,260,152		1,260,152	1,284,114		1,284,114	
15	0603112F	Advanced Materials for Weapon Systems	03	35,137	35,137		35,137	37,856		37,856	U
16	0603199F	Sustainment Science and Technology (S&T)	03	20,636	20,636		20,636	22,811		22,811	U

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17	0603203F	Advanced Aerospace Sensors	03	39,794	40,945	40,945					U
18	0603211F	Aerospace Technology Dev/Demo	03	95,266	130,950	130,950					U
19	0603216F	Aerospace Propulsion and Power Technology	03	168,542	94,594	94,594					U
20	0603270F	Electronic Combat Technology	03	45,359	58,250	58,250					U
21	0603401F	Advanced Spacecraft Technology	03	62,278	61,593	61,593					U
22	0603444F	Maui Space Surveillance System (MSSS)	03	12,303	11,681	11,681					U
23	0603456F	Human Effectiveness Advanced Technology Development	03	24,094	26,492	26,492					U
24	0603601F	Conventional Weapons Technology	03	42,204	102,009	102,009					U
25	0603605F	Advanced Weapons Technology	03	37,301	39,064	39,064					U
26	0603680F	Manufacturing Technology Program	03	51,467	46,344	46,344					U
27	0603788F	Battlespace Knowledge Development and Demonstration	03	41,568	58,110	58,110					U
		Advanced Technology Development		675,737	725,805	725,805					
28	0603260F	Intelligence Advanced Development	04	5,032	5,598	5,598					U
29	0603438F	Space Control Technology	04	3,955	7,534	7,534					U
30	0603742F	Combat Identification Technology	04	21,025	24,418	24,418					U
31	0603790F	NATO Research and Development	04	4,566	4,333	4,333					U
32	0603830F	Space Security and Defense Program	04	30,771	32,399	32,399					U
33	0603851F	Intercontinental Ballistic Missile - Dem/Val	04	34,765	108,663	108,663					U

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17	0603203F	Advanced Aerospace Sensors	03	40,945	40,945		40,945	40,978		40,978	U
18	0603211F	Aerospace Technology Dev/Demo	03	130,950	130,950		130,950	115,966		115,966	U
19	0603216F	Aerospace Propulsion and Power Technology	03	94,594	94,594		94,594	104,499		104,499	U
20	0603270F	Electronic Combat Technology	03	58,250	58,250		58,250	60,551		60,551	U
21	0603401F	Advanced Spacecraft Technology	03	61,593	61,593		61,593	58,910		58,910	U
22	0603444F	Maui Space Surveillance System (MSSS)	03	11,681	11,681		11,681	10,433		10,433	U
23	0603456F	Human Effectiveness Advanced Technology Development	03	26,492	26,492		26,492	33,635		33,635	U
24	0603601F	Conventional Weapons Technology	03	102,009	102,009		102,009	167,415		167,415	U
25	0603605F	Advanced Weapons Technology	03	39,064	39,064		39,064	45,502		45,502	U
26	0603680F	Manufacturing Technology Program	03	46,344	46,344		46,344	46,450		46,450	U
27	0603788F	Battlespace Knowledge Development and Demonstration	03	58,110	58,110		58,110	49,011		49,011	U
		Advanced Technology Development		725,805	725,805		725,805	794,017		794,017	
28	0603260F	Intelligence Advanced Development	04	5,598	5,598		5,598	5,652		5,652	U
29	0603438F	Space Control Technology	04	7,534	7,534		7,534		7,800	7,800	U
30	0603742F	Combat Identification Technology	04	24,418	24,418		24,418	24,397		24,397	U
31	0603790F	NATO Research and Development	04	4,333	4,333		4,333	3,851		3,851	U
32	0603830F	Space Security and Defense Program	04	32,399	32,399		32,399				U
33	0603851F	Intercontinental Ballistic Missile - Dem/Val	04	108,663	108,663		108,663	10,736		10,736	U

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34	0603859F	Pollution Prevention - Dem/Val	04								U
35	0604015F	Long Range Strike - Bomber	04	710,390	1,358,309	1,358,309					U
36	0604201F	Integrated Avionics Planning and Development	04								U
37	0604257F	Advanced Technology and Sensors	04		34,818	34,818					U
38	0604288F	National Airborne Ops Center (NAOC) Recap	04								U
39	0604317F	Technology Transfer	04	7,494	3,368	3,368					U
40	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	04	62,034	74,308	74,308					U
41	0604414F	Cyber Resiliency of Weapon Systems-ACS	04			40,000					U
42	0604422F	Weather System Follow-on	04	46,307	118,953	118,953					U
43	0604425F	Space Situation Awareness Systems	04		9,901	10,901					U
44	0604776F	Deployment & Distribution Enterprise R&D	04		25,890	25,890					U
45	0604857F	Operationally Responsive Space	04	22,123	7,921	17,921					U
46	0604858F	Tech Transition Program	04	264,673	347,304	349,304					U
47	0605230F	Ground Based Strategic Deterrent	04	64,966	113,919	113,919					U
48	0201184F	Counter Narco-Terrorism Program Office	04	1,850							U
49	0207110F	Next Generation Air Dominance	04	32,495	20,595	167,595					U
50	0207455F	Three Dimensional Long-Range Radar (3DELRR)	04	7,865	49,491	49,491					U

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34	0603859F	Pollution Prevention - Dem/Val	04					2		2	U
35	0604015F	Long Range Strike - Bomber	04	1,358,309	1,358,309		1,358,309	2,003,580		2,003,580	U
36	0604201F	Integrated Avionics Planning and Development	04					65,458		65,458	U
37	0604257F	Advanced Technology and Sensors	04	34,818	34,818		34,818	68,719		68,719	U
38	0604288F	National Airborne Ops Center (NAOC) Recap	04					7,850		7,850	U
39	0604317F	Technology Transfer	04	3,368	3,368		3,368	3,295		3,295	U
40	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	04	74,308	74,308		74,308	17,365		17,365	U
41	0604414F	Cyber Resiliency of Weapon Systems-ACS	04		40,000		40,000	32,253		32,253	U
42	0604422F	Weather System Follow-on	04	118,953	118,953		118,953				U
43	0604425F	Space Situation Awareness Systems	04	9,901	10,901		10,901				U
44	0604776F	Deployment & Distribution Enterprise R&D	04	25,890	25,890		25,890	26,222		26,222	U
45	0604857F	Operationally Responsive Space	04	7,921	17,921		17,921				U
46	0604858F	Tech Transition Program	04	347,304	349,304		349,304	840,650		840,650	U
47	0605230F	Ground Based Strategic Deterrent	04	113,919	113,919		113,919	215,721		215,721	U
48	0201184F	Counter Narco-Terrorism Program Office	04								U
49	0207110F	Next Generation Air Dominance	04	20,595	167,595		167,595	294,746		294,746	U
50	0207455F	Three Dimensional Long-Range Radar (3DELRR)	04	49,491	49,491		49,491	10,645		10,645	U

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51	0305164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04	143,118	278,147	278,147					U
52	0305236F	Common Data Link Executive Agent (CDL EA)	04		42,338	42,338					U
53	0306250F	Cyber Operations Technology Development	04	91,845	158,002	158,002		4,700		4,700	U
54	0306415F	Enabled Cyber Activities	04		15,842	15,842					U
55	0408011F	Special Tactics / Combat Control	04								U
56	0901410F	Contracting Information Technology System	04		5,782	5,782					U
57	1203164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04								U
58	1203710F	EO/IR Weather Systems	04								U
59	1206422F	Weather System Follow-on	04								U
60	1206425F	Space Situation Awareness Systems	04								U
61	1206434F	Midterm Polar MILSATCOM System	04								U
62	1206438F	Space Control Technology	04								U
63	1206730F	Space Security and Defense Program	04								U
64	1206760F	Protected Tactical Enterprise Service (PTES)	04								U
65	1206761F	Protected Tactical Service (PTS)	04								U
66	1206855F	Protected SATCOM Services (PSCS) - Aggregated	04								U

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51	0305164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04	278,147	278,147		278,147				U
52	0305236F	Common Data Link Executive Agent (CDL EA)	04	42,338	42,338		42,338	41,509		41,509	U
53	0306250F	Cyber Operations Technology Development	04	158,002	162,702		162,702	226,287	5,400	231,687	U
54	0306415F	Enabled Cyber Activities	04	15,842	15,842		15,842	16,687		16,687	U
55	0408011F	Special Tactics / Combat Control	04					4,500		4,500	U
56	0901410F	Contracting Information Technology System	04	5,782	5,782		5,782	15,867		15,867	U
57	1203164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04					253,939		253,939	U
58	1203710F	EO/IR Weather Systems	04					10,000		10,000	U
59	1206422F	Weather System Follow-on	04					112,088		112,088	U
60	1206425F	Space Situation Awareness Systems	04					34,764		34,764	U
61	1206434F	Midterm Polar MILSATCOM System	04					63,092		63,092	U
62	1206438F	Space Control Technology	04					7,842		7,842	U
63	1206730F	Space Security and Defense Program	04					41,385		41,385	U
64	1206760F	Protected Tactical Enterprise Service (PTES)	04					18,150		18,150	U
65	1206761F	Protected Tactical Service (PTS)	04					24,201		24,201	U
66	1206855F	Protected SATCOM Services (PSCS) - Aggregated	04					16,000		16,000	U

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67	1206857F	Operationally Responsive Space	04								U
		Advanced Component Development & Prototypes		1,555,274	2,847,833	3,047,833		4,700		4,700	
68	0604200F	Future Advanced Weapon Analysis & Programs	05								U
69	0604201F	Integrated Avionics Planning and Development	05								U
70	0604222F	Nuclear Weapons Support	05								U
71	0604270F	Electronic Warfare Development	05	813	12,476	12,476					U
72	0604281F	Tactical Data Networks Enterprise	05	49,495	82,380	82,380					U
73	0604287F	Physical Security Equipment	05	5,973	8,458	24,458		11,000		11,000	U
74	0604329F	Small Diameter Bomb (SDB) - EMD	05	27,950	54,838	54,838					U
75	0604421F	Counterspace Systems	05	24,134	34,394	41,494	425	425		425	U
76	0604425F	Space Situation Awareness Systems	05	30,116	23,945	23,945					U
77	0604426F	Space Fence	05	240,692	168,364	168,364					U
78	0604429F	Airborne Electronic Attack	05	8,067	9,187	9,187					U
79	0604441F	Space Based Infrared System (SBIRS) High EMD	05	291,510	181,966	218,766					U
80	0604602F	Armament/Ordnance Development	05	36,266	20,312	20,312					U
81	0604604F	Submunitions	05	2,419	2,503	2,503					U
82	0604617F	Agile Combat Support	05	56,178	53,680	53,680					U
83	0604618F	Joint Direct Attack Munition	05		9,901	9,901					U
84	0604706F	Life Support Systems	05	7,904	7,520	7,520					U

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67	1206857F	Operationally Responsive Space	04					87,577		87,577	U
		Advanced Component Development & Prototypes		2,847,833	3,052,533		3,052,533	4,605,030	13,200	4,618,230	
68	0604200F	Future Advanced Weapon Analysis & Programs	05					5,100		5,100	U
69	0604201F	Integrated Avionics Planning and Development	05					101,203		101,203	U
70	0604222F	Nuclear Weapons Support	05					3,009		3,009	U
71	0604270F	Electronic Warfare Development	05	12,476	12,476		12,476	2,241		2,241	U
72	0604281F	Tactical Data Networks Enterprise	05	82,380	82,380		82,380	38,250		38,250	U
73	0604287F	Physical Security Equipment	05	8,458	35,458		35,458	19,739		19,739	U
74	0604329F	Small Diameter Bomb (SDB) - EMD	05	54,838	54,838		54,838	38,979		38,979	U
75	0604421F	Counterspace Systems	05	34,819	41,919		41,919				U
76	0604425F	Space Situation Awareness Systems	05	23,945	23,945		23,945				U
77	0604426F	Space Fence	05	168,364	168,364		168,364				U
78	0604429F	Airborne Electronic Attack	05	9,187	9,187		9,187	7,091		7,091	U
79	0604441F	Space Based Infrared System (SBIRS) High EMD	05	181,966	218,766		218,766				U
80	0604602F	Armament/Ordnance Development	05	20,312	20,312		20,312	46,540		46,540	U
81	0604604F	Submunitions	05	2,503	2,503		2,503	2,705		2,705	U
82	0604617F	Agile Combat Support	05	53,680	53,680		53,680	31,240		31,240	U
83	0604618F	Joint Direct Attack Munition	05	9,901	9,901		9,901				U
84	0604706F	Life Support Systems	05	7,520	7,520		7,520	9,060		9,060	U

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85	0604735F	Combat Training Ranges	05	11,368	77,409	77,409					U
86	0604800F	F-35 - EMD	05	575,932	450,467	450,467					U
87	0604853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05	224,920	296,572	296,572					U
88	0604932F	Long Range Standoff Weapon	05	16,143	95,604	95,604					U
89	0604933F	ICBM Fuze Modernization	05	138,027	189,751	189,751					U
90	0605030F	Joint Tactical Network Center (JTNC)	05		1,131	1,131					U
91	0605031F	Joint Tactical Network (JTN)	05								U
92	0605213F	F-22 Modernization Increment 3.2B	05	115,603	70,290	70,290					U
93	0605214F	Ground Attack Weapons Fuze Development	05	3,477	937	937					U
94	0605221F	KC-46	05	572,118	261,724	261,724					U
95	0605223F	Advanced Pilot Training	05	10,395	12,377	12,377					U
96	0605229F	Combat Rescue Helicopter	05	150,341	319,331	319,331					U
97	0605431F	Advanced EHF MILSATCOM (SPACE)	05	208,095	259,131	259,131					U
98	0605432F	Polar MILSATCOM (SPACE)	05	71,867	50,815	50,815					U
99	0605433F	Wideband Global SATCOM (SPACE)	05	49,954	41,632	41,632					U
100	0605458F	Air & Space Ops Center 10.2 RDT&E	05	55,333	28,911	28,911					U
101	0605931F	B-2 Defensive Management System	05	261,162	315,615	315,615					U
102	0101125F	Nuclear Weapons Modernization	05	204,358	137,909	137,909					U
103	0207171F	F-15 EPAWSS	05	174,439	256,669	256,669					U

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85	0604735F	Combat Training Ranges	05	77,409	77,409		77,409	87,350		87,350	U
86	0604800F	F-35 - EMD	05	450,467	450,467		450,467	292,947		292,947	U
87	0604853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05	296,572	296,572		296,572				U
88	0604932F	Long Range Standoff Weapon	05	95,604	95,604		95,604	451,290		451,290	U
89	0604933F	ICBM Fuze Modernization	05	189,751	189,751		189,751	178,991		178,991	U
90	0605030F	Joint Tactical Network Center (JTNC)	05	1,131	1,131		1,131	12,736		12,736	U
91	0605031F	Joint Tactical Network (JTN)	05					9,319		9,319	U
92	0605213F	F-22 Modernization Increment 3.2B	05	70,290	70,290		70,290	13,600		13,600	U
93	0605214F	Ground Attack Weapons Fuze Development	05	937	937		937				U
94	0605221F	KC-46	05	261,724	261,724		261,724	93,845		93,845	U
95	0605223F	Advanced Pilot Training	05	12,377	12,377		12,377	105,999		105,999	U
96	0605229F	Combat Rescue Helicopter	05	319,331	319,331		319,331	354,485		354,485	U
97	0605431F	Advanced EHF MILSATCOM (SPACE)	05	259,131	259,131		259,131				U
98	0605432F	Polar MILSATCOM (SPACE)	05	50,815	50,815		50,815				U
99	0605433F	Wideband Global SATCOM (SPACE)	05	41,632	41,632		41,632				U
100	0605458F	Air & Space Ops Center 10.2 RDT&E	05	28,911	28,911		28,911	119,745		119,745	U
101	0605931F	B-2 Defensive Management System	05	315,615	315,615		315,615	194,570		194,570	U
102	0101125F	Nuclear Weapons Modernization	05	137,909	137,909		137,909	91,237		91,237	U
103	0207171F	F-15 EPAWSS	05	256,669	256,669		256,669	209,847		209,847	U

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104	0207328F	Stand In Attack Weapon	05								U
105	0207701F	Full Combat Mission Training	05	17,290	12,051	12,051					U
106	0303267F	Auctioned Spectrum Relocation Fund	05	40,571							U
107	0303367F	Spectrum Access Research and Development	05	383							U
108	0305176F	Combat Survivor Evader Locator	05	958	29,253	29,253					U
109	0307581F	JSTARS Recap	05	51,306	128,019	128,019					U
110	0401310F	C-32 Executive Transport Recapitalization	05								U
111	0401319F	Presidential Aircraft Recapitalization (PAR)	05	82,420	351,220	351,220					U
112	0701212F	Automated Test Systems	05	14,422	19,062	19,062					U
113	1203176F	Combat Survivor Evader Locator	05								U
114	1203940F	Space Situation Awareness Operations	05								U
115	1206421F	Counterspace Systems	05								U
116	1206425F	Space Situation Awareness Systems	05								U
117	1206426F	Space Fence	05								U
118	1206431F	Advanced EHF MILSATCOM (SPACE)	05								U
119	1206432F	Polar MILSATCOM (SPACE)	05								U
120	1206433F	Wideband Global SATCOM (SPACE)	05								U
121	1206441F	Space Based Infrared System (SBIRS) High EMD	05								U

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104	0207328F	Stand In Attack Weapon	05					3,400		3,400	U
105	0207701F	Full Combat Mission Training	05	12,051	12,051		12,051	16,727		16,727	U
106	0303267F	Auctioned Spectrum Relocation Fund	05								U
107	0303367F	Spectrum Access Research and Development	05								U
108	0305176F	Combat Survivor Evader Locator	05	29,253	29,253		29,253				U
109	0307581F	JSTARS Recap	05	128,019	128,019		128,019	417,201		417,201	U
110	0401310F	C-32 Executive Transport Recapitalization	05					6,017		6,017	U
111	0401319F	Presidential Aircraft Recapitalization (PAR)	05	351,220	351,220		351,220	434,069		434,069	U
112	0701212F	Automated Test Systems	05	19,062	19,062		19,062	18,528		18,528	U
113	1203176F	Combat Survivor Evader Locator	05					24,967		24,967	U
114	1203940F	Space Situation Awareness Operations	05					10,029		10,029	U
115	1206421F	Counterspace Systems	05					66,370		66,370	U
116	1206425F	Space Situation Awareness Systems	05					48,448		48,448	U
117	1206426F	Space Fence	05					35,937		35,937	U
118	1206431F	Advanced EHF MILSATCOM (SPACE)	05					145,610		145,610	U
119	1206432F	Polar MILSATCOM (SPACE)	05					33,644		33,644	U
120	1206433F	Wideband Global SATCOM (SPACE)	05					14,263		14,263	U
121	1206441F	Space Based Infrared System (SBIRS) High EMD	05					311,844		311,844	U

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Line No	Program Element Number	Item	Act	FY 2016 Base + OCO	FY 2017 PB Request with CR Adj Base	FY 2017 Total PB Requests* with CR Adj Base	FY 2017 PB Request with CR Adj OCO	FY 2017 Total PB Requests* with CR Adj OCO	FY 2017 Less Enacted Div B P.L.114-254** OCO	FY 2017 Remaining Req with CR Adj OCO	Sec
122	1206442F	Evolved SBIRS	05								U
123	1206853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05								U
		System Development & Demonstration		3,832,399	4,075,804	4,135,704	425	11,425		11,425	
124	0604256F	Threat Simulator Development	06	23,558	21,630	21,630					U
125	0604759F	Major T&E Investment	06	70,894	66,385	71,385					U
126	0605101F	RAND Project Air Force	06	33,943	34,641	34,641					U
127	0605502F	Small Business Innovation Research	06	337,762							U
128	0605712F	Initial Operational Test & Evaluation	06	11,172	11,529	11,529					U
129	0605807F	Test and Evaluation Support	06	683,307	661,417	680,217					U
130	0605826F	Acq Workforce- Global Power	06								U
131	0605827F	Acq Workforce- Global Vig & Combat Sys	06								U
132	0605828F	Acq Workforce- Global Reach	06								U
133	0605829F	Acq Workforce- Cyber, Network, & Bus Sys	06								U
134	0605830F	Acq Workforce- Global Battle Mgmt	06								U
135	0605831F	Acq Workforce- Capability Integration	06								U
136	0605832F	Acq Workforce- Advanced Prgm Technology	06								U
137	0605833F	Acq Workforce- Nuclear Systems	06								U

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122	1206442F	Evolved SBIRS	05					71,018		71,018	U
123	1206853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05					297,572		297,572	U
		System Development & Demonstration		4,076,229	4,147,129		4,147,129	4,476,762		4,476,762	
124	0604256F	Threat Simulator Development	06	21,630	21,630		21,630	35,405		35,405	U
125	0604759F	Major T&E Investment	06	66,385	71,385		71,385	82,874		82,874	U
126	0605101F	RAND Project Air Force	06	34,641	34,641		34,641	34,346		34,346	U
127	0605502F	Small Business Innovation Research	06								U
128	0605712F	Initial Operational Test & Evaluation	06	11,529	11,529		11,529	15,523		15,523	U
129	0605807F	Test and Evaluation Support	06	661,417	680,217		680,217	678,289		678,289	U
130	0605826F	Acq Workforce- Global Power	06					219,809		219,809	U
131	0605827F	Acq Workforce- Global Vig & Combat Sys	06					223,179		223,179	U
132	0605828F	Acq Workforce- Global Reach	06					138,556		138,556	U
133	0605829F	Acq Workforce- Cyber, Network, & Bus Sys	06					221,393		221,393	U
134	0605830F	Acq Workforce- Global Battle Mgmt	06					152,577		152,577	U
135	0605831F	Acq Workforce- Capability Integration	06					196,561		196,561	U
136	0605832F	Acq Workforce- Advanced Prgm Technology	06					28,322		28,322	U
137	0605833F	Acq Workforce- Nuclear Systems	06					126,611		126,611	U

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138	0605860F	Rocket Systems Launch Program (SPACE)	06	21,245	11,198	11,198					U
139	0605864F	Space Test Program (STP)	06	28,143	27,070	27,070					U
140	0605898F	Management HQ - R&D	06								U
141	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	06	40,518	134,111	134,111					U
142	0605978F	Facilities Sustainment - Test and Evaluation Support	06	27,895	28,091	28,091					U
143	0606017F	Requirements Analysis and Maturation	06	21,922	29,100	129,100					U
144	0606116F	Space Test and Training Range Development	06	18,465	18,528	18,528					U
145	0606392F	Space and Missile Center (SMC) Civilian Workforce	06	169,196	176,666	176,666					U
146	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	06	3,841	4,410	4,410					U
147	0702806F	Acquisition and Management Support	06	16,358	14,613	14,613					U
148	0804731F	General Skill Training	06	1,268	1,404	1,404					U
149	0909999F	Financing for Cancelled Account Adjustments	06	656							U
150	1001004F	International Activities	06	2,315	4,784	4,784					U
151	1206116F	Space Test and Training Range Development	06								U
152	1206392F	Space and Missile Center (SMC) Civilian Workforce	06								U
153	1206398F	Space & Missile Systems Center - MHA	06								U

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138	0605860F	Rocket Systems Launch Program (SPACE)	06	11,198	11,198		11,198				U
139	0605864F	Space Test Program (STP)	06	27,070	27,070		27,070				U
140	0605898F	Management HQ - R&D	06					9,154		9,154	U
141	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	06	134,111	134,111		134,111	135,507		135,507	U
142	0605978F	Facilities Sustainment - Test and Evaluation Support	06	28,091	28,091		28,091	28,720		28,720	U
143	0606017F	Requirements Analysis and Maturation	06	29,100	129,100		129,100	35,453		35,453	U
144	0606116F	Space Test and Training Range Development	06	18,528	18,528		18,528				U
145	0606392F	Space and Missile Center (SMC) Civilian Workforce	06	176,666	176,666		176,666				U
146	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	06	4,410	4,410		4,410	29,049		29,049	U
147	0702806F	Acquisition and Management Support	06	14,613	14,613		14,613	14,980		14,980	U
148	0804731F	General Skill Training	06	1,404	1,404		1,404	1,434		1,434	U
149	0909999F	Financing for Cancelled Account Adjustments	06								U
150	1001004F	International Activities	06	4,784	4,784		4,784	4,569		4,569	U
151	1206116F	Space Test and Training Range Development	06					25,773		25,773	U
152	1206392F	Space and Missile Center (SMC) Civilian Workforce	06					169,887		169,887	U
153	1206398F	Space & Missile Systems Center - MHA	06					9,531		9,531	U

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154	1206860F	Rocket Systems Launch Program (SPACE)	06								U
155	1206864F	Space Test Program (STP)	06								U
		Management Support		1,512,458	1,245,577	1,369,377					
156	0603423F	Global Positioning System III - Operational Control Segment	07	344,226	393,268	513,268					U
157	0604222F	Nuclear Weapons Support	07								U
158	0604233F	Specialized Undergraduate Flight Training	07	7,742	15,427	15,427					U
159	0604445F	Wide Area Surveillance	07	17,639	46,695	46,695					U
161	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	07	30,334	10,368	10,368					U
162	0605024F	Anti-Tamper Technology Executive Agency	07	25,857	31,952	31,952					U
163	0605117F	Foreign Materiel Acquisition and Exploitation	07	41,689	42,960	42,960					U
164	0605278F	HC/MC-130 Recap RDT&E	07	8,646	13,987	13,987					U
165	0606018F	NC3 Integration	07								U
166	0101113F	B-52 Squadrons	07	70,172	78,267	88,267					U
167	0101122F	Air-Launched Cruise Missile (ALCM)	07	451	453	453					U
168	0101126F	B-1B Squadrons	07	2,174	5,830	5,830					U
169	0101127F	B-2 Squadrons	07	105,914	152,458	152,458					U
170	0101213F	Minuteman Squadrons	07	128,492	182,958	182,958					U

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154	1206860F	Rocket Systems Launch Program (SPACE)	06					20,975		20,975	U
155	1206864F	Space Test Program (STP)	06					25,398		25,398	U
	Management Support			1,245,577	1,369,377		1,369,377	2,663,875		2,663,875	
156	0603423F	Global Positioning System III - Operational Control Segment	07	393,268	513,268		513,268				U
157	0604222F	Nuclear Weapons Support	07					27,579		27,579	U
158	0604233F	Specialized Undergraduate Flight Training	07	15,427	15,427		15,427	5,776		5,776	U
159	0604445F	Wide Area Surveillance	07	46,695	46,695		46,695	16,247		16,247	U
161	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	07	10,368	10,368		10,368	21,915		21,915	U
162	0605024F	Anti-Tamper Technology Executive Agency	07	31,952	31,952		31,952	33,150		33,150	U
163	0605117F	Foreign Materiel Acquisition and Exploitation	07	42,960	42,960		42,960	66,653		66,653	U
164	0605278F	HC/MC-130 Recap RDT&E	07	13,987	13,987		13,987	38,579		38,579	U
165	0606018F	NC3 Integration	07					12,636		12,636	U
166	0101113F	B-52 Squadrons	07	78,267	88,267		88,267	111,910		111,910	U
167	0101122F	Air-Launched Cruise Missile (ALCM)	07	453	453		453	463		463	U
168	0101126F	B-1B Squadrons	07	5,830	5,830		5,830	62,471		62,471	U
169	0101127F	B-2 Squadrons	07	152,458	152,458		152,458	193,108		193,108	U
170	0101213F	Minuteman Squadrons	07	182,958	182,958		182,958	210,845		210,845	U

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171	0101313F	Integrated Strategic Planning and Analysis Network (ISPAN) - USSTRATCOM	07	26,954	39,148	39,148					U
172	0101314F	Night Fist - USSTRATCOM	07	87							U
173	0101316F	Worldwide Joint Strategic Communications	07	3,815	6,042	6,042					U
174	0101324F	Integrated Strategic Planning & Analysis Network	07								U
176	0102110F	UH-1N Replacement Program	07		14,116	14,116					U
177	0102326F	Region/Sector Operation Control Center Modernization Program	07		10,868	10,868					U
178	0105921F	Service Support to STRATCOM - Space Activities	07	9,388	8,674	8,674					U
179	0205219F	MQ-9 UAV	07	124,695	151,373	151,373					U
180	0205671F	Joint Counter RCIED Electronic Warfare	07	300							U
181	0207040F	Multi-Platform Electronic Warfare Equipment	07	3,980							U
182	0207131F	A-10 Squadrons	07	16,200	14,853	21,353					U
183	0207133F	F-16 Squadrons	07	153,611	132,795	147,795					U
184	0207134F	F-15E Squadrons	07	210,029	356,717	356,717					U
185	0207136F	Manned Destructive Suppression	07	14,400	14,773	14,773					U
186	0207138F	F-22A Squadrons	07	224,550	387,564	387,564					U
187	0207142F	F-35 Squadrons	07	51,990	153,045	153,045					U

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171	0101313F	Integrated Strategic Planning and Analysis Network (ISPAN) - USSTRATCOM	07	39,148	39,148		39,148	25,736		25,736	U
172	0101314F	Night Fist - USSTRATCOM	07								U
173	0101316F	Worldwide Joint Strategic Communications	07	6,042	6,042		6,042	6,272		6,272	U
174	0101324F	Integrated Strategic Planning & Analysis Network	07					11,032		11,032	U
176	0102110F	UH-1N Replacement Program	07	14,116	14,116		14,116	108,617		108,617	U
177	0102326F	Region/Sector Operation Control Center Modernization Program	07	10,868	10,868		10,868	3,347		3,347	U
178	0105921F	Service Support to STRATCOM - Space Activities	07	8,674	8,674		8,674				U
179	0205219F	MQ-9 UAV	07	151,373	151,373		151,373	201,394		201,394	U
180	0205671F	Joint Counter RCIED Electronic Warfare	07								U
181	0207040F	Multi-Platform Electronic Warfare Equipment	07								U
182	0207131F	A-10 Squadrons	07	14,853	21,353		21,353	17,459		17,459	U
183	0207133F	F-16 Squadrons	07	132,795	147,795		147,795	246,578		246,578	U
184	0207134F	F-15E Squadrons	07	356,717	356,717		356,717	320,271		320,271	U
185	0207136F	Manned Destructive Suppression	07	14,773	14,773		14,773	15,106		15,106	U
186	0207138F	F-22A Squadrons	07	387,564	387,564		387,564	610,942		610,942	U
187	0207142F	F-35 Squadrons	07	153,045	153,045		153,045	334,530		334,530	U

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188	0207161F	Tactical AIM Missiles	07	33,615	52,898	52,898					U
189	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	44,335	62,470	62,470					U
190	0207224F	Combat Rescue and Recovery	07	398							U
191	0207227F	Combat Rescue - Pararescue	07	636	362	362					U
192	0207247F	AF TENCAP	07	37,489	28,413	28,413					U
193	0207249F	Precision Attack Systems Procurement	07	1,064	649	649					U
194	0207253F	Compass Call	07	32,024	13,723	23,923					U
195	0207268F	Aircraft Engine Component Improvement Program	07	104,092	109,859	109,859					U
196	0207277F	ISR Innovations	07								U
197	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	07	9,221	30,002	30,002					U
198	0207410F	Air & Space Operations Center (AOC)	07	20,588	37,621	37,621					U
199	0207412F	Control and Reporting Center (CRC)	07	557	13,292	13,292					U
200	0207417F	Airborne Warning and Control System (AWACS)	07	124,457	86,644	86,644					U
201	0207418F	Tactical Airborne Control Systems	07	5,786	2,442	2,442					U
203	0207431F	Combat Air Intelligence System Activities	07	6,793	10,911	10,911					U
204	0207444F	Tactical Air Control Party-Mod	07	10,747	11,843	11,843					U
205	0207448F	C2ISR Tactical Data Link	07	1,629	1,515	1,515					U
206	0207452F	DCAPES	07	12,909	14,979	14,979					U

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188	0207161F	Tactical AIM Missiles	07	52,898	52,898		52,898	34,952		34,952	U
189	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	62,470	62,470		62,470	61,322		61,322	U
190	0207224F	Combat Rescue and Recovery	07								U
191	0207227F	Combat Rescue - Pararescue	07	362	362		362	693		693	U
192	0207247F	AF TENCAP	07	28,413	28,413		28,413				U
193	0207249F	Precision Attack Systems Procurement	07	649	649		649	1,714		1,714	U
194	0207253F	Compass Call	07	13,723	23,923		23,923	14,040		14,040	U
195	0207268F	Aircraft Engine Component Improvement Program	07	109,859	109,859		109,859	109,243		109,243	U
196	0207277F	ISR Innovations	07						5,750	5,750	U
197	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	07	30,002	30,002		30,002	29,932		29,932	U
198	0207410F	Air & Space Operations Center (AOC)	07	37,621	37,621		37,621	26,956		26,956	U
199	0207412F	Control and Reporting Center (CRC)	07	13,292	13,292		13,292	2,450		2,450	U
200	0207417F	Airborne Warning and Control System (AWACS)	07	86,644	86,644		86,644	151,726		151,726	U
201	0207418F	Tactical Airborne Control Systems	07	2,442	2,442		2,442	3,656		3,656	U
203	0207431F	Combat Air Intelligence System Activities	07	10,911	10,911		10,911	13,420		13,420	U
204	0207444F	Tactical Air Control Party-Mod	07	11,843	11,843		11,843	10,623		10,623	U
205	0207448F	C2ISR Tactical Data Link	07	1,515	1,515		1,515	1,754		1,754	U
206	0207452F	DCAPES	07	14,979	14,979		14,979	17,382		17,382	U

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207	0207573F	National Technical Nuclear Forensics	07								U
208	0207590F	Seek Eagle	07	21,131	25,308	25,308					U
209	0207601F	USAF Modeling and Simulation	07	20,358	16,666	16,666					U
210	0207605F	Wargaming and Simulation Centers	07	5,819	4,245	4,245					U
211	0207697F	Distributed Training and Exercises	07	4,202	3,886	3,886					U
212	0208006F	Mission Planning Systems	07	54,176	71,785	71,785					U
213	0208007F	Tactical Deception	07								U
214	0208087F	AF Offensive Cyberspace Operations	07	14,939	25,025	25,025					U
215	0208088F	AF Defensive Cyberspace Operations	07	7,414	29,439	29,439					U
218	0301017F	Global Sensor Integrated on Network (GSIN)	07	5,803	3,470	3,470					U
219	0301112F	Nuclear Planning and Execution System (NPES)	07		4,060	4,060					U
226	0301400F	Space Superiority Intelligence	07	13,965	13,880	13,880					U
227	0301401F	Air Force Space and Cyber Non-Traditional ISR for Battlespace Awareness	07								U
228	0302015F	E-4B National Airborne Operations Center (NAOC)	07	76,760	30,948	30,948					U
229	0303001F	Family of Advanced BLoS Terminals (FAB-T)	07	12,313	42,378	52,578					U
230	0303131F	Minimum Essential Emergency Communications Network (MEECN)	07	92,036	47,471	47,471					U
231	0303140F	Information Systems Security Program	07	44,578	46,388	46,388					U

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207	0207573F	National Technical Nuclear Forensics	07					2,307		2,307	U
208	0207590F	Seek Eagle	07	25,308	25,308		25,308	25,397		25,397	U
209	0207601F	USAF Modeling and Simulation	07	16,666	16,666		16,666	10,175		10,175	U
210	0207605F	Wargaming and Simulation Centers	07	4,245	4,245		4,245	12,839		12,839	U
211	0207697F	Distributed Training and Exercises	07	3,886	3,886		3,886	4,190		4,190	U
212	0208006F	Mission Planning Systems	07	71,785	71,785		71,785	85,531		85,531	U
213	0208007F	Tactical Deception	07					3,761		3,761	U
214	0208087F	AF Offensive Cyberspace Operations	07	25,025	25,025		25,025	35,693	4,000	39,693	U
215	0208088F	AF Defensive Cyberspace Operations	07	29,439	29,439		29,439	20,964		20,964	U
218	0301017F	Global Sensor Integrated on Network (GSIN)	07	3,470	3,470		3,470	3,549		3,549	U
219	0301112F	Nuclear Planning and Execution System (NPES)	07	4,060	4,060		4,060	4,371		4,371	U
226	0301400F	Space Superiority Intelligence	07	13,880	13,880		13,880				U
227	0301401F	Air Force Space and Cyber Non-Traditional ISR for Battlespace Awareness	07					3,721		3,721	U
228	0302015F	E-4B National Airborne Operations Center (NAOC)	07	30,948	30,948		30,948	35,467		35,467	U
229	0303001F	Family of Advanced BLoS Terminals (FAB-T)	07	42,378	52,578		52,578				U
230	0303131F	Minimum Essential Emergency Communications Network (MEECN)	07	47,471	47,471		47,471	48,841		48,841	U
231	0303140F	Information Systems Security Program	07	46,388	46,388		46,388	42,973		42,973	U

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232	0303141F	Global Combat Support System	07		52	52					U
233	0303142F	Global Force Management - Data Initiative	07	2,470	2,099	2,099					U
234	0303601F	MILSATCOM Terminals	07	9,000							U
236	0304260F	Airborne SIGINT Enterprise	07	111,142	90,762	90,762					U
237	0304310F	Commercial Economic Analysis	07								U
240	0305020F	CCMD Intelligence Information Technology	07								U
241	0305099F	Global Air Traffic Management (GATM)	07	4,089	4,354	4,354					U
242	0305110F	Satellite Control Network (SPACE)	07	7,327	15,624	15,624					U
243	0305111F	Weather Service	07	28,812	19,974	19,974					U
244	0305114F	Air Traffic Control, Approach, and Landing System (ATCALS)	07	18,830	9,770	9,770					U
245	0305116F	Aerial Targets	07	2,578	3,051	3,051					U
248	0305128F	Security and Investigative Activities	07	455	405	405					U
249	0305145F	Arms Control Implementation	07	9,116	4,844	4,844					U
250	0305146F	Defense Joint Counterintelligence Activities	07	361	339	339					U
253	0305173F	Space and Missile Test and Evaluation Center	07	3,490	3,989	3,989					U
254	0305174F	Space Innovation, Integration and Rapid Technology Development	07	1,543	3,070	3,070	4,715	4,715		4,715	U
255	0305179F	Integrated Broadcast Service (IBS)	07	9,760	8,833	8,833					U

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232	0303141F	Global Combat Support System	07	52	52		52	105		105	U
233	0303142F	Global Force Management - Data Initiative	07	2,099	2,099		2,099	2,147		2,147	U
234	0303601F	MILSATCOM Terminals	07								U
236	0304260F	Airborne SIGINT Enterprise	07	90,762	90,762		90,762	121,948		121,948	U
237	0304310F	Commercial Economic Analysis	07					3,544		3,544	U
240	0305020F	CCMD Intelligence Information Technology	07					1,542		1,542	U
241	0305099F	Global Air Traffic Management (GATM)	07	4,354	4,354		4,354	4,453		4,453	U
242	0305110F	Satellite Control Network (SPACE)	07	15,624	15,624		15,624				U
243	0305111F	Weather Service	07	19,974	19,974		19,974	26,654		26,654	U
244	0305114F	Air Traffic Control, Approach, and Landing System (ATCALS)	07	9,770	9,770		9,770	6,306		6,306	U
245	0305116F	Aerial Targets	07	3,051	3,051		3,051	21,295		21,295	U
248	0305128F	Security and Investigative Activities	07	405	405		405	415		415	U
249	0305145F	Arms Control Implementation	07	4,844	4,844		4,844				U
250	0305146F	Defense Joint Counterintelligence Activities	07	339	339		339	3,867		3,867	U
253	0305173F	Space and Missile Test and Evaluation Center	07	3,989	3,989		3,989				U
254	0305174F	Space Innovation, Integration and Rapid Technology Development	07	7,785	7,785		7,785				U
255	0305179F	Integrated Broadcast Service (IBS)	07	8,833	8,833		8,833				U

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256	0305182F	Spacelift Range System (SPACE)	07	5,708	11,867	11,867					U
257	0305202F	Dragon U-2	07	34,471	37,217	37,217					U
258	0305205F	Endurance Unmanned Aerial Vehicles	07	5,000							U
259	0305206F	Airborne Reconnaissance Systems	07	61,742	3,841	3,841					U
260	0305207F	Manned Reconnaissance Systems	07	13,245	20,975	20,975					U
261	0305208F	Distributed Common Ground/Surface Systems	07	22,686	18,902	30,448					U
262	0305220F	RQ-4 UAV	07	180,547	256,307	256,307					U
263	0305221F	Network-Centric Collaborative Targeting	07	19,587	22,610	22,610					U
264	0305236F	Common Data Link Executive Agent (CDL EA)	07	43,709							U
265	0305238F	NATO AGS	07	131,900	38,904	38,904					U
266	0305240F	Support to DCGS Enterprise	07	28,336	23,084	23,084					U
267	0305258F	Advanced Evaluation Program	07		116,143	116,143					U
268	0305265F	GPS III Space Segment	07	147,398	141,888	179,188					U
269	0305600F	International Intelligence Technology and Architectures	07	2,298	2,360	2,360					U
270	0305614F	JSPOC Mission System	07	80,669	72,889	87,889					U
271	0305881F	Rapid Cyber Acquisition	07	3,036	4,280	4,280					U
272	0305906F	NCMC - TW/AA System	07		4,951	4,951					U
273	0305913F	NUDET Detection System (SPACE)	07	14,403	21,093	21,093					U

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256	0305182F	Spacelift Range System (SPACE)	07	11,867	11,867		11,867				U
257	0305202F	Dragon U-2	07	37,217	37,217		37,217	34,486		34,486	U
258	0305205F	Endurance Unmanned Aerial Vehicles	07								U
259	0305206F	Airborne Reconnaissance Systems	07	3,841	3,841		3,841	4,450		4,450	U
260	0305207F	Manned Reconnaissance Systems	07	20,975	20,975		20,975	14,269		14,269	U
261	0305208F	Distributed Common Ground/Surface Systems	07	18,902	30,448		30,448	27,501		27,501	U
262	0305220F	RQ-4 UAV	07	256,307	256,307		256,307	214,849		214,849	U
263	0305221F	Network-Centric Collaborative Targeting	07	22,610	22,610		22,610	18,842		18,842	U
264	0305236F	Common Data Link Executive Agent (CDL EA)	07								U
265	0305238F	NATO AGS	07	38,904	38,904		38,904	44,729		44,729	U
266	0305240F	Support to DCGS Enterprise	07	23,084	23,084		23,084	26,349		26,349	U
267	0305258F	Advanced Evaluation Program	07	116,143	116,143		116,143				U
268	0305265F	GPS III Space Segment	07	141,888	179,188		179,188				U
269	0305600F	International Intelligence Technology and Architectures	07	2,360	2,360		2,360	3,491		3,491	U
270	0305614F	JSPOC Mission System	07	72,889	87,889		87,889				U
271	0305881F	Rapid Cyber Acquisition	07	4,280	4,280		4,280	4,899		4,899	U
272	0305906F	NCMC - TW/AA System	07	4,951	4,951		4,951				U
273	0305913F	NUDET Detection System (SPACE)	07	21,093	21,093		21,093				U

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274	0305940F	Space Situation Awareness Operations	07	23,416	35,002	93,802					U
275	0305984F	Personnel Recovery Command & Ctrl (PRC2)	07								U
276	0307577F	Intelligence Mission Data (IMD)	07								U
277	0308699F	Shared Early Warning (SEW)	07	845	6,366	6,366					U
278	0401115F	C-130 Airlift Squadron	07	33,962	15,599	15,599					U
279	0401119F	C-5 Airlift Squadrons (IF)	07	22,766	66,146	66,146					U
280	0401130F	C-17 Aircraft (IF)	07	36,082	12,430	12,430					U
281	0401132F	C-130J Program	07	31,410	16,776	16,776					U
282	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	07	5,802	5,166	5,166					U
283	0401218F	KC-135s	07								U
284	0401219F	KC-10s	07	1,597							U
285	0401314F	Operational Support Airlift	07	46,453	13,817	13,817					U
286	0401318F	CV-22	07	26,821	16,702	28,702					U
287	0401840F	AMC Command and Control System	07								U
288	0408011F	Special Tactics / Combat Control	07	7,665	7,164	7,164					U
289	0702207F	Depot Maintenance (Non-IF)	07	1,514	1,518	1,518					U
290	0708055F	Maintenance, Repair & Overhaul System	07								U
291	0708610F	Logistics Information Technology (LOGIT)	07	52,482	61,676	61,676					U

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274	0305940F	Space Situation Awareness Operations	07	35,002	93,802		93,802				U
275	0305984F	Personnel Recovery Command & Ctrl (PRC2)	07					2,445		2,445	U
276	0307577F	Intelligence Mission Data (IMD)	07					8,684		8,684	U
277	0308699F	Shared Early Warning (SEW)	07	6,366	6,366		6,366				U
278	0401115F	C-130 Airlift Squadron	07	15,599	15,599		15,599	10,219		10,219	U
279	0401119F	C-5 Airlift Squadrons (IF)	07	66,146	66,146		66,146	22,758		22,758	U
280	0401130F	C-17 Aircraft (IF)	07	12,430	12,430		12,430	34,287		34,287	U
281	0401132F	C-130J Program	07	16,776	16,776		16,776	26,821		26,821	U
282	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	07	5,166	5,166		5,166	5,283		5,283	U
283	0401218F	KC-135s	07					9,942		9,942	U
284	0401219F	KC-10s	07					7,933		7,933	U
285	0401314F	Operational Support Airlift	07	13,817	13,817		13,817	6,681		6,681	U
286	0401318F	CV-22	07	16,702	28,702		28,702	22,519		22,519	U
287	0401840F	AMC Command and Control System	07					3,510		3,510	U
288	0408011F	Special Tactics / Combat Control	07	7,164	7,164		7,164	8,090		8,090	U
289	0702207F	Depot Maintenance (Non-IF)	07	1,518	1,518		1,518	1,528		1,528	U
290	0708055F	Maintenance, Repair & Overhaul System	07					31,677		31,677	U
291	0708610F	Logistics Information Technology (LOGIT)	07	61,676	61,676		61,676	33,344		33,344	U

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292	0708611F	Support Systems Development	07	13,987	9,128	9,128					U
293	0804743F	Other Flight Training	07	1,770	1,653	1,653					U
294	0808716F	Other Personnel Activities	07	117	57	57					U
295	0901202F	Joint Personnel Recovery Agency	07	5,741	3,663	3,663					U
296	0901218F	Civilian Compensation Program	07	3,475	3,735	3,735					U
297	0901220F	Personnel Administration	07	4,416	5,157	5,157					U
298	0901226F	Air Force Studies and Analysis Agency	07	1,064	1,523	1,523					U
299	0901538F	Financial Management Information Systems Development	07	95,053	10,581	10,581					U
300	1201921F	Service Support to STRATCOM - Space Activities	07								U
301	1202247F	AF TENCAP	07								U
302	1203001F	Family of Advanced BLoS Terminals (FAB-T)	07								U
303	1203110F	Satellite Control Network (SPACE)	07								U
305	1203165F	NAVSTAR Global Positioning System (Space and Control Segments)	07								U
306	1203173F	Space and Missile Test and Evaluation Center	07								U
307	1203174F	Space Innovation, Integration and Rapid Technology Development	07								U
308	1203179F	Integrated Broadcast Service (IBS)	07								U
309	1203182F	Spacelift Range System (SPACE)	07								U

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292	0708611F	Support Systems Development	07	9,128	9,128		9,128	9,362		9,362	U
293	0804743F	Other Flight Training	07	1,653	1,653		1,653	2,074		2,074	U
294	0808716F	Other Personnel Activities	07	57	57		57	107		107	U
295	0901202F	Joint Personnel Recovery Agency	07	3,663	3,663		3,663	2,006		2,006	U
296	0901218F	Civilian Compensation Program	07	3,735	3,735		3,735	3,780		3,780	U
297	0901220F	Personnel Administration	07	5,157	5,157		5,157	7,472		7,472	U
298	0901226F	Air Force Studies and Analysis Agency	07	1,523	1,523		1,523	1,563		1,563	U
299	0901538F	Financial Management Information Systems Development	07	10,581	10,581		10,581	91,211		91,211	U
300	1201921F	Service Support to STRATCOM - Space Activities	07					14,255		14,255	U
301	1202247F	AF TENCAP	07					31,914		31,914	U
302	1203001F	Family of Advanced BLoS Terminals (FAB-T)	07					32,426		32,426	U
303	1203110F	Satellite Control Network (SPACE)	07					18,808		18,808	U
305	1203165F	NAVSTAR Global Positioning System (Space and Control Segments)	07					10,029		10,029	U
306	1203173F	Space and Missile Test and Evaluation Center	07					25,051		25,051	U
307	1203174F	Space Innovation, Integration and Rapid Technology Development	07					11,390		11,390	U
308	1203179F	Integrated Broadcast Service (IBS)	07					8,747		8,747	U
309	1203182F	Spacelift Range System (SPACE)	07					10,549		10,549	U

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310	1203265F	GPS III Space Segment	07								U
311	1203400F	Space Superiority Intelligence	07								U
312	1203614F	JSpOC Mission System	07								U
313	1203620F	National Space Defense Center	07								U
314	1203699F	Shared Early Warning (SEW)	07								U
315	1203906F	NCMC - TW/AA System	07								U
316	1203913F	NUDET Detection System (SPACE)	07								U
317	1203940F	Space Situation Awareness Operations	07								U
318	1206423F	Global Positioning System III - Operational Control Segment	07								U
9999	9999999999	Classified Programs		12,052,624	13,091,557	13,243,393	27,765	84,865		84,865	U
		Operational Systems Development		15,915,939	17,457,056	17,915,438	32,480	89,580		89,580	
319	0901560F	Continuing Resolution Programs	20		-2,965,689	-2,965,689	-15,805	-15,805		-15,805	U
		Undistributed			-2,965,689	-2,965,689	-15,805	-15,805		-15,805	
Total Research, Development, Test & Eval, AF				25,243,981	25,146,562	25,988,644	17,100	89,900		89,900	

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310	1203265F	GPS III Space Segment	07					243,435		243,435	U
311	1203400F	Space Superiority Intelligence	07					12,691		12,691	U
312	1203614F	JSpOC Mission System	07					99,455		99,455	U
313	1203620F	National Space Defense Center	07					18,052		18,052	U
314	1203699F	Shared Early Warning (SEW)	07					1,373		1,373	U
315	1203906F	NCMC - TW/AA System	07					5,000		5,000	U
316	1203913F	NUDET Detection System (SPACE)	07					31,508		31,508	U
317	1203940F	Space Situation Awareness Operations	07					99,984		99,984	U
318	1206423F	Global Positioning System III - Operational Control Segment	07					510,938		510,938	U
9999	9999999999	Classified Programs		13,119,322	13,328,258		13,328,258	14,938,002	112,408	15,050,410	U
		Operational Systems Development		17,489,536	18,005,018		18,005,018	20,585,302	122,158	20,707,460	
319	0901560F	Continuing Resolution Programs	20	-2,981,494	-2,981,494		-2,981,494				U
		Undistributed		-2,981,494	-2,981,494		-2,981,494				
Total Research, Development, Test & Eval, AF				25,163,662	26,078,544		26,078,544	34,914,359	135,358	35,049,717	

R-1C1F: FY 2018 President's Budget Request (Published Version), as of May 4, 2017 at 10:09:41

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Air Force • Budget Estimates FY 2018 • RDT&E Program
Master Exhibit R-1
(Listing by Budget Activity, then Program Element Number)

BA# 01: Basic Research

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
1	01	0601102F	Defense Research Sciences	-	365.276	340.812	342.919	0.000	342.919
2	01	0601103F	University Research Initiatives	-	132.526	145.044	147.923	0.000	147.923
3	01	0601108F	High Energy Laser Research Initiatives	-	12.871	14.168	14.417	0.000	14.417
Total: Basic Research				-	510.673	500.024	505.259	0.000	505.259

BA# 02: Applied Research

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
4	02	0602102F	Materials	-	132.768	126.152	124.264	0.000	124.264
5	02	0602201F	Aerospace Vehicle Technologies	-	118.263	122.831	124.678	0.000	124.678
6	02	0602202F	Human Effectiveness Applied Research	0.000	108.784	111.647	108.784	0.000	108.784
7	02	0602203F	Aerospace Propulsion	-	184.498	185.671	192.695	0.000	192.695
8	02	0602204F	Aerospace Sensors	-	151.264	155.174	152.782	0.000	152.782
9	02	0602298F	Science and Technology Management - Major Headquarters Activities	-	0.000	0.000	8.353	0.000	8.353
10	02	0602601F	Space Technology	-	107.442	117.915	116.503	0.000	116.503

BA# 02: Applied Research

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
11	02	0602602F	Conventional Munitions	-	105.296	109.649	112.195	0.000	112.195
12	02	0602605F	Directed Energy Technology	-	122.835	127.163	132.993	0.000	132.993
13	02	0602788F	Dominant Information Sciences and Methods	-	171.196	161.650	167.818	0.000	167.818
14	02	0602890F	High Energy Laser Research	-	39.155	42.300	43.049	0.000	43.049
Total: Applied Research				0.000	1,241.501	1,260.152	1,284.114	0.000	1,284.114

BA# 03: Advanced Technology Development (ATD)

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
15	03	0603112F	Advanced Materials for Weapon Systems	-	38.238	35.137	37.856	0.000	37.856
16	03	0603199F	Sustainment Science and Technology (S&T)	-	17.323	20.636	22.811	0.000	22.811
17	03	0603203F	Advanced Aerospace Sensors	-	39.794	40.945	40.978	0.000	40.978
18	03	0603211F	Aerospace Technology Dev/Demo	-	95.266	130.950	115.966	0.000	115.966
19	03	0603216F	Aerospace Propulsion and Power Technology	-	168.542	94.594	104.499	0.000	104.499
20	03	0603270F	Electronic Combat Technology	-	45.359	58.250	60.551	0.000	60.551
21	03	0603401F	Advanced Spacecraft Technology	-	62.278	61.593	58.910	0.000	58.910

BA# 03: Advanced Technology Development (ATD)

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
22	03	0603444F	Maui Space Surveillance System (MSSS)	-	12.303	11.681	10.433	0.000	10.433
23	03	0603456F	Human Effectiveness Advanced Technology Development	-	24.094	26.492	33.635	0.000	33.635
24	03	0603601F	Conventional Weapons Technology	-	42.204	102.009	167.415	0.000	167.415
25	03	0603605F	Advanced Weapons Technology	-	37.301	39.064	45.502	0.000	45.502
26	03	0603680F	Manufacturing Technology Program	-	51.467	46.344	46.450	0.000	46.450
27	03	0603788F	Battlespace Knowledge Development and Demonstration	-	41.568	58.110	49.011	0.000	49.011
Total: Advanced Technology Development (ATD)				-	675.737	725.805	794.017	0.000	794.017

BA# 04: Advanced Component Development & Prototypes (ACD&P)

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
28	04	0603260F	Intelligence Advanced Development	-	5.032	5.598	5.652	0.000	5.652
29	04	0603438F	Space Control Technology	-	3.955	7.534	0.000	7.800	7.800
30	04	0603742F	Combat Identification Technology	-	21.025	24.418	24.397	0.000	24.397
31	04	0603790F	NATO Research and Development	-	4.566	4.333	3.851	0.000	3.851

BA# 04: Advanced Component Development & Prototypes (ACD&P)

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
32	04	0603830F	Space Security and Defense Program	-	30.771	32.399	0.000	0.000	0.000
33	04	0603851F	Intercontinental Ballistic Missile - Dem/Val	-	34.765	108.663	10.736	0.000	10.736
34	04	0603859F	Pollution Prevention - Dem/Val	-	0.000	0.000	0.002	0.000	0.002
35	04	0604015F	Long Range Strike - Bomber	-	710.390	1,358.309	2,003.580	0.000	2,003.580
36	04	0604201F	Integrated Avionics Planning and Development	-	0.000	0.000	65.458	0.000	65.458
37	04	0604257F	Advanced Technology and Sensors	-	0.000	34.818	68.719	0.000	68.719
38	04	0604288F	National Airborne Ops Center (NAOC) Recap	-	0.000	0.000	7.850	0.000	7.850
39	04	0604317F	Technology Transfer	-	7.494	3.368	3.295	0.000	3.295
40	04	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	440.671	62.034	74.308	17.365	0.000	17.365
41	04	0604414F	Cyber Resiliency of Weapon Systems-ACS	-	0.000	40.000	32.253	0.000	32.253
42	04	0604422F	Weather System Follow-on	-	46.307	118.953	0.000	0.000	0.000
43	04	0604425F	Space Situation Awareness Systems	-	0.000	10.901	0.000	0.000	0.000
44	04	0604776F	Deployment & Distribution Enterprise R&D	-	0.000	25.890	26.222	0.000	26.222
45	04	0604857F	Operationally Responsive Space	-	22.123	17.921	0.000	0.000	0.000
46	04	0604858F	Tech Transition Program	-	264.673	349.304	840.650	0.000	840.650
47	04	0605230F	Ground Based Strategic Deterrent	0.000	64.966	113.919	215.721	0.000	215.721
48	04	0201184F	Counter Narco-Terrorism Program Office	-	1.850	0.000	0.000	0.000	0.000

BA# 04: Advanced Component Development & Prototypes (ACD&P)

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
49	04	0207110F	Next Generation Air Dominance	-	32.495	167.595	294.746	0.000	294.746
50	04	0207455F	Three Dimensional Long-Range Radar (3DELRR)	91.723	7.865	49.491	10.645	0.000	10.645
51	04	0305164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	-	143.118	278.147	0.000	0.000	0.000
52	04	0305236F	Common Data Link Executive Agent (CDL EA)	-	0.000	42.338	41.509	0.000	41.509
53	04	0306250F	Cyber Operations Technology Development	-	91.845	162.702	226.287	5.400	231.687
54	04	0306415F	Enabled Cyber Activities	-	0.000	15.842	16.687	0.000	16.687
55	04	0408011F	Special Tactics / Combat Control	-	0.000	0.000	4.500	0.000	4.500
56	04	0901410F	Contracting Information Technology System	-	0.000	5.782	15.867	0.000	15.867
57	04	1203164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	354.744	143.118	278.147	253.939	0.000	253.939
58	04	1203710F	EO/IR Weather Systems	-	0.000	0.000	10.000	0.000	10.000
59	04	1206422F	Weather System Follow-on	146.931	46.307	118.953	112.088	0.000	112.088
60	04	1206425F	Space Situation Awareness Systems	-	0.000	10.901	34.764	0.000	34.764
61	04	1206434F	Midterm Polar MILSATCOM System	-	0.000	0.000	63.092	0.000	63.092
62	04	1206438F	Space Control Technology	-	3.955	7.534	7.842	7.800	15.642
63	04	1206730F	Space Security and Defense Program	-	30.771	32.399	41.385	0.000	41.385
64	04	1206760F	Protected Tactical Enterprise Service (PTES)	-	0.000	0.000	18.150	0.000	18.150

BA# 04: Advanced Component Development & Prototypes (ACD&P)

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
65	04	1206761F	Protected Tactical Service (PTS)	-	0.000	0.000	24.201	0.000	24.201
66	04	1206855F	Protected SATCOM Services (PSCS) - Aggregated	-	0.000	0.000	16.000	0.000	16.000
67	04	1206857F	Operationally Responsive Space	-	22.123	17.921	87.577	0.000	87.577
Total: Advanced Component Development & Prototypes (ACD&P)				1,034.069	1,801.548	3,518.388	4,605.030	21.000	4,626.030

BA# 05: System Development & Demonstration (SDD)

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
68	05	0604200F	Future Advanced Weapon Analysis & Programs	-	0.000	0.000	5.100	0.000	5.100
69	05	0604201F	Integrated Avionics Planning and Development	-	0.000	0.000	101.203	0.000	101.203
70	05	0604222F	Nuclear Weapons Support	-	0.000	0.000	3.009	0.000	3.009
71	05	0604270F	Electronic Warfare Development	-	0.813	12.476	2.241	0.000	2.241
72	05	0604281F	Tactical Data Networks Enterprise	-	49.495	82.380	38.250	0.000	38.250
73	05	0604287F	Physical Security Equipment	-	5.973	35.458	19.739	0.000	19.739
74	05	0604329F	Small Diameter Bomb (SDB) - EMD	1,032.472	27.950	54.838	38.979	0.000	38.979

BA# 05: System Development & Demonstration (SDD)

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
75	05	0604421F	Counterspace Systems	-	24.134	41.919	0.000	0.000	0.000
76	05	0604425F	Space Situation Awareness Systems	-	30.116	23.945	0.000	0.000	0.000
77	05	0604426F	Space Fence	-	240.692	168.364	0.000	0.000	0.000
78	05	0604429F	Airborne Electronic Attack	-	8.067	9.187	7.091	0.000	7.091
79	05	0604441F	Space Based Infrared System (SBIRS) High EMD	-	291.510	218.766	0.000	0.000	0.000
80	05	0604602F	Armament/Ordnance Development	-	36.266	20.312	46.540	0.000	46.540
81	05	0604604F	Submunitions	-	2.419	2.503	2.705	0.000	2.705
82	05	0604617F	Agile Combat Support	-	56.178	53.680	31.240	0.000	31.240
83	05	0604618F	Joint Direct Attack Munition	0.000	0.000	9.901	0.000	0.000	0.000
84	05	0604706F	Life Support Systems	-	7.904	7.520	9.060	0.000	9.060
85	05	0604735F	Combat Training Ranges	-	11.368	77.409	87.350	0.000	87.350
86	05	0604800F	F-35 - EMD	21,111.851	575.932	450.467	292.947	0.000	292.947
87	05	0604853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	-	224.920	296.572	0.000	0.000	0.000
88	05	0604932F	Long Range Standoff Weapon	10.274	16.143	95.604	451.290	0.000	451.290
89	05	0604933F	ICBM Fuze Modernization	205.638	138.027	189.751	178.991	0.000	178.991
90	05	0605030F	Joint Tactical Network Center (JTNC)	-	0.000	1.131	12.736	0.000	12.736
91	05	0605031F	Joint Tactical Network (JTN)	-	0.000	0.000	9.319	0.000	9.319

BA# 05: System Development & Demonstration (SDD)

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
92	05	0605213F	F-22 Modernization Increment 3.2B	362.577	115.603	70.290	13.600	0.000	13.600
93	05	0605214F	Ground Attack Weapons Fuze Development	-	3.477	0.937	0.000	0.000	0.000
94	05	0605221F	KC-46	5,319.514	572.118	261.724	93.845	0.000	93.845
95	05	0605223F	Advanced Pilot Training	7.747	10.395	12.377	105.999	0.000	105.999
96	05	0605229F	Combat Rescue Helicopter	472.534	150.341	319.331	354.485	0.000	354.485
97	05	0605431F	Advanced EHF MILSATCOM (SPACE)	-	208.095	259.131	0.000	0.000	0.000
98	05	0605432F	Polar MILSATCOM (SPACE)	-	71.867	50.815	0.000	0.000	0.000
99	05	0605433F	Wideband Global SATCOM (SPACE)	-	49.954	41.632	0.000	0.000	0.000
100	05	0605458F	Air & Space Ops Center 10.2 RDT&E	86.444	55.333	28.911	119.745	0.000	119.745
101	05	0605931F	B-2 Defensive Management System	726.260	261.162	315.615	194.570	0.000	194.570
102	05	0101125F	Nuclear Weapons Modernization	285.271	204.358	137.909	91.237	0.000	91.237
103	05	0207171F	F-15 EPAWSS	0.000	174.439	256.669	209.847	0.000	209.847
104	05	0207328F	Stand In Attack Weapon	-	0.000	0.000	3.400	0.000	3.400
105	05	0207701F	Full Combat Mission Training	-	17.290	12.051	16.727	0.000	16.727
106	05	0303267F	Auctioned Spectrum Relocation Fund	-	40.571	0.000	0.000	0.000	0.000
107	05	0303367F	Spectrum Access Research and Development	-	0.383	0.000	0.000	0.000	0.000
108	05	0305176F	Combat Survivor Evader Locator	-	0.958	29.253	0.000	0.000	0.000
109	05	0307581F	JSTARS Recap	85.879	51.306	128.019	417.201	0.000	417.201

BA# 05: System Development & Demonstration (SDD)

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
110	05	0401310F	C-32 Executive Transport Recapitalization	-	0.000	0.000	6.017	0.000	6.017
111	05	0401319F	Presidential Aircraft Recapitalization (PAR)	11.006	82.420	351.220	434.069	0.000	434.069
112	05	0701212F	Automated Test Systems	-	14.422	19.062	18.528	0.000	18.528
113	05	1203176F	Combat Survivor Evader Locator	-	0.958	29.253	24.967	0.000	24.967
114	05	1203940F	Space Situation Awareness Operations	-	0.000	0.000	10.029	0.000	10.029
115	05	1206421F	Counterspace Systems	-	24.134	34.819	66.370	0.000	66.370
116	05	1206425F	Space Situation Awareness Systems	0.000	30.116	23.945	48.448	0.000	48.448
117	05	1206426F	Space Fence	0.000	240.692	168.364	35.937	0.000	35.937
118	05	1206431F	Advanced EHF MILSATCOM (SPACE)	372.471	208.095	259.131	145.610	0.000	145.610
119	05	1206432F	Polar MILSATCOM (SPACE)	201.189	71.867	50.815	33.644	0.000	33.644
120	05	1206433F	WIDEBAND GLOBAL SATCOM (SPACE)	-	49.954	41.632	14.263	0.000	14.263
121	05	1206441F	Space Based Infrared System (SBIRS) High EMD	9,827.288	291.510	218.766	311.844	0.000	311.844
122	05	1206442F	Evolved SBIRS	-	0.000	0.000	71.018	0.000	71.018
123	05	1206853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	259.600	224.920	296.572	297.572	0.000	297.572
Total: System Development & Demonstration (SDD)				40,378.015	4,974.645	5,270.426	4,476.762	0.000	4,476.762

BA# 06: RDT&E Management Support

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
124	06	0604256F	Threat Simulator Development	-	23.558	21.630	35.405	0.000	35.405
125	06	0604759F	Major T&E Investment	-	70.894	71.385	82.874	0.000	82.874
126	06	0605101F	RAND Project Air Force	-	33.943	34.641	34.346	0.000	34.346
127	06	0605502F	Small Business Innovation Research	-	337.762	0.000	0.000	0.000	0.000
128	06	0605712F	Initial Operational Test & Evaluation	-	11.172	11.529	15.523	0.000	15.523
129	06	0605807F	Test and Evaluation Support	-	683.307	680.217	678.289	0.000	678.289
130	06	0605826F	Acq Workforce- Global Power	-	0.000	0.000	219.809	0.000	219.809
131	06	0605827F	Acq Workforce- Global Vig & Combat Sys	-	0.000	0.000	223.179	0.000	223.179
132	06	0605828F	Acq Workforce- Global Reach	-	0.000	0.000	138.556	0.000	138.556
133	06	0605829F	Acq Workforce- Cyber, Network, & Bus Sys	-	0.000	0.000	221.393	0.000	221.393
134	06	0605830F	Acq Workforce- Global Battle Mgmt	-	0.000	0.000	152.577	0.000	152.577
135	06	0605831F	Acq Workforce- Capability Integration	-	0.000	0.000	196.561	0.000	196.561
136	06	0605832F	Acq Workforce- Advanced Prgm Technology	-	0.000	0.000	28.322	0.000	28.322
137	06	0605833F	Acq Workforce- Nuclear Systems	-	0.000	0.000	126.611	0.000	126.611
138	06	0605860F	Rocket Systems Launch Program (SPACE)	-	21.245	11.198	0.000	0.000	0.000
139	06	0605864F	Space Test Program (STP)	-	28.143	27.070	0.000	0.000	0.000

BA# 06: RDT&E Management Support

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
140	06	0605898F	Management HQ - R&D	-	0.000	0.000	9.154	0.000	9.154
141	06	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	-	40.518	134.111	135.507	0.000	135.507
142	06	0605978F	Facilities Sustainment - Test and Evaluation Support	-	27.895	28.091	28.720	0.000	28.720
143	06	0606017F	Requirements Analysis and Maturation	-	21.922	129.100	35.453	0.000	35.453
144	06	0606116F	Space Test and Training Range Development	-	18.465	18.528	0.000	0.000	0.000
145	06	0606392F	Space and Missile Center (SMC) Civilian Workforce	-	169.196	176.666	0.000	0.000	0.000
146	06	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	-	3.841	4.410	29.049	0.000	29.049
147	06	0702806F	Acquisition and Management Support	-	16.358	14.613	14.980	0.000	14.980
148	06	0804731F	General Skill Training	-	1.268	1.404	1.434	0.000	1.434
150	06	1001004F	International Activities	-	2.315	4.784	4.569	0.000	4.569
151	06	1206116F	Space Test and Training Range Development	-	18.465	22.228	25.773	0.000	25.773
152	06	1206392F	Space and Missile Center (SMC) Civilian Workforce	-	169.196	176.666	169.887	0.000	169.887
153	06	1206398F	Space & Missile Systems Center - MHA	-	0.000	0.000	9.531	0.000	9.531
154	06	1206860F	Rocket Systems Launch Program (SPACE)	-	21.245	11.198	20.975	0.000	20.975
155	06	1206864F	Space Test Program (STP)	-	28.143	27.070	25.398	0.000	25.398

BA# 06: RDT&E Management Support

Line#	BA#	PE#	PE Title	Cost ($ in Millions) Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Total: RDT&E Management Support				-	1,748.851	1,606.539	2,663.875	0.000	2,663.875

BA# 07: Operational Systems Development

Line#	BA#	PE#	PE Title	Cost ($ in Millions) Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
156	07	0603423F	Global Positioning System III - Operational Control Segment	-	344.226	513.268	0.000	0.000	0.000
157	07	0604222F	Nuclear Weapons Support	-	0.000	0.000	27.579	0.000	27.579
158	07	0604233F	Specialized Undergraduate Flight Training	-	7.742	15.427	5.776	0.000	5.776
159	07	0604445F	Wide Area Surveillance	6.836	17.639	46.695	16.247	0.000	16.247
161	07	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	199.827	30.334	10.368	21.915	0.000	21.915
162	07	0605024F	Anti-Tamper Technology Executive Agency	-	25.857	31.952	33.150	0.000	33.150
163	07	0605117F	Foreign Materiel Acquisition and Exploitation	-	41.689	42.960	66.653	0.000	66.653
164	07	0605278F	HC/MC-130 Recap RDT&E	0.000	8.646	13.987	38.579	0.000	38.579
165	07	0606018F	NC3 Integration	-	0.000	0.000	12.636	0.000	12.636
166	07	0101113F	B-52 SQUADRONS	-	70.172	88.267	111.910	0.000	111.910

BA# 07: Operational Systems Development

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
167	07	0101122F	Air-Launched Cruise Missile (ALCM)	-	0.451	0.453	0.463	0.000	0.463
168	07	0101126F	B-1B Squadrons	-	2.174	5.830	62.471	0.000	62.471
169	07	0101127F	B-2 SQUADRONS	0.000	105.914	152.458	193.108	0.000	193.108
170	07	0101213F	Minuteman Squadrons	0.000	128.492	182.958	210.845	0.000	210.845
171	07	0101313F	Integrated Strategic Planning and Analysis Network (ISPAN) - USSTRATCOM	207.933	26.954	39.148	25.736	0.000	25.736
172	07	0101314F	Night Fist - USSTRATCOM	-	0.087	0.000	0.000	0.000	0.000
173	07	0101316F	Worldwide Joint Strategic Communications	-	3.815	6.042	6.272	0.000	6.272
174	07	0101324F	Integrated Strategic Planning & Analysis Network	-	0.000	0.000	11.032	0.000	11.032
176	07	0102110F	UH-1N Replacement Program	-	0.000	14.116	108.617	0.000	108.617
177	07	0102326F	Region/Sector Operation Control Center Modernization Program	-	0.000	10.868	3.347	0.000	3.347
178	07	0105921F	Service Support to STRATCOM - Space Activities	-	9.388	8.674	0.000	0.000	0.000
179	07	0205219F	MQ-9 UAV	958.691	124.695	151.373	201.394	0.000	201.394
180	07	0205671F	Joint Counter RCIED Electronic Warfare	-	0.300	0.000	0.000	0.000	0.000
181	07	0207040F	Multi-Platform Electronic Warfare Equipment	-	3.980	0.000	0.000	0.000	0.000
182	07	0207131F	A-10 Squadrons	-	16.200	21.353	17.459	0.000	17.459

BA# 07: Operational Systems Development

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
183	07	0207133F	F-16 Squadrons	-	153.611	147.795	246.578	0.000	246.578
184	07	0207134F	F-15E Squadrons	0.000	210.029	356.717	320.271	0.000	320.271
185	07	0207136F	Manned Destructive Suppression	-	14.400	14.773	15.106	0.000	15.106
186	07	0207138F	F-22A Squadrons	3,674.494	224.550	387.564	610.942	0.000	610.942
187	07	0207142F	F-35 Squadrons	61.782	51.990	153.045	334.530	0.000	334.530
188	07	0207161F	Tactical AIM Missiles	96.110	33.615	52.898	34.952	0.000	34.952
189	07	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	459.428	44.335	62.470	61.322	0.000	61.322
190	07	0207224F	Combat Rescue and Recovery	-	0.398	0.000	0.000	0.000	0.000
191	07	0207227F	Combat Rescue - Pararescue	-	0.636	0.362	0.693	0.000	0.693
192	07	0207247F	AF TENCAP	-	37.489	28.413	0.000	0.000	0.000
193	07	0207249F	Precision Attack Systems Procurement	-	1.064	0.649	1.714	0.000	1.714
194	07	0207253F	Compass Call	-	32.024	23.923	14.040	0.000	14.040
195	07	0207268F	Aircraft Engine Component Improvement Program	-	104.092	109.859	109.243	0.000	109.243
196	07	0207277F	ISR Innovations	-	0.000	0.000	0.000	5.750	5.750
197	07	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	209.212	9.221	30.002	29.932	0.000	29.932
198	07	0207410F	Air & Space Operations Center (AOC)	0.000	20.588	37.621	26.956	0.000	26.956
199	07	0207412F	Control and Reporting Center (CRC)	-	0.557	13.292	2.450	0.000	2.450

BA# 07: Operational Systems Development

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
200	07	0207417F	Airborne Warning and Control System (AWACS)	-	124.457	86.644	151.726	0.000	151.726
201	07	0207418F	Tactical Airborne Control Systems	-	5.786	2.442	3.656	0.000	3.656
203	07	0207431F	Combat Air Intelligence System Activities	-	6.793	10.911	13.420	0.000	13.420
204	07	0207444F	Tactical Air Control Party-Mod	-	10.747	11.843	10.623	0.000	10.623
205	07	0207448F	C2ISR Tactical Data Link	-	1.629	1.515	1.754	0.000	1.754
206	07	0207452F	DCAPES	186.286	12.909	14.979	17.382	0.000	17.382
207	07	0207573F	National Technical Nuclear Forensics	-	0.000	0.000	2.307	0.000	2.307
208	07	0207590F	Seek Eagle	-	21.131	25.308	25.397	0.000	25.397
209	07	0207601F	USAF Modeling and Simulation	-	20.358	16.666	10.175	0.000	10.175
210	07	0207605F	Wargaming and Simulation Centers	-	5.819	4.245	12.839	0.000	12.839
211	07	0207697F	Distributed Training and Exercises	-	4.202	3.886	4.190	0.000	4.190
212	07	0208006F	Mission Planning Systems	338.582	54.176	71.785	85.531	0.000	85.531
213	07	0208007F	Tactical Deception	-	0.000	0.000	3.761	0.000	3.761
214	07	0208087F	AF Offensive Cyberspace Operations	-	14.939	25.025	35.693	4.000	39.693
215	07	0208088F	AF Defensive Cyberspace Operations	-	7.414	29.439	20.964	0.000	20.964
218	07	0301017F	Global Sensor Integrated on Network (GSIN)	-	5.803	3.470	3.549	0.000	3.549
219	07	0301112F	Nuclear Planning and Execution System (NPES)	0.000	0.000	4.060	4.371	0.000	4.371

BA# 07: Operational Systems Development

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
226	07	0301400F	Space Superiority Intelligence	-	13.965	13.880	0.000	0.000	0.000
227	07	0301401F	Air Force Space and Cyber Non-Traditional ISR for Battlespace Awareness	-	0.000	0.000	3.721	0.000	3.721
228	07	0302015F	E-4B National Airborne Operations Center (NAOC)	-	76.760	30.948	35.467	0.000	35.467
229	07	0303001F	Family of Advanced BLoS Terminals (FAB-T)	-	12.313	52.578	0.000	0.000	0.000
230	07	0303131F	Minimum Essential Emergency Communications Network (MEECN)	-	92.036	47.471	48.841	0.000	48.841
231	07	0303140F	Information Systems Security Program	-	44.578	46.388	42.973	0.000	42.973
232	07	0303141F	Global Combat Support System	-	0.000	0.052	0.105	0.000	0.105
233	07	0303142F	Global Force Management - Data Initiative	-	2.470	2.099	2.147	0.000	2.147
234	07	0303601F	MILSATCOM Terminals	2,216.097	9.000	0.000	0.000	0.000	0.000
236	07	0304260F	Airborne SIGINT Enterprise	-	111.142	90.762	121.948	0.000	121.948
237	07	0304310F	Commercial Economic Analysis	-	0.000	0.000	3.544	0.000	3.544
240	07	0305020F	CCMD Intelligence Information Technology	-	0.000	0.000	1.542	0.000	1.542
241	07	0305099F	Global Air Traffic Management (GATM)	-	4.089	4.354	4.453	0.000	4.453
242	07	0305110F	Satellite Control Network (SPACE)	-	7.327	15.624	0.000	0.000	0.000
243	07	0305111F	Weather Service	-	28.812	19.974	26.654	0.000	26.654

BA# 07: Operational Systems Development

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
244	07	0305114F	Air Traffic Control, Approach, and Landing System (ATCALS)	-	18.830	9.770	6.306	0.000	6.306
245	07	0305116F	Aerial Targets	-	2.578	3.051	21.295	0.000	21.295
248	07	0305128F	Security and Investigative Activities	-	0.455	0.405	0.415	0.000	0.415
249	07	0305145F	Arms Control Implementation	-	9.116	4.844	0.000	0.000	0.000
250	07	0305146F	Defense Joint Counterintelligence Activities	-	0.361	0.339	3.867	0.000	3.867
253	07	0305173F	Space and Missile Test and Evaluation Center	-	3.490	3.989	0.000	0.000	0.000
254	07	0305174F	Space Innovation, Integration and Rapid Technology Development	-	1.543	3.070	0.000	0.000	0.000
255	07	0305179F	Integrated Broadcast Service (IBS)	-	9.760	8.833	0.000	0.000	0.000
256	07	0305182F	Spacelift Range System (SPACE)	-	5.708	11.867	0.000	0.000	0.000
257	07	0305202F	Dragon U-2	-	34.471	37.217	34.486	0.000	34.486
258	07	0305205F	Endurance Unmanned Aerial Vehicles	-	5.000	0.000	0.000	0.000	0.000
259	07	0305206F	Airborne Reconnaissance Systems	-	61.742	3.841	4.450	0.000	4.450
260	07	0305207F	Manned Reconnaissance Systems	-	13.245	20.975	14.269	0.000	14.269
261	07	0305208F	Distributed Common Ground/Surface Systems	-	22.686	30.448	27.501	0.000	27.501
262	07	0305220F	RQ-4 UAV	686.056	180.547	256.307	214.849	0.000	214.849
263	07	0305221F	Network-Centric Collaborative Targeting	-	19.587	22.610	18.842	0.000	18.842
264	07	0305236F	Common Data Link Executive Agent (CDL EA)	-	43.709	0.000	0.000	0.000	0.000

BA# 07: Operational Systems Development

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
265	07	0305238F	NATO AGS	-	131.900	38.904	44.729	0.000	44.729
266	07	0305240F	Support to DCGS Enterprise	-	28.336	23.084	26.349	0.000	26.349
267	07	0305258F	Advanced Evaluation Program	-	0.000	116.143	0.000	0.000	0.000
268	07	0305265F	GPS III Space Segment	-	147.398	179.188	0.000	0.000	0.000
269	07	0305600F	International Intelligence Technology and Architectures	-	2.298	2.360	3.491	0.000	3.491
270	07	0305614F	JSPOC Mission System	-	80.669	87.889	0.000	0.000	0.000
271	07	0305881F	Rapid Cyber Acquisition	-	3.036	4.280	4.899	0.000	4.899
272	07	0305906F	NCMC - TW/AA System	-	0.000	4.951	0.000	0.000	0.000
273	07	0305913F	NUDET Detection System (SPACE)	-	14.403	21.093	0.000	0.000	0.000
274	07	0305940F	Space Situation Awareness Operations	-	23.416	93.802	0.000	0.000	0.000
275	07	0305984F	Personnel Recovery Command & Ctrl (PRC2)	-	0.000	0.000	2.445	0.000	2.445
276	07	0307577F	Intelligence Mission Data (IMD)	-	0.000	0.000	8.684	0.000	8.684
277	07	0308699F	Shared Early Warning (SEW)	-	0.845	6.366	0.000	0.000	0.000
278	07	0401115F	C-130 Airlift Squadron	0.000	33.962	15.599	10.219	0.000	10.219
279	07	0401119F	C-5 Airlift Squadrons (IF)	-	22.766	66.146	22.758	0.000	22.758
280	07	0401130F	C-17 Aircraft (IF)	-	36.082	12.430	34.287	0.000	34.287
281	07	0401132F	C-130J Program	242.300	31.410	16.776	26.821	0.000	26.821

BA# 07: Operational Systems Development

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
282	07	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	-	5.802	5.166	5.283	0.000	5.283
283	07	0401218F	KC-135s	-	0.000	0.000	9.942	0.000	9.942
284	07	0401219F	KC-10s	-	1.597	0.000	7.933	0.000	7.933
285	07	0401314F	Operational Support Airlift	0.000	46.453	13.817	6.681	0.000	6.681
286	07	0401318F	CV-22	37.698	26.821	28.702	22.519	0.000	22.519
287	07	0401840F	AMC Command and Control System	-	0.000	0.000	3.510	0.000	3.510
288	07	0408011F	Special Tactics / Combat Control	-	7.665	7.164	8.090	0.000	8.090
289	07	0702207F	Depot Maintenance (Non-IF)	-	1.514	1.518	1.528	0.000	1.528
290	07	0708055F	Maintenance, Repair & Overhaul System	0.000	0.000	0.000	31.677	0.000	31.677
291	07	0708610F	Logistics Information Technology (LOGIT)	0.000	52.482	61.676	33.344	0.000	33.344
292	07	0708611F	Support Systems Development	-	13.987	9.128	9.362	0.000	9.362
293	07	0804743F	Other Flight Training	-	1.770	1.653	2.074	0.000	2.074
294	07	0808716F	Other Personnel Activities	-	0.117	0.057	0.107	0.000	0.107
295	07	0901202F	Joint Personnel Recovery Agency	-	5.741	3.663	2.006	0.000	2.006
296	07	0901218F	Civilian Compensation Program	-	3.475	3.735	3.780	0.000	3.780
297	07	0901220F	Personnel Administration	-	4.416	5.157	7.472	0.000	7.472
298	07	0901226F	Air Force Studies and Analysis Agency	-	1.064	1.523	1.563	0.000	1.563

BA# 07: Operational Systems Development

				Cost ($ in Millions)					
Line#	BA#	PE#	PE Title	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
299	07	0901538F	Financial Management Information Systems Development	496.071	95.053	10.581	91.211	0.000	91.211
300	07	1201921F	Service Support to STRATCOM - Space Activities	-	9.388	8.674	14.255	0.000	14.255
301	07	1202247F	AF TENCAP	-	37.489	28.413	31.914	0.000	31.914
302	07	1203001F	Family of Advanced BLoS Terminals (FAB-T)	-	12.313	52.578	32.426	0.000	32.426
303	07	1203110F	Satellite Control Network (SPACE)	-	7.327	15.624	18.808	0.000	18.808
305	07	1203165F	NAVSTAR Global Positioning System (Space and Control Segments)	-	0.000	0.000	10.029	0.000	10.029
306	07	1203173F	Space and Missile Test and Evaluation Center	-	3.490	3.989	25.051	0.000	25.051
307	07	1203174F	Space Innovation, Integration and Rapid Technology Development	-	1.543	3.070	11.390	0.000	11.390
308	07	1203179F	Integrated Broadcast Service (IBS)	-	9.760	8.833	8.747	0.000	8.747
309	07	1203182F	Spacelift Range System (SPACE)	-	5.708	11.867	10.549	0.000	10.549
310	07	1203265F	GPS III Space Segment	2,799.129	147.398	179.188	243.435	0.000	243.435
311	07	1203400F	Space Superiority Intelligence	-	13.965	13.880	12.691	0.000	12.691
312	07	1203614F	JSpOC Mission System	0.000	80.669	87.889	99.455	0.000	99.455
313	07	1203620F	National Space Defense Center	-	0.000	0.000	18.052	0.000	18.052
314	07	1203699F	Shared Early Warning (SEW)	-	0.845	6.366	1.373	0.000	1.373

BA# 07: Operational Systems Development

				Cost ($ in Millions)					
Line#	**BA#**	**PE#**	**PE Title**	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
315	07	1203906F	NCMC - TW/AA System	-	0.000	4.951	5.000	0.000	5.000
316	07	1203913F	NUDET Detection System (SPACE)	-	14.403	21.093	31.508	0.000	31.508
317	07	1203940F	Space Situation Awareness Operations	-	23.416	93.802	99.984	0.000	99.984
318	07	1206423F	Global Positioning System III - Operational Control Segment	2,804.399	344.226	513.268	510.938	0.000	510.938
Total: Operational Systems Development				15,680.931	4,575.255	5,725.530	5,647.300	9.750	5,657.050

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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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	365.276	340.812	342.919	0.000	342.919	348.323	357.213	364.271	371.549	Continuing	Continuing
613001: *Physics and Electronics*	-	108.850	100.067	100.693	0.000	100.693	102.281	104.890	106.962	109.100	Continuing	Continuing
613002: *Aerospace, Chemical and Material Sciences*	-	115.911	105.484	106.172	0.000	106.172	107.845	110.597	112.784	115.036	Continuing	Continuing
613003: *Mathematics, Information and Life Sciences*	-	110.161	101.258	101.920	0.000	101.920	103.526	106.168	108.265	110.428	Continuing	Continuing
613004: *Education and Outreach*	-	30.354	34.003	34.134	0.000	34.134	34.671	35.558	36.260	36.985	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 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: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	374.721	340.812	344.609	0.000	344.609
Current President's Budget	365.276	340.812	342.919	0.000	342.919
Total Adjustments	-9.445	0.000	-1.690	0.000	-1.690
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-9.445	0.000			
• Other Adjustments	0.000	0.000	-1.690	0.000	-1.690

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 613001: *Physics and Electronics*		
Congressional Add: *Program Increase*	15.666	0.000
Congressional Add Subtotals for Project: 613001	15.666	0.000
Project: 613002: *Aerospace, Chemical and Material Sciences*		
Congressional Add: *Program Increase*	11.167	0.000
Congressional Add Subtotals for Project: 613002	11.167	0.000
Project: 613003: *Mathematics, Information and Life Sciences*		
Congressional Add: *Program Increase*	11.167	0.000
Congressional Add Subtotals for Project: 613003	11.167	0.000
Project: 613004: *Education and Outreach*		
Congressional Add: *Program Increase*	7.000	0.000
Congressional Add Subtotals for Project: 613004	7.000	0.000
Congressional Add Totals for all Projects	45.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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*

Change Summary Explanation

Decrease in FY 2018 due to realignment of some HQ AFRL civilian personnel to PE 0602298F, Science and Technology Management - Major Headquarters Activities.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
613001: *Physics and Electronics*	-	108.850	100.067	100.693	0.000	100.693	102.281	104.890	106.962	109.100	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 2016	FY 2017	FY 2018
Title: Complex Electronics and Fundamental Quantum Processes	42.781	40.491	40.756
Description: Scientific focus areas are atomic and molecular physics, photonics, quantum electronic solids, adaptive multi-mode sensing and ultra-high speed electronics, semiconductor and electromagnetic materials, and optoelectronics. ***FY 2016 Accomplishments:*** Supported the development of a new type of ultra-thin semiconductor laser that can be integrated with mainstream electronics for increased capacity and energy efficiency. Explored a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, meta-materials, cathodes, dielectric and magnetic materials, semiconductor lasers, memristive systems, new classes of high-temperature superconductors, quantum dots, quantum wells and graphene. Included generating and controlling quantum states, such as superposition and entanglement, in photons and ultracold atoms and molecules. ***FY 2017 Plans:*** Explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, meta-materials, cathodes, dielectric and magnetic materials, semiconductor lasers, 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 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.			
Title: Plasma Physics and High Energy Density Non-Equilibrium Processes	18.768	20.856	20.993

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Scientific focus areas are plasma, electro-energetic physics and space sciences. ***FY 2016 Accomplishments:*** Supported research analyzing the energy entering the upper atmosphere following space weather events like solar flares to help refine the models used to forecast and track satellite trajectories. Explored a wide range of activities characterized by processes sufficiently energetic to require the understanding and managing of plasma phenomenology and the non-linear response of materials to high electric and magnetic fields. Included space weather, plasma control of boundary layers in turbulent flow, plasma discharges, Radio Frequency (RF) propagation, RF-plasma interaction, and high-power, beam-driven microwave devices. ***FY 2017 Plans:*** 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 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.			
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 2016 Accomplishments:*** Supported the development of a newly patented class of lasers that offer the potential for improved Laser Detection and Ranging (LADAR) capabilities and advanced remote sensing of chemical and biological agents. Explored 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. Investigated aspects of the phenomenology of lasers including high energy lasers, non-linear optics, and ultra-short pulse laser science. Included the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals. ***FY 2017 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	31.635	38.720	38.944

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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 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.			
Accomplishments/Planned Programs Subtotals	93.184	100.067	100.693

	FY 2016	FY 2017
Congressional Add: Program Increase	15.666	0.000
FY 2016 Accomplishments: Conducted Congressionally directed effort.		
FY 2017 Plans: N/A		
Congressional Adds Subtotals	15.666	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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
613002: *Aerospace, Chemical and Material Sciences*	-	115.911	105.484	106.172	0.000	106.172	107.845	110.597	112.784	115.036	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 thrust areas being investigated in this project are aero-structure interactions and control; energy, power, and propulsion; and complex materials and structures. Although the major thrust descriptions that follow are specific sub-areas of focus within this project, there is interest in exploring novel ideas that may bridge these major thrusts as well as those in the other projects within this program.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Aero Structure Interactions and Control	30.152	31.105	31.295
Description: Scientific focus areas are high temperature aerospace materials, hypersonics, aerothermodynamics and turbulence, and flow interactions and control.			
FY 2016 Accomplishments: Supported experimental and computational research on nonlinear interactions and energy transfer that arise from Turbulent Boundary Layers and Shock-Boundary Layer Interactions on various surfaces. The research will improve understanding of phenomena critical to the development of predictive models for high-speed air vehicles. Investigated 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. Explored the synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, material properties, high-performance structures, and thermodynamics.			
FY 2017 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, material properties, high-performance structures, and thermodynamics.			
FY 2018 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			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, high-performance structures, and thermodynamics.			
Title: Energy, Power, and Propulsion ***Description:*** Scientific focus areas are thermal control, theoretical chemistry, molecular dynamics, space power and propulsion, and combustion and diagnostics. ***FY 2016 Accomplishments:*** Funded the synthesis, characterization, and theoretical prediction of properties and processes of energetic ionic liquids. Exploited technological innovations and developed potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hybrid simulation, structures, and materials. Investigated processes associated with the generation, storage, and utilization of energy, specifically for Air Force systems. Included developing novel energetic materials as well as understanding and optimizing combustion processes. ***FY 2017 Plans:*** Exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hybrid simulation, structures, and materials. 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 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.	36.830	33.513	33.763
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 2016 Accomplishments:*** Supported the development of a graphene-based de-icing material that melts ice from wings and resists the formation of ice when temperatures are above seven degrees Fahrenheit. The material is intended for use in extreme environments. Investigated multifunctional materials and structures composed of different classes of materials 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. Explored complex materials, microsystems, and structures that incorporate	37.762	40.866	41.114

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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 2017 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 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 Plans:*** Continue to investigate multifunctional materials and structures composed of inorganic materials 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.			
Accomplishments/Planned Programs Subtotals	104.744	105.484	106.172

	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** Conducted Congressionally directed effort. ***FY 2017 Plans:*** N/A	11.167	0.000
Congressional Adds Subtotals	11.167	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
613003: *Mathematics, Information and Life Sciences*	-	110.161	101.258	101.920	0.000	101.920	103.526	106.168	108.265	110.428	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 2016	FY 2017	FY 2018
Title: Information and Complex Networks	26.921	25.825	25.982

Description: Scientific focus areas are systems and software, information operations and security, information fusion, and complex networks.

FY 2016 Accomplishments:

Supported the development of formal methods to automate the identification of cyber-physical system specification mismatches to enable safe upgrades of systems consisting of old and new subsystems. Designed and analyzed techniques to enable reliable and secure exchange of information and predictable operation of networks and systems. Included traditional aspects of information assurance, software engineering, and reliable systems, but the emphasis was on the underlying mathematics of secure-by-design architectures of networked communications and neural information processing. Sub-areas included system and network performance prediction, design and analysis, and modeling of human-machine systems.

FY 2017 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 2018 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

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
information processing. Sub-areas include system and network performance prediction, design and analysis, and modeling of human-machine systems.			
Title: Decision Making	19.347	20.140	20.263
Description: Scientific focus areas are mathematical modeling of cognition and decision making, trust between humans and autonomous agents, and mixed human-machine decision making. ***FY 2016 Accomplishments:*** Funded the development of a computational model that captures irrational aspects of human reasoning . The research will improve the reasoning of fully autonomous systems that interact with humans. Investigated 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. Included 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 2017 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 2018 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 to model individual and group cognitive processing and decision making.			
Title: Dynamical Systems, Optimization, and Control	28.112	26.575	26.782
Description: Scientific focus areas are computational mathematics, dynamics and control, and optimization and discrete mathematics. ***FY 2016 Accomplishments:*** Supported the investigation and formalization of a Bayesian inference approach to machine learning and concept formation that will provide measureable results and a significant reduction in costs for a system to learn and formulate new concepts. Developed 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. Included			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
study of novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments. ***FY 2017 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 2018 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.			
Title: Natural Materials and Systems ***Description:*** Scientific focus areas are renewable energy, natural materials and nature inspired systems. ***FY 2016 Accomplishments:*** Supported the development of a "liquid wire" material inspired by spider silk that extends like a solid and compresses like a liquid. The bio-inspired threads have potential applications in a broad range of areas including robotics and stretchable electronics. Investigated multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems accomplish their required tasks. Studied 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 2017 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 2018 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.	24.614	28.718	28.893
Accomplishments/Planned Programs Subtotals	98.994	101.258	101.920

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** Conducted Congressionally directed effort. ***FY 2017 Plans:*** N/A	11.167	0.000
Congressional Adds Subtotals	11.167	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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
613004: *Education and Outreach*	-	30.354	34.003	34.134	0.000	34.134	34.671	35.558	36.260	36.985	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 2016	FY 2017	FY 2018
Title: Outreach to International S&T Community	10.141	11.978	12.019

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 2016 Accomplishments:

Hosted the International Basic Research Infrastructure Meeting in collaboration with the Embassy of Italy in Washington, D.C. and the National Research Council of Italy. Participants from the U.S., Italy, Australia and South Africa explored building basic science partnerships by leveraging international investments in global research infrastructure. Leveraged international expertise and supported international technology liaison missions to identify and maintain awareness of foreign science and technology developments. Explored current foreign investments and influenced world-class scientific research on specific topics of Air Force interest. Pursued access to technical information on foreign research capabilities within our interests. Supported international visits by scientists and high-level Department of Defense (DoD) S&T delegations, and provided primary interface to coordinate international S&T participation among DoD organizations.

FY 2017 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 2018 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

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Title: Outreach to U.S. S&T Workforce ***Description:*** Strengthen science, mathematics, and engineering research and infrastructure in the U.S., thereby strengthening current and future Air Force S&T capabilities. ***FY 2016 Accomplishments:*** Awarded grants to 56 scientists and engineers from 41 research institutions and small businesses under the Air Force's Young Investigator Research Program. Increased 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. Supported science, mathematics, and engineering research, and educational outreach programs at U.S. colleges and universities, including Historically Black Colleges and Universities, Hispanic serving institutions, and other minority institutions. ***FY 2017 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 2018 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.	13.213	22.025	22.115
Accomplishments/Planned Programs Subtotals	23.354	34.003	34.134

	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** Conducted Congressionally directed effort. ***FY 2017 Plans:*** N/A	7.000	0.000
Congressional Adds Subtotals	7.000	0.000

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613004 / *Education and Outreach*

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	132.526	145.044	147.923	0.000	147.923	150.158	154.054	157.135	160.278	Continuing	Continuing
615094: *University Research Initiatives*	-	132.526	145.044	147.923	0.000	147.923	150.158	154.054	157.135	160.278	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 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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	141.754	145.044	147.923	0.000	147.923
Current President's Budget	132.526	145.044	147.923	0.000	147.923
Total Adjustments	-9.228	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	-4.253	0.000			
• SBIR/STTR Transfer	-4.975	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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*

Change Summary Explanation

Decreases in FY 2016 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Multidisciplinary University Research Initiative	73.554	82.207	83.839
Description: Promote fundamental, multi- and interdisciplinary science and engineering research projects involving multiple principle investigators. ***FY 2016 Accomplishments:*** Selected seven new projects for award under the Multidisciplinary University Research Initiative (MURI) program to 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. Sponsored grants under the Presidential Early Career Award for Scientists and Engineers (PECASE) program to support and recognize superior academic researchers in the early stages of their careers. Continued funding of multi-disciplinary programs initially awarded in prior years. ***FY 2017 Plans:*** Fund competitive research grants at U.S. universities that focus on significantly expanding the basic knowledge of Air Force-relevant science and technology areas, not normally achievable in smaller funded, single investigator awards. Support and recognize superior academic researchers in the early stages of their careers through the PECASE program. Continue funding of multi-disciplinary programs initially awarded in prior years. ***FY 2018 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.			
Title: Science and Engineering Education	43.998	48.337	49.296
Description: Support post-graduate, graduate, and undergraduate education in science and engineering disciplines at U.S. universities. ***FY 2016 Accomplishments:*** Selected 60 new fellows for the highly competitive National Defense Science and Engineering Graduate (NDSEG) fellowships. Continued to support competitive awards for graduate and undergraduate research experiences, including those established			

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
under the Awards to Stimulate and Support Undergraduate Research Experiences (ASSURE) program. Continued funding for awards initiated under prior year DoD programs. ***FY 2017 Plans:*** Award highly competitive NDSEG fellowships. 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 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.			
Title: Research Instrumentation ***Description:*** Enhance scientific and engineering research through advanced education infrastructure and instrumentation at U.S. universities. ***FY 2016 Accomplishments:*** Selected 59 proposals on a competitive basis for award 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 2017 Plans:*** 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 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.	14.974	14.500	14.788
Accomplishments/Planned Programs Subtotals	132.526	145.044	147.923

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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*

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	12.871	14.168	14.417	0.000	14.417	14.615	14.906	15.204	15.508	Continuing	Continuing
615097: *High Energy Laser Research Initiatves*	-	12.871	14.168	14.417	0.000	14.417	14.615	14.906	15.204	15.508	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 (DoD) high energy laser (HEL) systems. 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 interest in HELs. 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 DoD Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	13.778	14.168	14.417	0.000	14.417
Current President's Budget	12.871	14.168	14.417	0.000	14.417
Total Adjustments	-0.907	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	-0.413	0.000			
• SBIR/STTR Transfer	-0.494	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: HEL Devices	6.003	6.728	6.717
Description: Improve the fundamental understanding of HEL sources, to include solid state, fiber, and gas laser technologies.			
FY 2016 Accomplishments:			

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
Continued innovative laser technologies in diode-pumped alkali, short-pulse, fiber, and solid state laser technologies. Continued overseas efforts to leverage international technology advancements. ***FY 2017 Plans:*** Continue innovative laser technologies in diode-pumped alkali, short-pulse, fiber, and solid state laser technologies. Continue overseas efforts to leverage international technology advancements. ***FY 2018 Plans:*** Continue innovative laser technologies in diode-pumped alkali, short-pulse, fiber, and solid state laser technologies. Continue overseas efforts to leverage international technology advancements.			
Title: HEL Beam Control ***Description:*** Improve the fundamental understanding of beam control technologies, as they relate to HEL applications. Conduct research in atmospheric characterization, metrology, control systems, algorithms, and beam control component technology. ***FY 2016 Accomplishments:*** Continued research on innovative beam control architectures. Continued overseas efforts to leverage international technology advancements. ***FY 2017 Plans:*** Continue research on innovative beam control architectures. Continue overseas efforts to leverage international technology advancements. ***FY 2018 Plans:*** Continue research on innovative beam control architectures. Continue overseas efforts to leverage international technology advancements.	5.768	6.240	6.500
Title: HEL Education ***Description:*** Fund educational grants intended to stimulate interest in HELs among students. ***FY 2016 Accomplishments:*** Provided scholarships and internships to support college students studying HEL degrees. Provided grants to Service Academies to stimulate HEL studies among military cadets. Funded publication of journals and support continuing education for professionals in the HEL field. ***FY 2017 Plans:***	1.100	1.200	1.200

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
Provide scholarships and internships to support college students studying HEL degrees. Provide grants to Service Academies to stimulate HEL studies among military cadets. Fund publication of journals and support continuing education for professionals in the HEL field. ***FY 2018 Plans:*** Provide scholarships and internships to support college students studying HEL degrees. Provide grants to Service Academies to stimulate HEL studies among military cadets. Fund publication of journals and support continuing education for professionals in the HEL field.			
Accomplishments/Planned Programs Subtotals	12.871	14.168	14.417

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	132.768	126.152	124.264	0.000	124.264	124.561	127.835	127.827	131.745	Continuing	Continuing
624347: *Materials for Structures, Propulsion, and Subsystems*	-	54.699	46.444	45.059	0.000	45.059	46.915	48.265	46.335	47.806	Continuing	Continuing
624348: *Materials for Electronics, Optics, and Survivability*	-	34.530	32.866	31.523	0.000	31.523	32.703	33.732	34.690	35.992	Continuing	Continuing
624349: *Materials Technology for Sustainment*	-	43.539	46.842	47.682	0.000	47.682	44.943	45.838	46.802	47.947	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.

In FY 2018, a portion of HQ AFRL S&T civilian manpower in PE 0602102F, Materials, was transferred to PE 0602298F, Science and Technology Management - Major Headquarters Activities (MHA), to provide increased transparency to Congress on personnel in Major Headquarters Activities (MHA).

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: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	133.734	126.152	129.016	0.000	129.016
Current President's Budget	132.768	126.152	124.264	0.000	124.264
Total Adjustments	-0.966	0.000	-4.752	0.000	-4.752
• 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	0.963	0.000			
• SBIR/STTR Transfer	-1.929	0.000			
• Other Adjustments	0.000	0.000	-4.752	0.000	-4.752

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 624347: *Materials for Structures, Propulsion, and Subsystems*		
Congressional Add: *Air Force Educational and Outreach Program*	8.500	-
Congressional Add Subtotals for Project: 624347	8.500	-
Congressional Add Totals for all Projects	8.500	-

Change Summary Explanation

FY 2018 decrease due to realignment of Autonomy and Laser weapon system priorities and transfer of some HQ AFRL civilian manpower to PE 0602298F, Science and Technology Management - Major Headquarters Activities.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
624347: *Materials for Structures, Propulsion, and Subsystems*	-	54.699	46.444	45.059	0.000	45.059	46.915	48.265	46.335	47.806	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 2016	FY 2017	FY 2018
Title: Ceramics and Composites	22.316	27.378	26.585
Description: Develop ceramic, ceramic matrix composite, and hybrid materials technologies for performance and supportability improvement in propulsion systems and high temperature aerospace structures.			
FY 2016 Accomplishments: Continued to demonstrate new advanced processing methods, coating technologies, and behavior and life prediction for higher temperature capable organic and ceramic matrix composites. Demonstrated enviro-mechanical damage models that have been validated via ceramic matrix composite oxidation studies for the hot section of turbine engines. Finalized vane geometry for rig test to further validate damage models in realistic environment. Continued to advance the development and validation of new ceramic and organic matrix composite materials and processes with higher temperature capability for propulsion systems and aerospace structures. Continued 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. Demonstrated multi-functional materials and processes for applications requiring advanced electromagnetic and laser protection for aerospace structures.			
FY 2017 Plans: Validate repeatability of new advanced processing methods, coating technologies, and behavioral life prediction for higher temperature capable organic and ceramic matrix composites. Continue to demonstrate severe environment durability of advanced composite systems via mechanical testing. Continue to advance the development and validate new ceramic and organic matrix			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
composite materials and processes with higher temperature capability for 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 the development of composite damage progression models for application in an engineering environment. ***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. Continue to demonstrate severe environment durability of advanced composite systems via mechanical testing. Continue exploration of 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. Continue development of composite damage progression models for application in an engineering environment.			
Title: Metals ***Description:*** Develop lightweight and high temperature metallics, life prediction, and metals processing technologies for increased affordability, durability, and reliability. ***FY 2016 Accomplishments:*** Completed testing of heat treatments of advanced nickel alloys used in high pressure turbine disks to determine best conditions to minimize crack growth. Finalized the demonstration of analysis techniques for understanding and explicitly treating residual stress in nickel-base superalloy components. Validated repeatability of advanced computation methods to support material development and characterization modeling. Continued demonstration of quantitative, predictive models for performance of metallic based thermal management systems. Continued to analyze relationships between microstructure, processing, properties, and performance of metallic, hybrid, nanoscale, and gradient metallic materials. Continued development of integrated material/ manufacturing and component analysis for life management and development of structural materials innovative research. Supported the industry in developing affordable metal processes and components. Continued to advance the development of the next generation turbine engine disk. ***FY 2017 Plans:*** Implementation of advanced computation methods to support material development and characterization modeling. Continue demonstration of quantitative, predictive models for performance of metallic based thermal management systems. Continue to analyze relationships between microstructure, processing, properties, and performance of metallic, hybrid, nanoscale, and gradient metallic materials. Continue development of affordable integrated material/manufacturing and component analysis	19.101	14.357	13.968

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
for life management and development of structural materials innovative research. Continue to advance development of next generation turbine engine disk and reliable affordable metallic structural components through computational methods. Initiate the integration and demonstration of advanced analytical tools to optimize design and certification of additively manufactured metallic components. ***FY 2018 Plans:*** Continue implementation of advanced computation methods to support material development and characterization modeling. Continue demonstration of quantitative, predictive models for performance of metallic based thermal management systems. 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. Continue demonstration of 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.			
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 2016 Accomplishments:*** Demonstrated use of ceramic matrix composites in hypersonic jet engine to simplify internal fuel cooling system. Continued to refine and improve processing methods to fabricate materials required for expendable hypersonic applications. Continued development of unique experimental techniques to assess mechanical properties and time-dependent behavior. Assessed material properties and performance against requirements for control surfaces, leading edges and acreage. Validated computational models to assess environmental degradation of materials in a hypersonic environment. ***FY 2017 Plans:*** Continue to refine and demonstrate improved processing methods for fabricating materials required for expendable hypersonic applications. Refine and continue development of unique experimental techniques to assess mechanical properties and time-dependent behavior. Continue to validate and demonstrate material properties and performance meet design needs for control surfaces, leading edges and acreage. Continue to validate computational models to assess environmental degradation of materials in a hypersonic environment. ***FY 2018 Plans:***	4.782	4.709	4.506

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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. Continue to validate and demonstrate material properties and performance to meet design needs for control surfaces, leading edges and acreage. Continue to validate computational models to assess environmental degradation of materials in a hypersonic environment.			
Accomplishments/Planned Programs Subtotals	46.199	46.444	45.059

	FY 2016	FY 2017
Congressional Add: Air Force Educational and Outreach Program	8.500	-
FY 2016 Accomplishments: Conducted congressionally directed effort		
Congressional Adds Subtotals	8.500	-

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
624348: *Materials for Electronics, Optics, and Survivability*	-	34.530	32.866	31.523	0.000	31.523	32.703	33.732	34.690	35.992	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 2016	FY 2017	FY 2018
Title: Infrared Detector and Electromagnetic Device Materials	11.364	10.846	10.403
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 2016 Accomplishments: Demonstrated additively manufactured conformal electronic structures for communication applications. Demonstrated models of optical/IR behavior for materials. Developed nanoscale materials for use in producing detectors. Continued to develop materials for use in high resolution MWIR. Continued to develop materials to support and provide persistent air and space ISR. Continued to utilize computational materials science to improve performance prediction models. Continued development of quantum materials for aerospace applications. Continued development of SWIR detector materials and hyper-spectral LWIR. Continued development of radio frequency and IR photonics for air vehicle applications. Pursued development of nanostructured materials for components to enable agile radio frequency capability.			
FY 2017 Plans: 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. Demonstrate nanoscale materials, meta materials, and models for use in producing detectors. Continue to utilize computational materials			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
science to improve performance prediction and reliability models. Continue to demonstrate quantum materials for aerospace applications. Continue to develop and demonstrate SWIR detector materials and hyperspectral LWIR materials. Demonstrate materials and processes for the integration of radio frequency and optical signals, as well as concepts for novel optical devices and components. Continue development of radio frequency and IR photonics for air vehicle applications. Demonstrate nanostructured materials for components to enable agile radio frequency capability. ***FY 2018 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. 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 demonstrate quantum materials for aerospace applications. Continue to develop and demonstrate SWIR detector materials and hyper-spectral 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. Continue to demonstrate nanostructured materials for components to enable agile radio frequency capability.			
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 2016 Accomplishments:*** Demonstrated repeatability of materials and technologies to protect against directed energy threats. Developed advanced optical limiter materials for damage protection, enhanced hybrid materials for advanced applications in airborne, space, and personnel systems. Continued to validate materials for high energy laser interactions. Developed approaches for integration of multi-modal hardening into structures and devices. Continued to utilize computational materials science to employ multi-scale modeling for design of robust, reliable integrated protection. ***FY 2017 Plans:*** Continue to demonstrate repeatability of materials and technologies to protect against directed energy threats. Improve advanced optical limiter materials for damage protection, enhance hybrid materials for advanced applications in airborne, space, and personnel systems. Assess response of new materials for high energy laser interactions. Continue to 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 2018 Plans:***	13.017	12.160	11.979

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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. 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.			
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-IR spectral region (2-5 microns). ***FY 2016 Accomplishments:*** Demonstrated materials processes for fabricating new laser beam scanning devices to enable high-speed beam steering. Demonstrated material and growth processes for fabricating phase-matched crystals. Improved design and fabrication of waveguides for higher power pump lasing. Investigated power limitations of lasing of crystal fiber waveguide structures and performance limitations. Continued investigation of quasi-phase-matched materials and developed processes to reduce absorption. ***FY 2017 Plans:*** Develop materials and processing 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 with optical components. Demonstrate materials and models for directed energy sources. Continue development of both phase-matched crystals and crystal fiber waveguides sufficiently to demonstrate subsystem capability. ***FY 2018 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 demonstrate materials for frequency conversion, optical coatings, mirrors and high power microwave sources for directed energy sources.	1.425	1.315	1.261
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 2016 Accomplishments:*** Used advanced functional materials to develop wearable sensors to monitor biomarkers that will provide insight into human performance. Developed system to remove contamination on aircraft reducing spreading of diseases and corrosion. Validated	8.724	8.545	7.880

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
complex hybrid materials addressing unique requirements of Air Force sensors and electronic components. Advanced the use of computational materials science to model material development and to enable rapid in-situ experimental data acquisition. Validated reliable materials and processes to optimize components for compact, flexible, multi-functional devices. Developed accurate methods to assess microbial interactions with material to establish risk for property degradation. Demonstrated materials and processes for developing robust hybrid electronic packages on varied flexible and stretchable substrates with embedded energy. Continued to focus material and process development for integration of flexible components into multi-modal platform. Developed and demonstrated methods to assess reliability of nano and bio materials and processes. Supported Flexible Hybrid Electronics Institute for Manufacturing Innovation and the NanoBio Manufacturing Consortium. ***FY 2017 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. Explore biotechnology to assess the impact of microbes and fungi on Air Force systems. Continue to validate reliable materials and processes to optimize components for compact, flexible, stretchable multi-functional devices. Demonstrate materials and process for functional additive manufacturing of electronic components. Continue to develop methods to assess reliability of nano and bio materials and processes for Air Force applications. Continue to support Flexible Hybrid Electronics Institute for Manufacturing Innovation and the NanoBio Manufacturing Consortium. ***FY 2018 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. 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.			
Accomplishments/Planned Programs Subtotals	34.530	32.866	31.523

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624348 / *Materials for Electronics, Optics, and Survivability*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
624349: *Materials Technology for Sustainment*	-	43.539	46.842	47.682	0.000	47.682	44.943	45.838	46.802	47.947	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 2016	FY 2017	FY 2018
Title: Sensing Technologies	16.503	16.255	16.689
Description: Develop sensing and life prediction technologies to identify damage and characterize the health of aging structures, propulsion systems, and low-observable materials and structures.			
FY 2016 Accomplishments: Developed the remote access non-destructive evaluation tool for ease of inspection to limited access areas. Demonstrated non-destructive evaluation modeling capabilities and used these competencies to drive improvements in capability to detect and characterize damage in realistic aerospace structures and engine components. Continued to develop approaches to address the variability inherent in aerospace systems and materials and began to quantify the impact of that variability on non-destructive inspection capabilities and reliability. Demonstrated advanced sensing technologies to detect and characterize changes in material properties, damage evolution, and other factors that detrimentally affect aerospace systems. Continued development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Fully automated a laboratory test system with robotic hardware and machine learning software to optimize coating inspection. Continued development of advanced methods to monitor and evaluate material state awareness. Continued to demonstrate enhanced metals performance in aerospace systems. Continued to develop risk-based life management approaches for turbine engine structural materials.			
FY 2017 Plans: Continue to demonstrate non-destructive evaluation modeling capabilities and use these competences to drive improvements in capability to detect and characterize damage in realistic aerospace structures and engine components. Continue to develop			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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. Continue to 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. Continue development of advanced methods to monitor and evaluate low-observable material state awareness. Continue to demonstrate enhanced metals performance in aerospace systems. Continue to develop risk-based life management approaches for turbine engine structural materials. ***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. Continue to 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. Continue to 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. Continue to demonstrate enhanced metals performance in aerospace systems. Validate and continue to develop risk-based life management approaches for turbine engine structural materials.			
Title: Production and Repair Technologies ***Description:*** Develop support capabilities, information, and processes to resolve problems with materials in the production and repair of systems components and structures. ***FY 2016 Accomplishments:*** Developed a non-destructive inspection tool to confirm visual crack findings with unskilled/certified operators. Demonstrated non-destructive evaluation modeling capabilities and used these competencies to drive improvements in capability to detect and characterize damage in realistic aerospace structures and engine components. Continued to develop approaches to address the variability inherent in aerospace systems and materials and initiated efforts to quantify the impact of that variability on non-destructive inspection capability and reliability. Demonstrated advanced sensing technologies to detect and characterize changes in material properties, damage evolution, and other factors that detrimentally affect aerospace systems. Continued development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Continued to demonstrate enhanced metals performance in aerospace systems and to develop risk-based life management approaches for turbine engine structural materials. ***FY 2017 Plans:***	11.862	12.261	12.397

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continue to demonstrate non-destructive evaluation modeling capabilities and use these competences to drive improvements in capability to detect and characterize damage in realistic aerospace structures and engine components. Continue to 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. Continue to 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. Continue development of advanced methods to monitor and evaluate low-observable material-state awareness. Continue to demonstrate enhanced metals performance in aerospace systems. Continue to develop risk-based life management approaches for turbine engine structural materials. ***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.			
Title: Failure Analysis Technologies	15.174	18.326	18.596
Description: Develop support capabilities, information, and processes to resolve materials problems and provide electronic and structural failure analysis of components. ***FY 2016 Accomplishments:*** Performed quick response failure analyses and materials investigations. Improved analysis techniques to determine root cause materials failure/degradation. Provided advanced materials solutions to ensure critical warfighter system availability and safety of flight. Enhanced development of functional materials failure analysis capabilities. Validated advanced electrostatic discharge protection technologies and procedures for emerging avionics subsystems. Discovered environmentally safe materials and processes for extending the life of aluminum aircraft components. Transitioned advanced test methods for analyzing electrical and structural failures of emerging materials. Developed and transitioned materials with high durability and protection for high power wiring technologies for Air Force weapons systems. Provided advanced materials solutions to improve systems sustainment in field and Air Force Program Offices. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continue to perform quick response failure analysis and materials investigations. Continue to develop and investigate improved analysis techniques to determine root cause materials failure/degradation. Continue to develop and provide advanced materials solutions to ensure critical warfighter system availability and safety of flight. Continue development of functional materials failure analysis capabilities. Continue to analyze and validate advanced electrostatic discharge protection technologies and procedures for emerging avionics sub-systems. Continue to transition advanced test methods for analyzing electrical and structural failures of emerging materials. Continue development and demonstration of new, more durable materials and protection for high power wiring technologies for Air Force weapons systems. Continue research and development to provide advanced materials to improve systems sustainment. ***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. Continue to develop and provide advanced materials solutions to ensure warfighter system availability and safety of flight. Continue 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 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 and development to provide advanced materials to improve systems sustainment.			
Accomplishments/Planned Programs Subtotals	43.539	46.842	47.682

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.

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Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	118.263	122.831	124.678	0.000	124.678	128.303	131.790	134.761	143.189	Continuing	Continuing
622401: *Structures*	-	48.988	41.103	42.925	0.000	42.925	43.644	43.918	46.870	48.796	Continuing	Continuing
622403: *Flight Controls and Pilot-Vehicle Interface*	-	26.564	28.516	30.130	0.000	30.130	30.089	30.339	31.130	36.248	Continuing	Continuing
622404: *Aeromechanics and Integration*	-	27.854	34.470	29.557	0.000	29.557	30.080	29.118	30.452	31.318	Continuing	Continuing
622405: *High Speed Systems Technology*	-	14.857	18.742	22.066	0.000	22.066	24.490	28.415	26.309	26.827	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program 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. 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 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: FY 2018 Air Force					Date: May 2017
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	122.969	122.831	125.042	0.000	125.042
Current President's Budget	118.263	122.831	124.678	0.000	124.678
Total Adjustments	-4.706	0.000	-0.364	0.000	-0.364
• 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	-2.990	0.000			
• SBIR/STTR Transfer	-1.716	0.000			
• Other Adjustments	0.000	0.000	-0.364	0.000	-0.364

Change Summary Explanation

Decreases in FY 2016 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622401: *Structures*	-	48.988	41.103	42.925	0.000	42.925	43.644	43.918	46.870	48.796	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 2016	FY 2017	FY 2018
Title: Aircraft Service Life Technologies	22.234	21.431	22.381
Description: Develop an economic service life analysis capability comprised of analysis tools, methodologies, and structural health monitoring technologies. ***FY 2016 Accomplishments:*** Continued development of engineered residual stress methods for airframe life extension. Continued the technology development of failure criteria methods and tools for advanced aircraft composite and metallic components. Continued efforts in certification of advanced composite for aircraft structures. Continued 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. ***FY 2017 Plans:*** Continue development of engineered residual stress methods for airframe life extension. Continue efforts in certification of advanced composite for aircraft structures. Complete the technology development of failure criteria methods and tools for advanced aircraft composite and metallic components. Continue 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. ***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.			
Title: Vehicle Design Technologies	14.726	12.047	12.581
Description: Develop methodologies to reduce the cost and time involved from design to full-scale testing of structural concepts and aircraft systems.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Continued the development of advanced high fidelity aircraft design analysis tools. Continued design methods for innovative control of supersonic tailless aircraft. Continued parametric modeling methods for integrated multidiscipline collaborative design. Continued high-fidelity technology assessment and design of next generation mobility concepts. Initiated the development of design methods for low cost attritable aircraft concepts. ***FY 2017 Plans:*** Continue the development of advanced high fidelity aircraft design analysis tools. Complete design methods for innovative control of supersonic tailless aircraft. Continue parametric modeling methods for integrated multidiscipline collaborative design. Complete high-fidelity technology assessment and design of next generation mobility concepts. Continue the development of design methods for low cost attritable aircraft concepts. Initiate evaluation of control effector concepts for supersonic tailless aircraft. ***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 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.			
Title: Structural Concepts	12.028	7.625	7.963
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 2016 Accomplishments:*** Continued innovative energy efficient conformal load bearing antenna structural concepts. Continued development of lightweight, adaptive, and efficient structural concepts for mobility and special operations. Continued low cost airframe design and manufacturing methods. ***FY 2017 Plans:*** Continue innovative energy efficient conformal load bearing antenna structural concepts. Continue development of lightweight, adaptive, and efficient structural concepts for mobility and special operations. Complete low cost airframe design and manufacturing methods. Initiate development and verification of low cost attritable airframe concepts and manufacturing methods. Initiate development of lightweight aircraft structural concepts to support Air Superiority 2030 requirements. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Accomplishments/Planned Programs Subtotals	48.988	41.103	42.925

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622403: *Flight Controls and Pilot-Vehicle Interface*	-	26.564	28.516	30.130	0.000	30.130	30.089	30.339	31.130	36.248	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 2016	FY 2017	FY 2018
Title: Advanced Flight Controls Technologies	6.615	11.658	6.905
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 2016 Accomplishments:*** Continued the development, demonstration, and assessment of advanced flight control mechanization technologies for trusted and certifiable operations under adverse and contested environments. Continued the development of survivable and health-adaptive control system architecture and created a new line of research on adaptive power and thermal systems. Initiated development of advanced automation capabilities for mobility aircraft. Initiated study on implementation of collision avoidance technology on 6th-gen aircraft. Completed the development of adaptive guidance and control technologies for small-scale hypersonic air vehicles. ***FY 2017 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; developing new methods and expanding to include more aircraft systems. Continue the development of advanced automation capabilities for large 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.			
Title: Manned and Unmanned Teaming Technologies	6.754	10.026	17.941

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.. ***FY 2016 Accomplishments:*** Continued development, demonstration, and assessment of advanced control automation techniques. Continued 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. Initiated development of robust, affordable Unmanned Air Systems (UAS) operations in a terminal airspace environment. Completed development of airborne control of UAS in preparation for flight test activities. Initiated development of autonomy architecture development for unmanned tactical wingman. ***FY 2017 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 development of autonomy architecture for unmanned tactical wingman. ***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 UAS operations in a terminal airspace environment. Initiate development of autonomous behaviors for safe, loyal wingman.			
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 2016 Accomplishments:*** Continued 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. Continued analyses of automated unmanned air systems and manned-unmanned teams in controlled airspace and airbase operations, as well as in adversarial	13.195	6.832	5.284

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
mission environments. Continued trade studies of vehicle concepts for strike, mobility and reconnaissance. Completed mobility evaluations. Initiated manned-unmanned teaming testbed evaluations. ***FY 2017 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. ***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.			
Accomplishments/Planned Programs Subtotals	26.564	28.516	30.130

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622404: *Aeromechanics and Integration*	-	27.854	34.470	29.557	0.000	29.557	30.080	29.118	30.452	31.318	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 2016	FY 2017	FY 2018
Title: Aerodynamic Systems Technologies	8.440	9.117	7.818
Description: Develop aerodynamic assessment prediction methods centered on expanding the design capabilities of future air vehicles. ***FY 2016 Accomplishments:*** Continued to develop and assess aerodynamic technologies that enable future revolutionary manned and unmanned air vehicles. Completed development and assessment of advanced aircraft configurations for mobility. Continued to develop and assess advanced aircraft configurations for future air superiority. Continued technology assessments on next generation tanker systems. Initiated development and assessment of low cost attritable unmanned air systems concepts. ***FY 2017 Plans:*** Continue to develop and assess aerodynamic technologies that enable future revolutionary manned and unmanned air vehicles. Complete development and assessment of advanced aircraft configurations for future Air Superiority 2030 requirements. Complete technology assessments on next generation tanker systems. Continue development and assessment of low cost attritable Unmanned Aerial Vehicle (UAV) concepts. ***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 UAV concepts. Continue assessment of efficient airfoil flow control and distributed propulsion concepts. Initiate design assessments of distributed propulsion concepts for next generation Mobility.			
Title: Next Generation Aerodynamic Technologies	11.089	10.988	9.422
Description: Develop and assess technologies for the next generation of multi-role large aircraft.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Continued development of high fidelity aerodynamic analysis and method development for Mobility and future Air Superiority 2030. Continued development of practical laminar flow technologies for highly swept wings. Continued development of aerodynamics technologies to enable control of supersonic tailless aircraft. Initiated development of flow control techniques to increase the efficiency of practical laminar flow technologies for highly swept wings. ***FY 2017 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. Complete development of aerodynamics technologies to enable control of supersonic tailless aircraft. Initiate aerodynamic technology maturation for next generation tanker. Continue development of flow control techniques to increase the efficiency of practical laminar flow technologies for highly swept wings. ***FY 2018 Plans:*** Continue 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 wind tunnel test of natural laminar flow for Mobility hybrid wing body configuration. Initiate distributed embedded propulsion wind tunnel test.			
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 2016 Accomplishments:*** Continued to develop aerodynamic and propulsion integration technologies that enable future mobility and fighter aircraft. Completed analyses and experiments to investigate propulsion integration flow control to enhance mobility and future air superiority vehicle performance. Initiated advanced inlet and exhaust systems subscale tests for air superiority. Continued development of advanced kinetic and directed energy weapons integration technologies for future air superiority requirements. Completed innovative aerodynamic design methods for integrating high bypass propulsion for future mobility aircraft. ***FY 2017 Plans:*** Continue to develop aerodynamic and propulsion integration technologies that enable future mobility and fighter aircraft. Continue 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. Initiate analysis of innovative propulsion integration technologies that enable low cost attritable aircraft. ***FY 2018 Plans:***	8.325	14.365	12.317

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Accomplishments/Planned Programs Subtotals	27.854	34.470	29.557

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622405: *High Speed Systems Technology*	-	14.857	18.742	22.066	0.000	22.066	24.490	28.415	26.309	26.827	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program 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 2016	FY 2017	FY 2018
Title: High Speed/Hypersonics Structures	8.315	10.896	12.828

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

FY 2016 Accomplishments:

Completed fabrication and instrumentation representative oxide-oxide hypersonic hot structure and a metallic hot structure. Continued development of innovative structural concepts for high speed/hypersonic air vehicles. Continued development of analytical methods for predicting structural response needed for design and evaluation of hot primary structure for hypersonic vehicles. Continued to assess the impact of path dependent structural behavior on the service life prediction for hot structures encountering extreme environments. Continued to develop and integrate model uncertainty methods into multi-disciplinary simulations and quantify its impact on the structural margin. Continued development of structural analysis methods and technology for hot structure concepts under extreme environment loading conditions. Continued the assessment of the aerospace community to quantify the structural margins for extreme environment hot structure through experimental validation of ground test articles. Prepared for testing of representative vehicle structures for combined aero, thermal, and acoustic loads. Began validation of combined loads methodology to predict structural response. Initiated study to characterize attachment techniques for hot structures.

FY 2017 Plans:

Complete thermal/mechanical/acoustic testing of a representative oxide-oxide hypersonic hot structure and a metallic hot structure. 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

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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. Initiate development of structural life prediction methodology for extreme environment structures and thermal protection systems. ***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.			
Title: High Speed Vehicle Aeromechanics and Integration	6.542	7.846	9.238
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 2016 Accomplishments:*** Completed first ever time-accurate computational fluid dynamics (CFD) modeling of a full hypersonic vehicle. Successfully flew Hypersonic International Flight Research Experimentation flight 5b (HIFiRE-5b) collecting data on boundary-layer dynamics. Continued maturation of critical technologies for high speed/hypersonic flight. Continued 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. Completed performance and operability ground testing of advanced high contraction ratio inlets. Continued development of high speed system concepts that provide revolutionary capabilities. Investigated aeromechanic technologies to reduced drag and enable robust stability and control at low dynamic pressure flight conditions. Continued efforts to characterize high-speed phenomena and develop and validate fundamental high-speed technologies through experimental testing. As part of an international collaborative effort, continued flight tests of Mach 6 adaptive guidance and control flight experiment. Continued assessment of mission-level effectiveness and refinement of definition of preferred high speed weapon alternatives and limited life hypersonic intelligence, surveillance, and reconnaissance vehicles. Continued assessment of campaign-level benefits of preferred high speed weapon alternatives. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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 2018 Plans:*** Complete Critical Design Review (CDR) for 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.			
Accomplishments/Planned Programs Subtotals	14.857	18.742	22.066

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

N/A

D. Acquisition Strategy

Not Applicable.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622405 / *High Speed Systems 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.

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Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	108.784	111.647	108.784	0.000	108.784	111.326	114.615	116.718	121.505	Continuing	Continuing
621123: *Learning and Operational Readiness*	0.000	24.034	23.329	23.840	0.000	23.840	21.986	22.738	22.170	23.220	Continuing	Continuing
625328: *Human Dynamics Evaluation*	0.000	26.536	26.174	24.338	0.000	24.338	24.718	25.544	26.313	27.359	Continuing	Continuing
625329: *Sensory Evaluation and Decision Science*	0.000	31.923	31.539	29.476	0.000	29.476	30.487	31.183	32.103	33.374	Continuing	Continuing
627757: *Bioeffects*	0.000	26.291	30.605	31.130	0.000	31.130	34.135	35.150	36.132	37.552	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.

In FY 2018, a portion of HQ AFRL S&T civilian manpower in PE 0602202F, Human Effectiveness Applied Research, 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 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: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	110.221	111.647	114.704	0.000	114.704
Current President's Budget	108.784	111.647	108.784	0.000	108.784
Total Adjustments	-1.437	0.000	-5.920	0.000	-5.920
• 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	-0.001	0.000			
• SBIR/STTR Transfer	-1.436	0.000			
• Other Adjustments	0.000	0.000	-5.920	0.000	-5.920

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 621123: *Learning and Operational Readiness*		
Congressional Add: *Program Increase*	3.334	-
Congressional Add Subtotals for Project: 621123	3.334	-
Project: 625328: *Human Dynamics Evaluation*		
Congressional Add: *Program Increase*	3.333	-
Congressional Add Subtotals for Project: 625328	3.333	-
Project: 625329: *Sensory Evaluation and Decision Science*		
Congressional Add: *Program Increase*	3.333	-
Congressional Add Subtotals for Project: 625329	3.333	-
Congressional Add Totals for all Projects	10.000	-

Change Summary Explanation

Decrease in FY 2018 due to realignment of funds for autonomy and Laser Weapon System priorities and transfer of some HQ AFRL civilian manpower to PE 0602298F, Science and Technology Management - Major Headquarters Activities.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
621123: *Learning and Operational Readiness*	0.000	24.034	23.329	23.840	0.000	23.840	21.986	22.738	22.170	23.220	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 2016	FY 2017	FY 2018
Title: Continuous Learning	20.700	21.102	19.708

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 2016 Accomplishments:

Began to implement multiple agents as synthetic white forces for cost reduction in Air Support Operations Center training. Demonstrated adaptive ISR training in training research exercise. Completed evaluations and developed specifications for in-theater C2 trainer. Demonstrated integrated RPA, C2, and joint terminal attack controller (JTAC) training and assessment in routine DMO events. Demonstrated autonomous agents for asset management in RPA operations. Continued development of the Distributed Common Ground Station (DCGS) Weapons System Trainer (DWST). Continued research to create autonomous cognitive models to function in contested environments. Completed development of common scenario generation and readiness assessment methods for joint and coalition distributed training and exercise.

FY 2017 Plans:

Continue development of multiple agents as synthetic white forces to support Air Support Operations Center training. Develop, test, and validate a moderate fidelity F-35 non-proprietary simulator. Establish a baseline to evaluate first responder training gaps and support exercises to garner baseline data to quantify gaps and engineer and develop training curriculum. Complete the development of the Distributed Common Ground Station Weapons Systems Trainer. Conduct initial training effectiveness study to evaluate the transfer of training using the DWST. Begin a Fighter Integration evaluation and study to address future JSF training challenges. Develop innovative solutions for multi-level security. Support the development of cross domain solution for F-35. Demonstrate LVC in a five-eyes coalition environment. Continue to develop specifications for secure fifth generation LVC

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
operations to include executing a fourth and fifth generation platform study. Execute scalable studies to focus on the individualized learning and adapting the learner to the training environment. ***FY 2018 Plans:*** Transition automated scenario authoring tool set for Joint Theater Air Ground Simulation System (JTAGSS). Demonstrate cross domain solution ruleset in F-35 for secure fifth generation LVC operations. Continue to develop designs for outyear 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. Continue cyber intelligence training testbed into training research exercises. Continue development of the Distributed Immersion Global Intel Trainer (DIGIT).			
Title: Cognitive Modeling ***Description:*** Research explores application of cognitive science for performance improvement by enhancing training in mission-relevant environments (e.g., flight simulators). ***FY 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** For FY 2015 and FY 2016, the work for this effort was originally performed in the Continuous Learning effort. Apply predictive performance optimization to more complex warfighter training contexts. Evaluate robustness and stability of autonomous operations in mission-relevant simulations. Further develop mechanisms for effectiveness in human-machine teaming. Rapidly validate complex models through massively parallel computing architectures. Enhance constructive entities through infusion of intelligent agent technologies. Develop personalized learning through scheduling of learning events in intelligent tutors. Support career-wide continuous learning through development of persistent personalized learner models that may allow individual airmen training to be followed from accession to retirement. Refine and validate integration of intelligent agents into existing training testbeds. Apply vigilance research to long-duration missions to improve warfighter performance at the edges of human performance. ***FY 2018 Plans:*** Conduct studies in autonomous operations in mission-relevant simulations. Validate autonomous training agents in LVC testbeds. Continue to validate complex cognitive models through in computing architectures. Initiate studies in multi-level models for	0.000	2.227	4.132

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Accomplishments/Planned Programs Subtotals	20.700	23.329	23.840

	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** Conducted Congressionally-Directed Effort.	3.334	-
Congressional Adds Subtotals	3.334	-

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
625328: *Human Dynamics Evaluation*	0.000	26.536	26.174	24.338	0.000	24.338	24.718	25.544	26.313	27.359	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 2016	FY 2017	FY 2018
Title: Human Analyst Augmentation	8.904	10.269	9.339
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 2016 Accomplishments:*** Applied cognitive systems engineering research methods to airman-centered challenges surrounding contested environments to develop solutions for Air Force ISR analysts. Explored approaches to integrate semiautonomous machine analysis technologies into airman ISR analyst performance. ***FY 2017 Plans:*** Conduct research to understand factors that enable the Air Force's goal of full spectrum analysis, transitioning from individual analysts working a single intelligence source to exploiting multiple sources. Develop new human-centered methodologies and analyst processes integrating semiautonomous analysis technologies to create robust analytic capacity. ***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.			
Title: Human Trust and Interaction	7.266	8.188	8.063

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Conduct research in cross-cultural communication and automated speech translation tools for Air Force missions. Conduct research to address important aspects of trust in airman-machine teams including investigating how an airman knows an autonomous or semiautonomous system is safe to use and whether the system, data, conclusions, and decision recommendations can be trusted. ***FY 2016 Accomplishments:*** Experimented with guidelines for calibrated trust for symbiotic airman-machine teaming. Identified and studied appropriate levels of transparency between airmen and automated systems. Experimented with multiple language processing algorithms simultaneously to optimize system performance. Evaluated current advances in machine processing for new, militarily-relevant languages. ***FY 2017 Plans:*** Investigate trust between airmen and automation and airmen and robots to determine the appropriate levels of transparency in automatous and robotic systems. Implement emerging machine processing approaches for militarily-relevant languages including mission and domain specific applications. ***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.			
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 2016 Accomplishments:*** Developed advanced molecular and genetic diagnostic methodologies to better assess airman performance. Developed algorithm capable of reliably detecting and characterizing anthropometric signatures. ***FY 2017 Plans:*** Exploit novel, non-invasive biomarkers in sweat and exhaled breath, develop selective capture elements for detection of these markers, and incorporate and test these to provide real-time feedback to operators. Develop durable algorithm to provide persistent human detection and tracking throughout a single full motion video mission. ***FY 2018 Plans:***	7.033	7.717	6.936

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Accomplishments/Planned Programs Subtotals	23.203	26.174	24.338

	FY 2016	FY 2017
Congressional Add: Program Increase	3.333	-
FY 2016 Accomplishments: Conducted Congressionally-Directed Effort.		
Congressional Adds Subtotals	3.333	-

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
625329: *Sensory Evaluation and Decision Science*	0.000	31.923	31.539	29.476	0.000	29.476	30.487	31.183	32.103	33.374	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 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 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 2016	FY 2017	FY 2018
Title: Applied Neuroscience	12.108	15.642	12.719
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 2016 Accomplishments: Explored novel airman performance sensor and material solutions to increase sensing and assessing capabilities. Matured team workload and trust models for autonomy, increased airman performance monitoring, and performance improvement. Utilized knowledge of stress-driven metrics and processes to optimize airman performance. Applied neurophysiological, psychological, and genetic mechanisms and processes for developing guidelines to enhance airman performance and cognitive resiliency. Explored additional augmentation techniques such as supplementation and physical training for improving performance in operational environments that include airman-machine teaming. Applied interface technologies and exposure design criteria to protect airmen and mitigate injury and performance risks in current and future weapon systems. Refined physiology computational modeling methods to predict high-stress/extreme environmental effects on airmen. Continued contamination sensor technology development for on-board oxygen generation systems for hypoxia vulnerability risk mitigation. Evaluated new technologies for aircraft next generation on-board oxygen generation system.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Conduct research on sensing and assessment technologies for enhanced Airman performance. Investigate augmentation strategies for enhanced physical and cognitive performance to include non-invasive brain stimulation techniques. Establish method for use of real-time biomarker sensor technology. Begin development of human response models to enhance aircrew performance in extreme environments. Explore next generation aircraft injury exposure criteria for improved aircrew protection. Investigate on-board oxygen generating system performance vulnerabilities affecting oxygen production. Explore new technologies in support of next generation on-board oxygen generating system. ***FY 2018 Plans:*** Refine sensing and assessment technologies for enhanced Airman performance in operationally-relevant environments. Assess applicability of biomarker sensor technologies use in operational environments. Refine augmentation techniques for physical and cognitive performance optimization and stress resilience. Continue investigation of non-invasive brain stimulation techniques. 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. Develop an on-board oxygen generating system contamination database and susceptibility model.			
Title: Human Role in Semiautonomous Systems ***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 2016 Accomplishments:*** Integrated the current states of the platform, mission, environment, and airman operator into a global state database. Developed guidelines for interface design based upon computational problem solving method. Investigated ways to represent autonomous system competency against the current task/situation. Explored airman-autonomy teaming methods and metrics for Air Force applications. Performed advanced simulation of adjustable and adaptive automation to support flexible control of autonomous systems depending on mission and environmental context. ***FY 2017 Plans:*** Demonstrate effective deliberative-reactive control interaction methods of dynamic mission planning of heterogeneous multivehicle systems. Integrate agent architecture to perform sense-making of human, vehicle, and environmental factors to enhance task performance and mission effectiveness. Research advanced airman workload measurement technologies integrated with real-time adaptive airman-machine learning and task allocation methods. Demonstrate real time adaptive airman-machine teaming and task allocation methods. Develop and demonstrate distributed control methods for unmanned system	5.016	3.180	5.837

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
concepts in limited communication environments. Research and develop predictive, look-ahead tools for effects-based mission planning and execution. ***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.			
Title: Battlespace Visualization ***Description:*** Research the visualization, interaction and understanding of complex information to enhance warfighter decision making. ***FY 2016 Accomplishments:*** Created cyber operations visualization techniques for transforming numerical data into actionable information. Developed and evaluated cyber operator system interfaces. Designed decision aids for multisource fusion methods. Developed experimental test bed for more effective visualization of current and future sensor technologies. Prototyped 3-D spatial viewers for mobile devices. ***FY 2017 Plans:*** Explore alternative analytic strategies with emerging machine learning techniques to develop next generation automated data exploitation. Initiate data analytics research for human visualization of complex data. Assess cyber operations visualization techniques for transforming numerical data into actionable information. Continue development and begin performance-based comparisons of new cyber interfaces and visualization work aids for cyber warfare. Evaluate decision aids for multisource fusion imagery analysis. Assess preliminary geospatial viewers on mobile devices for improved operator performance. Initiate human-centric visual target detection and recognition model development. ***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 cyber domains.	8.233	8.474	6.867
Title: Battlespace Acoustics	3.233	4.243	4.053

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Conducts research on advanced auditory and communication technologies that mitigate effects of noise and enhance performance in operational environments. ***FY 2016 Accomplishments:*** Evaluated auditory interfaces that enable airmen to respond to cyber attacks through persistent auditory displays. Validated the use of multimodal displays and visualizations to communicate time-critical information to distributed teams. Enhanced the combined effectiveness of audio displays and multimodal interaction techniques to support airman decision-making. Developed communication metrics of intent of communicators compared to receivers' understanding. Developed metrics of airman-machine communication to incorporate emotional context. ***FY 2017 Plans:*** Conduct research on the impact of auditory context and synthetic voicing to inform the design of synthetic speech displays for improving communication effectiveness and enhancing decision making in human-machine teams. Examine listener adaptation to non-individualized spatial auditory displays and acoustic information distorted by tactical hearing protection and communication devices. Develop persistent auditory iconography for enhancing situation awareness and develop/evaluate source-based symbology to enhance auditory displays. Develop standard procedures and metrics for objectively characterizing the loss of situation awareness in tactical operations when wearing hearing protection and communication devices. ***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.			
Accomplishments/Planned Programs Subtotals	28.590	31.539	29.476

	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** Conducted Congressionally-directed effort.	3.333	-
Congressional Adds Subtotals	3.333	-

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
627757: *Bioeffects*	0.000	26.291	30.605	31.130	0.000	31.130	34.135	35.150	36.132	37.552	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), 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 2016	FY 2017	FY 2018
Title: Optical Radiation Bioeffects	8.181	8.991	11.695
Description: Conduct laboratory experiments and field research on laser bioeffects, enabling military exploitation of laser technology while providing countermeasures for optical hazards/threats.			
FY 2016 Accomplishments: Completed development of scalable effects simulation tool. Completed new standardized methodology for evaluation of laser devices that cause glare effects in multiple environments. Integrated probabilistic model of individual observer within overall modeling and simulation architecture for evaluating laser collateral effects. Completed integration of new distributed simulation standard into modeling and simulation components to enable risk-based assessment of personnel effects within real-time weapons concept exercises with other Air Force and DoD research organizations. Completed data collection for currently identified optical radiation damage and transient vision effects for use in next generation of standardized personnel vulnerability models.			
FY 2017 Plans: Expand research into pulse laser damage mechanisms for collateral hazard assessment of new high energy laser systems under development. Continue development of scalable effects simulation tool for solid state continuous wave lasers. Integrate probabilistic assessment using dose-response methodologies for realistic laser exposure scenarios. Initiate development of glare			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
assessment models that consider retinal pigmentation, dynamic background, and ocular scatter. Conduct studies to define impact of laser eye protection on performance and potential mitigation strategies. ***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 assessment 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 models reflecting the performance impact of laser exposures and develop mitigation strategies.			
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 2016 Accomplishments:*** Determined the impact of fast thermal gradients on neurological cells. Conducted empirical studies to verify computational tool for radio frequency-induced bio-thermal response. Validated radio frequency dosimetry suite for broad power and frequency range to support next generation high peak power dose determinations. Performed empirical and modeling studies to investigate the feasibility of using short pulse radio frequency energy for standoff membrane poration. ***FY 2017 Plans:*** Evaluate effects of whole body fast thermal gradients. Refine bioeffects approach to analyze effects of short pulse radio frequency energy. Finalize validation of dosimetry suite covering broad power and frequency range to support next-generation counter-electronic weapons and high power microwave smart weapons. ***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 dosimetry and computer effects model validation.	9.020	10.131	9.052
Title: Molecular Bioeffects ***Description:*** Conduct novel toxicology, nanotechnology and cognitive research to protect Airmen health and to augment Airman performance in diverse operational environments. Conduct studies to assess human responses to non-lethal weapons and effects/risks of these weapons. Leverage toxicological/biological data to improve airman performance and decision-making abilities.	9.090	11.483	10.383

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Conducted research to define toxicity issues in current and future aircraft environments. Pursued development and application capabilities of biomarkers for short-and long-term exposure modeling for existing and emerging militarily-relevant chemicals and materials. Conducted and developed novel research studies to elucidate mechanisms of fundamental interaction of nanomaterials in biological systems. Continued research to identify novel molecular mechanism and predictive biomarkers in connection with Airman state changes under diverse military relevant conditions for Airman health and performance sensing, assessment and augmentation. ***FY 2017 Plans:*** Advance knowledge and capability to complete analysis of aerospace fluid(s) toxicity characterization and impacts on high performance aircraft operators to best reduce Airmen health risk and Air Force mission risk. Characterize and examine novel mechanisms of fundamental interaction of nanomaterials in a biological system to best understand exposure effects on the Airman. 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 Airman performance. ***FY 2018 Plans:*** Complete toxicological analysis of several relevant aerospace fluids, such as coolants and jet fuels, that may negatively affect high performance aircraft operators. 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. 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 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.			
Accomplishments/Planned Programs Subtotals	26.291	30.605	31.130

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 627757 / *Bioeffects*

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	184.498	185.671	192.695	0.000	192.695	193.579	201.148	201.071	203.605	Continuing	Continuing
623012: *Advanced Propulsion Technology*	-	19.074	27.095	28.612	0.000	28.612	27.898	30.157	28.331	28.894	Continuing	Continuing
623048: *Combustion and Mechanical Systems*	-	11.482	10.574	10.833	0.000	10.833	11.010	11.206	11.421	11.646	Continuing	Continuing
623066: *Turbine Engine Technology*	-	62.716	52.519	55.304	0.000	55.304	55.222	56.944	58.330	59.490	Continuing	Continuing
623145: *Aerospace Power Technology*	-	28.240	34.703	34.736	0.000	34.736	36.287	37.715	36.386	35.658	Continuing	Continuing
624847: *Rocket Propulsion Technology*	-	58.121	56.278	58.594	0.000	58.594	58.472	60.354	61.735	62.950	Continuing	Continuing
625330: *Aerospace Fuel Technology*	-	4.865	4.502	4.616	0.000	4.616	4.690	4.772	4.868	4.967	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

In FY 2018, a portion of HQ AFRL S&T civilian manpower in PE 0602203F, Aerospace Propulsion, 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).

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	185.926	185.671	196.053	0.000	196.053
Current President's Budget	184.498	185.671	192.695	0.000	192.695
Total Adjustments	-1.428	0.000	-3.358	0.000	-3.358
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	1.836	0.000			
• SBIR/STTR Transfer	-3.264	0.000			
• Other Adjustments	0.000	0.000	-3.358	0.000	-3.358

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 624847: *Rocket Propulsion Technology*		
Congressional Add: *Program Increase*	3.600	-
Congressional Add Subtotals for Project: 624847	3.600	-
Congressional Add Totals for all Projects	3.600	-

Change Summary Explanation

Decrease in FY 2016 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Decrease in FY 2018 is due to realignment for autonomy and laser weapons systems priorities and transfer of some HQ AFRL civilian manpower to PE 0602298F, Science and Technology Management - Major Headquarters Activities.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
623012: *Advanced Propulsion Technology*	-	19.074	27.095	28.612	0.000	28.612	27.898	30.157	28.331	28.894	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 2016	FY 2017	FY 2018
Title: Hypersonic Scramjet Technologies	19.074	27.095	28.612

Description: Develop robust hydrocarbon fueled scramjet engine components and technologies to improve performance, operability, durability, and scalability for future platforms.

FY 2016 Accomplishments:

Tested advanced materials for application to scramjet engines. Completed design and fabrication of a powerhead supporting the development of a medium scale scramjet. Completed demonstration of a flexible-wall supersonic nozzle to enable flight Mach transition in ground testing of scramjets. Completed preparation for direct connect testing of first performing contractor medium scale (ten times) scramjet combustor from Mach 3.5 to Mach 7. Continued to develop advanced engine components to improve scramjet operating margin and to refine scramjet scaling laws for reusable applications. Continued 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). Continued to develop low internal drag flame stabilization devices and flight test engine components. Continued to fabricate heavyweight direct connect scramjet combustors in medium scale (ten times). Initiated facility reactivation for low Reynolds number supersonic and hypersonic flow research.

FY 2017 Plans:

Complete direct connect testing of second performing contractor medium scale (ten times) scramjet combustor from Mach 3.5 to Mach 7. 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 CCEs. Continue to develop low internal drag flame stabilization devices and flight test engine components. Continue testing advanced materials for application to scramjet engines.

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

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Accomplishments/Planned Programs Subtotals	19.074	27.095	28.612

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
623048: *Combustion and Mechanical Systems*	-	11.482	10.574	10.833	0.000	10.833	11.010	11.206	11.421	11.646	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. This effort 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 2016	FY 2017	FY 2018
Title: Combustion Technologies	4.454	4.402	4.510
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 2016 Accomplishments: Continued development of combustor, augmentor, constant volume combustion and pressure gain combustion technologies such as rotating detonation engines (RDEs), Inner-turbine burners (ITBs), and ultra-compact combustors (UCCs) to enable the next generation of gas turbine engines, new engine cycles, and combined-cycles. Continued using advanced diagnostics to obtain high-quality datasets that can be made available to and used by academia and industry for model development. Maintained efforts to determine necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon systems.			
FY 2017 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. Maintain efforts to determine necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon systems. Support development of advanced computational fluid dynamics (CFD) models to reduce combustor			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
and augmentor design costs. Maintain efforts to determine necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon 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. Maintain efforts to determine necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon systems. Support development of advanced CFD models to reduce combustor and augmentor design costs. Maintain efforts to determine necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon systems. Continue program development in 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).			
Title: Diagnostic Technologies ***Description:*** Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary propulsion technologies. ***FY 2016 Accomplishments:*** Continued development and demonstration of diagnostic systems for high-bandwidth kiloHertz-MegaHertz (kHz-MHz) measurements of combustion chemistry and physics based on 1) time-division-multiplexed hyperspectral absorption spectroscopy, 2) pulse-burst lasers, and 3) ultrashort-pulse (picosecond, femtosecond) lasers. Continued application to engine test cells, and fielded systems. Initiated providing sufficient data to support CFD combustion model development. Specific efforts were focused on systems to achieve high-bandwidth imaging of non-reacting and reacting flows. Such systems were applied for seminal demonstration of full four-dimensional (4D) high-speed, volumetric imaging of reactant mixing, combustion species, and pollutant emissions (soot). ***FY 2017 Plans:*** Continue development and demonstration of diagnostic systems for high-bandwidth kHz-MHz measurements of combustion chemistry and physics based on 1) time-division-multiplexed hyperspectral absorption spectroscopy, 2) pulse-burst lasers, and 3) ultrashort-pulse (picosecond, femtosecond) lasers. Continue application to engine test cells and fielded systems. Continue to provide sufficient data to support CFD combustion model development. ***FY 2018 Plans:***	0.887	0.700	0.717

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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 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 capability in engine test cells and full-annular ground-test environments. Developing systems to provide portable measurement capability throughout engine development and testing.			
Title: Lubricant Technologies ***Description:*** Develop, test, and qualify advanced turbine engine lubricants. Generate and maintain military specifications for aviation engine lubricants. ***FY 2016 Accomplishments:*** Demonstrated Enhanced Ester (EE) oils in F119 and F135 Component Improvement Program (CIP) Accelerated Maturation Testing (AMT) engines in preparation for transition to F-22 & F-35. Began developing Grade 4 oil Phase-out plan (F-22 & F-35). Planned for F-22 & F-35 flight tests of EE oils. Initiated Research and Development (R&D) investigation of novel ionic fluids as potential lubricants for extreme environments (i.e., hi-Mach). ***FY 2017 Plans:*** Continue investigating advanced thermal management technologies for fuel efficient engines & beyond. Continue developing Grade 4 oil Phase-out plan (F-22 & F-35). Continue developing on-line lube system health monitoring technologies. Continue supporting warfighter on field-related mechanical system issues. ***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 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. Implement new lubricant traction models into updated bearing design codes. Continue supporting the warfighter on field-related mechanical system issues.	2.986	2.701	2.767
Title: Bearing Technologies ***Description:*** Develop and test advanced bearing material technology and bearing concepts for small, intermediate, and large-scale turbine engine applications.	3.155	2.771	2.839

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Completed full-scale bearing rig testing in support of adaptive, fuel efficient engines. Completed oil-free, foil bearing R&D in support of supersonic expendable engines and remotely piloted aircraft. Experimentally validated improved bearing material life model. Investigated failure mechanisms of advanced bearing alloys. Continued maturing active bearing thrust control system and fuse with engine prognostics health monitoring system for future efficient engines. Initiated development of active thrust-balance/ prognostic health management (PHM) system for large man-rated and medium-scale propulsion. ***FY 2017 Plans:*** Continue developing physics-based bearing life model based on bearing alloy fatigue & microstructural investigations, including bearing life factors for advanced bearing materials. Initiate in-house investigation of small magnetic bearings & oil-free bearings for small & medium scale unmanned aerial systems (UAS). Continue development of active thrust-balance/PHM system for large man-rated and medium-scale propulsion. ***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 UAS, hi-Mach cruise missile and low-cost engines. Integrate 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.			
Accomplishments/Planned Programs Subtotals	11.482	10.574	10.833

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
623066: *Turbine Engine Technology*	-	62.716	52.519	55.304	0.000	55.304	55.222	56.944	58.330	59.490	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 program 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 2016	FY 2017	FY 2018
Title: Turbofan/Turbojet Engine Core Technologies	30.572	23.523	24.770
Description: Develop core turbofan/turbojet engine components (i.e., compressors, combustors, and turbines) for fighters, bombers, sustained supersonic/hypersonic cruise vehicles, and transports. ***FY 2016 Accomplishments:*** Completed development of modeling and simulation tools for advanced components including coupled aerothermal models; highly loaded, low emissions combustion systems; and turbine durability designs. Performed structural assessment research of mechanical and turbine components operating in a realistic engine environment. Continued development of improved compressor aerodynamic design tools to extend engine operability and efficiency. Completed detailed design of efficient, very high pressure ratio core component technologies. ***FY 2017 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 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.			
Title: Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies	25.872	23.589	24.840

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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 2016 Accomplishments:*** Completed preliminary designs of an adaptive engine to reduce specific fuel consumption reduction by up to 35% for embedded high bypass turbofans, and for sustained supersonic strike applications. Continued development of modeling and simulation tools, including methods to predict behavior of serpentine inlets and nozzles. Initiated rig tests to validate modeling and simulation tools to predict fan/inlet interaction for both podded and embedded propulsion systems. Completed rig tests to validate probabilistic ignition prediction tool for advanced augmentor design system. Validated models for function and durability of high temperature electronics for engine control. ***FY 2017 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. ***FY 2018 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. Identify control technology elements applicable to integrated propulsion/power/thermal solutions. Define actionable indicators and assess interface control gaps to enable decision-based informed lifecycle tools.			
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 2016 Accomplishments:*** Completed development of advanced modeling and simulation tools for variable cycle component design, advanced cooling concepts, compact augmentors, and composite structures. Continued to demonstrate advanced component designs in rig testing. Utilized validation data to develop improved test protocol for small engine augmentor designs. ***FY 2017 Plans:***	4.975	4.424	4.659

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continue to demonstrate advanced component designs in rig testing. Continue to utilize validation data to develop improved test protocol for small engine augmentor designs. Initiate 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. ***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. Develop and validate parameter, process, and performance modeling for components manufactured through additive technologies. Develop and validate rules and tools to enable flexible design for targeted life.			
Title: Turboshaft/Turboprop and Small Turbofan Engine Technologies ***Description:*** Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. ***FY 2016 Accomplishments:*** Continued to refine and apply advanced modeling and simulation tools for advanced cooling concepts, high efficiency gearboxes, and high performance airfoils. Demonstrated advanced vibration and temperature sensors for use in engine durability testing. ***FY 2017 Plans:*** Continue development and validation of modeling and simulation tools to achieve very high levels of loading for advanced low pressure turbine components. Continued to refine and apply advanced modeling and simulation tools for advanced cooling concepts, high efficiency gearboxes, and high performance airfoils. ***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. Begin exploration of advanced integrated engine controls with potential for synergistic airframe system level benefits.	1.297	0.983	1.035
Accomplishments/Planned Programs Subtotals	62.716	52.519	55.304

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623066 / *Turbine Engine 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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
623145: *Aerospace Power Technology*	-	28.240	34.703	34.736	0.000	34.736	36.287	37.715	36.386	35.658	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. 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 2016	FY 2017	FY 2018
Title: High Power System Technologies	28.240	34.703	34.736
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 2016 Accomplishments:*** Continued development of system and component electrical power, electro-mechanical, and thermal technologies for high-power applications. Continued development of hybrid approaches to power generation, storage, and application as well as thermal management. Continued testing of subsystems hardware in conjunction with continued platform level tip-to-tail modeling and simulation energy optimization. Completed integrated ground demonstration of adaptive power and thermal management system for next generation air platforms. Completed power, thermal and propulsion architecture study for future air platforms. Continued development of advanced, safe energy storage, power distribution, and management systems to include Silicon Carbide applications and batteries. Initiated power and thermal development toward demonstration of tactical aircraft high-power payload capability, e.g. laser weapon system. ***FY 2017 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			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
demonstration of tactical aircraft high-power payload capability, e.g. laser weapon system. Complete design of laser weapon system demonstration architecture. ***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.			
Accomplishments/Planned Programs Subtotals	28.240	34.703	34.736

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
624847: *Rocket Propulsion Technology*	-	58.121	56.278	58.594	0.000	58.594	58.472	60.354	61.735	62.950	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Fuel Technologies	6.461	6.854	7.136
Description: Develop, characterize, and test advanced hydrocarbons, energetics, solid propellants, and monopropellants to increase space launch payload capability and refine new synthesis methods.			
FY 2016 Accomplishments: Completed scale up methods for removing components from fuels that adversely affect fuel coking in rocket engine environments. Continued to evaluate scaled-up propellants in advanced combustion devices to determine materials compatibility and performance to include supporting large-scale motor tests. Continued to develop advanced binder systems to enable use of advance solid propellant ingredients with significant improvements over state-of-the-art. Continued to utilize 60-liter batch reactor to supplement micro continuous flow technology for the production of propellant ingredients. Continued development and characterization of next generation ionic liquid propellants for use in spacecraft and missile defense applications. Evaluated the effects of ingredient variability on solid propellant properties and ageing characteristics.			
FY 2017 Plans: Develop robust binder systems compatible with advanced energetic materials to significantly improve the performance of state-of-the-art solid propellants. Produce modular micro plant, which will allow for the production of desired chemicals on-demand. Promote acoustic resonant mixing in order to improve the homogeneity and reproducibility of solid propellant formulations. Develop scaled-up propellants for use in large-scale motor tests. Continue development and characterization of next generation			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
ionic liquid propellants for use in spacecraft and missile defense applications. Support NASA's Green Propellant Infusion mission to demonstrate a non-toxic ionic liquid based propulsion system in space. ***FY 2018 Plans:*** Continue developing solid rocket propellant binder systems for intended use across a variety operationally relevant conditions. 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. Transfer knowledge for making green monopropellants to the United States industrial base. Formulate, scale-up, and evaluate formulations of solid and liquid rocket propellants. Identify, evaluate, and adapt 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 fabrication techniques to enable high mass-fraction rocket motor cases. Initiate high-performance bi-propellant synthesis and formulation.			
Title: Liquid Engine Combustion Technologies ***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 2016 Accomplishments:*** Continued evaluation of injector concepts in hot fire conditions. Continued efforts looking at multi-injector designs and control effectors. Continued transition of candidate injector technologies to industry. Continued hot fire tests in combustion stability rig. Continued combustion stability modeling critical to supporting future hydrocarbon fueled liquid rocket engines. Developed reduced chemical kinetic mechanism for fuel combustion implementable in computational fluid dynamics (CFD) simulations (first & second phase: 1 to 80 atmospheres of pressure). Experimentally evaluated novel cooling channel designs developed via additive manufacturing. Extended modeling and simulation of fuel film cooling to include additional physical effects in order to close gaps with experimental data. Continued developing understanding of hydrocarbon fuel production, what components affect fuel coking and should be removed from the fuel (or added) during the production process, and how fuels can be engineered with a purpose. Completed a test article that enables heat transfer tests at conditions relevant to full scale boost engines in a laboratory environment. Continued to evaluate and develop advanced material solutions for high temperature components in rocket engines. Continued to develop high performance compact liquid rocket engine technologies. ***FY 2017 Plans:*** Continue evaluation of injector concepts in hot-fire conditions. Continue examination of multi-injector designs and control effectors. Deliver 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. Deliver combustion stability codes to rocket community, enabling more robust and stable engine designs. Continue developing understanding of hydrocarbon fuel	6.353	6.837	7.118

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
production, what components affect fuel coking and should be removed from the fuel (or added) during the production process, and how fuels can be engineered with a purpose. Employ 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. Develop refractory metallic film deposition techniques for application in catalytic thrusters. ***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. Deliver 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. Deliver 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. Employ 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).			
Title: Advanced Liquid Engine Technologies	17.610	17.906	18.644
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 2016 Accomplishments:*** Continued to develop enabling Hydrocarbon Boost (HCB) technology for future spacelift concepts and continued risk reduction activities for the development of HCB technologies (turbopump assembly, thrust chamber assembly). Completed Critical Design Review for the full-scale Preburner. Initiated long-lead fabrication of the Preburner. Began exploring engine concepts for next generation, beyond 2035, launch vehicles and concepts to effect cost reductions. Also explored changing facility needs and requirements to support characterization of components and research demonstrators. ***FY 2017 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. Continue exploring changing facility needs and requirements to support characterization of components and research demonstrators. ***FY 2018 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Complete architecture and cost-benefit study for next generation liquid propulsion, with efforts focused on modularity and cost reduction. 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.			
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 2016 Accomplishments:*** Completed support of NASA flight of Air Force Research Laboratory (AFRL) non-toxic monopropellant (replaces toxic monopropellant currently used in spacecraft). Conducted scale-up of advanced monopropellants and evaluated advanced ignition schemes and chamber concepts, including integration of advanced plume diagnostic capabilities. Continued development of next-generation high power electric spacecraft propulsion for increased efficiency, operability, and flexibility. Continued advanced modeling and simulation tool developments to improve design and analysis tools for a wide range of spacecraft propulsion concepts/technologies, to incorporate new concepts/technologies, and to model electric propulsion and chemical thruster physics accurately. Transitioned initial version of new thruster/plume modeling framework to spacecraft industry for use in future designs. Explored and developed new generation of chemical spacecraft thruster technologies. ***FY 2017 Plans:*** Continue scale-up research of the advanced monopropellant (AF-M315E) and continue supporting demonstrations of advanced ignition schemes and chamber concepts. Improve upon baseline plume diagnostic capabilities. Continue development of next-generation high power electric spacecraft propulsion, with efforts focused on two competing technology paths. Continue advanced modeling and simulation tool developments to improve design and analysis tools for a wide range of spacecraft propulsion concepts/technologies. Extend efforts to develop high fidelity modeling and simulation tools for both chemical and electric propulsion thrusters. Continue transition of new thruster/plume modeling framework to spacecraft industry for use in future designs. Release version 2 beta code to industry partners and provide user support. Explore and develop new generation of bipropellant chemical spacecraft thruster technologies. ***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. Support maturation of advanced plume diagnostics for both chemical and electric propulsion thrusters with potential for integrated state-of-health application. Expand 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	12.383	13.190	13.732

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Title: Space Access and Strike Applications ***Description:*** Develop missile propulsion and boost technologies for space access and strike applications. ***FY 2016 Accomplishments:*** Continued to develop advanced tactical propulsion. Continued development and evaluation of next generation of updated, physics-based modeling, simulation, and analysis tools for missile propulsion components and applications. Continued to develop advanced component technologies for missile propulsion applications for strategic and strike systems helping to ensure their long-term sustainment. Continued propellant development efforts including long-life propellants. ***FY 2017 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 use of tools in upcoming 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. Develop 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 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. Continue used tools in upcoming 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.	7.132	7.146	7.440
Title: Ballistic Missile Technologies ***Description:*** Develop missile propulsion technologies and aging and surveillance technologies for ballistic missiles. ***FY 2016 Accomplishments:*** Continued to apply next generation of chemical and aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, and non-destructive analysis tools. Continued advanced sensor development efforts to further improve data acquisition and reduce uncertainty in ballistic missile life predictions. Supported transition of previous tools, models, data management system to user. Improved the fidelity and precision of non-destructive evaluation tools, improving capability to determine flaw size,	4.582	4.345	4.524

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
orientation, and location. Initiated long-term validation of tools through long-term aging of sub-scale motors. Continually monitored and periodically tested sub-scale motors to validate the sensor and complete analytical analysis of each motor. ***FY 2017 Plans:*** Continue to apply next generation of chemical and aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, to user. Continue advanced sensor development efforts to further improve data acquisition and reduce uncertainty in ballistic missile 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 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.			
Accomplishments/Planned Programs Subtotals	54.521	56.278	58.594

	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** Conducted Congressionally directed efforts	3.600	-
Congressional Adds Subtotals	3.600	-

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
625330: *Aerospace Fuel Technology*	-	4.865	4.502	4.616	0.000	4.616	4.690	4.772	4.868	4.967	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 2016	FY 2017	FY 2018
Title: Alternative Fuels	0.195	0.100	0.102
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 2016 Accomplishments: Continued to evaluate advanced cellulosic alternative fuels being considered for addition to commercial aviation jet fuel, which Air Force (AF) will use due to conversion to new fuel standards.			
FY 2017 Plans: Continue to evaluate advanced alternative fuels being considered for addition to commercial aviation jet fuel, which AF will use due to conversion to new fuel standards.			
FY 2018 Plans: Complete evaluations of fully-synthetic jet fuels produced from alcohol and triglyceride feedstocks.			
Title: Integrated Thermal and Energy Management	1.468	1.401	1.437
Description: Develop and demonstrate advanced components and conduct performance assessments of advanced aircraft integrated thermal and energy management systems for engines and aircraft.			
FY 2016 Accomplishments: Evaluated fuel-based closed-loop liquid precooler systems for tactical air platforms. Optimized the composition of next generation endothermic fuel for use with catalysts for maximum heat sink and reduced coking.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continue to develop fuel and catalyst approaches to improve endothermic fuel heat sink and minimize coking. ***FY 2018 Plans:*** Evaluate advanced additives, catalysts, and fuel composition approaches to minimize endothermic fuel coking.			
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 2016 Accomplishments:*** Evaluated AF capability to reduce/eliminate fuel additives F-24/Jet A. ***FY 2017 Plans:*** Continue to develop tools to link changes in F-24/Jet A fuel composition over time with fuel properties and performance including infrastructure. ***FY 2018 Plans:*** Develop fuel temperature limits for full-life fuel systems as part of integrated power and thermal management systems	1.468	1.401	1.437
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 2016 Accomplishments:*** Initiated combustor/hot section materials durability study as a function of fuel composition. ***FY 2017 Plans:*** Evaluate fuel composition effects on operability and emissions of advanced developmental combustors and engines. ***FY 2018 Plans:*** Complete Aerospace Recommended Practice (ARP) for particulate emissions measurements for engine certification, joint with Federal Aviation Administration (FAA), NASA, and industry.	1.734	1.600	1.640
Accomplishments/Planned Programs Subtotals	4.865	4.502	4.616

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 625330 / *Aerospace Fuel Technology*

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	151.264	155.174	152.782	0.000	152.782	151.000	156.290	159.190	165.280	Continuing	Continuing
622002: *Electronic Component Technology*	-	37.851	41.326	38.522	0.000	38.522	37.679	39.576	40.557	41.479	Continuing	Continuing
622003: *EO Sensors & Countermeasures Tech*	-	27.169	21.535	24.473	0.000	24.473	24.901	26.989	27.509	28.050	Continuing	Continuing
622005: *Cyber Technology*	-	0.000	10.200	6.428	0.000	6.428	6.516	6.620	6.735	6.866	Continuing	Continuing
626095: *Sensor Fusion Technology*	-	26.726	35.322	32.370	0.000	32.370	32.205	32.975	33.566	36.376	Continuing	Continuing
627622: *RF Sensors and Countermeasures Tech*	-	59.518	46.791	50.989	0.000	50.989	49.699	50.130	50.823	52.509	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 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 (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

Starting in FY 2017 to improve reporting to Congress, Project 622005, Cyber Technology was created to capture all cyber activity that was previously performed in this program.

In FY 2018, a portion of HQ AFRL S&T civilian manpower in PE 0602204F, Aerospace Sensors, 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 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 technology performance parameters.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	152.175	155.174	162.992	0.000	162.992
Current President's Budget	151.264	155.174	152.782	0.000	152.782
Total Adjustments	-0.911	0.000	-10.210	0.000	-10.210
• 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	0.565	0.000			
• SBIR/STTR Transfer	-1.476	0.000			
• Other Adjustments	0.000	0.000	-10.210	0.000	-10.210

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 627622: *RF Sensors and Countermeasures Tech*		
Congressional Add: *Program Increase*	5.000	-
Congressional Add Subtotals for Project: 627622	5.000	-
Congressional Add Totals for all Projects	5.000	-

Change Summary Explanation

Decrease in FY 2018 is due to realignment for autonomy and laser weapons systems priorities and transfer of some HQ AFRL civilian manpower to PE 0602298F, Science and Technology Management - Major Headquarters Activities.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622002: *Electronic Component Technology*	-	37.851	41.326	38.522	0.000	38.522	37.679	39.576	40.557	41.479	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project focuses on the electronics and optoelectronics to generate, control, receive, and process electromagnetic spectrum for aerospace sensor and electronic warfare applications. The enabling technologies developed under this project will be used for intelligence, surveillance, reconnaissance (ISR), electronic warfare, battlespace access, and precision engagement capabilities. The technologies developed include exploratory electronic and optoelectronic device concepts; solid state power devices and amplifiers; low noise and signal control components; photonic components; high-temperature electronics; signal control and distribution; signal processing; multi-function monolithic integrated circuits; high-speed analog-to-digital and digital-to- analog mixed mode integrated circuits; reconfigurable electronics; power distribution; multi-chip modules; and high density packaging and interconnect technologies. This project also designs, develops, fabricates, and evaluates techniques 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, electronic warfare, navigation, and smart weapons.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Multifunction Sensor Subsystems	9.130	9.961	9.284
Description: Develop, analyze, demonstrate, and perform engineering trade studies for technologies for compact, affordable, multi-function microsystems and subsystems for aerospace sensors. ***FY 2016 Accomplishments:*** Completed baseline and advanced microsystem and subsystem models for use in trade space simulations. Initiated prototype multi-function microsystem and subsystem demonstrations. ***FY 2017 Plans:*** Continue microsystem and subsystem simulations to quantify performance versus cost, size, weight, power, trusts trades. Continue to develop and optimize multi-function prototypes. Refine fidelity of models for multifunction subsystem concepts. ***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 development of microsystem/subsystem prototypes for attritable platforms.			
Title: Microelectronic/Optoelectronic Technologies	10.043	10.987	10.242

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Assess, mature and demonstrate advanced electronic and optoelectronic material, device and fabrication technologies for next generation imaging, precision strike, and battlespace access across all Air Force domains. ***FY 2016 Accomplishments:*** Identified and evaluated several innovative concepts for generation-after-next, compact, high performance devices and circuits and microsystems. Demonstrated prototype of a highly integrated microsystem. Refined tools and methods to design, build and analyze game changing component technologies. Initiated evaluation of emerging component technologies against device concept baseline for multi-use applications. ***FY 2017 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 exploration and identification of emerging device concepts exploiting breakthrough materials discovery. ***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 prototype from identified emerging device concepts.			
Title: Apertures (was Antennas) ***Description:*** Design and develop aperture subsystems and components for airborne and space-based surveillance. Develop novel and advanced optoelectronic and infrared technologies for volume, power and cost-constrained platforms. ***FY 2016 Accomplishments:*** Continued development and demonstrations of multi-wavelength, agile and affordable advanced detectors and arrays. Explored and evaluated innovative devices and microsystems for increased multi-wavelength and tunability. Completed characterization and evaluation of novel high-brightness and agile waveform source. ***FY 2017 Plans:*** Continue to explore and evaluate innovative materials and devices for tunability, increased bandwidth and multi-wavelength operation. Continue demonstration of current advanced multi-wavelength, agile and affordable advanced detector and array. Initiate gimbal-less beamsteering prototype. ***FY 2018 Plans:*** 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.	5.363	5.851	5.454
Title: Trusted Systems for ISR and Avionics Systems	6.128	6.686	6.232

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Investigate and develop designs of trusted electronic and optoelectronic systems when integrating commercially available solutions (commercial-off-the-shelf (COTS)) with emerging government-off-the-shelf (GOTS) advanced technologies. Areas of development include: multi-function RF and EO subsystems, advanced electronic and optoelectronic materials, on-board sensor processing, high-frequency power modules, EO/Infrared (IR) sources, EO/IR detectors, beam control and waveguides, and trusted and reliable electronics. ***FY 2016 Accomplishments:*** Demonstrated preliminary verification and validation tool for integrity and reliability of electronics and integrated circuits. Initiated vulnerability model and simulation capability to assess cost and liability of trust in electronics. ***FY 2017 Plans:*** Continue modeling and simulation architecture development to inform and predict system assurance for highly integrated microsystems, devices and materials. Demonstrate current ability to determine trust in design and trust in fabrication of highly integrated microsystems. ***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.			
Title: Advanced Components for Electronic Warfare ***Description:*** Develop, mature, and demonstrate critical electronic technologies to enable revolutionary electronic warfare subsytems. ***FY 2016 Accomplishments:*** Demonstrated cutting edge electronics technologies for reconfigurable and agile RF front ends. Initiated highly reconfigurable microsystem prototype. ***FY 2017 Plans:*** Continue development of highly reconfigurable microsystem prototype. Initiate reconfigurable and agile RF front end prototype. Initiate investigation and demonstration of integrated photonic circuits. ***FY 2018 Plans:*** Complete reconfigurable and agile RF front end prototype. Continue development of highly reconfigurable microsystem prototype. Continue investigation and development of integrated photonic circuit prototype.	7.187	7.841	7.310
Accomplishments/Planned Programs Subtotals	37.851	41.326	38.522

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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)

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622003: *EO Sensors & Countermeasures Tech*	-	27.169	21.535	24.473	0.000	24.473	24.901	26.989	27.509	28.050	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 (UV) through the infrared (IR) 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. 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 2016	FY 2017	FY 2018
Title: Passive EO/IR Sensing in Contested Environments	9.038	7.178	8.157

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 ISR and air-to-air sensing.

FY 2016 Accomplishments:

Evaluated, via modeling and simulation, innovative sensor concepts to increase long range image quality for high altitude passive EO and IR reconnaissance sensors. Investigated system-level impacts of image restoration technology (hardware and software) using a commercial reconnaissance sensor and platform. Completed prototyping of a flexible, next generation long wave infrared hyperspectral imaging spectrometer. Completed evaluations of prototype Silicon-Gallium (SiGa) long wave infrared detectors at high operating temperatures. Completed investigation of high performance long wave infrared detectors for hyperspectral imaging. Study of computational image restoration and noise reduction continues. Continue to refine and demonstrate candidate component technologies for jitter mitigation and restoration in the presence of deep turbulence. Initiated technology developments for next generation infrared search and track (IRST) components and systems.

FY 2017 Plans:

Continue to evaluate, via modeling and simulation, innovative sensor concepts to increase long range image quality for high altitude passive EO and IR reconnaissance sensors. Conduct laboratory test of prototype systems and subsystems as appropriate to assess progress towards goals. Continue advance demonstrations of the effectiveness of computational image restoration and noise reduction. Refin and demonstrated candidate component (hardware and software) technologies for jitter mitigation and restoration in the presence of deep turbulence. Demonstrate and test system-level impacts of image restoration technology using

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
a relevant reconnaissance sensor and commercial platform. Continue the examination of non-traditional sensor architectures in improving image quality and the operational range of passive imagers. Continue technology and architecture developments for next generation IRST components and systems. Improve passive sensing models to support IRST technology trade analyses. Initiate assessment of technology options for hyperspectral imaging on small uninhabited aerial systems (UAS) for Air Force relevant missions. Initiate systems engineering strategy to examine cross domain EO sensing for Air Force relevant missions. ***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 EO and IR 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 uninhabited aerial systems (UAS) and advance their technology readiness level. Continue next generation IRST architecture and component development to improve system performance in clutter. Test these component prototypes in a laboratory environment. Improve passive sensing models to support IRST technology trade analyses. Examine potential new capabilities resulting from a systems engineering strategy on cross domain EO 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.			
Title: Laser Radar Sensing in Contested Environments ***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 2016 Accomplishments:*** Achieved synthetic aperture ladar (SAL) subsystem performance goal critical to meeting system level performance requirements. Increased emphasis on applications for long range air-to-air ladar updating modeling and simulation, phenomenology measurement capabilities and to support utility analysis and system design and evaluations. Conducted laboratory testing of initial foundry runs of focal planes optimized for three dimensional and holographic imaging. Designed next generation long range holographic aperture ladar imaging testbed focused on progression to platform compatible configurations. Tested prototype hardware for laser vibrometry and range-Doppler sensing technology to aid in target identification and decoy discrimination. Continued research in supporting phenomenology understanding, signature collection, sensor product visualization, and automatic target recognition. Continued development of SAL techniques based on modeling and simulation previously conducted to enhance spatial resolution beyond the diffraction limit of the available aperture. Researched parameters necessary for improving system capabilities to provide high confidence target identification at standoff ranges for both reconnaissance and targeting platforms. Continued fabrication and characterization of critical components for a long range SAL demonstration system. Initiated	18.131	14.357	16.316

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
assessment of technology options for ladar-based 3D imaging on small uninhabited aerial systems (UAS) for Air Force relevant missions. ***FY 2017 Plans:*** Complete fabrication and characterization of critical components for a long range SAL demonstration system. Complete laboratory testing of initial foundry runs of focal planes optimized for holographic imaging. Continued research in the use of remote laser vibrometry and range-Doppler sensing technology to aid in target identification. Continue research on technologies, architectures, and components needed for improving system capabilities to provide high confidence target. Advance development of SAL techniques to enhance spatial resolution beyond the diffraction limit of conventional optics. Design, fabricate, test, and explor limitations of next-generation long-range holographic aperture ladar imaging testbed focused on progression to platform compatible configurations. Test integrated direct detection ladar prototype and advance its technology readiness level. Increase emphasis on applications for long range air-to-air ladar updating modeling and simulation, phenomenology measurement capabilities and to support utility analysis and system design and evaluations. Initiate assessment of technology options for ladar-based 3D imaging on small uninhabited aerial systems (UAS) for Air Force relevant missions. ***FY 2018 Plans:*** Complete testing of next generation long range holographic aperture ladar 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 SAL 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 SAL techniques for enhancing spatial resolution beyond the diffraction limit of conventional optics in a laboratory environment. Conduct laboratory tests of prototype remote laser vibrometry and range-Doppler sensing technology to aid in target identification. Initiate investigation of advanced system architectures and evaluate candidates. This additional emphasis will involve both direction and synthetic aperture ladar approaches. Continue assessment of technology options for ladar-based 3D imaging on small uninhabited aerial systems (UAS) for Air Force relevant missions. Explore concepts for multi-function systems which also support electro-optical threat warning and countermeasures functions. Execute applied research to investigate technologies for improved sensor systems for integration with high-average power laser sources for proactive detection and defeat of EO threats such as search/track sensors, night vision devices, thermal cameras, missile seekers and other adjunct sensors for integrated air defense systems. Investigate technologies for cost, size, weight and power (C-SWaP) reduced multi-function systems for unmanned platforms and SWAP constrained platforms.			
Accomplishments/Planned Programs Subtotals	27.169	21.535	24.473

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622003 / *EO Sensors & Countermeasures Tech*

C. Other Program Funding Summary ($ in Millions)

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622005: *Cyber Technology*	-	0.000	10.200	6.428	0.000	6.428	6.516	6.620	6.735	6.866	Continuing	Continuing

A. Mission Description and Budget Item Justification

Project 622005, Cyber Technology was new in FY 2017. Work from this effort was previously performed under Project 627622, RF Sensors and Countermeasures Tech, in this program.

The goal of this activity is twofold. First, this effort is designed to advance 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/mitigated/protected. Second, this effort 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Vulnerability Mitigation (was Malware Detection)	0.000	4.453	2.806

Description: Apply knowledge from computer vulnerability discovery and computer security to investigate capabilities for identifying and mitigating vulnerabilities in U.S. 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 2016 Accomplishments:
N/A

FY 2017 Plans:
For FY 2016, the work for this effort was performed in Project 627622, RF Sensors and Countermeasures Tech, under the effort RF Sensor Technologies.

Develop common classes/groups of vulnerabilities and characterize advanced hardware (such as multi-core processors and intelligent I/O interfaces), real time operating systems, and emerging open avionics standards. In parallel develop methods, techniques, and technical tools to enable, assist, and improve the efficiency of assessments and vulnerability discovery processes. These tools and techniques will be developed to be applied to the assessment of avionics boxes, systems, busses, and components.

FY 2018 Plans:
Based on the vulnerabilities discovered in FY17 effort and the characterized hardware: Investigate means to automate and make scalable vulnerability assessment tools and techniques. Investigate systematic methodologies to achieve repeatable and reliable

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Title: Adaptive Cyber Protections ***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 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** For FY 2016, this work was performed in Project 627622, RF Sensors and Countermeasures Tech, under the effort RF Sensor Technologies. Develop testbed to apply and evaluate protection tools and techniques. Applied knowledge of existing x86 protections to avionics real time operating system (RTOS) environment. Investigate applicability of existing x86 based protections to avionics. Leverage and enhance existing protection concepts for application in avionics environments. ***FY 2018 Plans:*** From knowledge gained in FY17 efforts on protection concepts for application will continue avionics protections research into real-time software/hardware monitoring tools. Apply these techniques to next-generation ISR and avionics system architectures to investigate avionics malware detection and response protection system.	0.000	5.747	3.622
Accomplishments/Planned Programs Subtotals	0.000	10.200	6.428

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
626095: *Sensor Fusion Technology*	-	26.726	35.322	32.370	0.000	32.370	32.205	32.975	33.566	36.376	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 and ISR, 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 U.S. 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 2016	FY 2017	FY 2018
Title: Target Signature Modeling	3.726	4.919	4.508
Description: Develop, evaluate, and demonstrate target signature models to support sensor exploitation algorithm development and testing for reconnaissance and strike mission applications.			
FY 2016 Accomplishments: Continued development of all-source target models for emerging threat systems in contested environments. Demonstrated maturing methods for validating all-source signature models. Continued maturing promising approaches to develop a single target model for application to all parts of the spectrum. Developed ground clutter modeling and reduced feature-set target signature prediction techniques for radio frequency sensors. Initiated controlled data collections and high resolution feature database for emerging sensors. Initiated implementation of advanced theoretical approaches to salient feature extraction from limited sensor data.			
FY 2017 Plans: Continue development of all-source target models for emerging threat systems in contested environments. Continue to demonstrate maturing methods for validating all-source signature models. Continue efficient target modeling representation to enable more rapid model development and reduced database storage requirements. Continue maturing promising approaches to develop a single target model for application to all parts of the spectrum. Continued ground clutter modeling. Reduce feature-set			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
target signature prediction techniques for radio frequency sensors. Continue controlled data collections and high resolution feature database for emerging sensors. Continue implementation of advanced theoretical approaches to salient feature extraction from limited sensor data. ***FY 2018 Plans:*** Continue development of all-source target models for emerging threat systems in contested environments. Demonstrate maturing methods for validating all-source signature models. Demonstrate ground clutter modeling and reduced feature-set target signature prediction techniques for radio frequency sensors. Continue controlled data collections and high resolution feature database for emerging sensors. Continue advanced theoretical approaches to salient feature extraction from limited sensor data.			
Title: Sensor Exploitation Technologies ***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. ***FY 2016 Accomplishments:*** Initiated analysis of sensor data where the transmitter and receiver are from distinct platforms or sensing devices. Developed and assessed techniques for near real time extraction, representation, and analysis of multi-dimensional information from image sequences. Continued development of novel techniques for analysis of large sensor data sets to discover, characterize, and identify threatening activities in contested environments. Continued to demonstrate application of sensor and algorithm performance models in Planning and Direction, Collection, Processing and Exploitation, Analysis and Production, Dissemination, Experimental Cell (PCPAD-X). Continued to enhance development of an integrated, unified ATR methodology through industry and university outreach. ***FY 2017 Plans:*** Continue analysis of sensor data where the transmitter and receiver are from distinct platforms or sensing devices. Develop and assessed techniques for near real time extraction, representation, and analysis of multi-dimensional information from image sequences. Continue development of novel techniques for analysis of large sensor data sets to discover, characterize, and identify threatening activities in contested environments. Continue to enhance development of an integrated, unified ATR methodology through industry and university outreach. Finish application of sensor and algorithm performance models in PCPAD-X. ***FY 2018 Plans:*** Continue analysis of sensor data where the transmitter and receiver are from distinct platforms or sensing devices. Develop and assess techniques for near real time extraction, representation, and analysis of multi-dimensional information from image sequences. Continue development of novel techniques for analysis of large sensor data sets to discover, characterize, and identify threatening activities in contested environments. Demonstrate target classification techniques through deep learning	5.682	7.504	6.877

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
methods and state of the art neural network methods. Develop embedded implementations of deep learning methods on small SWaP platforms.			
Title: Sensor Management for ATR	13.540	17.910	16.413
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 (multi-INT) data fusion capabilities. Assess advantages of multi-sensor closed loop control techniques for platform survival, command and control, ISR, and strike missions. Enhance existing ATR sensor management, and sensor fusion technologies by application of multi-sensor data and distributed data processing. ***FY 2016 Accomplishments:*** Explored multi-sensor inference and control approaches for autonomous operations. Developed metrics for assessing multi-sensor control techniques with regard to assured threat avoidance and optimal sensor positioning. Initiated size-weight-power-constrained processing assessment approaches for future platform on-board processing of multi-sensor data. Defined and developed multi-sensor performance assessment approaches for inclusion in PCPAD-X. ***FY 2017 Plans:*** Demonstrate exploration of multi-sensor inference and control approaches for autonomous operations. Continue to develop metrics for assessing multi-sensor control techniques with regard to assured threat avoidance and optimal sensor positioning. Develope size-weight-power constrained processing assessment approaches for future platform on-board processing of multi-sensor data. ***FY 2018 Plans:*** Continue exploration of multi-sensory inference and control approaches for autonomous operations. Continue use of metrics for assessing multi-sensor control techniques with regard to assured threat avoidance and optimal sensor positioning. Continue size-weight-power constrained processing assessment approaches for future platform on-board processing of multi-sensor data. Develop joint inference and control methods for challenging autonomous sensor operations management.			
Title: Distributed Sensing for ATR	3.778	4.989	4.572
Description: Develop techniques and metrics for adaptive, penetrating, distributed RF exploitation in contested environments. ***FY 2016 Accomplishments:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Developed bi-static phenomenology models. Designed new waveforms to exploit bi-static RF phenomenology. Developed a systems theory for incorporating identification uncertainty in ATR algorithms. Developed distributed exploitation algorithms. Designed a closed loop sensor mode controller for adaptive transmit and receive. ***FY 2017 Plans:*** Continue to develop bi-static phenomenology models. Continue to design new waveforms to exploit bi-static RF phenomenology. Continue to develop a systems theory for incorporating identification uncertainty in ATR algorithms. Continue to develop distributed exploitation algorithms. Continue to design a closed loop sensor mode controller for adaptive transmit and receive. Collect operationally relevant data for distributed sensing experimentation. ***FY 2018 Plans:*** continue to develop bi-static phenomenology models. Demonstrate new waveforms to exploit bi-static RF phenomenology. Continue to develop a systems theory for incorporating ID uncertainty in ATR algorithms. Demonstrate distributed exploitation algorithms on prior data collections. Continue to design a closed-loop sensor mode controller for adaptive transmit and receive.			
Accomplishments/Planned Programs Subtotals	26.726	35.322	32.370

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
627622: *RF Sensors and Countermeasures Tech*	-	59.518	46.791	50.989	0.000	50.989	49.699	50.130	50.823	52.509	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and assesses affordable, reliable all weather radio frequency (RF) sensing and countermeasure concepts for aerospace applications covering the range of RF sensors including communications, navigation, 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 RF 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 RF phenomenologies, multi-dimensional adaptive processing, advanced waveforms and knowledge-aided processing techniques. This project also develops the RF 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 air defense systems and hostile command and control networks. The project also exploits emerging technologies and components to provide increased capability for offensive and defensive RF sensors, including radar warning, RF electronic warfare, and electronic intelligence applications.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Hybrid Sensor Technologies	12.025	10.329	11.256
Description: Develop hybrid sensor solutions to be responsive to needs and detect difficult targets. Develop resilient position, navigation, and time (PNT) sensors. Explore PNT solutions to enable novel distributed RF sensing and countermeasure techniques. ***FY 2016 Accomplishments:*** Developed technologies to ensure robust and accurate navigation in GPS contested and denied environments. Matured navigation augmentation and GPS resilience technologies, such as taking advantage of signals of opportunity, as well as environmental sensing, such as vision or magnetic sensors, to improve inertial measurement unit aided navigation accuracy in GPS sparse or denied environments. ***FY 2017 Plans:*** Provide a robust simulation environment to validate GPS receiver operation in sparse and denied environments to ascertain areas which require additional research to maintain accurate geolocation reporting. ***FY 2018 Plans:*** Conduct research to provide optimal frameworks for hybrid navigation sensor integration and modeling and simulation.			
Title: RF Sensor Technologies	15.940	13.655	14.878

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Conduct applied research and development for the advancement of passive and active RF sensors; including phenomenology, modeling and simulation, algorithm development, and experimentation. Plan, execute, and maintain state-of-the-art RF sensor research and development facilities. Conduct research on sensing, learning, and adapting to enable the countering of emerging adaptive, agile RF threats. ***FY 2016 Accomplishments:*** Continued research and development of RF sensor technologies, including antennas, electromagnetic structures, propagation in plasma medium, computational electromagnetic modeling & simulation, and prototype experimentation for efficient combat identification capabilities. Developed agile, spectrally efficient, radar waveforms and robust distributed sensing techniques for dominance in non-traditional RF environments. Initiated development of electromagnetics forensics techniques for passive RF sensing and EW applications. Initiated research on fully polarimetric bistatic RF ground target and clutter phenomenology and relevant ground vehicle dynamics for RF sensing. ***FY 2017 Plans:*** For FY17 and beyond, advanced cyber technology development research under this effort will be reported in Project 622005, Cyber Technology, under efforts Malware Detection and Adaptive Cyber Protections. The RF and EW efforts will continue under this BPAC. Continue development of agile, spectrally efficient, radar waveforms and initiate robust distributed sensing techniques for dominance in non-traditional RF environments. Continue development of advanced electromagnetic forensics and illumination selection management techniques for passive RF and EW applications. Validate via exploratory research and development of fully polarimetric persistent representation of critical mobile targets and bistatic phenomenology with realistic low grazing angle experiments. Develop electromagnetics based modeling, simulation, and measurement tools for propagation, scattering, and radiation application to improve RF sensors capabilities. ***FY 2018 Plans:*** Continue to explore novel and advanced sensing technologies for use in demanding electromagnetic environments for future platform capability. Develop methods to electronically attack passive sensing systems used by red forces to degrade this capability.			
Title: Multi-Band/Multi-Beam Technologies ***Description:*** Develop multi-band and multi-beam forming technologies. Address technologies for antenna array operations in dynamic sensor networks.	10.876	9.342	10.181

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Developed conformal/planar RF antenna concepts from X-Band to Ka-Band. Demonstrated advanced geo-location algorithms for single and multiple platform operations. Continued research in advanced RF/electro-optical (EO) subsystem concepts to support expendable RF systems configurations. Continued research in highly integrated digital microsystems for reconfigurable and tunable capabilities. Initiated concepts to support expendable and affordable RF ISR sensors (radar, SIGINT, electronic support, and combat ID). ***FY 2017 Plans:*** Continue research and development of conformal/planar RF antenna concepts from C-Band to Ka-Band. Continue research in highly integrated digital microsystems for reconfigurable and tunable capabilities. Develop test-bed vehicle for static and dynamic testing of RF/EO sensors and algorithms. Expand concepts to support expendable RF ISR sensors (radar, SIGINT, electronic support, and combat ID), and demonstrate these capabilities for next-generation attritable platforms. Transition advanced geo-location algorithms for single and multiple platform into operational cases. ***FY 2018 Plans:*** Integrate conformal/planar RF antenna proof-of-concepts for multi-band(C and Ka-Bands) 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.			
Title: Sensor Resource Management	15.677	13.465	14.674
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 2016 Accomplishments:*** Continued research of advanced electronic support (ES) concepts and exploration of adaptable electronic attack (EA)/ES capabilities. Developed distributed sensor management techniques utilizing an open mission systems (OMS) context and service oriented architecture (SOA) common set of messages and data models. Used electronic warfare and communications as first functional disciplines to initiate SOA constructs. Initiated layered effects analyses on next generation RF based threats, counters and perform vulnerability assessments. Initiated operational architecture and mission services through common mission control center constructs. ***FY 2017 Plans:*** Continue research into effective management of electronic warfare assets in operational environments focusing on a multi-ship strike package employment. Conduct electro-magnetic/electronic warfare (EW) battle management optimization service research on electronic attack (EA) and electronic support (ES) and asses against current and future integrated air defense systems and RF			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
threats. Develop robust modeling and simulation capability to study the efficiency versus effectiveness of distributed electronic warfare assets. Initiate development of additional functional disciplines (radar, EO/IR, high energy laser) in the SOA and sensor resource optimization. Initiate bandwidth efficient communication protocol research to support collaborative state estimation techniques to enable common model referencing for positioning navigation and timing (PNT) in GPS denied environments. ***FY 2018 Plans:*** Continue demonstration of robust modeling and simulation capability to study the efficiency versus effectiveness of distributed EW assets including ES and EA capabilities. Continue research into effective management of EW 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 such as AFSIM, and under the construct of an OMS architecture. Continue to develop additional functional disciplines (radar, EO/IR, high energy laser) in the SOA and sensor resource optimization. Continue bandwidth efficient communication protocol research to support collaborative state estimation techniques to enable common model referencing for PNT in GPS denied environments.			
Accomplishments/Planned Programs Subtotals	54.518	46.791	50.989

	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** Conducted Congressionally directed effort.	5.000	-
Congressional Adds Subtotals	5.000	-

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	0.000	0.000	8.353	0.000	8.353	8.314	8.425	8.575	8.738	Continuing	Continuing
622520: *Science and Technology Management - Major HQ*	-	0.000	0.000	8.353	0.000	8.353	8.314	8.425	8.575	8.738	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 is an administrative realignment and not a new start. Funding in this exhibit was previously budgeted in the Air Force S&T RDT&E PEs listed above.

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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	8.353	0.000	8.353
Total Adjustments	0.000	0.000	8.353	0.000	8.353
• 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	8.353	0.000	8.353

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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*

Change Summary Explanation

In FY 2018, a portion of HQ AFRL civilian manpower was realigned from the following Air Force S&T RDT&E PEs: 0601102F, 0602102F, 0602201F, 0602203F, 0602204F, 0602601F, 0602601F, 0602602F, 0602605F, and 0602788F to establish the MHA baseline for AFRL.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622520: *Science and Technology Management - Major HQ*	-	0.000	0.000	8.353	0.000	8.353	8.314	8.425	8.575	8.738	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 is an administrative realignment and not a new start. Funding in this exhibit was previously budgeted in the Air Force S&T RDT&E PEs listed above.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: AFRL - Major Headquarters Activities	0.000	0.000	8.353
Description: Provide professional government civilian workforce in support of all AFRL programs and activities.			
FY 2016 Accomplishments: In FY 2016 and FY 2017, this effort was accomplished in the following programs: 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.			
FY 2017 Plans: N/A			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Provide professional government civilian workforce in support of all AFRL programs and activities.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	8.353

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	107.442	117.915	116.503	0.000	116.503	114.683	123.420	126.098	130.414	Continuing	Continuing
621010: *Space Survivability & Surveillance*	-	41.872	39.163	39.100	0.000	39.100	29.280	35.477	36.236	35.172	Continuing	Continuing
624846: *Spacecraft Payload Technologies*	-	12.128	15.732	15.841	0.000	15.841	16.021	16.480	16.770	17.154	Continuing	Continuing
625018: *Spacecraft Protection Technology*	-	14.817	19.411	21.720	0.000	21.720	25.548	26.818	27.170	27.323	Continuing	Continuing
628809: *Spacecraft Vehicle Technologies*	-	38.625	43.609	39.842	0.000	39.842	43.834	44.645	45.922	50.765	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program focuses on four major areas. First, space survivability and surveillance develops technologies to understand space weather and the geophysics environment for mitigation and exploitation of these effects to Air Force systems. Second, spacecraft payload technologies improve satellite payload operations by developing advanced component and subsystem capabilities. Third, spacecraft protection develops technologies for protecting U.S. 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 (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 0602601F, Space Technology, 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 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: FY 2018 Air Force					Date: May 2017
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	109.122	117.915	121.663	0.000	121.663
Current President's Budget	107.442	117.915	116.503	0.000	116.503
Total Adjustments	-1.680	0.000	-5.160	0.000	-5.160
• 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	-1.680	0.000			
• Other Adjustments	0.000	0.000	-5.160	0.000	-5.160

Change Summary Explanation

Decrease in FY 2018 due to realignment of funds for autonomy and Laser Weapon System priorities and transfer of some HQ AFRL civilian manpower to PE 0602298F, Science and Technology Management - Major Headquarters
Activities.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
621010: *Space Survivability & Surveillance*	-	41.872	39.163	39.100	0.000	39.100	29.280	35.477	36.236	35.172	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Space Environment Research	14.417	13.606	13.460

Description: Develop techniques, forecasting tools, sensors, and technologies for specifying, monitoring, predicting, and controlling space environmental conditions hazardous to DoD operational space and radar systems.

FY 2016 Accomplishments:
Continued developing requirement recommendations for operational space environment sensors necessary for rapid anomaly attribution in contested space. Continued developing predictive model for optical and dielectric spacecraft material property changes due to space environment aging. Initiated evaluation of prototype solar particle event prediction model, began evaluation for suitability to support operational needs. Continued exploitation of new on-orbit data sources to enhance energetic space environment models supporting spacecraft design and mission planning. Developed a suite of codes that will be used for attribution of satellite communication interference. Delivered block upgrades to address future needs of DoD satellite communication users. Developed models for error corrections caused by ionospheric disturbances and provided upgrades to the state-of-the-art model currently used for those corrections. Assessed future signature packages that should be added to the hypersonics flow solver. Continued the assessment of new geometry and material impacts on mission success for strategic systems.

In FY2016 and beyond, the Ionospheric Research effort has been combined with this effort in the same project to better align technical efforts.

FY 2017 Plans:
Finalize requirement recommendations for operational space environment sensors. Complete initial predictive model for optical and select dielectric spacecraft material property changes. Select improved solar magnetic field and energetic particle models for further development as future spirals of anomaly attribution tools. Begin analyzing and exploiting data from the on-orbit

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
radiation remediation proof-of-concept experiment and other on-orbit spacecraft. Assess impacts of the artic ionosphere on sensor systems. Create environment impact on space-ground radio frequency links attribution tool. Evaluate and refine Global Positioning System (GPS) radio frequency exploitation algorithms for global scintillation specification. Improve state-of-the-art solar magnetic flux transport model for more reliable forecast of solar radio and extreme ultraviolet flux levels. Derive an advanced ionosphere-thermosphere model using these parameters and evaluate the performance. Couple optical and infrared signature codes to the hypersonic solver. Support high temperature material on-orbit experiment. ***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 GPS 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.			
Title: Surveillance Technologies	8.144	7.990	8.202
Description: Develop advanced target detection techniques, spectral signature libraries, and decision aids for space-based sensors and surveillance systems. ***FY 2016 Accomplishments:*** Expanded evaluation of hyper temporal imaging (HTI) data processing methods and target detection algorithms to wider range of real-world and simulated target-background missile warning scenarios as well as to space-based imagery data that is compressed to reduce satellite downlink problems. Delivered detailed technical evaluation of potential HTI detection methods for concealed activity, including identification of technology gaps needing additional investigation for use in monitoring difficult threats. Initiated development of HTI space-based data collection events and ground truth field campaigns for new HTI flight experiment investigating advanced concept for early missile warning and dim target detection. ***FY 2017 Plans:*** Deliver algorithm testbed trade studies and benchmarked HTI target detection algorithms for improved detection of increasingly dim infrared target signatures commensurate with new and emerging space-based sensors having higher sensitivity for missile warning and battlespace awareness. Conduct trade studies of computational methods for compressing large amounts of data from missile warning satellites while maximizing target detection probabilities, minimizing false alarms, and mitigating satellite downlink issues. Provide final recommendations and complete study of the potential detection of concealed activity from space-based systems. Continue development of HTI space-based data collection events and ground truth field campaigns for new HTI flight experiment. Initiate modeling and laboratory studies to establish performance baseline for HTI-dedicated space experiment			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
for testing new capability option for early missile warning. Develop and implement methods for processing and exploiting HTI data for dim target detection in complex environments. ***FY 2018 Plans:*** Complete assessment of target detection methodologies for HTI-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 HTI-dedicated space experiment to continue evaluation of HTI 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.			
Title: Ionospheric Research ***Description:*** Develop techniques, forecasting tools, and sensors for ionospheric specification and forecasting, space-based geolocation demonstrations, and determination of potential radar degradation. ***FY 2016 Accomplishments:*** In FY 2016 and beyond, this effort is combined with the Space Environment Research effort in the same project to better align technical efforts.	0.000	-	-
Title: Radiation Remediation Research ***Description:*** Conduct Radiation Belt Remediation (RBR) research through developing and validating analytical performance models for remediation of Earth radiation belts following high altitude nuclear detonation. ***FY 2016 Accomplishments:*** Validated RBR end-to-end model version 3.0 using ground and space-based measurements with satellite and terrestrial experiments. Conducted fielded RBR capability assessments to determine rough order fielded system requirements. ***FY 2017 Plans:*** Complete fielded RBR capability assessments of ground and space based systems to determine rough order fielded system requirements. Perform reduction and exploitation of science data from the on-orbit radiation remediation proof-of-concept experiment in support of validation of the final spiral of the RBR end-to-end model. ***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.	4.634	3.946	2.625
Title: Seismic Technologies	7.340	6.565	6.281

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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 2016 Accomplishments:*** Delivered discrimination capabilities using full seismic waveforms based on three-dimensional models to fill critical capability gaps. Used three-dimensional attenuation models to improve signal loss prediction for seismic signals used in discrimination. Investigated the use of modern high speed computing capabilities and massive data archives to automate the detection, location, and discrimination of seismic events. ***FY 2017 Plans:*** Advance signal and array processing methods to dramatically improve detection at target sites and increase automation of detection, location, and discrimination of other seismic events from nuclear explosions. Improve mission-critical discrimination accuracy using source characterizations based on full seismic waveforms. Develop, test, and apply methods to use surface wave travel times and amplitudes for greater location and discrimination accuracy. Improve the resolution and accuracy of three-dimensional attenuation models to improve signal loss prediction for seismic signals used in discrimination. ***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.			
Title: Alternative Navigation Technologies ***Description:*** Develop new technologies based on cold atom physics that provide autonomous jam-proof precision inertial navigation to augment GPS in case of GPS-denial. Develop atomic clocks based on new technologies to replace legacy GPS atomic clocks. ***FY 2016 Accomplishments:*** Continued to advance the development of compact atomic clocks with improved accuracy and stability to replace legacy atomic clocks. Continued construction of a free space, cold atom 3-axis gyroscope/accelerometer that would enable GPS-free precision navigation. Completed further tests of free space, cold atom single-axis gyroscope/accelerometer to learn about its strengths and limitations. Developed a confined cold atom gyroscope with reduced size and weight over free space cold atom gyroscopes to provide a GPS-free navigation system for DoD platforms. ***FY 2017 Plans:***	7.337	7.056	8.532

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continue to advance the development of compact atomic clocks with improved accuracy and stability to replace legacy atomic clocks. Begin testing of advanced clock from National Institute of Standards and Technology. Complete development of free space, cold atom 3-axis gyroscope/accelerometer that will enable GPS-free precision navigation. Develop test plans for cold atom 3-axis gyroscope/accelerometer. ***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 GPS-free precision navigation. Begin planning for packaging of system for test on aircraft flight experiment or other suitable platform.			
Accomplishments/Planned Programs Subtotals	41.872	39.163	39.100

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
624846: *Spacecraft Payload Technologies*	-	12.128	15.732	15.841	0.000	15.841	16.021	16.480	16.770	17.154	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Space-Based Detector Technologies	2.225	3.379	3.290

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 2016 Accomplishments:
Continued alternative sensor material architecture development, focused on minimizing yield limitations and producing a lower cost detector that can perform the mission at more cost-effective operating temperatures. Completed laboratory demonstration of tunable detector technology and validated basic functionality over a militarily significant range of wavelengths. Initiated development of radiation tolerant detectors to achieve dim object tracking for next-generation space situational awareness systems. Completed support for novel cloud-penetrating missile warning experiment. Continued development of foundational sensor modeling and novel detector enhancement methodologies to leverage tactical infrared detector developments for use in space systems.

FY 2017 Plans:
Maintain alternative sensor material-based detector development for lowering noise and raising detector efficiency. Characterize detector performance in both gamma and proton environments to develop full understanding of degradation mechanisms present. Iterate design, growth, and characterization as needed to achieve desired performance in space-radiation environment. Characterize resiliency of detectors, read-out integrated circuits, and focal plane arrays to focused photons and other space phenomenology.

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

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
space environment to include surface charging, latch-up, and displacement damage. Iterate upon design to ensure suitability for space operation.			
Title: Space Situational Awareness Sensing (SSA) Research ***Description:*** Develop innovative means for measuring, modeling, and predicting phenomena for SSA and protection applications. Develop new methods to evaluate how well specific data contributes to identifying particular physical and functional information about a space-based object, and ultimately enable decision-makers to pursue courses of action. ***FY 2016 Accomplishments:*** In FY 2016, this effort will be combined with the Threat Warning Research effort in Project 625018, Spacecraft Protection Technology, to better align technical efforts.	0.000	-	-
Title: Space Electronics Research ***Description:*** Develop technologies for space-based payload components such as radiation-hardened electronic devices, micro-electro-mechanical system devices, and advanced electronics packaging. ***FY 2016 Accomplishments:*** Continued research into advanced transistor types for use at ultra-submicron technology nodes. Documented initial small-feature-size reliability findings and transitioned results to device development community to improve spacecraft electronic lifetime predictions. Completed investigation of advanced electronic circuit technology and transitioned to development phase. Initiated development of low-order benchmarking tools for quantifying and assessing the impact that emerging satellite electronics technologies have on component and system-level metrics, such as size, weight, power and cost. Initiated development of path for trusted electronics as it applies to space electronics. ***FY 2017 Plans:*** Continue advanced transistor efforts transitioning from single transistors into circuits on targeted fabrication nodes for digital applications and provide Gallium Nitride transistor radiation results to electronics manufacturing community. Continue development of benchmarking tool suite, demonstrating capability across multiple user systems and applications. Transition results to user for selection of technology path. Continue development of trusted electronics path as it applies to space technology tools and fabrication. Initiate development of three-dimensional electronics to extend technology node density. ***FY 2018 Plans:*** 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. Continue development	2.162	2.659	2.715

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
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 2016 Accomplishments:*** Continued to develop spacecraft and mission simulations in close conjunction with customers across the DoD and other government agencies. Continued to integrate state-of-the-art system performance and mission planning algorithms into modeling and simulation tools. Revised flight tools based on recent flight program experience. Supported technology maturation through capability and mission utility studies, size, weight, and power-cost trade studies, and wargaming activities. Provided utility analysis to future flight experiments. ***FY 2017 Plans:*** Explore mission-level military utility analyses of various space sensing, satellite navigation, and communication architecture approaches. Develop initial guidelines and checkpoints to evaluate maturity and applicability of emerging space technologies to support various Air Force Research Laboratory (AFRL) technical programs, DoD customers, and wargame events. Begin development of models and mission simulations enabling analysis of contested space environment and space enterprise capabilities. ***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 AFRL technical programs, DoD customers and wargame events. Continue development of models and mission simulations enabling analysis of contested space environment and space enterprise capabilities.	4.013	5.054	5.306
Title: Alternative Positioning, Navigation, and Timing Technology ***Description:*** Identify and develop technologies that enable new, or enhance existing, U.S. positioning, navigation, and timing (PNT) 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 PNT space payload technology needs. ***FY 2016 Accomplishments:*** Initiated experiments establishing the sensitivity of various PNT payload units/sub-units to off-nominal operating conditions and established laboratory readiness for incorporation of experimental hardware from other, on-going PNT technology developments.	3.728	4.640	4.530

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continued studies to identify alternative and innovative technologies that are viable for PNT payloads. Initiated study of advanced signal concept to protect both military and civilian signals from adversary countermeasures. ***FY 2017 Plans:*** Incorporate advanced amplifiers into in-house PNT payload laboratory testbed. Establish the sensitivity of various PNT payload units/sub-units to off-nominal operating conditions and establish laboratory readiness for incorporation of experimental hardware from other, on-going PNT technology developments. Continue studies to identify alternative and innovative technologies that are viable for PNT payloads and investigate advanced signal concepts. ***FY 2018 Plans:*** Complete in-house laboratory feasibility experiments on an advanced digital payload for future GPS 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 PNT payloads and to investigate advanced signal concepts.			
Accomplishments/Planned Programs Subtotals	12.128	15.732	15.841

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
625018: *Spacecraft Protection Technology*	-	14.817	19.411	21.720	0.000	21.720	25.548	26.818	27.170	27.323	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops the technologies for protecting U.S. 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Threat Warning Research	14.817	19.411	21.720

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 2016 Accomplishments:

Completed experimental measurements of satellite components to verify and validate predictive modeling capabilities. Continued analysis of next-generation sensing methods and phenomena to exploit for space protection. Completed assessments of proximity sensor options and transitioned findings, as appropriate, to satellite system developers. Began new SSA-focused data analysis methods including physics-based sensor model development for use in data filtering; advanced filtering techniques accommodating nonlinear dynamics and non-normal random variable distributions; and data-driven methods applicable where physical models are highly uncertain or altogether unknown. Initiated development of advanced algorithms for satellite threat detection and response for both ground-based and space-based implementations. Continued development of capabilities to increase satellite autonomy and perform closed loop demonstration showing threat detection and responsive courses of action. Initiated systems engineering studies on resilience augmentation of high value assets. Continued development of bare-metal hypervisor for satellite cyber resilience.

FY 2017 Plans:

Continue development of advanced algorithms for sensor data fusion and satellite threat detections, assessment, and response. Begin integrating results of advanced algorithm development with satellite autonomous operation demonstrating improved threat detection and response capabilities. Continue SSA-focused data analysis methods including physics-based sensor model development for use in data filtering. Continue advancing filtering techniques accommodating nonlinear dynamics and non-normal random variable distributions. Complete data driven methods applicable where physical models are highly uncertain or altogether unknown. Initiate analysis of new electro-optical and radio frequency sensor concepts for space object identification and characterization. Continue development of closed loop sensor tasking prototype for space surveillance

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
combining commercial and government sensor assets. Complete demonstration of end-to-end threat detection, assessment, and course of action response system implemented within space operations environment. Evaluate potential ability of commercial remote sensing data and information to fill gaps in coverage for monitoring and tracking ground and space objects. Investigate potential sensor tasking, data management, and dissemination architectures for utilization of commercial global geospatial-referenced information for finding and maintaining custody of mobile ground targets. Investigate potential engagements with commercial space data providers for testing new enabling technologies on commercial satellites. Deliver initial spacecraft bare-metal hypervisor for cyber security evaluation and testing; and integrate security primitives and modules. Begin development of hosted payload options for resilience spacecraft. Develop ground test capability for evaluation of technology performance in contested space environments. ***FY 2018 Plans:*** Add satellite protection techniques to continued development of advanced algorithms for sensor data fusion and satellite threat detection, assessment, and response. Expand SSA-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.			
Accomplishments/Planned Programs Subtotals	14.817	19.411	21.720

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
628809: *Spacecraft Vehicle Technologies*	-	38.625	43.609	39.842	0.000	39.842	43.834	44.645	45.922	50.765	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Space Power/Thermal Research	4.496	4.933	4.547
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 2016 Accomplishments:*** Completed solid state refrigeration research and documented low-temperature semiconductor materials findings. Focused development of greater than 40% efficient solar cells by demonstrating increased photocurrent using nano-enhanced cells. Continued to investigate advanced photon management approaches to increase efficiency and radiation hardness. Completed Flex-Array initial development for 60 kW/m3 power density performance. Initiated follow-on development for achieving 70-80 kW/m3 array performance. ***FY 2017 Plans:*** Continue evaluation of nano-enhanced solar cell approaches. Evaluate alternative cell and array approaches for greater than 40% solar cell efficiency. Continue investigation of approaches, such as advanced photon management, to increase end-of-life array performance. Continue development of advanced array technologies to meet 70-80 kW/m3 array performance. ***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 kW/m3 array performance.			
Title: Space Structures and Controls Research	8.886	10.911	8.527
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 2016 Accomplishments:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continued advanced guidance and navigation algorithms integration into advanced autonomous spacecraft software. Continued collaborative autonomous multi-spacecraft algorithms in laboratory and high-fidelity simulations/breadboards including embedded processor implementations. Began reactive maneuver strategies for spacecraft resiliency in laboratory simulation. Developed alternative GPS technologies for contested environments. Transitioned methods to improve the fabrication and manufacture of precision and high tolerance composite structures to spacecraft prime contractors. Initiated development of technologies to increase the resiliency and affordability of spacecraft structures through the development and test of new, actively-controlled thermal technologies. Continued core research in thermal technologies that increase high-power heat dissipation for high-energy density electronics and radio-frequency components currently slated for Air Force communications and GPS spacecraft. Explored new meta-material technologies to improve the electromagnetic interaction characteristics of Air Force spacecraft structures. ***FY 2017 Plans:*** Complete advanced guidance and navigation algorithms integration into advanced autonomous spacecraft software. Continue collaborative autonomous multi-spacecraft control algorithms in laboratory and high-fidelity simulations/breadboards including embedded processor implementations. Continue reactive maneuver strategies for spacecraft resiliency in laboratory simulation. Initiate research in verification and validation techniques for autonomous spacecraft flight software. Begin development of technologies to increase protection for U.S. on-orbit assets through high-strain composites, actively-controlled thermal technologies, and local area sensing. Complete and transition thermal technologies that enable high-energy density electronics and radio-frequency components currently slated for Air Force communications and GPS spacecraft. Continue developing meta-material concepts and energy responsive technologies to improve the electromagnetic interaction characteristics of spacecraft structures. Initiate advanced spacecraft production and assembly technologies to increase system performance and affordability. ***FY 2018 Plans:*** Continue collaborative autonomous multi-spacecraft control algorithms in laboratory and high-fidelity simulations/breadboards including embedded processor implementations. 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. 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 developing U.S. space asset protection technologies including deployable structures enabling affordable protection concepts, thermal technologies for threat identification and mitigation, and local area sensing concepts. Continue developing 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.			
Title: Space Experiments ***Description:*** Develop flight experiments to improve the capabilities of existing operational space systems and to enable new transformational space capabilities.	17.208	18.423	18.435

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Continued testing and integration of satellite experiment to investigate remediation techniques for enhanced space radiation. Completed development and continued testing and verification of a fourth generation geosynchronous orbit (GEO) based missile warning payload to demonstrate hyper temporal imaging (HTI) capabilities to detect missile launches under sun-lit clouds, potentially enabling all weather early missile detection. Continued testing and verification of an integrated, on-board sensing, assessment, and autonomy technology demonstration payload at GEO, demonstrating GEO asset resiliency to a specific set of on-orbit events enabling system mission assurance in a degraded space environment. Assessed technology readiness and risks for a space based integrated demonstration of an advanced GPS payload for contested environments. Developed mission science objectives and on-orbit data collection/analysis requirements to support an integrated experiment in the FY2021-2023 timeframe. ***FY 2017 Plans:*** Complete final integration, test, and launch vehicle integration of satellite experiment to investigate remediation techniques for enhanced space radiation. Train the operations team and conduct mission rehearsals. Launch experimental satellite and conduct on-orbit checkout and begin one year experimental operations. Complete ground testing and verification of a fourth GEO based missile warning payload to demonstrate hyper temporal imaging (HTI) capabilities to detect missile launches under sun-lit clouds, potentially enabling all weather early missile detection. Complete ground testing and verification of an integrated, on-board sensing, assessment, and autonomy technology demonstration payload at GEO, demonstrating GEO asset resiliency to a specific set of on-orbit events enabling system mission assurance in a degraded space environment. Develop and initiate test planning for next-generation small satellite space experiment. Develop on-orbit experiment plan and refine mission objectives/ data requirements for space based integrated demonstration of an advanced GPS payload for contested environments. ***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 GEO based missile warning payload to demonstrate hyper temporal imaging (HTI) 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 GEO, demonstrating GEO 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 developing on-orbit experiment plan and mission objectives/data requirements for space based integrated demonstration of an advanced GPS payload for contested environments.			
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.	8.035	9.342	8.333

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Completed design phase of W and V frequency band flight experiment. Initiated fabrication of the flight instrument and ground receiver. Established an operational W/V-band terrestrial link experiment for pre-launch testing of W and V frequency band data collection instruments and computer analysis tools. Completed fabrication of a remotely controlled, deployable W and V frequency band ground terminal and shelter. Completed spectrum filing for flight experiment. Continued studies of cognitive satellite radio concepts. ***FY 2017 Plans:*** Deliver W and V frequency band flight instrument to the host spacecraft provider for assembly, integration, test, and launch in FY2019. Fabricate, test, and deploy the first two operational, remotely controlled W and V frequency band ground terminals and shelter units which provide environmental control, power, wireless broadband connectivity, and computer processing/storage for entire sensor suite. Initiate development of a laboratory testbed for a cognitive satellite radio network to assess strategies to mitigate impacts from spectrum congestion and interference. Evaluate alternatives for a follow-on project that would demonstrate W and V frequency band satellite communications (bi-directional, modulated signals) and mitigate technology risks to facilitate transition to an operational system. ***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 breadboard 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.			
Accomplishments/Planned Programs Subtotals	38.625	43.609	39.842

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	105.296	109.649	112.195	0.000	112.195	113.831	121.081	129.017	132.593	Continuing	Continuing
622068: *Advanced Guidance Technology*	-	49.267	52.733	55.925	0.000	55.925	57.016	60.826	64.981	72.403	Continuing	Continuing
622502: *Ordnance Technology*	-	56.029	56.916	56.270	0.000	56.270	56.815	60.255	64.036	60.190	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 program 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 warheads, hard-target fuzing, precise terminal guidance, and high performance and insensitive explosives. 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 0602602F, Conventional Munitions, 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 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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	99.851	109.649	114.114	0.000	114.114
Current President's Budget	105.296	109.649	112.195	0.000	112.195
Total Adjustments	5.445	0.000	-1.919	0.000	-1.919
• 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	7.090	0.000			
• SBIR/STTR Transfer	-1.645	0.000			
• Other Adjustments	0.000	0.000	-1.919	0.000	-1.919

Change Summary Explanation

Increase in FY 2016 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*

Decrease in FY 2018 is due to realignment for autonomy and laser weapons systems priorities and transfer of some HQ AFRL civilian manpower to PE 0602298F, Science and Technology Management - Major Headquarters Activities.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622068: *Advanced Guidance Technology*	-	49.267	52.733	55.925	0.000	55.925	57.016	60.826	64.981	72.403	Continuing	Continuing

A. Mission Description and Budget Item Justification

Mission Description not provided.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Seeker Technologies	11.588	10.529	9.495

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

FY 2016 Accomplishments:

Continued to refine wide-field-of-view seeker proofs-of-concept with emphasis on high-resolution sensors, emphasizing bio-inspired and high-rate processing characteristics to allow precise munition terminal guidance in degraded, contested environments, for multiple applications. Continued to develop technologies to simplify, increase flexibility, and reduce cost of advanced seekers (passive and active electro-optical, infrared, and radar) with focus on combat operations in adverse weather and in high-speed applications. Built adjustable height seeker test tower essential for full spectrum of testing required for research, development, and test of next generation of weapons seekers. Completed conceptual design studies for next generation air-to-air missile. Completed Joint Capability Technology Demonstration(JCTD) to mitigate helicopter brown out on landing; technology transitioned to program office for acquisition. Continued to develop algorithmic approaches to integrate weapons into the kill chain and enable flexible targeting with or without an operator in the loop. Continued to develop mathematical techniques that enable distributive seeker imaging and targeting. Explored terminal seeker technologies that enable innovative air-to-air engagements for fifth generation aircraft and beyond. Explored incorporation of open architecture principles to reduce cost and enable technology refresh within seeker subsystems.

FY 2017 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 technology refresh within seeker

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
subsystems. Develop distributed, low-cost seeker technology hardware. Conduct research on integrated processing techniques to enable networked systems. ***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. 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. Begin small, air-to-air, self-defense munitions research effort.			
Title: Aerodynamics, Navigation and Control Technologies	28.169	29.944	28.178
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 2016 Accomplishments:*** Demonstrated technologies to enable Global Positioning System (GPS) guidance in high jamming environments, and demonstrated first-ever closed loop image aiding without GPS. Continued to develop aero-structural-thermal computational tools to predict performance of hypersonic weapons used to shape concepts for further analysis. Continued to develop technologies for precision weapon navigation independent of GPS availability to include celestial navigation and optical aiding techniques. Continued to develop algorithms and analysis tools to explore distributed collaboration and autonomy concepts in advanced threat environments. Implemented autonomy algorithms testbed to fly multiple vehicles simultaneously. Advanced simulation technologies to evaluate innovative air-to-air engagements. Developed a real-time radar/millimeter wave signature generation capability for testing algorithms in software and hardware in-the-loop environments. Developed simulation technologies that evaluate cooperative, flexible munition target engagements. Developed a modular radio-frequency hardware-in-the-loop capability to support munitions concepts with high speed target engagement. Developed new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems. ***FY 2017 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			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
navigation under GPS-degraded and GPS-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. Conduct flight demonstrations of precision navigation of weapons without GPS experiments to characterize innovative air-to-air high off-bore sight missile maneuverability and hit-to-kill agility. Conduct experiments to demonstrate precision navigation using celestial aiding for long range flights at high and low altitudes. Conduct experiments to demonstrate algorithms implementing cooperation and collaboration between multiple surrogate weapon platforms. Develop and demonstrate component modular and service oriented weapon architectures for seeker, navigation, and data services that use reconfigurable weapon sensors. Conduct flight innovative air-to-air high off-bore sight missile maneuverability and hit-to kill agility. Conduct ground tests of rocket motor component technologies to evaluate their ability to increase weapon range and reduce size and weight. ***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 GPS-degraded and GPS-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. Conduct flight demonstrations of precision navigation of weapons without GPS experiments to characterize innovative air-to-air high off-bore sight missile maneuverability and hit-to-kill agility. Conduct experiments to demonstrate precision navigation using celestial aiding for long range flights at high and low altitudes. Conduct experiments to demonstrate algorithms implementing cooperation and collaboration between multiple surrogate weapon platforms. Develop and demonstrate component modular and service oriented weapon architectures for seeker navigation, and data services that use reconfigurable weapon sensors. Conduct flight innovative air-to-air high off-bore sight missile maneuverability and hit-to kill agility. Conduct ground tests of rocket motor component technologies to evaluate their ability to increase weapon range and reduce size and weight. Begin small, air-to-air, self-defense munitions research effort.			
Title: Guidance Technologies ***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 2016 Accomplishments:*** Implemented autonomy algorithms in flying testbed to experiment with multiple vehicles simultaneously. Advanced simulation technologies to evaluate innovative air-to-air engagements. Developed a real-time radar/millimeter wave signature generation capability for testing algorithms in software and hardware in-the-loop environments. Developed simulation technologies that	9.510	12.260	18.252

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
evaluate cooperative, flexible munition target engagements. Conducted seven flight tests demonstrating an integrated Command and Control (C2) and video data link with cryptographic key management and encryption which is a key step for assured communications for net-enabled cooperative strike. Developed a modular radio-frequency hardware-in-the-loop capability to support munitions concepts with high speed target engagement. Developed new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems. ***FY 2017 Plans:*** Continue to support flight demonstrations of critical behaviors for Distributed, Cooperative, Collaborative (DC2) 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 target engagement. Continue to develop new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems. ***FY 2018 Plans:*** Continue to support flight demonstrations of critical behaviors for DC2 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 target engagement. Continue to develop new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems.			
Accomplishments/Planned Programs Subtotals	49.267	52.733	55.925

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622068 / *Advanced Guidance 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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
622502: *Ordnance Technology*	-	56.029	56.916	56.270	0.000	56.270	56.815	60.255	64.036	60.190	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, submunitions, 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 submunition dispensing, low-cost airframe/subsystem components and structures, and reduced aerospace vehicle and weapon drag.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Energetic Materials Technology	10.200	10.098	9.897

Description: Investigates and develops energetic materials and technology that safely and securely optimize survivability, cost and weapon lethality for air-delivered munitions.

FY 2016 Accomplishments:
Developed and qualified a new explosive formulation for extreme high temperature environments, e.g. hypersonic weapon applications; conducted testing to validate equation of state and provide fragmentation data to develop modeling and simulation (M&S) tools for computational mechanics and lethality codes. Developed novel oxidizers with potential for formulations with greater energy density. Investigated two synthesis methods for scaling up production of nanoenergetic materials. Demonstrated bulk printing of explosives; critical for future additive manufacturing initiatives. Refined design for distributed and multi-point initiation. Released first version of Energetics Design Studio, software that will revolutionize explosive formulation methodology.

FY 2017 Plans:
Continue to investigate materials to increase energy density over traditional explosives while enhancing damage mechanisms and lethality for mass and volume constrained applications. Continue to investigate and design experimental techniques/capabilities to quantify dynamic and mechanical properties as well as survivability of energetic materials in extreme temperature and vibrational environments. Continue to mature theoretical and virtual formulation and processing techniques for energetic materials. Continue to develop tools and analysis techniques to further understanding of energy partitioning in order to optimize lethality. Continue investigating additive manufacturing techniques to increase the design space for kinetic weapon lethality. Investigate liner technologies to improve Insensitive Munitions performance.

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

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
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 2016 Accomplishments:*** Developed advanced test capabilities for initiation studies; allows evaluation of initiation reliability during penetration scenarios and provided data for validation of physics-based M&S tools. Developed advanced algorithms to optimize ground-profiling during flight endgame which allows an optimized burst point for height-of-burst (above ground) applications which provides the necessary building blocks for focused lethality and minimized collateral damage. Matured test methodology and completed experiments to assess performance of fuze electronic components in extreme shock environments commonly associated with hard target defeat. Conducted tailored lethal effects research on improved detonators, primary explosives used therein, and algorithm development which enables reliable safe and arm fuze capability for all fuzing applications. Developed affordable general purpose fireset for distributed embedded fuzing concepts. ***FY 2017 Plans:*** Continue to develop M&S and test capabilities for penetration scenarios. Continue to develop and demonstrate alternative packaging technology for the fuze electronic components. Continue to investigate the capability 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. Implement additive manufacturing techniques to increase fuze reliability. ***FY 2018 Plans:*** Continue to develop testing capabilities for munitions penetration scenarios and increase M&S capabilities to reduce research and development costs and timelines. Continue to develop and demonstrate alternative packaging technology for survivable fuze electronic components. Continue to investigate the reliability and survivability of electronic components to predict and measure fuze performance during 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.	14.729	10.697	9.969
Title: Warhead Technologies	18.213	20.123	19.617

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018

Description: Investigate and develop innovative warhead kill mechanisms for air-delivered weapons that maximize weapon lethality for all engagement scenarios.

FY 2016 Accomplishments:
Tested multiple designs of small, multi-output warhead technologies with penetration capability for soft surface targets and limited capability for hardened, shallow structures. Continued development of novel warhead technologies to increase lethality in innovative air-to-air engagements. Conducted research to improve warhead stability and integrity for penetration applications at high-speed. Conducted experiments on novel warhead technologies and materials to characterize lethality. Developed thermite-based metal cutting technology and began transition for operational use. Established testing capability for characterization of explosive materials and quantified material behavior during shock for inclusion in high fidelity M&S tools. Started the evaluation of utility of blast wave interactions and determined embedded particle flow fields to validate computational models for collaborative damage mechanisms which synergized multi-phased and multi-point initiation effects against specific target sets. Developed additive manufacturing designs of warheads and tested sub-scale articles in high-speed penetration applications. Successfully "poured" 52,000 pounds of AF9628 steel, which had no defects, substantially reduced costs, and transitioned to program offices for utilization.

FY 2017 Plans:
Continue to develop small, multi-output warhead technologies for soft surface targets with limited penetration capability for hardened structures. Continue to test warhead materials to quantify the mechanical response under high-rate, high-pressure loading conditions for use in high fidelity modeling and simulation tools. Continue to implement additive manufacturing techniques to open the design space for novel warhead designs. Continue to develop 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. Initiate research to develop cumulative damage mechanisms that take advantage of distributed blast, as well as shock wave and reactive particle interactions.

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 M&S 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

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
integration of warhead research with related activities planned for the advanced/integrated ordnance subsystems research capability.			
Title: Ordnance Technologies	12.887	15.998	16.787
Description: Investigate and develop ordnance sub-system (energetics, fuzes, and warheads) and integrated system concepts using both high fidelity and fast-running engineering level M&S tools. ***FY 2016 Accomplishments:*** Implemented multiphase physics models in high fidelity codes to predict and characterize warhead detonation providing virtual analysis of novel ordnance concepts in myriad target engagement scenarios. Analyzed innovative ordnance concepts that could increase the capacity and capability of fifth generation aircraft. Developed engineering-level simulation architecture setting new Air Force standard. This cutting-edge architecture enabled greater scale and fidelity of weapon system and weapon technology assessments. Implemented improved design for inventory warhead and demonstrated improved affordability, sustainability, and survivability. Explored technologies for low-cost, long-range munition concepts. ***FY 2017 Plans:*** Continue to develop validated mesoscale M&S tools for computational physics sciences. Continue to develop engineering-level simulation architecture capability to enable weapon sub-system and system-level technology assessments. Continue to implement cost-effective and rapid transition warhead technologies for inventory penetrators. Continue to conduct M&S 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 M&S tools to characterize lethality, survivability, and performance of sub-systems and integrated ordnance systems. ***FY 2018 Plans:*** Continue to develop validated mesoscale M&S 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 warhead technologies for inventory penetrators. Continue to conduct M&S 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 M&S tools to characterize lethality, survivability, and performance of sub-systems and integrated ordnance systems. Develop M&S 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.			
Accomplishments/Planned Programs Subtotals	56.029	56.916	56.270

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622502 / *Ordnance Technology*

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	122.835	127.163	132.993	0.000	132.993	128.039	125.076	126.207	128.448	Continuing	Continuing
624866: *Lasers & Imaging Technology*	-	83.718	92.445	99.946	0.000	99.946	94.480	90.704	90.559	90.876	Continuing	Continuing
624867: *Advanced Weapons & Survivability Technology*	-	39.117	34.718	33.047	0.000	33.047	33.559	34.372	35.648	37.572	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program covers research in directed energy (DE) technologies, primarily high energy lasers (HELs); including devices, optical beam control and integration; and high power electromagnetics (HPEM). Laser research includes moderate to high power laser devices that are applicable to a wide range of Air Force applications, optical technologies to propagate laser beams from a device, and integration of these technologies. In HPEM, this research examines technologies for applications such as counter-electronics and non-lethal weapons. Research into other novel DE applications will be conducted. DE vulnerability/lethality assessments are conducted and protection technologies are developed. Research into other advanced non-conventional/innovative weapons will be conducted. Tools are developed and used to compare solutions and to determine the most effective and efficient DE technologies to meet Air Force needs. This program also performs ground-based optical research for space situational awareness (SSA). In SSA, 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. 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 0602605F, Directed Energy Technology, 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 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: FY 2018 Air Force					Date: May 2017
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	115.105	127.163	120.059	0.000	120.059
Current President's Budget	122.835	127.163	132.993	0.000	132.993
Total Adjustments	7.730	0.000	12.934	0.000	12.934
• 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	9.997	0.000			
• SBIR/STTR Transfer	-2.267	0.000			
• Other Adjustments	0.000	0.000	12.934	0.000	12.934

Change Summary Explanation

Increase in FY 2016 reflects reprogramming for Air Dominance activities and to support Research and Development Projects, 10 U.S.C. Section 2358.

Increase in FY 2018 due to realignment of funds for Laser Weapon System priorities.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
624866: *Lasers & Imaging Technology*	-	83.718	92.445	99.946	0.000	99.946	94.480	90.704	90.559	90.876	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 DE and non-DE concept development and assessment tools to determine which technology solutions to pursue. Research supporting ground-based optical space situational awareness is conducted.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: High Energy Laser Technologies and Directed Energy Assessments	55.635	65.056	66.657

Description: Develop and demonstrate HEL device technologies for Air Force applications. Develop and demonstrate optical laser beam control technologies including atmospheric compensation 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 DE concepts and tradeoffs between DE and non-DE 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 lasers.

FY 2016 Accomplishments:

Continued beam control and monolithic fiber amplifier integration and ground tests. Continued conducting effects testing to establish system requirements and validate modeling efforts. Performed airborne tests of turret beam control technologies. Began integration of beam control and low power laser technologies for aircraft self-protection. Completed Integrated Weapons Environment for Analysis (IWEA) Build 1 and continued to conduct assessments of concepts for laser weapon systems to help users plan weapon investments. Continued to model and characterize foreign HEL threats to blue systems and provide assessments to developers for hardening materials and designs. Completed research supporting the joint Air Force/ DARPA ground HEL demonstration.

FY 2017 Plans:

Continue with beam control and scaling of monolithic fiber amplifier scaling using advanced fibers. Continue with the development of beam control aero-effects mitigating techniques. Continue with the conduct of effects tests to establish system requirements and validity models. Continue integration of beam control and low power laser system for future pod-mounted moderate power laser demonstration. Transition IWEA Build 1 to external users and complete IWEA Build 2. Conduct assessments of DE and/

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
or synergistic DE/Kinetic Energy (KE) weapon capabilities to help users plan weapon investments. Continue to model and characterize foreign HEL threats and provide information to develop mitigation techniques to protect blue assets. ***FY 2018 Plans:*** Continue with beam control and scaling of monolithic fiber amplifier scaling using advanced fibers. Continue with the development of beam control aero-effects mitigating techniques. Continue with the conduct of effects tests to establish system requirements and validity models. Continue integration of beam control and low power laser system for future pod-mounted moderate power laser demonstration. Transition IWEA Build 2 to external users and complete IWEA transition into an advanced framework to support Air Force Research Laboratory (AFRL)-wide Modeling, Simulation & Analysis (MS&A) environment. Conduct assessments of DE and/or synergistic DE/KE weapon capabilities to help users plan weapon investments. Continue to model and characterize foreign HEL threats, and provide information to develop mitigation techniques to protect blue assets.			
Title: Optical Space Situational Awareness and Satellite Vulnerability	28.083	27.389	33.289
Description: Develop advanced, long-range, electro-optical technologies that support ground-based optical SSA. Develop and use technologies to better understand the vulnerability of blue satellite systems to lasers. Operate the Starfire Optical Range in support of internal and customer requirements. ***FY 2016 Accomplishments:*** Began integration of geosynchronous satellite characterization and local-space search as components of a dynamic telescope demonstration to keep track of potential threat objects in space. Initiated comparison of capabilities for extending telescope operation into daylight hours to provide Air Force Space Command programs with technology options for their requested products. Demonstrated techniques for persistent monitoring of space events and capability to detect threat objects in close proximity to our high-value satellite assets, including those in geosynchronous orbits. ***FY 2017 Plans:*** Complete integration of geosynchronous satellite characterization and local-space search for bright objects as components of a dynamic telescope demonstration to keep track of potential threat objects in space. Investigate daylight detection of geosynchronous satellites to address the long-duration gaps during daytime hours when satellites cannot normally be detected by our optical systems. Explore techniques to detect smaller objects and characterize their relative orbits around our assets. Investigate through modeling and simulation the susceptibility of satellite optical systems to laser threats to support course of action decision-making for protection and design improvements for resilience. ***FY 2018 Plans:*** Complete integration of geosynchronous satellite characterization and local-space search for dim objects as a component of a dynamic telescope demonstration to keep track of potential threat objects in space. Mature daylight detection of geosynchronous satellites to allow custody through the long-duration gaps during daytime hours when satellites cannot normally be detected by our ground-based optical systems. Mature 24/7 real-time optical imaging of near-earth satellites to allow characterization on tactical			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
timelines. Investigate through modeling and simulation the susceptibility of satellite optical systems to laser threats to support course of action decision-making for protection and design improvements for resilience.			
Accomplishments/Planned Programs Subtotals	83.718	92.445	99.946

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
624867: *Advanced Weapons & Survivability Technology*	-	39.117	34.718	33.047	0.000	33.047	33.559	34.372	35.648	37.572	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project explores the use of HPEM 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 HPEM weapons and how to mitigate those effects on US assets, as well as producing and applying DE and non-DE concept development and assessment tools to determine which technology solutions to pursue. HPEM includes but is not limited to high power microwaves, plasmas, particle beams and millimeter waves.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: HPEM and Unconventional Weapon Technologies	20.038	18.120	10.598
Description: Investigate technologies for HPEM components. Investigate HPEM and other unconventional weapon concepts using innovative technologies. Investigate advanced technologies that support force protection tactical applications, including non-lethal counter-personnel applications. ***FY 2016 Accomplishments:*** Refined initial ultra-short pulsed laser atmospheric propagation studies. Conducted effects studies on electronics based on the assessments from FY15. Continued work on compact 50 kilovolt solid state switch. Completed preliminary designs for 100 megavolt test facility accelerator. Began design of smaller, higher power, source technology for the Next Generation High Power Microwaves(HPM) demonstration. ***FY 2017 Plans:*** Refine ultra-short pulsed laser atmospheric propagation studies. Conduct effects studies on electronics based on the assessments from FY15 and FY16. Continue compact 50 kilovolt solid state switch research. Complete research on smaller, higher power, source technology for joint Air Force-Navy HPM technologies. ***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 FY16 and FY17 to support HIgh power Joint Electromagnetic Non-Kinetic Strike (HiJENKS). Complete compact 50 kilovolt solid state switch for a militarily relevant platform. Initiate design of smaller, higher power, source technology for the joint AF-Navy HiJENKS HPM demonstration.			
Title: HPEM Effects and Mitigation Research	19.079	16.598	22.449

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Assess the effects/lethality of HPEM technologies. Develop and apply sophisticated models to enhance the development of HPEM and related technology. Develop tools and perform assessments which allow comparisons among DE concepts and tradeoffs between DE and non-DE solutions. Investigate technologies to counter the effects of HPEM. ***FY 2016 Accomplishments:*** Completed source for effects testing that operates in three microwave bands. Tested and validated Phase 1 of DE High Performance Computing Software Applications Institute software, which allows modeling of DE sources and propagation that involves plasmas. Assessed potential improvements to US weapons systems from employing HPEM weapons technologies for platform protection and target prosecution. Conducted assessments of HPEM and kinetic energy (KE) weapon concepts in a common environment to help users plan weapons investments. Continued to model and characterize HPEM threats to blue systems and provide assessments developers for hardening materials and designs. ***FY 2017 Plans:*** Test and validate Phase 2 of DE High Performance Computing Software Applications Institute software, which allows modeling of DE sources and propagation that involves plasmas and laser DE weapons. Continue to assess potential improvements to US weapons systems from employing HPEM weapons technologies for platform protection and target prosecution. Continue further assessments of HPEM and KE weapon concepts in a common environment to help users plan weapons investments. Transition Modeling, Simulation & Analysis (MS&A) tools to the broader MS&A community. Continue to model and characterize current and projected HPEM threats to blue systems and provide assessments to developers for hardening materials and designs. ***FY 2018 Plans:*** Test and validate Phase 3 of DE High Performance Computing Software Applications Institute software, which allows modeling of DE sources and propagation that involves plasmas and laser DE weapons. Assess potential improvements to US weapons systems from employing HPEM weapons technologies for platform protection and target prosecution. Continue assessments of HPEM and synergistic/KE weapon concept capabilities to help users plan weapons investments. Transition MS&A tools to the broader MS&A community.			
Accomplishments/Planned Programs Subtotals	39.117	34.718	33.047

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	171.196	161.650	167.818	0.000	167.818	162.216	163.708	167.041	173.284	Continuing	Continuing
625315: *Connectivity and Protection Tech*	-	77.642	31.228	30.914	0.000	30.914	32.335	30.253	30.648	33.604	Continuing	Continuing
625316: *Info Mgt and Computational Tech*	-	31.638	12.966	10.720	0.000	10.720	11.978	12.416	12.167	13.161	Continuing	Continuing
625317: *Information Decision Making Tech*	-	20.962	14.770	28.349	0.000	28.349	16.625	16.389	17.341	17.562	Continuing	Continuing
625318: *Operational Awareness Tech*	-	19.698	21.246	21.514	0.000	21.514	22.979	23.335	24.136	24.602	Continuing	Continuing
625319: *Cyberspace Dominance Technology*	-	0.000	59.712	55.801	0.000	55.801	57.493	60.195	61.063	62.247	Continuing	Continuing
62OMMS: *Research Site Support*	-	21.256	21.728	20.520	0.000	20.520	20.806	21.120	21.686	22.108	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops enterprise-centric information technology for the Air Force. Advances in enterprise-centric information technologies are required to increase warfighter readiness and effectiveness by providing the right information, at the right time, in the right format, anytime, anywhere in the world. The Connectivity and Protection Tech project provides the technologies for multi-level, secure, seamless networks; advanced communications processors; anti-jam and low probability of intercept techniques, as well as technologies that deter any adversary from attacking computer systems while allowing access to, presence on, manipulation of, and operational effects on adversary computer systems. This project also develops the technology base for the next generation of ultra-wide-bandwidth, multi-channeled, air- and space-based communications networks. The Information Management and Computational Tech project provides advances in information management and dissemination technologies to ensure the delivery of high-quality, timely, secure information to the warfighter, and develop technologies to produce both advanced on demand computational processing and computer architectures with greater capacity and sophistication for addressing dynamic mission objectives under constraints imposed by Air Force systems. The Information Decision Making Tech project develops the technology to support the commander and staff's ability to command all viable options to achieve desired effects across the full spectrum of operations. The Operational Awareness Tech project develops technologies that improve their capability to generate, process, manage, fuse, exploit, interpret, and disseminate timely and accurate information. The Research Site Support project provides the Rome Research Site infrastructure at Rome, NY 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: FY 2018 Air Force	Date: May 2017
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*

Starting in FY 2017 to improve reporting to Congress, Project 625319, Cyberspace Dominance Technology was created to capture all cyber activity that was previously performed in this program. Cyberspace Dominance Technology will develop technologies that deter any adversary from attacking computer systems while allowing access to, presence on, manipulation of, and operational effects on adversary computer systems; technologies to produce both advanced on demand computational processing and computer architectures; and technologies for secure and survivable enterprise operating at multiple domains.

In FY 2018, a portion of HQ AFRL S&T civilian manpower in PE 0602788F, Dominant Information Sciences and Methods, 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 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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	169.183	161.650	159.214	0.000	159.214
Current President's Budget	171.196	161.650	167.818	0.000	167.818
Total Adjustments	2.013	0.000	8.604	0.000	8.604
• 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	4.253	0.000			
• SBIR/STTR Transfer	-2.240	0.000			
• Other Adjustments	0.000	0.000	8.604	0.000	8.604

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 625315: *Connectivity and Protection Tech*		
Congressional Add: *Program Increase*	4.500	-
Congressional Add Subtotals for Project: 625315	4.500	-
Congressional Add Totals for all Projects	4.500	-

Change Summary Explanation

Increase in FY 2016 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Increase in FY 2018 is due to development of new future command and control capability for Air Combat Command.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
625315: *Connectivity and Protection Tech*	-	77.642	31.228	30.914	0.000	30.914	32.335	30.253	30.648	33.604	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, dynamic policy based network management capabilities; and modular, programmable, low-cost software radios. This project also develops both the technology base for ultra-wide bandwidth, multi-channeled air- and space-based communications networks on and between platforms. In addition, 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. This project provides the technologies required to 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 as well as provide forensic analysis concerning those attack attempts; and provide cyber situational awareness to Air Force commanders. Starting in FY 2017 cyber work previously performed within this project will be reported under Project 625319, Cyberspace Dominance Technology.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Advanced Connectivity Technologies	22.498	31.228	30.914

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 2016 Accomplishments:

Performed a field demonstration of the 32 by 32 multiple input, multiple output (MIMO) system. Demonstrated a three node quantum key distribution (QKD) multi-access laser communications system. Planned an electromagnetic frequency band space experiment in the V and W bands for ground site locations, defining ground site equipment and data collection capabilities and analysis. Developed a software implementation of a low-bandwidth protocol for network situational awareness and management across heterogeneous networks. Derived an Air Force specification and S&T strategy for next-generation directional capabilities. Continued development of an automated process to port communication models to a real-time hardware in the loop simulation. Continued the development and integration of waveform components, tools, and hardware into an innovative ecosystem for affordable rapid waveform development over a continuum of commercial-off-the-shelf (COTS)/government-off-the-shelf (GOTS) software defined radio frequency (SDRF) architectures. Continued both the development of secure video distribution over tactical internets on demand and the design of distributed, cross-layer protocols for cognitive radio ad hoc networks with decentralized control. Continued the development of a modular airborne network bridge for the creation of an air-air/air-ground secure tactical

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
intranet. Continued the development of wideband, long range, rapidly deployable aerial backbone network for command, control, intelligence, surveillance, and reconnaissance (C2ISR) dissemination. Continued research to advance autonomy in unmanned air vehicles to support distributed cooperative airborne tactics using advanced communications techniques. ***FY 2017 Plans:*** Continue to demonstrate Aerial Layer Network Components; low-bandwidth protocol for network situational awareness (SA) and management across heterogeneous networks (Internet Protocol (IP)/Non IP/Other Tactical). Initiate investigation and research into new, high frequency pathways (i.e. V and W band of the electromagnetic spectrum) to support aerial and space-based Beyond Line of Sight (BLOS) communications. Initiate dynamic map-to-mission software for operations continuity and agile info management technology for secure message exchange. Work to continue the investigation of the use of autonomy on small unmanned aircraft system platforms to support semi-autonomous distributed cooperative airborne tactics using airborne networks. Initiate development of advanced hardware with embedded cyber protection for multi-mission agile radio frequency (RF) capability. Demonstrate Traveling Wave Tube Amplifier (TWTA) at 81 to 86 gigahertz (GHz) continuous power of approximately 45 watts. Demonstrate a multi-access optical link at 30 kilometers. ***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 BLOS 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 (SUAS) 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 RF capability.			
Title: Cyber Defense Technologies ***Description:*** Develop cyber defense and supporting technologies to detect, defend, and respond to attacks on computer systems as well as provide forensic analysis concerning the attacks. ***FY 2016 Accomplishments:*** Continued development of embedded and resilient technologies; developed an initial prototype with separation, monitoring service and cryptographic key management. Continued enhancement, maturation, testing, and demonstration of Cyber Agility technologies through exercises and other user-focused venues toward the objective of transition. Continued Cyber Intelligence, Surveillance, and Reconnaissance (ISR) research by demonstrating of the first components of Cyber ISR and exploring the integration of any newly developed capability with existing ISR systems such as the Distributed Common Ground Station (DCGS). Continued interaction with the University Center of Excellence (UCoE) in Assured Cloud Computing. Continued research for	17.998	0.000	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
an innovative approach to mission awareness by making mission model, information, and behavioral analytical assessments of mission execution status and mission phase changes. ***FY 2017 Plans:*** For FY 2017 and beyond, work accomplished under this Effort will be reported in Project 625319, Cyberspace Dominance Technology, under the Effort Cyber Defense Technologies.			
Title: Cyber Offense Technologies ***Description:*** Develop offensive cyber operations technologies to access, maintain presence on, and deliver effects to adversary systems. ***FY 2016 Accomplishments:*** Continued development of existing capabilities to exploit and mitigate adversary threats in the electromagnetic spectrum (EMS). Continued closed-loop learning techniques for applying electronic warfare (EW) and cyberspace operations in composite fashion based on near-real-time feedback loops. Continued to mature software-defined radio (SDR) hardware and software at national-level exercises and pursue technology transfer/transition to Joint platforms and Programs of Record. Continued to research and develop emerging technology for impacts to our cyber operation mission and determine how to incorporate the most promising technology into our cyber toolset. Continued development of technologies to remain current with new waveforms and signals. Continued Service Oriented Architecture (SOA) mission component development for use in the Air Force Life Cycle Management Center Cyber Mission Platform (CMP). Transitioned components, including mission reporting, for use in CMP. Continued red-teaming new components to improve security. ***FY 2017 Plans:*** For FY 2017 and beyond, work accomplished under this Effort will be reported in Project 625319, Cyberspace Dominance Technology, under the Effort Cyber Offense Technologies.	21.965	0.000	-
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 2016 Accomplishments:*** Continued research to orchestrate the dynamic employment of multiple survive and recover defense components, configurations, and services at the system level to assure and empower the mission. Focused effort on hiding mission essential functions (MEFs) in the cloud and rapidly recovering MEFs using the vast computing cloud resources. ***FY 2017 Plans:***	7.171	0.000	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
For FY 2017 and beyond, work accomplished under this Effort will be reported in Project 625319, Cyberspace Dominance Technology, under the Effort Survivability Technologies.			
Title: Cyber Technologies for Spectrum Warfare ***Description:*** Develop technologies combining electronic warfare, signals intelligence (SIGINT), communications, and cyber technologies that provide synergistic access, exploitation, and effects across air and cyber domains in congested and contested environments. ***FY 2016 Accomplishments:*** Continued development of methods to improve the identification, collection and geo-location, analysis and correlation of parametric data and information. These methods maximized the information that can be extracted to include: source of the communication, location of the transmitter, function of the transmitter, RF and other technical characteristics of the transmission. ***FY 2017 Plans:*** For FY 2017 and beyond, work accomplished under this Effort will be reported in Project 625319, Cyberspace Dominance Technology, under the Effort Cyber Technologies for Spectrum Warfare.	3.510	0.000	-
Accomplishments/Planned Programs Subtotals	73.142	31.228	30.914

	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** Conducted Congressionally directed effort.	4.500	-
Congressional Adds Subtotals	4.500	-

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
625316: *Info Mgt and Computational Tech*	-	31.638	12.966	10.720	0.000	10.720	11.978	12.416	12.167	13.161	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. In addition, the Air Force requires the development of superior, intelligent, on-demand computing to enable information superiority. Technology development in this project focuses on producing: computer 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. Starting in FY 2017 cyber work previously performed within this project will be reported under project 625319, Cyberspace Dominance Technology.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Dissemination Technologies	10.591	12.966	10.720
Description: Investigate and develop technologies for decision quality information dissemination services via publish, subscribe, and query across the Global Information Grid (GIG) to enterprise and tactical assets and coalition partners.			
FY 2016 Accomplishments: Continued research into scalable mission responsive data systems by mapping mission requirements to information flows. Continued development and design of cloud-based information management services for provisioning sufficient computational power for high demand semantic processing of large data sets within mission timeline constraints. Continued development of responsive autonomous control for tactical sensor control. Continued the development 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. Continued the development of information management capabilities that			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
securely bridge the gaps between enterprise and tactical domains for increased shared SA across the theater of war for targeting and force protection operations. ***FY 2017 Plans:*** Continue to research scalable mission responsive data systems by mapping mission requirements to information flows and develop mission event trigger response components and complex event processing algorithms to monitor environment state across federations. 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. Demonstrate multi-platform opportunistic sensor resource management. ***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 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.			
Title: Processing Technologies ***Description:*** Develop automatic and dynamically reconfigurable, affordable, scalable, distributed petaflop processing technologies for real-time global information systems. ***FY 2016 Accomplishments:*** Continued research to develop and demonstrate embedded high performance computing systems and integrate bio-inspired embedded computing hardware that delivers a set of autonomous sensing capabilities for Air Force ISR missions in the contested and anti-access area-denial (A2AD) environments. Developed autonomous methods of discovering salient events by exploiting disparate sensor data via bio-logically inspired neuromorphic learning algorithms. Developed algorithms that automatically make associations of disparately sensed signatures for a given event(s). Developed the algorithms so that they exploit low level information (raw data) from ISR sensors. Fabricated the enhanced Air Force Research Laboratory Secure Processor. ***FY 2017 Plans:*** For FY 2017 and beyond, work accomplished under this Effort will be reported in Project 625319, Cyberspace Dominance Technology, under the Effort Processing Technologies.	8.552	0.000	-
Title: Cross Domain Technologies	3.092	0.000	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Develop secure cross domain discovery services for access to services outside of existing domain. Develop the tools to allow collaboration of workflows required by the Air Force net-centric information management environment. ***FY 2016 Accomplishments:*** Developed techniques to allow rapid cross security domain enablement of information technology (IT) systems. Continued development of a secure multiple levels of security (MLS) mobile foundation. Continued development of malicious code detection techniques based upon runtime performance of applications. ***FY 2017 Plans:*** For FY 2017 and beyond, work accomplished under this Effort will be reported in Project 625319, Cyberspace Dominance Technology, under the Effort Cross Domain Technologies.			
Title: Advanced Architectural Technologies ***Description:*** Develop the architectural mechanisms that form the basis for predictable software and high assurance systems. ***FY 2016 Accomplishments:*** Integrated the hardened secure processor with its stacked dynamic random-access memory (DRAM) memory. Packaged the stacked chipset and test it on a printed circuit board. Continued research on a calculus of trust for measurement and understanding. Developed theory and techniques to continuously validate and/or reestablish trust in resilient systems as they fight through attacks and failures (utilizing mission objectives and warfighter perspectives). Developed automated repairs that are trusted, understandable and maintainable by humans. ***FY 2017 Plans:*** For FY 2017 and beyond, work accomplished under this Effort will be reported in Project 625319, Cyberspace Dominance Technology, under the Effort Advanced Architectural Technologies.	9.403	0.000	-
Accomplishments/Planned Programs Subtotals	31.638	12.966	10.720

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
625317: *Information Decision Making Tech*	-	20.962	14.770	28.349	0.000	28.349	16.625	16.389	17.341	17.562	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 and course of action development, planning, scheduling and assessment, and the real-time effective portrayal of complex data sets.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Campaign Planning Technologies	6.251	9.960	5.405
Description: Develop advanced monitoring, planning, and assessment technologies enabling aerospace commanders to develop effects-based campaigns. ***FY 2016 Accomplishments:*** Initiated development of capabilities for combat planning and tactical assessment software services supporting distributed command and control (C2) capabilities at Tactical Air Control Systems (TACS) entities. Continued development of robust autonomous control algorithms for heterogeneous and distributed assets capable of learning in dynamic environments. Initiated research for robust autonomous system capable of self-adjustment and active learning under unforeseen circumstances. Demonstrated multi-agent autonomous ISR capabilities, given limited communications in Autonomous Test and Evaluation Environment simulations. Continued the development of a capability to allow operators to specify their own assessments and incorporate real world feedback to update and refine confidence metrics. ***FY 2017 Plans:*** Continue to develop and deliver combat planning and tactical assessment software services supporting distributed C2 capabilities at TACS entities. Continue to develop and demonstrate multi-agent autonomous ISR capabilities, given simulated hostile environments and limited communications at the Stockbridge testing site. ***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 & environmental conditions, in a manner consistent with mission-planned contracts. Continue to develop and deliver combat planning and tactical assessment software services supporting distributed C2 capabilities.			
Title: Command and Control System Technologies	14.711	4.810	22.944

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Investigate, analyze, and develop technologies for planning, execution, and automatic rapid reconfiguration of distributed intelligent and integrated C2 information systems to achieve the commander's intent throughout varying crisis levels. ***FY 2016 Accomplishments:*** Continued development of concepts for space operations. Continued electromagnetic spectrum course of action generation/ optimization, discrete optimization from a large input set, electromagnetic spectrum visualization, resource-oriented hybridized architecture and group-sourcing for command and control. Worked to complete development of capability for the orchestration of the dynamic employment of multiple moving target defense components, configurations and services across the information enterprise to ensure the mission. Provided final delivery of Attack Surface Reasoning and Characterization of Proactive Defenses integration with local and remote testbeds. ***FY 2017 Plans:*** Initiate horizontal and vertical integration of kinetic and non-kinetic effects assessment across domains. Initiate validity estimation and correlation. Initiate optimization and dynamic constraint monitoring. Initiate advanced visualizations of heterogeneous sources for understanding complex interaction. Continue electromagnetic spectrum course of action generation/optimization, discrete optimization from a large input set, electromagnetic spectrum visualization, resource-oriented hybridized architecture and group-sourcing for C2. ***FY 2018 Plans:*** Continue development of assessment services allowing the ability to recognize plan deviations and determine the need for re-planning across a degraded operational environment. Continue development of the application of group-sourcing methods, and advanced visualization capabilities, for Space C2. Leverage DARPA Future C2 R&D efforts to support Air Force science and technology need for Air Combat Command capability gap.			
Accomplishments/Planned Programs Subtotals	20.962	14.770	28.349

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
625318: *Operational Awareness Tech*	-	19.698	21.246	21.514	0.000	21.514	22.979	23.335	24.136	24.602	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 (ID), 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 2016	FY 2017	FY 2018
Title: Multi-Source Fusion Technologies	10.900	9.744	11.902
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 2016 Accomplishments: Completed in-house and university research dealing with the information fusion using intelligence (INT) from multiple sources and sensor feeds to advance the Air Force capability to anticipate the variety of threats from the ground, air, and cyber domains. Analyzed emerging activities across multiple domains in both tactical and strategic timelines. Continued applying advanced reasoning techniques to multi-INT data including SIGINT and space surveillance network (SSN) data to assess space objects and determine significance of activity. Addressed the contested operations ISR analysis needs for multi-INT breadth spanning standoff-perishable-hard/soft collection & processing via development of spatial-temporal mining and correlation capabilities across the INT spectrum using both batch and streaming cloud analytics. Provided advanced Activity-Based Intelligence (ABI) tools with built-in optimization tailored against operator objectives. Developed techniques to provide a deeper understanding of the meaning of information extracted from open source text, messages, reports, social media and other associated data sources and large scale, time dependent, network based analytics.			
FY 2017 Plans: Continue to develop Space Situational Awareness & Space Protection Domain Specific Applications. Continue to analyze and correlate observations from sensors, to produce tracks, to extract kinematic and non-kinematic features, and to learn target			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
object behavior. This information will be used to assess capabilities, purpose, and intent and produce indications and warnings of anomalies associated with the object behavior. Continue to develop multi-INT techniques using context-based, pattern of life analysis for permissive and contested environments. Continue development of techniques (a) for information extraction from network analysis; (b) for complex event extraction to understand how individual events fit together conceptually, into some higher-level logical structure (e.g., based on causality, temporal ordering, etc.); and (c) for social media analytics focused on entity and account resolution, spatial and content analysis, temporal analysis, noise reduction, and community structures. Continue to develop a distributed multi-INT processing, exploitation, and dissemination (PED) software framework. Incorporate automated or operator-assist ABI product generation to expedite analyst workflow, and provide ABI analytics with PED (both streaming and forensic) driven by the analyst. ***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 multi-INT techniques using context-based, pattern of life analysis for permissive and contested environments. Continue development of techniques (a) for information extraction from network analysis. Continue to develop a distributed multi-INT PED software framework. Incorporate automated or operator-assist product generation to expedite analyst workflow, and provide analytics with based on input from the analyst.			
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 2016 Accomplishments:*** Continued development prototype hardware and software solutions for modern emitter signals which improve upon the signal characterization, detection and mitigation of coding and channel condition effects, and advance information extraction capabilities. Continued algorithmic improvements in signal characterization, detection and mitigation of coding/channel condition effects. Developed improvements for feature extraction methods and performance across multiple data sets. Finalized evaluation of full motion video (FMV) exploitation tools, and select the best of breed. Initiated the development of capabilities for the exploitation of intelligence information using topological mathematical approaches applied to the SIGINT domain. ***FY 2017 Plans:*** Test and integrate enhanced Electronic signals intelligence non-traditional feature extraction capabilities into airborne platforms. Investigate Deep Neural Network features and classifiers. Improve scatter statistics for model mismatch conditions. Refine confidence measures for real-time language identification. Continue to develop topological algorithm analytics to exploit features	6.928	8.753	8.353

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
for anomaly and/or pattern detection. Continue SIGINT characterization algorithm development and refine methods based on feedback. Develop specialized SIGINT change detection. ***FY 2018 Plans:*** Continue to develop topological algorithm analytics to exploit features for anomaly and/or pattern detection. Continue SIGINT characterization algorithm development and refine methods based on operator feedback. Develop specialized SIGINT alerting and change detection.			
Title: Next Generation Command Technologies ***Description:*** Develop modeling and simulation technologies for the next generation of planning, assessment, and execution environments. ***FY 2016 Accomplishments:*** Continued to develop a capability that identifies targets with non-kinetic data and propose new workflows for such targets. Worked towards illustrating the time saved for Battle Damage Assessment (BDA) by performing assessment with non-geospatial intelligence data. Conducted tests using electromagnetic data. ***FY 2017 Plans:*** Continue building capabilities to support BDA and non-kinetic integration. Develop capability that semi-automatically extracts and visualizes relationships within target system, automatically prioritize/rank targets based on identified relationships, semi-automatically update understanding of the target situation analysis when new batches of reports arrive and illustrates how integration of non-kinetics and prioritization that comes from target system analysis can help bomb damage assessment. ***FY 2018 Plans:*** Continue research and development of capabilities to support BDA 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.	1.870	2.749	1.259
Accomplishments/Planned Programs Subtotals	19.698	21.246	21.514

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
625319: *Cyberspace Dominance Technology*	-	0.000	59.712	55.801	0.000	55.801	57.493	60.195	61.063	62.247	Continuing	Continuing

A. Mission Description and Budget Item Justification

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; assess, 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.

Prior to FY 2017 cyber work performed internal to this program within Project 625315, Connectivity and Protection Technology, and Project 625316, Info Management and Computational Technology now will be reported under this project, Cyberspace Dominance Technology.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Cyber Defense Technologies	0.000	15.411	17.850
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 2016 Accomplishments: For FY 2016, the work for this effort originally was performed under Project 625315, Connectivity and Protection Technology in the effort, Cyber Defense Technologies.			
FY 2017 Plans: Continue development of Decision Engine and tesbed. Initiate demonstration of all system system components, with reduced scale and feature set. Develop validation techniques that assess qualitative effects of mission awareness analytics. Develop a secure foundation for mission models that cross DoD-domains while maintaining robustness, awareness capabilities, and engage assurance technologies. Include live autonomous systems and integrate Stockbridge facility into cyber exercise structure. Address new gaps			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
identified in the initial effort, expand upon results of initial effort, and explore additional capabilities. Continue collaborations with University Center of Excellence in Assured Cloud Computing. ***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 DoD-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 results obtained from previous research and development, and explore additional capabilities.			
Title: Cyber Offense Technologies ***Description:*** Develop offensive cyber operations technologies to access, maintain presence on, and deliver effects to adversary systems. ***FY 2016 Accomplishments:*** For FY 2016, the work for this effort originally was performed under Project 625315, Connectivity and Protection Technology in the effort, Cyber Offense Technologies. ***FY 2017 Plans:*** Continue to research new technology that shows promise and game changing possibility. Develop technologies to remain current with new waveforms and signals. Continue SOA mission component development for use in the Air Force Life Cycle Management Center CMP system. Transition components, including Cyber Time and Cyber Mission Planning, for use in the CMP system. Continue red-teaming new components to improve security. ***FY 2018 Plans:*** Continue to research and develop dynamic waveform techniques and cyberspace capabilities in order to detect, identify, locate and attack in A2AD 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.	0.000	15.975	6.079
Title: Advanced Architectural Technologies ***Description:*** Develop the architectural mechanisms that form the basis for predictable software and high assurance systems. ***FY 2016 Accomplishments:***	0.000	8.804	12.165

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
For FY 2016, the work for this effort originally was performed under Project 625316, Info Management and Computational Technology in the effort, Advanced Architectural Technologies. ***FY 2017 Plans:*** Continue cyber hardened processor for embedded weapon systems. Develop a runtime environment that can monitor and maintain a trusted and resilient envelope of operation. Initiate fabrication for the prototype neuromorphic processor hardware. ***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.			
Title: Processing Technologies ***Description:*** Develop automatic and dynamically reconfigurable, scalable, affordable distributed peta-flop processing technologies for real-time global information systems. ***FY 2016 Accomplishments:*** For FY 2016, the work for this effort originally was performed under Project 625316, Info Management and Computational Technology in the effort, Processing Technologies. ***FY 2017 Plans:*** Advance and test 128 by 128 Memristor Cross-Bar and apply application. Develop and test TrueNorth and Secure Processor input/output native network. Work to complete evaluation and test of context-aware services for historical human intelligence and scene understanding on open source database. Test and evaluate capability to automatically generate tactical actionable intel relevant to mission/analyst needs. ***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, further evolve the adapt the photon-based interconnects, and develop an integration scheme to interface a quantum network with the existing free-space optical link between AFRL Information Directorate laboratory facility in Rome and the Stockbridge remote test site.	0.000	7.775	6.938
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 2016 Accomplishments:***	0.000	4.214	3.599

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
For FY 2016, the work for this effort originally was performed under Project 625315, Connectivity and Protection Technology in the effort, Survivability Technologies. ***FY 2017 Plans:*** Continue to research revolutionary concepts and capabilities for automated and autonomous processes addressing cyber survivability using an operational system laboratory to host modular RDT&E. Integrate basic machine learning functions into defensive cyber operations systems. Research and create prototype for memory isolation and disk introspection. Research processing vulnerabilities between encryption mechanisms. ***FY 2018 Plans:*** Continue to research concepts and capabilities for automated and autonomous processes addressing cyber survivability using an operational system laboratory to host modular RDT&E. Continue to integrate autonomous machine learning functions into defensive cyber operations systems.			
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 2016 Accomplishments:*** For FY 2016, the work for this effort originally was performed under Project 625316, Info Management and Computational Technology in the effort, Cross Domain Technologies. ***FY 2017 Plans:*** Continue research on cross domain change detection, cross domain machine to machine mediation layer and multiple levels of security mobile secure foundation technologies. ***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.	0.000	3.744	3.663
Title: Cyber Technologies for Spectrum Warfare ***Description:*** Develop technologies combining electronic warfare, signals intelligence (SIGINT), communications, and cyber technologies that provide synergistic access, exploitation and effects across air and cyber domains in congested and contested environments. ***FY 2016 Accomplishments:***	0.000	3.789	5.507

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
For FY 2016, the work for this effort originally was performed under Project 625315, Connectivity and Protection Technology in the effort, Cyber Technologies for Spectrum Warfare. ***FY 2017 Plans:*** Continue development of active and passive methods to locate, acquire and process data and signals of interest. ***FY 2018 Plans:*** Continue development of active and passive methods to locate, acquire and process data and signals of interest.			
Accomplishments/Planned Programs Subtotals	0.000	59.712	55.801

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
62OMMS: *Research Site Support*	-	21.256	21.728	20.520	0.000	20.520	20.806	21.120	21.686	22.108	Continuing	Continuing

A. Mission Description and Budget Item Justification

The AFRL Information Directorate leads the discovery, development and implementation of information science and technology to drive transformation within the Air Force and across the DoD. 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 not located on a military installation, the Information Directorate has unique requirements for supporting its S&T mission. As the host unit, the directorate is responsible to provide the Rome Research Site infrastructure at Rome, NY 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 2016	FY 2017	FY 2018
Title: Rome Research Infrastructure	21.256	21.728	20.520

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 (GSA) set of NETWORX contracts for Continental U.S.), trunk connectivity and wireless communications.

FY 2016 Accomplishments:

Provided civilian payroll and non-pay costs for installation operations in support of the Rome Research Site property and all onsite personnel. Provided 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. Provided 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-SRM service calls. Provided basic installation

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
communication services, including long haul trunk and telecommunications services. Provided site vehicle lease under GSA for logistics, security, and mission support. ***FY 2017 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-SRM service calls. Provide basic installation communication services, including long haul trunk and telecommunications services. Provide site vehicle lease under GSA for logistics, security, and mission support. ***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-SRM service calls. Provide basic installation communication services, including long haul trunk and telecommunications services. Provide site vehicle lease under GSA for logistics, security, and mission support.			
Accomplishments/Planned Programs Subtotals	21.256	21.728	20.520

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	39.155	42.300	43.049	0.000	43.049	43.685	44.553	45.443	46.352	Continuing	Continuing
625096: *High Energy Laser Research*	-	39.155	42.300	43.049	0.000	43.049	43.685	44.553	45.443	46.352	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program funds Department of Defense (DoD) high energy laser (HEL) applied research through the Joint Directed Energy Transition Office (JDETO). This program is part of an overall DoD HEL Science and Technology (S&T) program. HEL 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. HELs have the potential to perform a wide variety of military missions including defeat of high-speed, maneuvering anti-ship and anti-aircraft missiles and the ultra-precision negation of targets in urban environments with minimal collateral damage. Efforts funded under this program are generally chosen for their potential to have an impact on multiple HEL 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 also supports the Senior Official as required. Efforts in this program have been coordinated through the DoD S&T Executive Committee process to harmonize efforts and eliminate duplication.

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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	41.855	42.300	43.049	0.000	43.049
Current President's Budget	39.155	42.300	43.049	0.000	43.049
Total Adjustments	-2.700	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	-1.261	0.000			
• SBIR/STTR Transfer	-1.439	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

Change Summary Explanation

Decrease in FY 2016 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
Title: Robust Electric Laser Initiative	1.540	0.000	-
Description: Advance solid-state laser development via the Robust Electric Laser Initiative (RELI). ***FY 2016 Accomplishments:*** Completed a joint high power electric laser product improvement program, as part of the RELI effort. Monitored technical progress of the four efforts and other sources. Monitored performance of the lasers as integrated onto relevant military platforms. Completed analysis of trade space to understand performance, fielding, robustness and integration issues for future platforms. Completed government-sponsored measurements to validate performance. ***FY 2017 Plans:*** In FY2016, the RELI effort completes.			
Title: Solid State Laser Technologies	7.900	7.650	7.650
Description: Mature technologies that will provide system level performance commensurate with fieldable laser devices. ***FY 2016 Accomplishments:*** Completed a joint high-power electric laser product improvement program as part of the RELI effort. Monitored technical progress of the four efforts and other sources. Monitored performance of the lasers as integrated onto relevant military platforms. Completed analysis of trade space to understand performance, fielding, robustness and integration issues for future platforms. Completed government-sponsored measurements to validate performance. ***FY 2017 Plans:*** Continue to develop high reliability, lower cost, efficient and high temperature diode pump sources. Scale alternate laser wavelengths to additional militarily relevant power levels. Investigate high power fiber technologies. Continue risk reduction in solid state lasers for their inclusion in future laser systems. Monitor performance of the RELI lasers as integrated onto relevant military platforms. Conduct analysis of trade space to understand performance, fielding, robustness and integration issues for future platforms. ***FY 2018 Plans:*** Continue to develop high reliability, lower cost, efficient and high temperature diode pump sources. Scale alternate laser wavelengths to additional militarily relevant uses and power levels. Investigate high power fiber technologies. Continue risk reduction in solid state lasers for their inclusion in future laser systems. Conduct analysis of trade space to understand performance, fielding, robustness and integration issues for future platforms.			
Title: Advanced High Energy Laser Technologies	5.300	6.210	6.210

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
Description: Investigate new technologies that have revolutionary potential HEL applications. ***FY 2016 Accomplishments:*** Explored novel laser technologies to improve efficiency and decrease mass/volume for future laser weapon systems. Evaluated additional materials for high energy laser applications. Continued to improve understanding of short pulse laser technology to include material interaction and propagation. Continued to scale electrically pumped alkali lasers to kilowatt (KW)-class power levels. Continued efforts to characterize and understand the physics of HEL propagation in adverse weather conditions such as fog, rain, smoke and dust. Continued development of the Avoidance and Air Space Deconfliction system and continued early-phase testing on HEL test range(s). Conducted a Service and Agency call for FY17. ***FY 2017 Plans:*** Explore novel laser technologies to improve efficiency and decrease mass/volume for future laser weapon systems. Evaluate additional materials for high energy laser applications. Continue to improve understanding of short pulse laser technology to include material interaction and propagation. Continue to scale electrically pumped alkali lasers to higher KW-class power levels. Continue efforts to characterize and understand the physics of HEL propagation in adverse weather conditions. Conduct verification and validation for airspace de-confliction (AD), integrate AD with predictive avoidance tools to support an integrated demonstration. Establish a technical transition partner for program of record status designation. ***FY 2018 Plans:*** Explore novel laser technologies to improve efficiency and decrease mass/volume for future laser weapon systems. Evaluate additional materials for high energy laser applications. Continue to improve understanding of short pulse laser technology to include material interaction and propagation. Continue to scale electrically pumped alkali lasers to higher KW-class power levels. Continue efforts to characterize and understand the physics of HEL propagation in adverse weather conditions such as fog, rain, smoke and dust. Continue testing of the Avoidance and Air Space De-confliction system on HEL test range(s).			
Title: Laser Beam Control Technologies ***Description:*** Develop technology to support high performance beam control systems and integrated demonstrations. ***FY 2016 Accomplishments:*** Continued development of beam control technologies for laser weapon use on multiple platforms (aircraft, ground vehicles and shipboard systems) in stressing environments. Continued development of a predictive avoidance fire control system for use on multiple platforms. Enhanced execution of a program for kill assessment technologies. Continued joint investigations of beam control hardware and technologies to improve throughput efficiency through the beam director, decrease component weight, and	18.055	21.080	21.080

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
improve tracking and compensation through the atmosphere. Conducted a Service and Agency call for FY17. ***FY 2017 Plans:*** 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 Plans:*** 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.			
Title: 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 2016 Accomplishments:*** Integrated lethality data into campaign-level HEL system level models. Conducted laser vulnerability experiments on materials, components, and targets. Continued development of an unmanned air vehicle vulnerability module for integration into the modeling and simulation toolkit. Continued development of a suite of directed energy weapon (DEW) tools to be used in a database from which the warfighter can assess target vulnerabilities and mission utility for a given DEW platform and engagement. ***FY 2017 Plans:*** Continue to integrate recent lethality data into campaign-level HEL system models. Conduct laser vulnerability experiments on additional materials, components, and targets. Continue the development of a suite of DEW tools to be used in a database from which the warfighter can assess target vulnerabilities and mission utility for a given DEW platform and engagement. ***FY 2018 Plans:*** Continue to integrate recent lethality data into campaign-level HEL system models. Conduct laser vulnerability experiments on materials, components, and targets. Continue development of a suite of DEW tools to be used in a database from which the	3.220	3.720	4.095

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
warfighter can assess target vulnerabilities and mission utility for given DEW platform and engagement using standard Joint Munitions Effectiveness Standards criteria.			
Title: High Energy Laser Modeling	3.140	3.640	4.014
Description: Maintain and evaluate high-fidelity engineering models for HEL system scenario evaluation and incorporation into the HEL toolkit. Provide for HEL system modeling for mission-level war gaming activities. ***FY 2016 Accomplishments:*** Provided maintenance, verification, validation, and accreditation for updated system level HEL models, continued validation and verification of HEL models. Conducted mission-level HEL engagement scenarios and wargame HEL concepts. Created a Model Based Systems Engineering (MBSE) framework that provides criteria for design, test, and investment of a full system represented by an end-to-end model. Validated databases plus models provide accurate performance envelopes for advanced beam control tasks. Output is end-to-end model incorporating upgraded components and demonstration of new engagement capability. Continued analysis of scenario conditions to understand relative gains in hardware developments. ***FY 2017 Plans:*** Provide continued maintenance, verification, validation, and accreditation for updated system level HEL models. Conduct additional mission-level HEL engagement scenarios and wargame HEL concepts. Continue to update atmospheric data into theater models to support performance characterization tables. Support risk assessment for the unintentional illumination of air and space objects by tactical laser weapons. ***FY 2018 Plans:*** Provide continued maintenance, verification, validation, and accreditation for updated system level HEL models. Collaborate with Service sponsored field test planning to correlate model predictions to measured data for surface, maritime and aerospace environments. Continue to update atmospheric data into theater models to support performance characterization tables. Conduct verification and validation planning to support advanced beam control objectives.			
Accomplishments/Planned Programs Subtotals	39.155	42.300	43.049

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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*

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: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
Total Program Element	-	38.238	35.137	37.856	0.000	37.856	35.139	36.861	37.849	39.306	Continuing	Continuing
632100: *Laser Hardened Materials*	-	8.655	15.472	14.948	0.000	14.948	15.139	15.926	16.245	16.570	Continuing	Continuing
633153: *Non-Destructive Inspection Development*	-	4.906	6.350	6.331	0.000	6.331	6.423	6.550	6.681	6.815	Continuing	Continuing
633946: *Materials Transition*	-	24.677	13.315	16.577	0.000	16.577	13.577	14.385	14.923	15.921	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates materials technology for transition into Air Force systems. The program has three projects which develop: hardened materials technologies for the protection of aircrews and sensors; non-destructive inspection and evaluation technologies; and materials transition technologies on structural and non-structural materials for aerospace applications. 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 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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	46.665	35.137	36.664	0.000	36.664
Current President's Budget	38.238	35.137	37.856	0.000	37.856
Total Adjustments	-8.427	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	-7.510	0.000			
• SBIR/STTR Transfer	-0.917	0.000			
• Other Adjustments	0.000	0.000	1.192	0.000	1.192

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 633946: *Materials Transition*		
Congressional Add: *Metals Affordability Research*	9.000	-

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017
Congressional Add Subtotals for Project: 633946	9.000	-
Congressional Add Totals for all Projects	9.000	-

Change Summary Explanation

Decrease in FY 2016 reflects reprogramming for Air Dominance activities and to support Research and Development Projects, 10 U.S.C. Section 2358.

Increase FY 2018 due higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
632100: *Laser Hardened Materials*	-	8.655	15.472	14.948	0.000	14.948	15.139	15.926	16.245	16.570	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 2016	FY 2017	FY 2018
Title: Aerospace Systems Protection	4.068	7.306	7.026

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

FY 2016 Accomplishments:

Developed survivable electro-optic sensors that provide full spectrum protection for missile warning. Continued development of protection materials for visual/near infrared (NIR) Intelligence Surveillance Reconnaissance (ISR) sensors. Demonstrated use of protection technologies for future ISR sensor designs and strategies to mitigate directed energy damage for visual/NIR, short-wave infrared (SWIR), and mid-wave infrared (MWIR) detectors. Continued evaluating the performance impact of damage-limiting semiconductor materials designed to harden electro-optic imaging sensors. Developed laser countermeasures for survivability of dynamic electro-optic/infrared imagers. Continued to employ computational materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings for use in sensor hardening. Initiated air systems airframe and anti-access munitions hardening assessment.

FY 2017 Plans:

Continue to analyze and develop protection materials for visual/near infrared ISR sensors. Continue to demonstrate use of protection technologies for future sensor designs and strategies to mitigate directed energy damage for visual/NIR, SWIR, and MWIR detectors. Continue to develop 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 to develop laser countermeasures for survivability of dynamic electro-optic/infrared imagers. Continue to employ computational materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings for use in sensor hardening. Develop air systems airframe and anti-access munitions hardening assessments and solutions.

FY 2018 Plans:

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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. 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. Continue technology stimulation and maturation to develop defensive capability for air systems airframe and anti-access munitions hardening assessments and solutions.			
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 2016 Accomplishments:*** Developed and demonstrated laser protection materials and technologies for personnel protection. Validated and continued development of helmet mounted sensor hardening materials. Continued to advance development of visor based aircrew protection materials. Characterized and demonstrated eye protection technologies using computational materials science tools. Improved functionality and performance of personnel protection technologies in expected operational conditions. ***FY 2017 Plans:*** Continue to develop 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 characterize and demonstrate eye protection technologies using computational materials science tools. Demonstrate and continue to improve functionality and performance of personnel protection technologies in expected operational conditions. ***FY 2018 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. 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.	4.587	8.166	7.922
Accomplishments/Planned Programs Subtotals	8.655	15.472	14.948

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
633153: *Non-Destructive Inspection Development*	-	4.906	6.350	6.331	0.000	6.331	6.423	6.550	6.681	6.815	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 2016	FY 2017	FY 2018
Title: Advanced Engine Inspection Technologies	1.207	1.964	1.558
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 2016 Accomplishments:*** Demonstrated a robotic snake-arm system, designed to reach difficult-to-access areas, performed accurate inspections without major disassembly of aircraft structure while proving quick logistics deployment and ease of operator interaction. Demonstrated nondestructive 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. ***FY 2017 Plans:*** Continue to demonstrate nondestructive evaluation approaches to assess material 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. Validate robotic nondestructive inspection methods to minimize disassembly and reduced maintenance burden to perform inspections of aircraft structures. Continue to develop novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. ***FY 2018 Plans:*** Validate repeatability of NDI/E 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.			
Title: Special Material Inspection Technologies (formerly known as "Low-Observable Inspection Technologies")	0.916	1.585	1.182

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Develop and demonstrate advanced inspection technologies supporting low-observable (LO) systems to enhance affordability and ensure full performance and survivability. ***FY 2016 Accomplishments:*** Demonstrated a hand-held aircraft exhaust surface coating damage registration sensor with automatic database information transfer which reduces inspection time and increases accuracy compared to current manual system. Initiated new and continued development of improved methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of LO materials that enables/ensures more affordable signature assessment. ***FY 2017 Plans:*** Continue to improve methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of special materials that enables/ensures more affordable signature assessment. Develop tools to improve characterization of specialty multilayer coatings. Initiate development of 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 2018 Plans:*** 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. Continue to 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.			
Title: Advanced System Monitoring Technologies ***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 2016 Accomplishments:*** Transitioned improved field and depot-level NDI/E technologies and methodologies for assessing the structural integrity of airframes. Continued development of analytical methods to assess the location of damage in multi-layered structures using nondestructive inspection data and results. Developed robotic nondestructive inspection methods to minimize disassembly and reduced maintenance burden to perform inspections of aircraft structures. Initiated development of novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. Continued enhanced methods for	2.783	2.801	3.591

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
collecting and analyzing digital NDI/E data necessary for improved damage detection and characterization. Demonstrated the integration of computational materials science tools with life prediction methods to enable risk-based life management. ***FY 2017 Plans:*** Continue development of analytical methods to assess the location of damage in multi-layered structure base on nondestructive inspection data and results. Validate 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 NDI/E data necessary for improved damage detection and characterization. Continue the integration of computational materials science tools with life prediction methods to enable risk-based life management. ***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. 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 NDI/E data necessary for improved damage detection and characterization. Continue the integration of computational materials science tools with life prediction methods to enable risk-based life management. Continue comprehensive development of physical and digital nondestructive evaluation tools to support and provide concept approach of Damage State Awareness of materials.			
Accomplishments/Planned Programs Subtotals	4.906	6.350	6.331

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
633946: *Materials Transition*	-	24.677	13.315	16.577	0.000	16.577	13.577	14.385	14.923	15.921	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 2016	FY 2017	FY 2018
Title: Air Vehicle Materials Technologies	13.388	10.672	14.090
Description: Develop and demonstrate materials and processes technologies for air vehicle and subsystems to enhance lift, propulsion, LO performance, power generation management, and affordability of air vehicles. ***FY 2016 Accomplishments:*** Demonstrated processing methods and lifing tools for ceramic matrix composites and graded microstructure turbine engine disk concepts. Continued developing the repeatability and modernizing of magnetoresistive sensing technologies. Integrated damage with risk-based life management strategies for turbine engines. Developed materials and processes to increase LO, special materials and metals affordability. ***FY 2017 Plans:*** Demonstrate in field the repeatability of magnetoresistive sensing. Transition materials and processes to increase LO materials affordability. Initiate development of methods to perform damage characterization of turbine engines. Continue to develop affordable metals and computational technologies for advanced aero structure and engine components. ***FY 2018 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.			
Title: High Temperature Material Technologies	2.289	2.643	2.487
Description: Develop and demonstrate affordable, novel high temperature materials/structures and thermal management concepts to enable future defense capabilities for prompt global strike concepts.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: High temperature alloy compositions were selected for the bore, rim, and disk assembly portions of the advanced high pressure turbine disk for the next-generation turbine engine. Demonstrated the 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 metals, and intermetallics. Validated enviro-mechanical damage models of 2700-degree Fahrenheit ceramic matrix composites used in turbine hot section components and finalized vane geometry for rig test to further validate damage models in realistic environment. Advanced development of high temperature materials for next-generation turbine engine disks. ***FY 2017 Plans:*** Continue to 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. Continue to demonstrate and model 2700-degree Fahrenheit ceramic matrix composites for turbine hot section components. Continue to develop high temperature materials for next-generation turbine engine disks. ***FY 2018 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 temperature materials for next-generation turbine engine disks.			
Accomplishments/Planned Programs Subtotals	15.677	13.315	16.577

	FY 2016	FY 2017
Congressional Add: Metals Affordability Research ***FY 2016 Accomplishments:*** Conducted congressionally directed effort in low-cost special aerospace metals.	9.000	-
Congressional Adds Subtotals	9.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
Total Program Element	-	17.323	20.636	22.811	0.000	22.811	23.217	23.680	24.154	24.637	Continuing	Continuing
635351: *Technology Sustainment*	-	17.323	20.636	22.811	0.000	22.811	23.217	23.680	24.154	24.637	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates mature Air Force Research Laboratory (AFRL) sustainment technologies such as: materials, corrosion, maintenance/repair techniques, state awareness/non-destructive inspection, health management, life prediction, low observable materials and processes, composite materials and logistics for transition into fielded Air Force systems to reduce life cycle sustainment costs and increase readiness. Technologies matured and demonstrated impact affordability and availability of fielded aerospace weapon systems by reducing sustainment costs, extending service life, and maintaining mission readiness and capability.
This project 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 project 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 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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	18.378	20.636	22.811	0.000	22.811
Current President's Budget	17.323	20.636	22.811	0.000	22.811
Total Adjustments	-1.055	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	-0.496	0.000			
• SBIR/STTR Transfer	-0.559	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
Title: System Health Management/Assessment Technologies	4.722	4.952	5.325
Description: Develop, demonstrate, and transition state awareness/system health management technologies. Conduct studies and analyses to design sustainability into future applications. The short-term efforts in this project are selected based on warfighter needs identified via a bi-annual, competitive process. ***FY 2016 Accomplishments:*** Continued development of diagnostic technology to monitor/assess health of airframe/engines and components, for example: completed passive fuel bladder leak detection development, integration, and demonstration. Continued health assessment capability development for fielded systems and components. Continued development and demonstration of diagnostic technology to monitor/assess health of airframe/engine and components such as aircraft electrical systems maintenance testing capability and converting a text and media analysis system into a sustainable, web-based application which will make the tools sustainable for the next ten years or more. ***FY 2017 Plans:*** Continue development of diagnostic technology to monitor/assess health of airframe/engines and components. Continue health assessment capability development for fielded systems and components. Continue development and demonstration of diagnostic technology to monitor/assess health of airframe/engine and components. ***FY 2018 Plans:*** Continue health assessment capability development for fielded air/space/cyber systems and components. 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 new efforts based on competitive selection processes in FY 2017.			
Title: Prevention/Enhanced Maintainability Technologies	3.998	5.024	5.325
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 efforts in this project are selected based on warfighter needs identified via a bi-annual, competitive process. ***FY 2016 Accomplishments:*** Continued development of materials and processes to reduce low observable (LO). Continued efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions. Continued airframe/			

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
engine subsystem technology efforts including honeycomb structures. Continued solid state amplifier replacement for B-1B. Continued enhanced ester oil and integrally bladed rotor repair modeling. Initiated thermal spray coating process. ***FY 2017 Plans:*** Complete first LO articles. 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, replacement, and concepts for performance improvement and reduced maintenance burden spanning Air Force Air, Space, and Cyber mission areas. Continue development and transition of technologies that simplify training for maintainers and improving their performance. Continue airframe/engine subsystem technology efforts. Continue solid state amplifier replacement for B-1B. Continue enhanced ester oil and integrally bladed rotor repair modeling. Continue thermal spray coating process. ***FY 2018 Plans:*** 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, replacement, and concepts for performance improvement and reduced maintenance burden spanning Air Force Air, Space, and Cyber mission areas. Continue development and transition of technologies that simplify training for maintainers and improving their performance. Complete enhanced ester oil and integrally bladed rotor repair modeling. Initiate new efforts based on competitive selection processes in FY 2017.			
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 efforts in this project are selected based on warfighter needs identified via a bi-annual, competitive process. ***FY 2016 Accomplishments:*** Completed data visualization tool expansion to depot maintenance data. Continued efforts to develop system fleet management decision-making tools, repair data base technologies and techniques, and supply chain/infrastructure approaches to reduce sustainment costs. Continued durable structure demonstrations. Continued C-5 corrosion project. ***FY 2017 Plans:*** Continue efforts to develop system fleet management decision-making tools, repair data base technologies and techniques, and supply chain/infrastructure approaches to reduce sustainment costs. Continue durable structure demonstrations. Continue C-5 corrosion project. ***FY 2018 Plans:***	4.476	4.649	4.144

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
Continue efforts to develop system fleet management decision-making tools, repair data base technologies and techniques, and supply chain/infrastructure approaches to reduce sustainment costs. Develop, demonstrate, and transition technologies to improve existing and new components to decrease repair/sustainment costs and increase reliability. These efforts span Air Force Air, Space, and Cyber mission areas. Complete durable structure demonstrations. Complete C-5 corrosion project. Initiate new efforts based on competitive selection processes in FY 2017.			
Title: Composite Certification ***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 2016 Accomplishments:*** Completed demonstration of accurate prediction of the probability of failure and life of bonded and unitized composite structures. Continued demonstration of manufacturing processes and manufacturing process control of composite primary structures. Completed testing of the feasibility of implementing a damage tolerant design approach for composite structures. Continued 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. Continued demonstration of life extension of a composite primary structure beyond that of the original certified service life. Initiated assessment and designs of affordable low cost composite manufacturing methods and processes. ***FY 2017 Plans:*** Continue demonstration of manufacturing processes and manufacturing process control of composite primary structures. Complete demonstrating the feasibility of implementing a damage tolerant design approach for composite structures. Continue 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. Continue demonstration of life extension of a composite primary structure beyond that of the original certified service life. Complete assessment and designs of affordable low cost composite manufacturing methods and processes. ***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. Initiate flight demonstration of a composite compliant trailing edge on a legacy fleet aircraft.	4.127	6.011	8.017
Accomplishments/Planned Programs Subtotals	17.323	20.636	22.811

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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)*

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	39.794	40.945	40.978	0.000	40.978	43.010	45.125	48.158	49.676	Continuing	Continuing
63665A: *Advanced Aerospace Sensors Technology*	-	16.443	19.547	19.734	0.000	19.734	21.258	21.620	21.992	22.372	Continuing	Continuing
6369DF: *Target Attack and Recognition Technology*	-	23.351	21.398	21.244	0.000	21.244	21.752	23.505	26.166	27.304	Continuing	Continuing

A. Mission Description and Budget Item Justification

Divided into two broad project areas, Advanced Aerospace Sensors develops technologies to enable the continued superiority of sensors from aerospace platforms. The first project area develops and demonstrates advanced technologies for electro-optical sensors, radar sensors and electronic counter-countermeasures, and components and algorithms. The second project area 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. Together, the projects in this program develop 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 (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	42.001	40.945	38.547	0.000	38.547
Current President's Budget	39.794	40.945	40.978	0.000	40.978
Total Adjustments	-2.207	0.000	2.431	0.000	2.431
• 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	-1.139	0.000			
• SBIR/STTR Transfer	-1.068	0.000			
• Other Adjustments	0.000	0.000	2.431	0.000	2.431

Change Summary Explanation

Decrease in FY 2016 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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*

Increase in FY 2018 is a realignment of funds for increased integrated technology demonstrations.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
63665A: *Advanced Aerospace Sensors Technology*	-	16.443	19.547	19.734	0.000	19.734	21.258	21.620	21.992	22.372	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project area develops and demonstrates aerospace sensor and processing technologies for intelligence, surveillance, reconnaissance (ISR), 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. Desired warfighting capabilities include the ability to detect concealed targets in difficult background conditions.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Integrated Navigation Technologies	4.227	0.000	-
Description: Develop and demonstrate technologies to provide precision position and timing information to enable distributed, layered sensing on air and space vehicles in Global Positioning System (GPS) degraded/denied environments. Develop technologies to maximize positional accuracy, timing accuracy, and exploitation techniques to improve offensive and defensive combat capabilities. Simulate, develop, and demonstrate integrated navigation warfare technologies, to establish and maintain a military advantage in satellite-based navigation. ***FY 2016 Accomplishments:*** Demonstrated GPS augmentation technologies which include use of Global Navigation Satellite System (GNSS) signals with functionality to minimize point source interference while maintaining robust position, navigation & timing (PNT). Continued to develop and mature technologies to incorporate GNSS capability in user equipment to include GPS Modernized Signals. Developed technologies to minimize the hardware and software overhead required on user equipment to process GNSS signals with precision. ***FY 2017 Plans:*** For FY 2017 and beyond, work accomplished under this effort will be reported in Program 0603270F, Electronic Combat Technology, in Projects 633720, EW Quick Reaction Capabilities, and 63431G, RF Warning & Countermeasures Tech.			
Title: Persistent Sensing in Contested Environment Technologies	3.150	2.358	2.381
Description: Develop active RF sensor solutions to use against difficult-to-detect targets in challenging environments, and advanced RF architectures for open and reconfigurable systems. Enable persistent ISR over wide areas, and detect advanced air and ground targets.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Developed wideband apertures, beamforming networks, signal processing and receiver technology to support passive Electronic Support and Passive Radar modes. Continued research and development of high performance conformal array antenna technology, novel waveforms, multiple input multiple output (MIMO) signal processing techniques, and cooperative RF sensing from multiple platforms in congested electromagnetic environments. Characterized and simulated system performance of active and passive RF sensing systems (measured and modeled environments) in terms of RF sensing geometry, environmental phenomenology, clutter, and interference. ***FY 2017 Plans:*** For FY 2017 and beyond, the laser radar technology development work will be performed under the Laser Radar for Non-Cooperative Identification effort. Continue research and development of wideband apertures, beamforming networks, signal processing and receiver technology to support electronic support and passive radar modes. Demonstrate wideband phased array and antenna technology in a laboratory and RF range environments. Demonstrate MIMO waveform characteristics and evaluate performance using laboratory assets. ***FY 2018 Plans:*** Develop multichannel transmit and receive hardware for distributed MIMO applications. Explore methodologies for coherent signal processing modes supporting electronic support and passive radar receivers.			
Title: Passive Radio Frequency (RF) Sensing Technologies	6.043	4.422	4.464
Description: Develop advanced techniques and prototype passive RF sensors to intercept, collect, locate and track enemy RF sensor systems for ISR of air and ground targets. ***FY 2016 Accomplishments:*** Researched an illumination selection manager to support passive radar functions in an anti-access/area denial (A2/AD) environment. Continued research and data analysis of passive multi-mode radar technology, including signals intelligence (SIGINT), airborne moving target indicator (AMTI), ground moving target indicator (GMTI), and synthetic aperture radar (SAR) imaging. Demonstrated technique for significantly increasing useful range of a passive EO/IR ISR sensor beyond the current state of the art. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
For FY 2017 and beyond, Passive EO Sensing work accomplished under this effort will be reported under the Passive EO Sensing for Surveillance and Reconnaissance effort. Develop concepts for Distributed Passive Geolocation from multiple standoff platforms. Continue development of an illumination selection manager to support passive radar functions, including signals intelligence (SIGINT), airborne moving target indicator (AMTI), ground moving target indicator (GMTI), and synthetic aperture radar (SAR) imaging in an A2/AD environment. ***FY 2018 Plans:*** Conduct a laboratory-based critical experiment of an illumination selection manager to support passive radar functions, including SIGINT, AMTI, and GMTI, and synthetic aperture radar (SAR) imaging in an A2/AD environment.			
Title: Long Range Sensing Technologies ***Description:*** Develop RF 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 2016 Accomplishments:*** Developed improved algorithms for low grazing angle, long stand-off GMTI and SAR. Collected data for testing of algorithms. Extended prior radar systems engineering and developed improved algorithms and multi-static cooperative radar techniques to address the challenges of long stand-off RF sensing in A2/AD airspace. Demonstrated significant subsystem breakthrough critical to advancing synthetic aperture ladar technology demonstration currently under development. ***FY 2017 Plans:*** For FY 2017 and beyond, Passive EO Sensing work accomplished under this effort will be reported under the Passive EO Sensing for Surveillance and Reconnaissance effort. Develop concepts for Distributed Passive Geolocation from multiple standoff platforms. Continue development of an illumination selection manager to support passive radar functions, including signals intelligence (SIGINT), airborne moving target indicator (AMTI), ground moving target indicator (GMTI), and synthetic aperture radar (SAR) imaging in an A2/AD environment. ***FY 2018 Plans:*** Extend open architecture constructs to incorporate electronic warfare and communication functions.	3.023	2.212	2.233

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continue to develop radar systems and algorithms for multi-static cooperative radar to address the challenges of long stand-off RF sensing in A2/AD airspace. Collect multi-static data with cooperative targets to test algorithms.			
Title: Passive EO Sensing for Surveillance and Reconnaissance Technologies	0.000	6.778	6.843
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 A2/AD environment. This effort includes the development of systems, subsystems, and components necessary to yield new capabilities. ***FY 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** In FY 2016, the work for this effort originally was performed under Passive Radio Frequency (RF) Sensing Technologies effort and the Long Range Sensing Technologies effort. Continue testing of prototyped strategy for improving the useful range of passive electro-optical and infrared reconnaissance sensors beyond the current state of the art. Advance and refine engineering trades and system optimization, via modeling, simulation, and laboratory test, of innovative sensor concepts. Continue development and refinement of advanced prototypes for hyperspectral imaging and infrared search and track sensors to achieve operationally useful radiometric sensitivity, detection performance, and area coverage rates. Test candidate systems and subsystems in a laboratory environment. Prepare and conduct technology demonstrations to advance system, subsystem, and component technology readiness levels (TRL) as required. Initiate subsystem development critical to meeting performance requirements for advanced infrared search and track systems. ***FY 2018 Plans:*** Refine and integrate advanced subsystem technology for infrared search and track systems. Test in a laboratory environment to enhance subsystem technology readiness level. Advance refinement of prototypes for longwave infrared hyperspectral imaging to achieve operationally useful radiometric sensitivity, detection performance, and area coverage rates. Test candidate systems and subsystems in a laboratory environment. Initiate refinement and prototyping of novel software/hardware combined sensing strategy for turbulence mitigation in passive EO/IR reconnaissance systems to improve the useful range beyond the current state of the art. Advance and refine engineering trades and system optimization for this novel approach, through modeling and simulation.			
Title: Laser Radar for Non-Cooperative Identification	0.000	3.777	3.813

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Advance, demonstrate, and transition innovative laser radar sensing technologies for non-cooperative identification of airborne and ground objects of interest in an A2/AD environment. This effort includes the development of systems, subsystems and components necessary to yield new capabilities. ***FY 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** In FY 2016, the work was originally performed under the Persistent Sensing in Contested Environment Technologies effort and the Long Range Sensing Technologies effort. Refine Synthetic Aperture Laser Radar (SAL) technology demonstrators under development based on modeling and simulation to enhance spatial resolution beyond the diffraction limit of equivalent optical apertures. Continue research on technologies, architectures and components needed for improving system capabilities to provide high confidence target identification at standoff ranges for both reconnaissance and targeting platforms. Fabricate, characterize, and test critical components for a long range SAL demonstration in a laboratory environment. Refine sensor product visualization and automatic target recognition by applying previous phenomenology. Increase emphasis on applications for long range air-to-air ladar, updating modeling and simulation to support system design and analysis of alternatives. Conduct technology demonstrations to advance system, subsystem, and component TRL as required. ***FY 2018 Plans:*** Refine and test SAL technology demonstrators under development based on modeling and simulation to enhance spatial resolution beyond the diffraction limit of equivalent optical apertures. Fabricate, characterize, and test critical components and subsystems for a SAL 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 concepts. Continue emphasizing long range air-to-air ladar concepts through modeling and simulation to support system design and analysis of alternatives. Prepare for future technology demonstrations to advance system, subsystem, and component TRL.			
Accomplishments/Planned Programs Subtotals	16.443	19.547	19.734

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 63665A / *Advanced Aerospace Sensors 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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
6369DF: *Target Attack and Recognition Technology*	-	23.351	21.398	21.244	0.000	21.244	21.752	23.505	26.166	27.304	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 (DARPA) 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 2016	FY 2017	FY 2018
Title: Integrated Sensor Targeting Technologies	4.340	3.960	3.932
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 2016 Accomplishments: Demonstrated phenomenology-derived feature toolkit for high resolution characterization of salient RF and EO features for select targets; Initiated development and assessment of reduced feature set target models and update target signature database; demonstrated salient feature extraction for distributed radar and ladar. Continued development of applications to utilize target signature databases from electro-optical, synthetic aperture radar, and multi-source sensor data for targets representing the highest priority threat systems. Initiated challenge problem development for assessment of reduced target feature sets in PCPAD-experimental (PCPAD-X).			
FY 2017 Plans: Continue development and assessment of reduced feature set target models and update target signature database; continue development of applications to utilize target signature databases from electro-optical, synthetic aperture radar, and multi-source			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
sensor data for targets representing the highest priority threat systems. Demonstrate phenomenology-derived feature toolkit for high resolution characterization of salient RF and EO features for select targets; demonstrate salient feature extraction for distributed radar and ladar. ***FY 2018 Plans:*** Continue development and assessment of reduced feature set target models and update target signature database. Demonstrate phenomenology-derived feature toolkit for high resolution characterization of salient RF and EO features for select targets.			
Title: Multi-Sensor Target Recognition ***Description:*** Develop and assess multi-sensor automatic target recognition for intelligence, surveillance, reconnaissance, strike, and weapon systems. ***FY 2016 Accomplishments:*** Demonstrated and characterized accuracy in uncertainty estimation for vision-aided navigation and geo-registration; demonstrated onboard image processing on unmanned air systems for insertion into information fusion and decision making systems; conducted PCPAD-X assessments of multi-sensor tracking and change detection applications for mobile targets in contested environments. Continued multi-sensor data collections for RF and EO sensors; initiated development of applications to characterize and suppress clutter in bi-static and passive RF sensors; initiated development of advanced tracking algorithms for bi-static and passive RF sensors. ***FY 2017 Plans:*** Continue development of applications to characterize and suppress clutter in bi-static and passive RF sensors; continue multi-sensor data collections for RF and EO sensors. Demonstrate and characterize accuracy in uncertainty estimation for vision-aided navigation and geo-registration; demonstrate onboard image processing on unmanned air systems for insertion into information fusion and decision making systems; conduct PCPAD-X assessments of tracking and change detection applications for mobile targets in contested environments. Develop multi-sensor exploitation and fusion methods for use by analysts. Initiate development of advanced tracking algorithms for bi-static and passive RF sensors. ***FY 2018 Plans:*** Continue development of applications to characterize and suppress clutter in bistatic and passive RF sensors. Continue multisensory data collections for RF and EO sensors. Demonstrate and characterize accuracy in uncertainty estimation for vision-aided navigation and geo-registration. Demonstrate multi-sensor exploitation and fusion methods for use by analysts. Initiate development of advanced tracking algorithms for bistatic and passive RF sensors.	9.643	8.800	8.737
Title: Wide-Angle Continuously-Staring Technologies	9.368	8.638	8.575

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Develop wide angle, continuous staring, multi-sensor/wavelength sensing and automated exploitation technology to detect, track, and identify targets over large areas at low sensor update rates. ***FY 2016 Accomplishments:*** Demonstrated tracking, change detection, and image processing capabilities for data representative of contested and denied environments; collected, process, and catalogue data from advanced wide-angle sensor; demonstrated reduced size, weight and power (SWaP) image processing and change detection from large SAR data sets; demonstrated improved geo-registration and PNT from wide-area EO imagery; continued development of stand-off (air and space) and episodic stand-in sensing capabilities for contested and denied environments. ***FY 2017 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; demonstrate reduced size, weight and power (SWaP) image processing and change detection from large SAR data sets; demonstrate improved geo-registration and PNT from wide-area EO imagery. ***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 RF sensors.			
Accomplishments/Planned Programs Subtotals	23.351	21.398	21.244

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	95.266	130.950	115.966	0.000	115.966	115.861	98.894	73.508	78.836	Continuing	Continuing
634920: *Flight Vehicle Tech Integration*	-	24.374	23.873	19.734	0.000	19.734	19.828	25.258	26.783	28.319	Continuing	Continuing
634926: *High Speed/Hypersonic Intgr and Demo*	-	47.994	92.801	78.762	0.000	78.762	78.914	49.328	21.755	22.190	Continuing	Continuing
634927: *Flight Systems Control*	-	22.898	14.276	17.470	0.000	17.470	17.119	24.308	24.970	28.327	Continuing	Continuing

A. Mission Description and Budget Item Justification

These projects support Department of Defense (DoD) priorities for demonstrations in hypersonics and unmanned systems, respectively. This program 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. Efforts 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 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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	100.622	130.950	119.280	0.000	119.280
Current President's Budget	95.266	130.950	115.966	0.000	115.966
Total Adjustments	-5.356	0.000	-3.314	0.000	-3.314
• 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	-2.725	0.000			
• SBIR/STTR Transfer	-2.631	0.000			
• Other Adjustments	0.000	0.000	-3.314	0.000	-3.314

Change Summary Explanation

FY 2016 decrease reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358. FY 2018 decrease is due to Hypersonic funding realignment.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
634920: *Flight Vehicle Tech Integration*	-	24.374	23.873	19.734	0.000	19.734	19.828	25.258	26.783	28.319	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 2016	FY 2017	FY 2018
Title: Aerospace Vehicle Technology Integration	10.632	12.546	10.371
Description: Develop, simulate, and demonstrate integrated technologies to improve the performance of aerospace platform capabilities. ***FY 2016 Accomplishments:*** Continued development of the C-17 formation flight Advanced Technology Demonstration (ATD). Completed feasibility flight test of C-17 aircraft with aft body drag reduction devices. Completed development of advanced engine system design integration to mature adaptive turbine engine technologies for advanced air vehicles along with thrust augmentors and exhaust systems to provide technical options for highly fuel-efficient engines. Initiated quiet small unmanned aerospace systems (UAS) integrated flight test. Initiated and completed designs and utility analysis of multiple low cost attritable unmanned systems viable for flight experiments. ***FY 2017 Plans:*** Complete development of the C-17 formation flight ATD. Complete quiet small UAS integrated flight test. Initiate mobility aerodynamic swept wing laminar flow flight demonstration. Initiate full flow path demonstration of a medium bypass embedded engine for next generation mobility. Initiate risk reduction exhaust systems demonstrations for future air superiority. ***FY 2018 Plans:*** Complete risk reduction of exhaust systems component demonstration for future air superiority. Initiate a large scale efficient hybrid wing body (HWB) flight validation experiment for Mobility application.			
Title: Advanced Aerospace Structure Technologies	13.742	11.327	9.363
Description: Develop and demonstrate affordable, lightweight, adaptive, and multifunctional structural concepts integrated into aerospace systems.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Initiated an electronic warfare and passive radar flight demonstration of an integrated antenna into load-bearing structures for small remotely piloted aircraft. Initiated a low cost airframe design and manufacturing demonstration. Initiated low cost attritable aircraft flight demonstration. ***FY 2017 Plans:*** Continue an electronic warfare and passive radar flight demonstration of an integrated antenna into load-bearing structures for small remotely piloted aircraft. Continue low cost airframe design and manufacturing demonstrations. Continue low cost attritable aircraft flight demonstration analysis and support. ***FY 2018 Plans:*** 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.			
Accomplishments/Planned Programs Subtotals	24.374	23.873	19.734

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
634926: *High Speed/Hypersonic Intgr and Demo*	-	47.994	92.801	78.762	0.000	78.762	78.914	49.328	21.755	22.190	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 2016	FY 2017	FY 2018
Title: High Speed/Hypersonic Vehicle Technologies	47.994	92.801	78.762

Description: Develop, simulate, and demonstrate integrated vehicle technologies to enable and improve the performance of future high-speed and hypersonic systems.

FY 2016 Accomplishments:

Completed preliminary design review (PDR) for Hypersonic Air-breathing Weapon Concept (HAWC) and Tactical Boost Glide (TBG) demos. Continued 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. Continued advancement of high temperature materials and structures for hypersonic vehicles. Initiated detailed design of air-breathing weapon concept.

FY 2017 Plans:

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. Continue design of boost-glide weapon concept vehicle. Initiate the fabrication of sufficient number of hypersonic demonstration vehicles and support hardware to execute an extensive multi-year flight test program to validate several different approaches and concepts to achieve hypersonic speed.

FY 2018 Plans:

Start and complete critical design review for HAWC and TBG demonstrations. Continue accelerated development and demonstration of tactically-relevant long-range high-speed strike technologies including ground and flight demonstrations needed

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
for potential follow-on acquisition program. Continue advancement of high temperature materials and structures for hypersonic vehicles.			
Accomplishments/Planned Programs Subtotals	47.994	92.801	78.762

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
634927: *Flight Systems Control*	-	22.898	14.276	17.470	0.000	17.470	17.119	24.308	24.970	28.327	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 2016	FY 2017	FY 2018
Title: Autonomous Systems Control	22.898	14.276	17.470

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 2016 Accomplishments:

Continued development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems and manned platforms. Continued demonstration of autonomous and safe airspace interoperability for manned and remotely piloted aircraft systems. Continued development and demonstration of airborne control of teams of unmanned aircraft. Continued development and demonstration of improved accuracy, situational awareness, and safety for air drop operations. Completed development and demonstration of robust, adaptive guidance, and control of hypersonic aircraft. Completed demonstration of digital ground collision avoidance capability hosted in an analog flight control system.

FY 2017 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. Complete development and demonstration of improved accuracy, situational awareness, and safety for air drop operations. Complete demonstration of integrated ground & air collision avoidance.

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

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
and remotely piloted aircraft systems. Continue development and demonstration of airborne control of teams of unmanned aircraft. Initiate development and demonstration of reduced crew operations of future mobility aircraft.			
Accomplishments/Planned Programs Subtotals	22.898	14.276	17.470

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	168.542	94.594	104.499	0.000	104.499	112.332	116.482	118.570	116.573	Continuing	Continuing
632480: *Aerospace Fuels*	-	2.194	2.262	2.302	0.000	2.302	2.358	2.404	2.452	2.501	Continuing	Continuing
633035: *Aerospace Power Technology*	-	18.992	11.010	13.934	0.000	13.934	20.135	22.337	22.544	18.626	Continuing	Continuing
634921: *Aircraft Propulsion Subsystems Int*	-	74.654	19.757	17.902	0.000	17.902	18.194	18.539	18.909	19.287	Continuing	Continuing
634922: *Space & Missile Rocket Propulsion*	-	29.714	24.314	28.799	0.000	28.799	29.484	30.072	30.673	31.287	Continuing	Continuing
635098: *Advanced Aerospace Propulsion*	-	22.599	25.013	28.797	0.000	28.797	20.346	20.751	21.167	21.590	Continuing	Continuing
63681B: *Advanced Turbine Engine Gas Generator*	-	20.389	12.238	12.765	0.000	12.765	21.815	22.379	22.825	23.282	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 weapons systems. The Aerospace Fuels project develops and demonstrates improved hydrocarbon fuels and advanced propulsion systems, including those for air-breathing high-speed/hypersonic flight. The Aerospace Power Technology project develops and demonstrates adaptive power and thermal management components, controls, and systems for high-power payloads and aircraft as part of energy-optimized aircraft development. The Aircraft Propulsion Subsystems Integration project integrates the engine cores demonstrated in the Advanced Turbine Engine Gas Generator project with low-pressure components into demonstrator engines. 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, Advanced Turbine Engine Gas Generator, and Aerospace Propulsion Subsystems Integration 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. 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 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: FY 2018 Air Force	Date: May 2017
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*

B. Program Change Summary ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	178.594	94.594	104.499	0.000	104.499
Current President's Budget	168.542	94.594	104.499	0.000	104.499
Total Adjustments	-10.052	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	-4.557	0.000			
• SBIR/STTR Transfer	-5.495	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 633035: *Aerospace Power Technology*		
Congressional Add: *Silicon Carbide Research*	10.000	-
Congressional Add Subtotals for Project: 633035	10.000	-
Congressional Add Totals for all Projects	10.000	-

Change Summary Explanation

Decreases in FY 2016 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
632480: *Aerospace Fuels*	-	2.194	2.262	2.302	0.000	2.302	2.358	2.404	2.452	2.501	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 2016	FY 2017	FY 2018
Title: Fuel-Related Thermal Management	0.607	0.662	0.674
Description: Demonstrate thermally stable fuels and fuel system hardware concepts to enhance cooling capacity (performance), minimize fuel coking, and reduce fuel system maintenance.			
FY 2016 Accomplishments: Demonstrated nano-catalysts/nano-additives for enhancing heat sink and reducing coking.			
FY 2017 Plans: Investigate adaptable heat sink alternatives for advanced thermal management.			
FY 2018 Plans: Continue investigation of fuel heat sink approaches for thermal management of adaptive engines, including on-board fuel deoxygenation.			
Title: Gas Turbine Combustion, Emissions, and Performance	0.608	0.600	0.611
Description: Develop and demonstrate efficacy of low-cost, environmentally friendly fuel approaches to assess and reduce soot/ particulate emissions from gas turbine engines.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Assessed operability in referee combustor of reference jet fuels representing range of conventional jet fuels being used by Air Force. ***FY 2017 Plans:*** Support industry combustor model development by supplying referee combustor validation data. ***FY 2018 Plans:*** Initiate development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions.			
Title: Fuel Logistics ***Description:*** Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Air Force. ***FY 2016 Accomplishments:*** Continued bio-contamination, mitigation and risk assessment of aviation fuels. Demonstrated anti-microbial peptides and biological active control for mitigating biological growth in aviation fuels. ***FY 2017 Plans:*** Continue analysis of the benefits of additives in commercial aviation jet fuel for military use and potential for additive removal. ***FY 2018 Plans:*** Complete evaluation of advanced additives for water sequestration and mitigation of biological growth.	0.785	0.800	0.813
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 2016 Accomplishments:*** Continued analysis of approaches for evaluating and approving alternative jet fuels added to commercial jet aviation fuel specifications. ***FY 2017 Plans:*** Continue analysis of new approaches for evaluating and approving alternative jet fuels added to commercial jet aviation fuel specifications. ***FY 2018 Plans:*** Complete development of generic alternative fuel specification annexes for commercial jet fuels used by Air Force.	0.194	0.200	0.204
Accomplishments/Planned Programs Subtotals	2.194	2.262	2.302

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
633035: *Aerospace Power Technology*	-	18.992	11.010	13.934	0.000	13.934	20.135	22.337	22.544	18.626	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates 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 2016	FY 2017	FY 2018
Title: High Power Aircraft Subsystem Technologies	8.992	11.010	13.934
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 2016 Accomplishments: Continued development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Continued development of actuation technology for applications with power, volume, and thermal limitations. Initiated the development of hybrid-cycle power and thermal management system. Completed demonstration of platform-level hardware-in-the-loop integrated power and thermal management. Initiated development of advanced power generation and distribution system. Initiated development and demonstration of integrated, adaptive megawatt-class tactical aircraft power and thermal capability.			
FY 2017 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.			
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			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Accomplishments/Planned Programs Subtotals	8.992	11.010	13.934

	FY 2016	FY 2017
Congressional Add: Silicon Carbide Research	10.000	-
FY 2016 Accomplishments: Conduct Congressionally directed efforts		
Congressional Adds Subtotals	10.000	-

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
634921: *Aircraft Propulsion Subsystems Int*	-	74.654	19.757	17.902	0.000	17.902	18.194	18.539	18.909	19.287	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 Aerospace 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 2016	FY 2017	FY 2018
Title: Missile/Remotely Piloted Aircraft Engine Performance	19.853	11.757	10.653
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 2016 Accomplishments: Assembled final ground test demonstrators for supersonic, long endurance turbine engines at simulated altitude conditions. Completed fabrication and instrumentation of a subsonic small turbine engine technology experimental test. Completed detailed design of subsonic mid-sized turbine engine technology for remotely piloted aircraft. Completed final ground testing of demonstration for supersonic, long endurance turbine engines at simulated altitude conditions.			
FY 2017 Plans: Initiate follow-on conceptual design and fabrication effort for improved capability supersonic, long endurance turbine engines at simulated altitude conditions. Conduct ground test of subsonic small turbine engine for missile application. Increase effort in			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
efficient limited-life medium scale propulsion development for future Intelligence, Surveillance, and Reconnaissance (ISR) and strike capability. ***FY 2018 Plans:*** Conduct design and initiate fabrication of efficient limited-life medium scale propulsion concepts for future ISR and strike capability. Continue conceptual design and initiate long lead procurement for follow-on improved capability supersonic, long endurance turbine engines at simulated altitude conditions.			
Title: Adaptive Turbine Engine Technologies ***Description:*** Design, fabricate, and demonstrate performance, durability, and operability technologies to mature adaptive turbine engine technologies. ***FY 2016 Accomplishments:*** Continued fabrication, instrumentation and assembly of core experimental adaptive turbine engines. ***FY 2017 Plans:*** Support successful technology transition to Adaptive Engine Transition Program. This work includes completing fabrication, instrumentation and assembly of core experimental adaptive turbine engine. Initiating and completing ground testing of first core experimental adaptive turbine engine. Completing the assessment of the acquired and processed data from the ground testing of core experimental adaptive turbine engines and comparison to analytical prediction tools to validate reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. ***FY 2018 Plans:*** Initiate and complete final ground testing of core experimental adaptive turbine engine. Complete the assessment of the acquired and processed data from the ground testing of core experimental adaptive turbine engines and comparison to analytical prediction tools to validate reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. Provide subject matter expert support to Adaptive Engine Transition Program. Initiate and complete design for integrated power and thermal management engine demonstrator. Initiate hardware fabrication for integrated power and thermal management engine demonstrator.	54.801	8.000	7.249
Accomplishments/Planned Programs Subtotals	74.654	19.757	17.902

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
634922: *Space & Missile Rocket Propulsion*	-	29.714	24.314	28.799	0.000	28.799	29.484	30.072	30.673	31.287	Continuing	Continuing

A. Mission Description and Budget Item Justification

Mission Description not provided.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Liquid Rocket Propulsion Technologies	21.937	18.330	20.923
Description: Develop liquid rocket propulsion technology for current and future space launch vehicles. ***FY 2016 Accomplishments:*** Completed sub-scale preburner risk reduction testing. Continued development of hydrocarbon engine components for integration and demonstration of advanced technologies applicable to future expendable and reusable launch vehicles. Continued fabrication of full-scale preburner. Initiated full-scale fuel kick pump testing. ***FY 2017 Plans:*** Complete fabrication of the full-scale preburner and initiate testing. Complete critical design review (CDR) for the full-scale Turbopump and begin fabrication. Continue development of hydrocarbon engine components for integration and demonstration in an advanced hydrocarbon engine concept applicable to future expendable and reusable launch vehicles. ***FY 2018 Plans:*** Complete development of hydrocarbon engine components and begin 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.			
Title: On-Orbit Propulsion Technologies	0.000	0.429	1.649
Description: Develop solar electric, electric, and monopropellant propulsion technologies for existing and future satellites, upper stages, orbit transfer vehicles, and satellite maneuvering. ***FY 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** Initiate maturation of advanced thruster technologies with emphasis on longer lifetime and improved quantification of thrust profiles through experimental, theoretical and modeling and simulation approaches. Initiate development of experimental			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
capability for longer-lifetime thruster testing, non-invasive diagnostic techniques to study plume composition, and improved fidelity thrust stands for thruster characterization. Initiate integration of system level and detailed modeling and simulation tools to improve selection of new candidate propellants and possible multimode propulsion alternatives. Initiate effort to extend and refine theoretical models for advanced propellant chemistry to assist with advanced chemical thruster design. ***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. 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 multimode propulsion opportunities to combine high efficiency and high thrust capabilities on a common propellant.			
Title: Ballistic Missile Technologies ***Description:*** Develop and demonstrate missile propulsion and post-boost control systems technologies for ballistic missiles. ***FY 2016 Accomplishments:*** Continued to develop advanced missile case, insulation, and nozzle technologies. Continued validation of modeling and simulation tools through upcoming demonstration. Initiated technology demonstration effort on advanced missile case, insulation, and nozzle technologies and validation of physics-based modeling, simulation, and analysis tools. ***FY 2017 Plans:*** Continue technology demonstration effort on advanced missile case, insulation, and nozzle technologies and validation of physics-based modeling, simulation, and analysis tools. Initiate technology demonstration effort of post-boost technologies. ***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.	5.760	4.428	2.664
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 2016 Accomplishments:*** Applied next generation of chemical and aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, and non-destructive analysis tools. Continued advanced sensor development efforts to further improve data acquisition and	2.017	1.127	3.563

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
reduce uncertainty in ballistic missile life predictions. Improved the fidelity and precision of non-destructive evaluation tools to increase capability to determine flaw size, orientation, and location. Supported transition of previous tools, models, data management system to user. Started long-term validation of tools through long-term aging of sub-scale motors. Continued sub-scale motors dissection to validate the sensor and analytical analysis of each motor. ***FY 2017 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. Support 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. ***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. Support 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.			
Accomplishments/Planned Programs Subtotals	29.714	24.314	28.799

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635098: *Advanced Aerospace Propulsion*	-	22.599	25.013	28.797	0.000	28.797	20.346	20.751	21.167	21.590	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates, via ground and flight tests, the scramjet propulsion cycle to a technology readiness level appropriate for full integration with other engine cycles (including turbine and rocket-based) to provide the Air Force with transformational military capabilities. The primary focus is on the hydrocarbon-fueled, scramjet engine. Multi-cycle engines will provide the propulsion systems for possible application to support aircraft and weapon platforms operating up to Mach 7. Efforts include: scramjet flow-path optimization to enable operation over the widest possible range of Mach numbers; active combustion control to assure continuous positive thrust (even during mode transition); robust flame-holding to maintain stability through flow distortions; and maximized volume-to-surface area to minimize the thermal load imposed by the high-speed engine. Thermal management plays a vital role in scramjet and combined cycle engines, including considerations for protecting low speed propulsion systems (e.g., turbine engines) during hypersonic flight.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Scramjet Technologies	22.599	25.013	28.797
Description: Develop and demonstrate technologies for a hydrocarbon-fueled scramjet with robust operation up to Mach 7.			
FY 2016 Accomplishments: Completed the assessment of cold-start systems and progressed in the design of flight weight, insensitive munition (IM) compliant systems for testing. Completed additional component development and testing for insensitive munition compliant scramjet cold start system in both X-51 heritage, two-dimensional, engine lines and axisymmetric, three-dimensional, scramjet flow lines. Designed flight weight cold start system for demonstration in direct-connect test hardware. Developed scramjet technologies to enhance operability including robust operation during maneuvers. Continued accelerated development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and engine controls. Continued to accelerate 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. Initiated detailed design of scramjet engine for air breathing weapon concept.			
FY 2017 Plans: Continue development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and engine controls. Complete additional component development and testing for insensitive munition compliant scramjet cold start system in both X-51 heritage, two-dimensional, engine lines and axisymmetric, three-dimensional, scramjet flow lines. 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. Continue accelerated development			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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. Initiate fabrication of scramjet engine for air breathing weapon concept. ***FY 2018 Plans:*** 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. Complete additional component development and testing for insensitive munition compliant scramjet cold start system in both X-51 heritage, two-dimensional, engine lines and axisymmetric, three-dimensional, scramjet flow lines. 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.			
Accomplishments/Planned Programs Subtotals	22.599	25.013	28.797

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
63681B: *Advanced Turbine Engine Gas Generator*	-	20.389	12.238	12.765	0.000	12.765	21.815	22.379	22.825	23.282	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 2016	FY 2017	FY 2018
Title: Core Engine Technologies	6.961	5.238	5.463
Description: Design, fabricate, and demonstrate performance predictions in core engines, using innovative engine cycles and advanced materials for turbofan and for turbojet engines. ***FY 2016 Accomplishments:*** Continued instrumentation and assembly of component hardware for rig demonstration and validation of increased reliability, maintainability, and affordability. Completed design and fabrication of remaining components for core demonstration for potential acquisition program for transition to fielded systems. ***FY 2017 Plans:*** Finish assembly, instrumentation and test of core engine. Begin design of medium-scale efficient core demonstrator. ***FY 2018 Plans:*** Conduct post test assessment of core engine. Complete design and initiate fabrication of medium-scale efficient core demonstrator.			
Title: High Pressure Ratio Core Engine Technologies	0.757	1.900	1.982

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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 2016 Accomplishments:*** Completed risk reduction rig testing of components for small efficient engine core concepts with advanced technologies such as high pressure ratio/high temperature capability compressors, high heat release combustors, high cooling effectiveness turbine with an integrated thermal management system, and advanced mechanical systems. ***FY 2017 Plans:*** Complete data reduction of test data for potential follow-on transition to ground engine demonstration or for fielded systems. Initiate design and fabrication of components for small efficient engine core concept with advanced technologies such as high pressure ratio/high temperature capability compressors, high heat release combustors, high cooling effectiveness turbine. ***FY 2018 Plans:*** Complete design, fabrication, and initiate assembly of components for small efficient engine core concept with advanced technologies such as high pressure ratio/high temperature capability compressors, high heat release combustors, high cooling effectiveness turbine.			
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 2016 Accomplishments:*** Continued fabrication, instrumentation, and assembly of components for experimental engine core demonstration of an adaptive turbine engine with reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. ***FY 2017 Plans:*** Complete testing of first adaptive core demonstrator. Finish manufacturing and begin assembly of final core demonstrator. Begin preliminary design for advanced air dominance adaptive core demonstrator. ***FY 2018 Plans:*** Complete final ground testing of final core demonstrator. Continue design and initiate long lead procurement for advanced air dominance adaptive core demonstrator.	12.671	5.100	5.320
Accomplishments/Planned Programs Subtotals	20.389	12.238	12.765

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	45.359	58.250	60.551	0.000	60.551	61.945	62.607	64.800	62.016	Continuing	Continuing
633720: *EW Quick Reaction Capabilities*	-	26.497	30.912	31.254	0.000	31.254	34.200	35.531	38.072	34.887	Continuing	Continuing
63431G: *RF Warning & Countermeasures Tech*	-	14.622	19.671	18.284	0.000	18.284	17.012	15.106	14.560	14.688	Continuing	Continuing
634335: *Cyber Concepts*	-	0.000	2.635	6.087	0.000	6.087	5.876	7.017	7.116	7.288	Continuing	Continuing
63691X: *EO/IR Warning & Countermeasures Tech*	-	4.240	5.032	4.926	0.000	4.926	4.857	4.953	5.052	5.153	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 (EW) 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.

Starting in FY 2017 to improve reporting to Congress, Project 634335, Cyber Concepts was created to capture all cyber activity that was previously performed under Project 633720, EW Quick Reaction Capabilities.

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: FY 2018 Air Force					Date: May 2017
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	46.946	58.250	60.851	0.000	60.851
Current President's Budget	45.359	58.250	60.551	0.000	60.551
Total Adjustments	-1.587	0.000	-0.300	0.000	-0.300
• 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	-0.510	0.000			
• SBIR/STTR Transfer	-1.077	0.000			
• Other Adjustments	0.000	0.000	-0.300	0.000	-0.300

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
633720: *EW Quick Reaction Capabilities*	-	26.497	30.912	31.254	0.000	31.254	34.200	35.531	38.072	34.887	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 navigation technologies and capabilities in the context of systemic electronic warfare (EW) effects (EW-threat interactions) in a congested/contested electromagnetic spectrum (EMS), 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 2016	FY 2017	FY 2018
Title: Disruptive EW and Countermeasure Technologies	11.792	13.790	13.943
Description: Develop disruptive EW and countermeasure concepts specifically selected for rapidly fieldable, high-impact effects and demonstrate them in an operational environment. ***FY 2016 Accomplishments:*** Leveraged developments in directed energy and cyber techniques to effectively simulate electronic attack against a modeled integrated air defense network to determine deficiencies in the attack capability. Focused research methods to mitigate the determined deficiencies in attack methodology and developed alternative strategies for employment to enable successful suppression of threat representative integrated air defense systems. Began to develop capabilities to integrated RF/infrared (IR) sensors to improve situational awareness & self protection. ***FY 2017 Plans:*** Continue to develop capability to use RF electronic attack (EA) techniques to deliver cyber effects. Continue supporting the cyber efforts in Project 634335, Cyber Concepts, to model cyber effects on an integrated air defense system and simulate their utility. Continue to develop, integrate and demonstrate required navigation and timing technologies required for distributed EA concepts. Continue to develop and evaluate countermeasures to adversary use of satellite navigation. Continue to integrate RF/IR sensors to improve situational awareness and self protection. ***FY 2018 Plans:*** Conduct sense, learn, and adapt demonstrations illustrating advancements in electromagnetic spectrum awareness, reasoning, and collaborative effects. Demonstrate advanced counter satellite navigation techniques			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
in an operational environment. Begin the development and demonstration efforts to prove the concepts for “full spectrum” countermeasures capabilities.			
Title: Threat-to-Countermeasure System of Systems (SoS) Methods ***Description:*** Establish and maintain an all-source, physics-based, design-level, red-blue, comparative, threatto-countermeasure SoS techniques methodology. This systems engineering-based EW approach will inform programmatic planning, quantify desirable research areas with realistic SoS metrics, and foster improved understanding of future concept contributions to EW warfighting capabilities. ***FY 2016 Accomplishments:*** Demonstrated improvements in SoS analysis capability through virtual simulation mechanisms. Used metrics to show the value added proposition of multi-spectral techniques to address the threat to countermeasure system performance. ***FY 2017 Plans:*** Continue to use system engineering analysis techniques to identify the requirements for SoS operations in anti-access/area-denial (A2/AD) environments. Specifically work toward showing how EW techniques and capabilities can be modeled and show support of mission operations (such as Intelligence Surveillance Reconnaissance (IRS) or strike) in A2/AD scenarios. Continue to develop, integrate and demonstrate required navigation technologies required for SoS operations in A2/AD environments. ***FY 2018 Plans:*** Demonstrate robust distributed time transfer in a Global Positioning System (GPS) jamming environment. Demonstrate effects of a coordinated EA capability.	6.871	8.000	8.089
Title: Evaluation of Advanced Countermeasure Concepts ***Description:*** Develop a core analytic function, supported by simulation-based wargaming and engineering modeling capabilities for evaluation, development, and demonstration of advanced EW, cyber, directed energy (DE) and integrated/systemic, non-kinetic concepts to include special capability programs. ***FY 2016 Accomplishments:*** Demonstrated reconfigurable closed-loop hardware-in-the-loop (HWIL) assessment capability for discovering and evaluating advanced EW techniques, including diverse distributed concepts. This development of advanced techniques will ensure aircraft survivability against future threats with highly agile and adaptable waveform structures. Demonstrated in-house analysis and	7.834	9.122	9.222

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
assessment technologies for countering A2/AD scenarios. Demonstrated the Proactive Mid-Infrared Situation Awareness (MISA) system in tower and field tests. ***FY 2017 Plans:*** For FY 2016, the navigation work in this effort was performed in Program 0603203F, Advanced Aerospace Sensors, Project 63655A, Advanced Aerospace Sensors Technology, under the effort Integrated Navigation Technologies. For FY2017 and beyond, the advanced cyber technology work accomplished under this effort will be reported in Project 634335, Cyber Concepts, under the efforts, Avionics Cyber Vulnerabilities and Avionics Cyber Protections. Continue development, integration and demonstration of required navigation technologies required for operations in contested and denied environments. Develop adaptable threat emulation capability to simulate modern and expected threats for future conflicts. Use these simulations to assess blue force hardware against these future red force systems. Conduct flight tests of the MISA system. Analyze the data and refine the requirements for AFSOC scenarios. Begin the data collection and analysis of the advanced defeat concepts for imaging sensors. Refine requirements for lasers required to defeat this threat class. ***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 EW threats. Demonstrate trusted use of foreign satellite navigation signals through signal authentication techniques, constellation signal monitoring and data dissemination, and jamming countermeasure techniques. Address size, weight and power (SWAP)requirements for application to the whole range of Air Force platforms. Begin the incorporation of the proactive situational awareness (SA) and countermeasures capabilities into engagement models.			
Accomplishments/Planned Programs Subtotals	26.497	30.912	31.254

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
63431G: *RF Warning & Countermeasures Tech*	-	14.622	19.671	18.284	0.000	18.284	17.012	15.106	14.560	14.688	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 2016	FY 2017	FY 2018
Title: Electronic Attack	14.622	19.671	18.284
Description: Develop aerospace platform jamming concepts, technologies and techniques to counter advanced RF threats associated with current and future aerospace weapon systems. Provide navigation system resilience via open architecture solutions.			
FY 2016 Accomplishments: Collected and analyzed high fidelity RF data representative of airborne high threat engagements. Leveraged advances in cognitive machine learning from DARPA and industry to perform demonstrations and assessments that measured improved abilities to autonomously identify modern adaptive programmable threats. Developed concepts/techniques to ascertain the efficacy of advanced EA methods employed against modern threats to close the loop allowing optimization of the EA technique. Prototyped an example government reference architecture on the next generation of embedded GPS inertial (EGI) system avionics. Initiated requirements definition and systems engineering analysis for an advanced EW receiver algorithm and architecture project.			
FY 2017 Plans: For FY 2016, the navigation work in this effort originally was performed in Program 0603203F, Advanced Aerospace Sensors, Project 63655A, Advanced Aerospace Sensors Technology, under the effort Integrated Navigation Technologies. Continue to collect and analyze high fidelity RF data representative of airborne high threat engagements. Continue to develop concepts/techniques and advanced EA methods (techniques and employment) against modern threats to close the loop allowing a more optimized EA effectiveness. Perform demonstrations and assessments in cognitive machine learning from Air Force,DARPA and industry that measure improved abilities to autonomously identify modern adaptive programmable threats.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Develop algorithms for vision aiding the navigation solution in a targeting pod. Initiate an external industry-led project in advanced EW receiver algorithms and architectures. ***FY 2018 Plans:*** Continue efforts in advanced electronic warfare (EW) receiver algorithms and architectures, as well as machine learning ("cognitive") algorithms. Continue research into innovative EA concepts/techniques including use of closed loop, cooperatively controlled, distributed unmanned aerial vehicles (UAVs) and their performance against integrated air defense networks and adaptable techniques for use against any threats. Fabricate and demonstrate an advanced capability EA pod against emerging, high priority threats. Develop, integrate and demonstrate distributed EA concepts and their required navigation and datalink technologies. Demonstrate integration of navigation signals of opportunity and vision aiding into an open EGI system prototype.			
Accomplishments/Planned Programs Subtotals	14.622	19.671	18.284

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
634335: *Cyber Concepts*	-	0.000	2.635	6.087	0.000	6.087	5.876	7.017	7.116	7.288	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.

Project 634335, Cyber Concepts is new for FY 2017. Work from this effort was previously performed under Project 633720, EW Quick Reaction Capabilities, in this program.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Avionics Cyber Vulnerabilities	0.000	1.464	3.382
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. ***FY 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** For FY 2016, the work for this effort originally was performed in Project 633720, EW Quick Reaction Capabilities, under the effort Evaluation of Advanced Countermeasure Concepts. Prototype and demonstrate a series of cyber testing tools that assess vulnerabilities related to deficiencies in traditional testing (i.e. positive testing) that does not consider cyber effects. Assess USAF platforms (manned, unmanned aircraft) and weapon systems for specific cyber vulnerabilities and develop avionics enhancements to increase security and resiliency. ***FY 2018 Plans:*** Continue vulnerability investigations with the intent to provide a standardized methodology and set of tools for performing a thorough cyber vulnerability assessment of a weapon system. Transition assessment tools to DoD test communities. Continue to develop and transition protection/mitigation technologies.			
Title: Avionics Cyber Protections	0.000	1.171	2.705

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Develop and demonstrate advanced automated analysis tools and protection techniques to prevent exploitation of cyber susceptibilities in avionics systems. This strategy would include discovery and mitigation of likely attack vectors, remediation of susceptibilities, and safeguards to assure the integrity of embedded software. ***FY 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** For FY 2016, the work for this effort originally was performed in Project 633720, EW Quick Reaction Capabilities, under the effort Evaluation of Advanced Countermeasure Concepts. Prototype and demonstrate a suite of protection tools composed of application, operating system kernel, hypervisor and hardware-assisted technologies to provide defense-in-depth of avionics, sensors, and weapon systems. This demonstration will focus on protections for a representative intelligence surveillance and reconnaissance (ISR) platform. Develop a patterns database that detects and classifies benign and malicious behaviors, and validate proof-of-concept for x86 computer architectures. Create other architecture specific translators (e.g. PowerPC) to further validate concept. ***FY 2018 Plans:*** Continue to extend 2017 work on a suite of protection tools with focus on their application to unmanned aircraft systems (UAS) 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.			
Accomplishments/Planned Programs Subtotals	0.000	2.635	6.087

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
63691X: *EO/IR Warning & Countermeasures Tech*	-	4.240	5.032	4.926	0.000	4.926	4.857	4.953	5.052	5.153	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, (EO/IR) 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 EO/IR tracking systems used to direct EO/IR and radar-guided missiles.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Advanced Electro-Optical (EO)/Infrared (IR) Warning and Countermeasure Technologies	4.240	5.032	4.926

Description: Analyze the vulnerabilities of current IR missile systems and future imaging IR sensors. Develop advanced countermeasure system technologies to exploit vulnerabilities for use against IR and EO guided missile threats. Develop advanced optical and infrared sensor systems for airborne and space situational awareness and threat warning.

FY 2016 Accomplishments:

Characterized and exploited several advanced threat IR guided missiles and collected laboratory and field data on many EO/IR fire-control systems and sensors including night vision goggles and thermal imagers. Continued the development of high-fidelity surrogates and associated algorithms, scene generation and modeling and simulation for testing and countermeasure development and verification/correlation to hardware in the loop results. Defined the requirements for novel countermeasure effects against advanced IR and multispectral threats. Conducted data collection using advanced next generation missile warning sensors and hostile fire indication system. Transitioned an advanced laser warning and protection capability to the US Army.

FY 2017 Plans:

Develop advanced capability to defeat imaging optical sensors across the EO spectrum from ultra-violet (UV) to long-wave infrared wavelengths. Investigate low size, weight, power, and cost systems for smaller/expendable platforms to enhance their survivability in active threat areas using the modeling and HWIL simulation capability established through this funding area. Perform verification and validation activities utilizing the MOdeling System for Advanced Investigation of Countermeasures (MOSAIC), infrared countermeasure (IRCM) engagement model and correlate results with the Guided Weapon Evaluation Facility and the US Navy laboratories at China Lake.

FY 2018 Plans:

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continue characterization and exploitation of newly acquired advanced threats. Correlate the results from the at-range testing of EO/IR adjuncts to integrated air defense systems (IADS) and refine the requirements for the detection and countermeasure concepts and demonstration system to defeat multi-spectral threats.			
Accomplishments/Planned Programs Subtotals	4.240	5.032	4.926

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	62.278	61.593	58.910	0.000	58.910	57.237	58.424	60.614	62.681	Continuing	Continuing
632181: *Spacecraft Payloads*	-	15.555	15.936	15.767	0.000	15.767	16.600	16.807	16.353	17.514	Continuing	Continuing
633834: *Integrated Space Technology Demonstrations*	-	21.204	22.416	21.424	0.000	21.424	13.113	13.846	17.430	17.796	Continuing	Continuing
634400: *Space Systems Protection*	-	10.191	8.091	7.964	0.000	7.964	9.921	9.872	9.420	9.625	Continuing	Continuing
635021: *Space Systems Survivability*	-	2.202	1.849	1.820	0.000	1.820	1.942	1.940	1.796	1.836	Continuing	Continuing
635083: *Ballistic Missiles Technology*	-	3.913	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.913
63682J: *Spacecraft Vehicles*	-	9.213	13.301	11.935	0.000	11.935	15.661	15.959	15.615	15.910	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, ballistic missiles, 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 (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	61.813	61.593	60.243	0.000	60.243
Current President's Budget	62.278	61.593	58.910	0.000	58.910
Total Adjustments	0.465	0.000	-1.333	0.000	-1.333
• 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	2.153	0.000			
• SBIR/STTR Transfer	-1.688	0.000			
• Other Adjustments	0.000	0.000	-1.333	0.000	-1.333

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 633834: *Integrated Space Technology Demonstrations*		
Congressional Add: *Program Increase*	3.000	-
Congressional Add Subtotals for Project: 633834	3.000	-
Project: 634400: *Space Systems Protection*		
Congressional Add: *Program Increase*	4.000	-
Congressional Add Subtotals for Project: 634400	4.000	-
Congressional Add Totals for all Projects	7.000	-

Change Summary Explanation

Decrease in FY 2016 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Funding realigned in FY 2018 to support higher DoD priorities for Autonomy and Laser Weapon.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
632181: *Spacecraft Payloads*	-	15.555	15.936	15.767	0.000	15.767	16.600	16.807	16.353	17.514	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 (i.e., 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 (DoD) 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 2016	FY 2017	FY 2018
Title: Advanced Space Electronics	4.111	4.834	4.156
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 2016 Accomplishments:*** Began development of advanced electronic circuit components to achieve increased memory density with greater resiliency to the space environment. Continued development of mission-enabling advanced processors, memory, analog to digital/digital to analog converters, field programmable gate arrays (FPGAs), and electron-beam lithography tool. ***FY 2017 Plans:*** Continue development of advanced electronic circuit components producing first pass component. Complete first pass of split-fabrication and begin verification. Complete commercialization development of programmable analog array. Continue technical lead for electron-beam transition and trusted FPGA development. Complete development of high density non-volatile memory technologies. Continue development of high-efficiency power conversion devices. ***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 FPGA 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.			
Title: Advanced Space Modeling and Simulation Tools	1.262	1.149	1.192

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Description: Develop modeling, simulation, and analysis tools for space-based surveillance systems, space capability protection technologies, access/mobility technologies, and flight experiments. ***FY 2016 Accomplishments:*** Updated modeling and simulation tools for flight programs using data sets from recent missions. Continued evaluating the military and technical utility of emerging space vehicle technologies and associated software algorithms. ***FY 2017 Plans:*** Begin development of models for cross-platform modeling, simulation, and analysis support of multi-mission geosynchronous space flight demonstration. Support trade studies and utility analysis for concept development of emerging space technologies and associated software algorithms, including advanced positioning, navigation, and timing technologies. ***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.			
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 2016 Accomplishments:*** Continued to investigate and develop alternative sensor systems that provide wide field of view capabilities to enable advanced missile warning, space-based reconnaissance, space situational awareness and threat warning and assessment applications. Initiated development of long wavelength infrared detector options to enable future satellite characterization and threat warning & assessment capabilities. Continued support to device radiation performance characterization and evaluation. ***FY 2017 Plans:*** Characterize the material damage caused by both surface charging and displacement damage in alternative detector materials and compare results to model developed. Perform experiments as needed to align model predictions with the degradation observed. Investigate potential detector materials for long wavelength infrared detection. ***FY 2018 Plans:***	1.804	2.367	2.316

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Deliver a scanning focal plane array (FPA) for missile warning capability demonstration during laser impingement. Characterize performance of scanning FPA in representative space environment to include natural and man-made radiation including focused photons.			
Title: Positioning, Navigation, and Timing (PNT) Space Payload Technologies ***Description:*** Develop, validate, and transition technologies that: enable new, or enhance existing, U.S. PNT satellite capabilities by increasing resiliency and availability of accuracy; and/or increase the affordability of providing current capabilities. Develop, validate, and transition technologies to meet identified Air Force Space Command/Space and Missile Systems Center PNT space payload technology needs. ***FY 2016 Accomplishments:*** Completed initial reviews of the on-orbit reprogrammable digital waveform generator for PNT/Global Positioning System (GPS). Completed advanced technology space qualifiable L-band radio frequency amplifier(s) for PNT/GPS. ***FY 2017 Plans:*** Finalize design and begin brass-board performance evaluation of on-orbit reprogrammable digital waveform generator for PNT/GPS. Initiate critical design activity. Establish hardware feasibility of advanced phased-array elements for future GPS satellites and begin engineering development unit design. ***FY 2018 Plans:*** Complete designs of on-orbit reprogrammable digital waveform generator for PNT/GPS and deliver engineering development units. Initiate development of broadband amplifier for GPS application.	8.378	7.586	8.103
Accomplishments/Planned Programs Subtotals	15.555	15.936	15.767

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
633834: *Integrated Space Technology Demonstrations*	-	21.204	22.416	21.424	0.000	21.424	13.113	13.846	17.430	17.796	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 U.S. 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 2016	FY 2017	FY 2018
Title: Integrated Satellite Demonstrations	18.204	22.416	21.424

Description: Develop satellite technologies for integrated, robust, and flexible satellite demonstrations building on previous work and leveraging investments by other organizations.

FY 2016 Accomplishments:

Continued payload integration for geosynchronous spaceflight demonstration. Demonstration payloads include hyper temporal imaging (HTI) sensor to detect missile launches under sun-lit clouds which could enable all weather early missile detection; integrated on-board sensing, assessment, and autonomy technology payload which could enable Air Force space asset resiliency to a specific set of threats; and an experiment to demonstrate increased autonomy and safety in advanced proximity operations which could enable Air Force inspector satellites for high value Air Force assets. The spacecraft will demonstrate a multi-orbit, multi-mission-capable, propulsive secondary payload adapter which could enable increased flexibility and affordability for the Evolved Expendable Launch Vehicle (EELV). Developed space and ground segment concepts for integrated demonstration of an advanced GPS payload for contested environments. Determined military utility and defined specific goals, scope, technical objectives, and concepts of operation. Began design engineering trade studies for space flight demonstration with target launch of FY2021-2023.

FY 2017 Plans:

Complete payload integration and begin launch vehicle integration of geosynchronous spaceflight demonstration targeted for early FY2018 launch. Demonstration payloads include HTI sensor to detect missile launches under sun-lit clouds which could enable all weather early missile detection; integrated on-board sensing, assessment, and autonomy technology payload which could enable Air Force space asset resiliency to a specific set of threats; and an experiment to demonstrate increased autonomy and safety in advanced proximity operations which could enable Air Force inspector satellites for high value Air Force assets. The spacecraft will demonstrate a multi-orbit, multi-mission-capable, propulsive secondary payload adapter which could enable increased flexibility and affordability for the EELV. Design and build space segment of space based integrated demonstration of

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 633834 / *Integrated Space Technology Demonstrations*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
an advanced GPS payload for contested environments with a target launch of FY2021-2023. Refine experiment plans and ground segment concept for experimental operations. ***FY 2018 Plans:*** Complete launch vehicle integration for geosynchronous spaceflight demonstration. Support launch operations. Begin on-orbit operations; conduct experimental flight operations of HTI 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 GPS demonstration for contested environments -- target launch of FY2021-2023.			
Accomplishments/Planned Programs Subtotals	18.204	22.416	21.424

	FY 2016	FY 2017
Congressional Add: Program Increase	3.000	-
FY 2016 Accomplishments: Conducted Congressionally-Directed effort		
Congressional Adds Subtotals	3.000	-

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
634400: *Space Systems Protection*	-	10.191	8.091	7.964	0.000	7.964	9.921	9.872	9.420	9.625	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates tools, instruments, and mitigation techniques required to assure operation of U.S. space assets in hostile warfighting environments. The project performs assessments of critical components and subsystems, and evaluates susceptibility and vulnerability to radio frequency (RF) 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 2016	FY 2017	FY 2018
Title: Space Situational Awareness (SSA) Capability Development	1.370	1.778	1.846
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 2016 Accomplishments: Transitioned space-based imaging concepts to system development community for further maturation. Began development of integrated tracking filter incorporating physics-based neutral density drag models for improved SSA.			
FY 2017 Plans: Continue development of integrated tracking filter incorporating physics-based neutral density drag models for improved SSA. Initiate testing of sensors with reduced solar exclusion angle constraints to provide improved coverage for SSA sensors. Initiate second level testing of ground-based RF sensing package and continue end-to-end processing chain to demonstrate SSA utility of in-house algorithm development.			
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 SSA. Continue maturation of RF sensing modalities. Complete processing chain showing end-to-end tracking and characterization capabilities incorporating real data.			
Title: Space Indicators and Warning Research	1.697	2.268	2.014
Description: Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites.			
FY 2016 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Reviewed improvements in local environment sensing technologies in support of rapid space-based threat identification and attribution capabilities to enable/improve spacecraft resilient course-of-action options in a threat environment. Identified and reviewed holistic, resilient spacecraft concept technologies. Identified and developed integration paths for key resilient spacecraft technology discoveries. ***FY 2017 Plans:*** Identify enabling rapid space-based threat identification and attribution capabilities. Assess, refine, and begin developing best candidate resilient spacecraft concept technologies. Continue to identify and develop integration paths for resiliency enabling technology discoveries. ***FY 2018 Plans:*** Integrate space cyber resilience concepts into ground and flight experiments. 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.			
Title: Spacecraft Threat Detection ***Description:*** Develop active satellite local space awareness technologies and exploitation tools for satellite systems. ***FY 2016 Accomplishments:*** Refined capabilities to perform on-board course of action mission planning which involved tasking of satellite subsystems as well as other space system entities; matured technology through ground and flight demonstration opportunities, including delivery of hardware for flight experiment. Selected cross-queuing concepts and identified specific candidate technologies to integrate and increase cross-coordination between space and ground sensor assets. ***FY 2017 Plans:*** Continue to advance technology for on-board threat detection and course-of-action generation and response using live satellite data. Complete demonstration of closed loop tasking and sensor cross-queuing utilizing on-orbit and ground assets. Initiate development of enterprise-level situation monitoring and command and control. ***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.	3.124	4.045	4.104
Accomplishments/Planned Programs Subtotals	6.191	8.091	7.964

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 634400 / *Space Systems Protection*

	FY 2016	FY 2017
Congressional Add: Program Increase ***FY 2016 Accomplishments:*** Conducted Congressionally-Directed effort.	4.000	-
Congressional Adds Subtotals	4.000	-

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635021: *Space Systems Survivability*	-	2.202	1.849	1.820	0.000	1.820	1.942	1.940	1.796	1.836	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 2016	FY 2017	FY 2018
Title: Spacecraft Survivability/Reliability	2.202	1.849	1.820
Description: Develop technologies to provide improved space radiation and ionospheric hazard specification and forecasting. ***FY 2016 Accomplishments:*** Enhanced computational performance of standard radiation belt model for satellite design while continuing to add new on-orbit data. Transitioned spiral one of anomaly attribution tool to operational demonstration. Began upgrading design of compact energetic particle sensor to meet requirements for use in contested space. Completed specification and forecasting of solar radio-frequency interference affecting Air Force communications and satellite systems. ***FY 2017 Plans:*** Support spiral one anomaly attribution tool demonstration and transition to operational use with common ground system. Initiate spiral two development for anomaly attribution tool to include additional information for operators and incorporate limited space environment forecast demonstrations. Begin detailed design, assembly, and calibration of energetic particle sensor for use in contested space. Begin development of automated exploitation tool for on-orbit data for rapid detection and characterization of space environment impacts. Investigate and improve forecasting of solar radio events that impact Air Force operational systems. ***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.			
Accomplishments/Planned Programs Subtotals	2.202	1.849	1.820

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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)

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: FY 2018 Air Force			Date: May 2017
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 635083 / *Ballistic Missiles Technology*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635083: *Ballistic Missiles Technology*	-	3.913	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.913

A. Mission Description and Budget Item Justification

This project develops, integrates, and demonstrates advanced technologies for sustainment and modernization of strategic ballistic missiles. The project focuses on developing robust, low maintenance inertial navigation instruments to sustain current ballistic missile systems, as well as provide new, small, low-powered, high-precision instrumentation for next generation missile systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Advanced Navigation Instruments	3.913	0.000	0.000
Description: Develop, integrate, and demonstrate advanced navigation instrumentation applied to emerging vehicle designs and other technologies that support warfighter needs for a safe, secure, and reliable strategic deterrence. ***FY 2016 Accomplishments:*** Completed weapons hardening of solid-state gyroscope sensor. Completed architecture studies to leverage communications links to provide position and time knowledge, and initiated demonstration of performance on hand held military radios. ***FY 2017 Plans:*** In FY 2017, PE 0603401F, Advanced Spacecraft Technology, Project 635083, Ballistic Missiles Technology efforts were transferred to PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles, in order to better align advanced navigation technology research and development. ***FY 2018 Plans:*** N/A			
Accomplishments/Planned Programs Subtotals	3.913	0.000	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 635083 / *Ballistic Missiles 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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
63682J: *Spacecraft Vehicles*	-	9.213	13.301	11.935	0.000	11.935	15.661	15.959	15.615	15.910	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 2016	FY 2017	FY 2018
Title: Space Power Technologies	1.159	0.990	1.110
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 2016 Accomplishments:*** Selected candidate approaches for achieving greater than 35% efficient solar cells and initiated cell performance and radiation optimization for selected method. Continued development of resilient technologies for module/array survivability. Initiated demonstrations of flexible array technology through ground demo and/or flight experiments. ***FY 2017 Plans:*** Continue to optimize 35% efficient solar cell architectures for end-of-life performance. Initiate mitigation approaches for thermal excursion events for resilient array technologies. Complete on-orbit flight experiment demonstration of flexible array technology. ***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.			
Title: Spacecraft Thermal Technologies	0.254	0.000	0.000
Description: Develop technologies for long-life, efficient, low-vibration, lightweight mechanical cryocoolers and integration components for space applications. ***FY 2016 Accomplishments:*** Completed validation of high-order models to low-order models to reduce optimization time through quick parametric analysis. In FY2016, Project 63682J, Spacecraft Thermal Technologies, completes. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
N/A ***FY 2018 Plans:*** N/A			
Title: Spacecraft Structures Technologies ***Description:*** Develop, integrate, and demonstrate composite spacecraft structures and thermal technologies for deployable structures, antennas, electronics cooling, and structural sensing. ***FY 2016 Accomplishments:*** Completed contracted efforts and in-house government testing, delivered high-performance heat spreader, compliant thermal interface material, and electronics cooling technologies for spaceflight experiment. Using the International Space Station, tested the micro-gravity deployment of a new passive-strain-energy-deployed, flexible composites solar array expected to improve capability on Air Force spacecraft six-fold. Developed and tested deployment of a lightweight baffle and an affordable deployable radio-frequency aperture for communication and high-gain GPS signals. Initiated spaceflight experiment planning to test structurally-integrated sensing technologies for on-orbit impact detection and situational awareness of potential threats. ***FY 2017 Plans:*** Complete high-performance heat spreader, compliant thermal interface material, electronics cooling technologies, roll-out solar array, and deployable baffle development for potential applications by DoD programs and prime contractors. Continue spaceflight experiment to test structurally-integrated sensing technologies for on-orbit impact detection and situational awareness of potential threats. Initiate flight experiment to test an affordable deployable aperture for denied area communication and high-gain, anti-jam GPS applications. ***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 GPS applications. Initiate integrated experiment concepts testing structures and thermal technologies for high energy density, full spectrum radio frequency reconfigurabilty, adaptability, and protection.	1.159	0.992	1.109
Title: On-Orbit Satellite Controls ***Description:*** Develop technologies for spacecraft controls and mechanisms for on-orbit applications. ***FY 2016 Accomplishments:***	0.452	0.423	0.433

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Initiated development of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions. ***FY 2017 Plans:*** Continue development and initiate testing of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions. ***FY 2018 Plans:*** Continue development and testing of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions.			
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 2016 Accomplishments:*** Supported fabrication and testing of the W and V frequency band space flight instrument and ground receiver unit. Identified a host spacecraft for the flight experiment; launch is anticipated in 2019. Completed fabrication and test of transmit antenna array. Completed analysis of the data from the Compact Laser Terminal flight experiment. ***FY 2017 Plans:*** Complete testing and qualification of the payload for the W and V frequency band satellite communications flight experiment. Initiate testing and evaluation of a software defined radio for a low Earth orbiting cube-satellite experiment operating in S and L frequency bands providing wide-band, high-date-rate satellite telemetry, command, and control. ***FY 2018 Plans:*** Support integration and test of the W and V frequency band flight instrument onto the host spacecraft. Support initial design and breadboard 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.	3.291	2.812	1.905
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 2016 Accomplishments:***	2.898	8.084	7.378

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continued efforts to develop atomic clock technology from laboratory experiments into flight experiment payload units to transition to industry. Continued fabrication and development of engineering models of the clocks for testing and integration. ***FY 2017 Plans:*** Finalize efforts to develop atomic clock technology from laboratory experiments into flight experiment payload units to transition to industry. Begin integration and testing of clock engineering models. Begin development of radiation-hardened, ultra-stable laser needed for cold-atom atomic clocks, accelerometers, and gyroscopes operating in space or nuclear environments. Begin 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. In FY 2017, PE 0603401F, Advanced Spacecraft Technology, Project 635083, Ballistic Missiles Technology efforts were transferred to PE 0603401F, Advanced Spacecraft Technology, Project 63682J, Spacecraft Vehicles, in order to better align advanced navigation technology research and development. ***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.			
Accomplishments/Planned Programs Subtotals	9.213	13.301	11.935

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: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
Total Program Element	-	12.303	11.681	10.433	0.000	10.433	11.912	12.147	12.390	12.638	Continuing	Continuing
634868: *Maui Space Surveillance System*	-	12.303	11.681	10.433	0.000	10.433	11.912	12.147	12.390	12.638	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program funds ground-based optical space situational awareness (SSA) technology development and demonstration at the Maui Space Surveillance System (MSSS) in Hawaii, as well as the operation and upgrade of the facility. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	12.853	11.681	11.681	0.000	11.681
Current President's Budget	12.303	11.681	10.433	0.000	10.433
Total Adjustments	-0.550	0.000	-1.248	0.000	-1.248
• 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	-0.347	0.000			
• SBIR/STTR Transfer	-0.203	0.000			
• Other Adjustments	0.000	0.000	-1.248	0.000	-1.248

Change Summary Explanation

FY 2018 reduction is due to higher DoD priorities.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Operate and Upgrade Maui Space Surveillance System (MSSS)	10.316	9.271	9.454
Description: Operate and upgrade the MSSS to support development, demonstration, and integration of ground-based optical SSA technologies.			

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: Maintained MSSS facility and experimental equipment in a mission-ready state. Performed needed upgrades and modernization to keep facilities and equipment in good working order and allow MSSS to perform efficiently and reliably. Operated MSSS facility for development and demonstration of ground based optical SSA capabilities in conjunction with customer programs and an operational SSA mission. Installed Laser Guidestar system for atmospheric compensation at MSSS and initiated on-sky testing demonstration. ***FY 2017 Plans:*** Maintain MSSS facility and experimental equipment in a mission-ready state. Perform needed upgrades and modernization to keep facilities and equipment in good working order and allow MSSS to perform efficiently and reliably. Operate MSSS facility for development and demonstration of ground based optical SSA capabilities in conjunction with customer programs and an operational SSA mission. Apply Laser Guidestar system at MSSS to geosynchronous satellite imaging demonstration and detection of closely-spaced orbital objects. ***FY 2018 Plans:*** Maintain MSSS facility and experimental equipment in a mission-ready state. Perform needed upgrades and modernization to keep facilities and equipment in good working order and allow MSSS to perform efficiently and reliably. Operate MSSS facility for development and demonstration of ground based optical SSA capabilities in conjunction with customer programs and an operational SSA mission. Apply Laser Guidestar system at MSSS to geosynchronous satellite imaging demonstration.			
Title: Geosynchronous Object Sensor	1.987	2.410	0.979
Description: Develop and demonstrate dual-use integrated sensor technology for imaging of geosynchronous objects as well as other long-range applications. ***FY 2016 Accomplishments:*** Initiated low power demonstration of augmented objects for refinement of full-power system. Completed build-out of low-power transceiver hardware and initiated telescope modifications for future demonstration of laser imaging of objects in geosynchronous orbit. ***FY 2017 Plans:*** Complete low power demonstration of augmented objects for refinement of full-power system. Begin build-out of full-power transceiver hardware and initiate telescope modifications for future demonstration of laser imaging of objects in geosynchronous orbit. Begin full-power demonstration of laser imaging of objects in geosynchronous orbit. ***FY 2018 Plans:***			

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
Complete 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.			
Accomplishments/Planned Programs Subtotals	12.303	11.681	10.433

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	24.094	26.492	33.635	0.000	33.635	36.737	37.824	36.510	37.338	Continuing	Continuing
635323: *Directed Energy Bioeffects Parameters*	-	2.375	4.909	5.388	0.000	5.388	5.290	5.193	5.320	6.650	Continuing	Continuing
635324: *Human Dynamics and Terrain Demonstration*	-	6.274	6.759	5.432	0.000	5.432	5.449	5.930	6.046	7.500	Continuing	Continuing
635325: *Mission Effective Performance*	-	10.444	10.141	6.626	0.000	6.626	6.846	6.982	7.122	7.265	Continuing	Continuing
635327: *Warfighter Interfaces*	-	5.001	4.683	16.189	0.000	16.189	19.152	19.719	18.022	15.923	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 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: FY 2018 Air Force					Date: May 2017
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	25.448	26.492	22.811	0.000	22.811
Current President's Budget	24.094	26.492	33.635	0.000	33.635
Total Adjustments	-1.354	0.000	10.824	0.000	10.824
• 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	-0.688	0.000			
• SBIR/STTR Transfer	-0.666	0.000			
• Other Adjustments	0.000	0.000	10.824	0.000	10.824

Change Summary Explanation

Increase in FY 2018 due to increased emphasis on autonomy and human-machine teaming.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635323: *Directed Energy Bioeffects Parameters*	-	2.375	4.909	5.388	0.000	5.388	5.290	5.193	5.320	6.650	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 2016	FY 2017	FY 2018
Title: Optical Radiation Bioeffects	1.558	3.550	4.324

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 2016 Accomplishments:

Completed initial demonstration of physiological/behavioral response model in engagement-level simulation within distributed simulation and Air Force modeling and simulation architecture for overall weapons evaluations. Completed initial demonstration of human vulnerability model built within a DoD standardized format and continued additional component development, integrating vision effects along with probability of eye and skin injury. Completed effort to design probabilistic risk assessment tools for lasers. Extended laser eye protection (LEP) evaluations to perform night visor aircrew acceptance testing, including laboratory testing, and ground and flight assessments.

FY 2017 Plans:

Further integration of physiological/behavioral response models into engagement-level simulation capabilities for directed energy weapon threats and concepts. Validate and demonstrate modeling and simulation tools which transition engagement-level simulations to mission and campaign models to evaluate the utility and impact of directed energy systems. Develop human systems integration modeling tools for laser eye protection devices. Evaluate new technologies for laser eye protection.

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

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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 mission assessment of campaign 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.			
Title: Radio Frequency Bioeffects ***Description:*** Develop and demonstrate technologies to assess RF bioeffects and collateral hazards from high power RF directed energy systems. ***FY 2016 Accomplishments:*** Developed fast (near real-time) anatomy and physiology-based computational tool for RF-induced thermal response. Completed prototype high peak power effects model integration into software suite and began verification and validation studies. Increased efficiency of human posing and morphing for electromagnetic analysis. ***FY 2017 Plans:*** Continue verification and validation studies for high peak power effects model in support of next-generation counter-electronics weapons. Develop and validate a model of effects of low gigahertz radiation. Inform development of fire control technology for millimeter wave and high power microwave technologies based on safety and effectiveness. ***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.	0.817	1.359	1.064
Accomplishments/Planned Programs Subtotals	2.375	4.909	5.388

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635324: *Human Dynamics and Terrain Demonstration*	-	6.274	6.759	5.432	0.000	5.432	5.449	5.930	6.046	7.500	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 2016	FY 2017	FY 2018
Title: Human Analyst Augmentation	4.319	4.215	3.717
Description: Develop and demonstrate human-centered design processes and operational tools that optimize ISR information exploitation and analysis.			
FY 2016 Accomplishments: Demonstrated initial analytical work environments and toolsets to advance performance for ISR work roles in contested environments that span the processing, exploitation, and dissemination process from time-dominated tactical work situations to content-dominated operational and strategic reach back operations.			
FY 2017 Plans: Develop analytical work environment concepts to support advanced multi-intelligence analysis. Demonstrate airmen-centered tools for future distributed ground processing concepts. Assess efficacy of new concepts, methodologies, and tools.			
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.			
Title: Human Trust and Interaction	1.206	2.044	1.715
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 2016 Accomplishments: Demonstrated and tested advanced multimedia machine translation and automatic speech recognition tools.			
FY 2017 Plans:			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Investigate advanced multimedia translation and automatic speech recognition tool applications in military environments for mission focus areas and domains. ***FY 2018 Plans:*** 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.			
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 2016 Accomplishments:*** Investigated integration of normative anthropometric-based human signatures algorithms into sensor system processors. ***FY 2017 Plans:*** Integrate human detection algorithm to provide operators with real-time counts of gender and age differentiation into operationally relevant sensor applications. ***FY 2018 Plans:*** No current plans as funding has been reallocated in FY18 to support AFRL Autonomy Initiative.	0.749	0.500	0.000
Accomplishments/Planned Programs Subtotals	6.274	6.759	5.432

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635325: *Mission Effective Performance*	-	10.444	10.141	6.626	0.000	6.626	6.846	6.982	7.122	7.265	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 2016	FY 2017	FY 2018
Title: Continuous Learning	10.444	10.141	6.626
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 2016 Accomplishments: Completed operational trials of integrated LVC operations training and assessment methods in large force exercise. Demonstrated shareable content and metrics in joint and coalition mission training contexts. Began development of reusable models for improving adversary realism in distributed mission operations (DMO) and LVC environments. Demonstrated deployable LVC training in integrated manned and unmanned aircraft and ground operations exercise. Began development of scenario and metrics specifications and standards for deployable LVC operations.			
FY 2017 Plans: Begin definition of standards for sharable scenario content, data, models, and metrics across a range of military operations. Transition fast jet learning management system into routine operational training and to an alternate research domain. Begin development of methods to create adaptive learning environments across multiple missions contexts. Define studies to evaluate efficiencies to be derived from the creation and use of more sharable scenario content models and metrics in LVC testbeds.			
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. Continue development of methods to create adaptive			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
learning environments across multiple missions contexts. Execute evaluation studies on sharable scenario content models and metrics in LVC testbeds.			
Accomplishments/Planned Programs Subtotals	10.444	10.141	6.626

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635327: *Warfighter Interfaces*	-	5.001	4.683	16.189	0.000	16.189	19.152	19.719	18.022	15.923	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 2016	FY 2017	FY 2018
Title: Applied Neuroscience	0.437	0.000	0.000
Description: Develop sense, assess, and augment technologies to facilitate efficient workflow in distributed operational environments. Develop empirically validated cyber operator-centered tools for distributed cyber operations integrated into a single user interface. ***FY 2016 Accomplishments:*** Verified and validated design recommendations for an integrated offensive and defensive cyber operator tool set. Finalized design of neurophysiological-based Airman performance sensor suite. Refreshed sensors, methodologies, and approaches to assess operator functional state relating to stress, cognition, trust, and airman-machine teaming. ***FY 2017 Plans:*** No FY17 plans due to reallocation of funds to support AFRL Autonomy Initiative and BATMAN III ***FY 2018 Plans:*** No FY18 plans due to reallocation of funds to support AFRL Autonomy Initiative and BATMAN III			
Title: Battlespace Acoustics	2.984	3.073	4.071
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 2016 Accomplishments:*** Validated real-time 3-D acoustic models into mission planning tools. Evaluated high-fidelity 3-D acoustic models against real-world data obtained from airborne platform measurements in different weather and terrain environments. Conducted human panel			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
validation studies of weather effects, landscape sounds, and geography used in developed acoustic models. Initiated applications of physiological sensors, usability engineering methodologies to prototype and test innovative solutions required for battlefield airmen and pararescue jumpers. ***FY 2017 Plans:*** Transition real-time 3-D acoustic models into mission planning tools. Transition high-fidelity 3-D acoustic models against real world data obtained from airborne platform measurements in different weather and terrain environments. Model and validate (through human listener studies) the impact of weather, landscape, and geography on acoustic propagation. Evaluate applications of physiological sensors and human performance assessment technologies for the battlefield airmen and pararescue jumpers. Refresh usability engineering methodologies to prototype and test innovative solutions required for battlefield airmen and pararescue jumpers. ***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.			
Title: Human Role in Semiautonomous Systems ***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 2016 Accomplishments:*** Fostered advancements in the design, demonstration, and evaluation of novel airman interface designs that support decision-making and situation awareness while controlling multiple RPAs in a highly dynamic mission environment. Performed final evaluations of multi-transit control station interface technologies that will enable a single Airman to simultaneously control multiple, heterogeneous RPAs transiting through airspace by using high-fidelity simulations and flight tests. Delivered mature prototype of RPA transit operations workstation. Enhanced and evaluated initial designs of interfaces for a networked RPA collaborative environment to permit teams of pilot, sensor, and payload operators to collaborate for mission execution purposes, during various RPA mission phases in various threat environments. ***FY 2017 Plans:***	1.580	1.610	12.118

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Enhance and evaluate refined interface designs for a networked collaborative environment to enable distributed teams of manned and unmanned systems to work synergistically to maximize mission effectiveness. Establish design patterns for optimal human-autonomy dialog tailored to the specific computational methods utilized by the underlying autonomy. Refine intelligent agents for decision support and plan monitoring, across a wide range of applications. ***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.			
Accomplishments/Planned Programs Subtotals	5.001	4.683	16.189

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
Total Program Element	-	42.204	102.009	167.415	0.000	167.415	197.001	233.030	205.660	230.332	Continuing	Continuing
63670A: *Weapon Technology Development*	-	42.204	60.509	87.215	0.000	87.215	96.401	58.330	46.660	75.396	Continuing	Continuing
63670B: *Weapon Concept Development*	-	0.000	41.500	80.200	0.000	80.200	100.600	174.700	159.000	154.936	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops, integrates, and demonstrates advanced ordnance and guidance technologies for air-launched conventional weapons. The program focuses on conventional ordnance component technologies such as warheads, 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 (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	43.036	102.009	155.804	0.000	155.804
Current President's Budget	42.204	102.009	167.415	0.000	167.415
Total Adjustments	-0.832	0.000	11.611	0.000	11.611
• 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	-0.832	0.000			
• Other Adjustments	0.000	0.000	11.611	0.000	11.611

Change Summary Explanation

Increase in FY 2018 due to increased emphasis and endeavor to fully fund small-sized air-to-air weapon technology-demonstration.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
63670A: *Weapon Technology Development*	-	42.204	60.509	87.215	0.000	87.215	96.401	58.330	46.660	75.396	Continuing	Continuing

A. Mission Description and Budget Item Justification

Mission Description not provided.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Ordnance Technologies	9.252	32.569	49.817

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 (M&S)tools.

FY 2016 Accomplishments:

Demonstrated revolutionary embedded fuzing technologies to increase the reliability of legacy penetrating weapons and portends selectable and dialable weapon effects. Continued to develop and assess ordnance technologies for challenging high-speed strike weapon employment concepts. Matured M&S tools to determine survivability and lethality of general purpose and future weapons systems across an ever increasing spectrum of targets. Continued to research alternative fuzing systems pervasive across a spectrum of currently fielded and future munitions that will reduce logistics tail and associated costs. Demonstrated live drop of selectable effects weapon with precision height of burst technology and custom warhead. Conducted proof-of-concept test of sub-scale dialable effects munition which enables wide area attack, provides limited penetration capability and has applications for close air support. Completed trade study for next generation research for hard target defeat, including assessment of very high-speed penetration and multi/cumulative attack.

FY 2017 Plans:

Continue to mature distributed fuzing concepts for close-controlled strike, area attack, and penetration applications, including assessing long term safety, survivability and functionality. Continue to research ordnance technologies to allow tailored lethality by controlling weapon fragmentation. Continue to mature ordnance technologies for rapid transition into high-speed strike weapon concepts. 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. Initiate research into armament systems for Special Operations applications. Conduct lethality analyses for air-to-air weaponry. Research distributed, collaborative, cooperative effects munitions technologies.

FY 2018 Plans:

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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. 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.			
Title: Guidance Technologies	8.051	27.940	37.398
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 2016 Accomplishments:*** Established Integrated Guidance Evaluation and Verification (IGEV) team and initiated configuration management high fidelity simulation software for high-speed, long-range weapon research. Demonstrated end-to-end functionality of high fidelity, six degree of freedom model for investigating guidance modes and stressing vehicle dynamics in a hypersonic environment. Refurbished a new five axis flight motion simulator for FY 2017 installation. Upgraded computing capabilities to full capability for analyzing integrated functionality of guidance, navigation, inertial sensing, executive control, and a seeker. Demonstrated software defined approach to radio frequency target simulation, in preparation for future hardware-in-the-loop demonstrations of high-speed weapon concepts and eventual transition to acquisition. Established contracts to research test methods for seeker performance in a hypersonic environment and a revolutionary new autopilot design approach. Delivered weapon simulation data supporting analysis tools and documentation to contractors and developed scenarios to support seeker trade studies. Initiated contract actions to develop initial weapons carriage and release systems to include initial rack and integral weapon ejector rack. Initiated process to construct state-of-art M&S analysis center, to provide interoperable warfighter solutions in a live, virtual, and constructive environment including engagement, mission, campaign, hardware-in-the-loop, human-in-the-loop, and live flight. ***FY 2017 Plans:*** Continue to conduct wind-tunnel and limited flight experiments to characterize air-to-air guidance and control. Continue to conduct research on integrated hardware and software-in-the-loop demonstrations of high speed weapon technologies. Continue to develop advanced modular and service oriented weapon architectures. Continue design and development of seeker subsystem prototypes for platform self-defense. Continue to develop projector and common scene generator technologies for design, development, and analysis of advanced weapon concepts in representative environments for assets networked and			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
operating in future battle spaces. Develop technologies for precision navigation of weapons in global Positioning System (GPS)-denied scenarios. Continue to develop technologies for precision navigation of weapons. Evaluate and categorize multiple advanced carriage and release concepts, conduct design reviews and begin construction of new systems. Continue M&S center design to enable simultaneous, multi-level security M&S activities. ***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 M&S 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 RF test chamber, scene generation, mission, engagement, campaign level simulations, and panoramic infrared dome technologies. Continue to develop technologies for precision navigation of weapons in GPS-denied scenarios. Continue to mature and integrate advanced carriage and release concepts and sub-systems. Complete design of M&S capability and initiate approval processes to permit simultaneous multi-level security M&S activities. Complete M&S center design and security approval processes to enable simultaneous, multi-level security M&S activities.			
Title: Advanced Munition Concept Technologies	24.901	0.000	0.000
Description: Demonstrate advanced conventional munitions concepts. These innovative concepts integrate ordnance, guidance, and carriage and release technologies to demonstrate warfighter capability. ***FY 2016 Accomplishments:*** Initiated program planning for subsonic, standoff, low cost cruise missile. Launched Joint Capability Technology Demonstration for enabling technologies for low-cost standoff delivery vehicle. Performed risk reduction activities in support of air-to-air weapons for both offensive and defensive purposes. Awarded multiple competitive contracts for maturation of propulsion and warhead technologies for advanced air-to-air weapons. Conducted wind tunnel test series to explore aerodynamics and agility on numerous candidate airframe designs. Continued to mature high risk technologies in ordnance, guidance, airframe, and conducted lethality analysis of candidate warhead technologies. Performed high fidelity lethality and weapons engagement analysis for air-to-air and air-to-ground weapons concepts. Released version 1.4 of weapon effect server capability which enhanced fidelity of directed energy engagement analysis and initiated pilot analyses supporting the future air dominance platforms. Successfully completed a systems analysis of modular weapons systems to determine early requirements and impacts of modular weapon components. Demonstrated several modular weapons concepts in a digital simulation environment. Performed risk reduction activities in support of air-to-air weapons for both offensive and defensive purposes. ***FY 2017 Plans:***			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Starting in FY 2017 and beyond, work accomplished under this effort will be reported in Project 63670B, Weapon Concept Development. ***FY 2018 Plans:*** N/A			
Accomplishments/Planned Programs Subtotals	42.204	60.509	87.215

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
63670B: *Weapon Concept Development*	-	0.000	41.500	80.200	0.000	80.200	100.600	174.700	159.000	154.936	Continuing	Continuing

A. Mission Description and Budget Item Justification

Starting in FY 2017, Project 63670B, Weapon Concept Development, was created and activities were re-aligned from Project 63670A, Conventional Weapons Development, under the effort, Advanced Munition Concept Technologies. In order to further focus this new Project, two efforts were created under it: Air-to-Air Concept Development and Air-to-Ground Concept Development. This project will develop, refine, and integrate ordnance and guidance technologies into demonstrations to reduce risk for potential air-launched conventional weapons acquisitions.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Air-to-Air Concept Development	0.000	5.000	30.220
Description: Mature, integrate, and demonstrate air-to-air weapon components and systems (ordnance, guidance, and carriage and release technologies) to demonstrate warfighter capability.			
FY 2016 Accomplishments: N/A			
FY 2017 Plans: For FY 2016, the work for this effort was performed under Project 63670A, Weapon Technology Development, in the effort, Advanced Munition Concept Technologies. Continue to demonstrate weapon integration concept for air target engagement. Continue planning and technology risk reduction for weapon concepts responsive to the 2030 timeframe 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.			
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 timeframe 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			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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. maneuver			
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 warfighter capability. ***FY 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** For FY 2016, the work for this effort was performed under Project 63670A, Weapon Technology Development, in the effort, Advanced Munition Concept Technologies. Increase emphasis in conducting relevant long range strike weapon technology demonstrations to reduce risk for potential follow on acquisition programs. Continue the development of munition concepts to incorporate technologies for carriage and terminal impact at high speed. Increase emphasis in investigating 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 timeframe 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. ***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 timeframe 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	0.000	36.500	49.980

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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.			
Accomplishments/Planned Programs Subtotals	0.000	41.500	80.200

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-2, RDT&E Budget Item Justification: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	37.301	39.064	45.502	0.000	45.502	45.271	37.240	31.458	32.088	Continuing	Continuing
633151: *High Power Solid State Laser Technology*	-	16.865	20.824	24.635	0.000	24.635	27.912	18.880	12.730	12.985	Continuing	Continuing
633152: *High Power Microwave Development and Integration*	-	20.436	18.240	20.867	0.000	20.867	17.359	18.360	18.728	19.103	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 (HEL), high power electromagnetics (HPEM), 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 advanced optical imaging for space situational awareness. 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 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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	35.195	39.064	38.677	0.000	38.677
Current President's Budget	37.301	39.064	45.502	0.000	45.502
Total Adjustments	2.106	0.000	6.825	0.000	6.825
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	3.134	0.000			
• SBIR/STTR Transfer	-1.028	0.000			
• Other Adjustments	0.000	0.000	6.825	0.000	6.825

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 633152: *High Power Microwave Development and Integration*		
Congressional Add: *Counter-electronics high power microwave advanced missile*	5.000	-

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017
Congressional Add Subtotals for Project: 633152	5.000	-
Congressional Add Totals for all Projects	5.000	-

Change Summary Explanation

FY 2017 increase reflects reprogramming for Air Dominance activities and to support Research and Development Projects, 10 U.S.C. Section 2358.

FY 2018 increase due to increased priority of high energy laser research.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
633151: *High Power Solid State Laser Technology*	-	16.865	20.824	24.635	0.000	24.635	27.912	18.880	12.730	12.985	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project provides for the development, integration, demonstration, and detailed assessment of HEL devices, advanced imaging and beam control technologies needed for applications such as force protection, force application, precision engagement, and aircraft self-protection. Laser system concept assessments to include vulnerability assessments and target effect testing are performed.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: High Energy Laser/Beam Control	16.865	20.824	24.635
Description: Develop and demonstrate advanced beam control technologies, integrated laser systems, and aircraft self-protection laser technologies. Demonstrate beam control components integrated with HELs for Air Force utility. ***FY 2016 Accomplishments:*** Completed experiments with the joint DARPA and Air Force HEL system against various targets including ground targets and surface-to-air missiles. Continued to document field lethality data, modeling and simulation tools, and lessons learned on the tests. Began preparation for integration of a moderate power laser system into a pod for aircraft self-protection ground demo. Continued with the design of a full scale turret with aero-effects mitigation, integrate with light weight beam director and control system, and plan for testing. ***FY 2017 Plans:*** Continue the integration of a moderate power laser system into a pod for aircraft self protection ground demo. Complete the integration/verification of the beam control systems into a pod. Continue the development of vulnerability criteria for the Air Superiority mission. Complete verification tests of the moderate power ground-to-air fiber laser weapons system demonstration. ***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.			
Accomplishments/Planned Programs Subtotals	16.865	20.824	24.635

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
633152: *High Power Microwave Development and Integration*	-	20.436	18.240	20.867	0.000	20.867	17.359	18.360	18.728	19.103	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates HPEM and other unconventional weapon generation and transmission technologies that support a wide range of Air Force missions such as the potential disruption, degradation, damage, or destruction of an adversary's electronic infrastructure and military capability and non-lethal, anti-personnel weapon applications. It also provides inputs to the susceptibility, vulnerability, and lethality databases.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: HPEM Technologies	15.436	18.240	20.867
Description: Develop and evaluate HPEM and other unconventional weapon technologies for various platforms, including aerial, for applications such as counter-electronics. Develop and evaluate HPEM technologies for non-lethal, anti-personnel weapon applications. ***FY 2016 Accomplishments:*** Refined design of a class of reusable, multi-pulse, multi-target counter-electronics payloads capable of being hosted in various advanced platforms. Characterized, modeled, tested and evaluated red directed energy threats on blue assets. Began initial preparations of advanced system technologies for the High power Joint Electromagnetic Non-Kinetic Strike (HiJENKS) high power microwave (HPM) flight demonstration. ***FY 2017 Plans:*** Continue the 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. Continue to characterize, model, test and evaluate current and projected blue directed energy threats on red assets. Continue the system design effort with the Navy for the HiJENKS HPM flight demonstration. ***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 HiJENKS HPM flight demonstration with the Navy.			
Accomplishments/Planned Programs Subtotals	15.436	18.240	20.867

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017
Congressional Add: Counter-electronics high power microwave advanced missile ***FY 2016 Accomplishments:*** Conduct Congressionally directed effort.	5.000	-
Congressional Adds Subtotals	5.000	-

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: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	51.467	46.344	46.450	0.000	46.450	42.953	43.441	44.751	46.588	Continuing	Continuing
635280: *Manufacturing Technologies*	-	51.467	46.344	46.450	0.000	46.450	42.953	43.441	44.751	46.588	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 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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	52.630	46.344	45.386	0.000	45.386
Current President's Budget	51.467	46.344	46.450	0.000	46.450
Total Adjustments	-1.163	0.000	1.064	0.000	1.064
• 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	-0.048	0.000			
• SBIR/STTR Transfer	-1.115	0.000			
• Other Adjustments	0.000	0.000	1.064	0.000	1.064

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2016	FY 2017
Project: 635280: *Manufacturing Technologies*		
Congressional Add: *Additive Manufacturing*	10.000	-

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017
Congressional Add Subtotals for Project: 635280	10.000	-
Congressional Add Totals for all Projects	10.000	-

Change Summary Explanation

Funding realigned in FY 2018 to support higher Department of Defense priorities.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Sustainment Manufacturing Technologies	12.440	12.873	13.006
Description: Develop and transition pervasive affordability and producibility technologies for weapons systems and processes. ***FY 2016 Accomplishments:*** Validated and demonstrated laser bond inspection methodology. Developed cost effective conventional and special material production and repair technologies to enable affordable sustainment of aircraft systems. Continued manufacturing technology development for depot maintenance. ***FY 2017 Plans:*** Continue development of cost effective conventional production and special material repair technologies to enable affordable sustainment of aircraft systems. Continue agile sustainment manufacturing technology development for depot maintenance. ***FY 2018 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.			
Title: Advanced Manufacturing Technologies	29.027	33.471	33.444
Description: Develop and transition pervasive affordability and producibility technologies for weapons systems and processes. ***FY 2016 Accomplishments:*** Developed and demonstrated manufacturing capabilities for more affordable advanced turbine engine propulsion technologies, communications technologies, advanced active electronically scanned array (AESA) sensor applications, and mid-wave infrared (MWIR) optics producibility. Demonstrated integrated direct-write electronics and manufacturing technology for vertical cavity surface emitting lasers. Improved casting processes through advanced modeling and manufacturing processes. Continued			

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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 2016	FY 2017	FY 2018
development of agile manufacturing applications and hot structures affordability and continued to mature advanced material development. ***FY 2017 Plans:*** Continue development and demonstration of agile manufacturing capabilities for more affordable advanced turbine engine propulsion technologies, intelligence, surveillance, and reconnaissance 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 mature advanced material manufacturing development and transition to the field. ***FY 2018 Plans:*** Continue development and demonstration of 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. 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, precision guided munitions, and hypersonics.			
Accomplishments/Planned Programs Subtotals	41.467	46.344	46.450

	FY 2016	FY 2017
Congressional Add: Additive Manufacturing ***FY 2016 Accomplishments:*** Conducted congressionally directed effort	10.000	-
Congressional Adds Subtotals	10.000	-

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.

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Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	41.568	58.110	49.011	0.000	49.011	52.995	57.387	59.714	62.223	Continuing	Continuing
635319: *Anticipatory OPS Intent and Response*	-	3.516	3.562	3.602	0.000	3.602	6.144	6.267	6.392	6.520	Continuing	Continuing
635320: *Assured Worldwide Connectivity*	-	22.424	20.837	12.813	0.000	12.813	12.753	12.370	14.297	14.268	Continuing	Continuing
635321: *Global Battlespace Awareness*	-	10.592	8.425	11.017	0.000	11.017	12.874	14.616	14.908	15.205	Continuing	Continuing
635322: *Knowledge Management and Computing*	-	5.036	4.767	3.369	0.000	3.369	3.811	3.676	2.068	2.109	Continuing	Continuing
635329: *Cyber Battlespace Dev & Demo*	-	0.000	20.519	18.210	0.000	18.210	17.413	20.458	22.049	24.121	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates Air Force enterprise-centric information technologies for the warfighter. 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 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 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 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. 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.

Starting in FY 2017 to improve reporting to Congress, Project 635329, Cyber Battlespace Dev & Demo was created to capture all cyber activity that was previously performed in this program.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force	Date: May 2017
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*

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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Previous President's Budget	46.196	58.110	61.169	0.000	61.169
Current President's Budget	41.568	58.110	49.011	0.000	49.011
Total Adjustments	-4.628	0.000	-12.158	0.000	-12.158
• 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	-3.122	0.000			
• SBIR/STTR Transfer	-1.506	0.000			
• Other Adjustments	0.000	0.000	-12.158	0.000	-12.158

Change Summary Explanation

Decrease in FY 2016 because of reprogramming of funds to support Air Dominance activities and Research and Development Projects, 10 U.S.C. Section 2358.

Decrease in FY 2018 is due realignment of funds to focus on Directed Energy and Autonomy Game Changer efforts.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635319: *Anticipatory OPS Intent and Response*	-	3.516	3.562	3.602	0.000	3.602	6.144	6.267	6.392	6.520	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Adaptive Planning and Decision Tools	3.516	2.366	2.520
Description: Develop and demonstrate the integration of planning tools and information-based intelligent agents for adaptive replanning and decision support tools.			
FY 2016 Accomplishments: Prototyped a mission assurance framework and integrated service oriented architecture for a set of planning tools and services that proactively build and shape the portion of cyberspace employed in support of mission assurance objectives. Demonstrated net-centric mission planning and execution concepts to support a net-enabled dynamic decision support capability for a variety of air, space and cyber missions in support of combined, global operations. Validated the ability to synchronize efforts across warfighting domains (air, space, cyber, land and maritime) to create desired effects.			
FY 2017 Plans: Continue planned work in real-time course of action generation and prioritization, extensible command and control (C2) framework modernizing Joint Space Operations Center (JSpOC) operations, advanced indications and warning tipping C2 system for proactive countermeasure actions and visualization of the complete electromagnetic spectrum for enhancing JSpOC decision making. Initiate effort for Distributed Operations in a Contested Environment. Create and use scenarios and evaluation metrics for integrated demonstration and testing.			
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.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continue planned work in real-time course of action generation and prioritization, extensible C2 framework modernizing JSpOC operations, advanced indications and warning tipping C2 system for proactive countermeasure actions and visualization of the complete electromagnetic spectrum for enhancing JSpOC decision making.			
Title: Next Generation Planning and Assessment Tools ***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 2016 Accomplishments:*** Due to higher Air Force priorities, delayed until FY 2017 development of links and tools to effectively employ cyber, directed energy and electronic warfare weaponry within a target folder environment. Delayed until FY 2017 the provision of a set of models that will give targeteers greater comprehension of the second and third order effects of targeting actions. ***FY 2017 Plans:*** Develop links and tools to effectively employ cyber, directed energy and electronic warfare weaponry within a target folder environment. Provide a set of models that will give targeteers greater comprehension of the second and third order effects of targeting actions. Initiate the subsequent development and demonstration of capabilities that utilize a mixture of analytics and visualization methods to determine progress relative to the achievement of objectives and end states. Initiate the development and demonstration of capabilities that provide ability to make actionable recommendations to assist the strategy division in identifying resource constraints, adversary actions, rules of engagement restrictions, and realignment of forces to assure commander's intent is met. ***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.	0.000	1.196	1.082
Accomplishments/Planned Programs Subtotals	3.516	3.562	3.602

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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*

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635320: *Assured Worldwide Connectivity*	-	22.424	20.837	12.813	0.000	12.813	12.753	12.370	14.297	14.268	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 Air Operations Center (AOC) and aircraft, either en route or in theater. This project provides secure information transmission capabilities for a persistent, global, survivable communications backbone network accessible for warfighters operating in all domains. It provides self-healing, self-configuration, anti-jam communication networking capabilities, and provides enterprise networking capabilities for agile, policy-based network management. In addition, this project develops and demonstrates flight ready systems consisting of high capacity radio frequency (RF) and optical components and architectures for next generation communications. The Air Force also 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 and persistence, cyber intelligence, and weapons delivery), cyber defense capabilities (attack detection, attack attribution, and response automation), and cyber support capability (situational awareness and war gaming.)

Starting in FY 2017 cyber work previously performed within this project will be reported under Project 635329, Cyber Battlespace Dev & Demo.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Cyber Offense	4.986	0.000	-
Description: Develop and demonstrate offensive cyber operations capabilities in a series of experimental technology demonstrations. ***FY 2016 Accomplishments:*** Merged next generation cyber operations technologies with other relevant military programs and demonstrate enhanced capabilities that allow non-kinetic capabilities to aid kinetic missions. Developed technologies to remain current with new waveforms and signals. Continued Service Oriented Architecture component development for use in the Air Force Lifecycle Management Center (AFLCMC) Cyber Mission Platform (CMP). Scheduled final delivery and demonstration of the highly configurable cyber simulation environment which produces network traffic annotated with high fidelity cyber telemetry. ***FY 2017 Plans:*** For FY 2017, the work for this effort will be performed under Project 635329, Cyber Battlespace Dev & Demo in an effort of the same name.			
Title: Connectivity Technologies	10.547	20.837	12.813

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
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 2016 Accomplishments:*** Continued development of a network level encryption and traffic-aware router, allowing enclaves at different security levels to share common network. Continued research to push the limits of technologies that improve the Aerial Layer Networks used by the Air Force. Developed optimal universal waveform sets for multipath multi-access communications. Initiated the integration, test & evaluation, and demonstration of an integrated version of the capabilities developed under this program. Performed an advanced technology demonstration of key technologies on tactical software radios. ***FY 2017 Plans:*** Continue to develop a Compact Rugged High assurance Crypto-Router with Network. Continue to develop a set of domain specific ontologies, extractors, relevancy assessment rule sets, mission templates and interfaces to support an operationally relevant Limited Technology Experiment (LTE). Demonstrate the next-generation wireless communications and networking technology. Demonstrate public key infrastructure (PKI)-enabled authentication services to enable task submission from authenticated enterprise consumers. Initiate the development and transition of a componentized building-block approach for a modular upgradable design for rapid waveform development of multi-mission RF capability. Support the development of a high-speed strike capability in line with higher Air Force emphasis areas. ***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 RF capability. Continue the development and demonstration of a large area multiple-input and multiple-output (MIMO) antenna capabilities.			
Title: Resiliency ***Description:*** Integrate and demonstrate a resilient and self-regenerating information enterprise that dynamically recognizes, characterizes, and understands novel cyber attacks and reconfigures and self-optimizes to resist new attacks. ***FY 2016 Accomplishments:*** Continued developing techniques to allow rapid analytical assessments of mission-mapped information, enhancing mission monitoring and mission assurance capabilities to conform and interoperate with DoD standards. Continued developing mature doctrinal representations for cross-DoD mission ontologies and use cases. Continued developing SecureServe to include updating and enhancing virtual machine (VM) communication channels, network monitoring, failover, snapshot, and migration. Integrated	2.898	0.000	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
the dynamic attestation prototype into the SecureServe baseline. Continued development and evaluation of an agile, modular, and pluggable framework for integration of open source algorithms. ***FY 2017 Plans:*** For FY 2017, the work for this effort will be performed under Project 635329, Cyber Battlespace Dev & Demo in an effort of the same name.			
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 2016 Accomplishments:*** Completed development and demonstration of new enhancements into the active steganalysis product. Initiated research into novel resiliency technologies to package into an adaptive systems solution. Completed the initial prototyping of defensive cyber deception technologies. ***FY 2017 Plans:*** For FY 2017, the work for this effort will be performed under Project 635329, Cyber Battlespace Dev & Demo in an effort of the same name.	3.993	0.000	-
Accomplishments/Planned Programs Subtotals	22.424	20.837	12.813

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635321: *Global Battlespace Awareness*	-	10.592	8.425	11.017	0.000	11.017	12.874	14.616	14.908	15.205	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 2016	FY 2017	FY 2018
Title: Advanced Signal and Data Exploitation Technologies	4.624	3.036	1.049
Description: Demonstrate advanced signal and data exploitation technologies for detection, tracking, identification, and targeting of time-critical targets, and information extraction.			
FY 2016 Accomplishments: Refined and tested technologies to enhance electronic signals intelligence (ELINT) detection and processing capabilities against emerging emitter weapon systems. Developed strategies for multi-source intelligence (multi-INT) exploitation. Investigated algorithms that can improve upon the audio prioritization capabilities, improvements to detection and correction methods, and mitigation techniques for modeling differences. Completed new enhancements and inserted them into active steganalysis products. Developed technologies to remain current with new waveforms and signals. Integrated full motion video object of interest detection and exploitation algorithms with multi-INT correlation algorithms and demonstrated the capability. Integrated enhanced motion imagery capabilities with existing imagery exploitation tools. Continued the development of automated capabilities to exploit signals of interest.			
FY 2017 Plans: Continue to refine and test technologies for ultra-wideband ELINT signal detection and prosecution. Continue planned development of data association/curation from historical analysis, multi-INT discovery, and entity resolution for contested			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
environments. 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 2018 Plans:*** Continue to refine and test technologies for ultra-wideband ELINT 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.			
Title: Advanced Data Handling, Visualization and Distributed Data Fusion ***Description:*** Develop and demonstrate advanced data handling, event visualization technologies, and distributed data fusion to enable a more effective utilization of data available. ***FY 2016 Accomplishments:*** Continued the application of object based processing and activity based intelligence tradecraft to selected domains and intelligence problems. Transitioned advanced activity-based intelligence (ABI) tools with built-in optimization tailored against operator objectives to National Air and Space Intelligence Center and National Geospatial-Intelligence Agency. Continued developing, demonstrating, and transitioning technology solutions for automated recognition of indicators to associate potential and emerging threats against blue assets. Continued developing computational capabilities that automate the decision-making process and that encompass sensing, data mining and analysis, information extraction and understanding, and activity recognition. Continued the development of technologies to create activity based intelligence from motion data. ***FY 2017 Plans:*** Continue the planned development of automated detection and recognition of indicators that associate threats against blue forces in multiple domain. Continue to develop near real time data mining and analysis capabilities by incorporating automated knowledge discovery, modeling and reasoning, and data fusion, exploitation and processing. Plan for forthcoming delivery of baseline advanced ABI toolkit. Complete multi-source/multi-INT raw data collection experiment at the Stockbridge Site in Rome, NY. Prepare to evaluate distributed multiple multi-INT Processing, Exploitation and Dissemination (PED) software framework capabilities compared to current methods for multi-INT data mining, correlation and fusion analytics. ***FY 2018 Plans:*** Continue development and demonstration of ABI analysis capabilities from multi-INT 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	2.311	3.138	6.829

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
distributed multi-node multi-INT PED software framework capabilities compared to current methods for multi-INT data mining, correlation, and fusion analytics. Initiate the automation of collected audio data for enhanced exploitation.			
Title: Autonomous Text Exploitation ***Description:*** Develop and demonstrate capabilities for reasoning and learning, text understanding, link and group discovery, and advanced analysis for situational awareness and understanding. ***FY 2016 Accomplishments:*** Continued developing cross-document co-reference capability integrated into document processing pipeline. Continued developing web-based Text Exploitation and Analysis framework. Initiated research and development for plug and play modules for deeper text understanding and large scale, time dependent, network based analytics. ***FY 2017 Plans:*** Continue plans to develop and transition end-to-end flexible and scalable technology transition platform enabling text exploitation and layered multi-intelligence network analysis and visualization in support of multi-source analysis. Continue research and development for plug and play modules for deeper text understanding and large scale, time dependent, network based analytics. ***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.	1.067	1.228	1.982
Title: Adversary Courses of Action ***Description:*** Develop models to provide detailed understanding of the adversary's probable intent and future strategy to identify adversary COAs, the most likely COA, and the COA most dangerous to friendly forces and mission accomplishment. ***FY 2016 Accomplishments:*** Continued developing links and tools to effectively employ cyber, directed energy and electronic warfare weaponry within a target folder environment and developing a set of models that will give targeteers greater comprehension of the second and third order effects of targeting actions. Continued developing a demonstration of advanced analytical capabilities that integrate kinetic and non-kinetic options for full spectrum targeting. Continued developing tools that assist the analyst/operator in determining the success/failure of a given target set and/or plan in meeting a stated set of mission objectives. Continued adding targeting capabilities to increase the full range of options available. ***FY 2017 Plans:***	2.590	1.023	1.157

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
Continue developing kinetic and non-kinetic, full spectrum targeting tools to create a demonstrable concept where new batches of battlefield reports semi-automatically update the understanding of the target system analysis. ***FY 2018 Plans:*** Continue to develop and demonstrate kinetic and non-kinetic, full spectrum targeting software tools that will semi-automatically extracts and visualizes relationships within target system; automatically prioritize/rank targets based on identified relationships; and semi-automatically update understanding of the target system analysis (TSA) when new batches of reports arrive.			
Accomplishments/Planned Programs Subtotals	10.592	8.425	11.017

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635322: *Knowledge Management and Computing*	-	5.036	4.767	3.369	0.000	3.369	3.811	3.676	2.068	2.109	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 AOC, 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. This project will also develop: 1) a computational 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, complex, software intensive systems.

Starting in FY 2017 cyber work previously performed within this project will be reported under Project 635329, Cyber Battlespace Dev & Demo.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Game Changing Computing Power	1.854	0.000	-
Description: Develop and demonstrate computer architectures with greater capacity and sophistication to enable game changing computing power to the warfighter, anywhere, anytime. ***FY 2016 Accomplishments:*** Continued designing, developing and demonstrating affordable, high performance, interactive, parallel data exploitation and massively parallel systems. Developed and demonstrate embedded high performance computing systems and integrate bio-inspired embedded computing hardware that delivers a set of autonomous sensing capabilities for Air Force Intelligence, Surveillance and Reconnaissance (ISR) missions in the contested anti-access/area denial (A2/AD) environments. Continued to develop capabilities to simultaneously assess, maintain or reestablish trust as resiliency actions respond to failures and/or attacks. Continued to develop new approaches to building trusted and resilient systems. Demonstrated trusted and resilient systems in a realistic operational environment. Initiated the development of technologies for neuromorphic co-processing, memristive technologies for use in reducing the size weight and power of conventional processing. This technology also will provide intrinsic, hardware based cyber security features for encryption, anti-tamper and unique identification, algorithm and system operation			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
control for continuous, dynamic autonomous operations. The output will develop a processor capable of universal quantum computation. ***FY 2017 Plans:*** For FY 2017, the work for this effort will be performed under Project 635329, Cyber Battlespace Dev & Demo in an effort of the same name.			
Title: Advanced Information Management ***Description:*** Demonstrate how a publish, subscribe, and query information management (IM) paradigm can enable vertical and horizontal integration of Air Force information systems. ***FY 2016 Accomplishments:*** Continued developing, demonstrating and transitioning information management capabilities that securely bridge the gaps between enterprise and tactical domains for increased shared situational awareness (SA) across the theater of war for targeting and force protection operations. Initiated 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 AFSOC Special Tactics (ST) mission sets so that ST operators can have superior SA and communications. ***FY 2017 Plans:*** Continue plans to develop, demonstrate and transition information management capabilities that securely bridge the gaps between enterprise and tactical domains for increased shared SA across the theater of war for targeting and force protection operations. Focus will be on the development of capabilities for disruption tolerant information delivery, data synchronization, and improved Quality of Service (QoS) in congested and contested tactical network environments. 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 AFSOC Special Tactics mission sets so that ST operators can have superior SA and communications. Starting in FY 2017, the cyber activities within this effort (advanced cross-domain solution capabilities) will move to Project 635329, Cyber Battlespace Dev & Demo within the effort, Autonomous, Multi-level Access & Transfer. ***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 SA across the theater of war for targeting and force protection	3.182	4.767	3.369

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
operations. Focus will be on vulnerability assessments of the developed software; and 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 AFSOC Special Tactics mission sets so that ST operators can have superior SA and communications.			
Title: Agile Information Management Services ***Description:*** Demonstrate how agile information management services enable effective information sharing in a tactical environment. ***FY 2016 Accomplishments:*** Effort terminated due to higher DoD priorities.	0.000	-	-
Accomplishments/Planned Programs Subtotals	5.036	4.767	3.369

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: FY 2018 Air Force			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
635329: *Cyber Battlespace Dev & Demo*	-	0.000	20.519	18.210	0.000	18.210	17.413	20.458	22.049	24.121	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, cyber 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 computational 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, complex software intensive systems.

Project 635329, Cyber Battlespace Dev & Demo is new for FY 2017. Work from this effort was previously performed under Projects 635320, Assured Worldwide Connectivity and 635322, Knowledge Management and Computing in this program.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Cyber Offense	0.000	5.891	3.241
Description: Develop and demonstrate offensive cyber operations capabilities in a series of experimental technology demonstrations.			
FY 2016 Accomplishments: For FY 2016, the work for this effort originally was performed under Project 635320, Assured Worldwide Connectivity in an effort of the same name.			
FY 2017 Plans: Continue to research technologies that show maturation promise and enhance the capabilities to make it transitionable to the warfighter. Develop technologies to remain current with new waveforms and signals. Continue Service-Oriented Architecture (SOA) mission component development for use in the AFLCMC CMP. Transition components, including Cyber Time and Cyber Mission Planning, for use in CMP. Continue red-teaming new components to improve security.			
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 (EMS), and other signals			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
of interest, for access and mission effects. Continue performing cyber vulnerability assessments to strengthen the security of the developed software.			
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 2016 Accomplishments:*** For FY 2016, the work for this effort originally was performed under Project 635320, Assured Worldwide Connectivity in an effort of the same name. ***FY 2017 Plans:*** Continue to develop technologies for the proactive control of cyber defenses, integrating with existing mission assurance framework(s). Develop and deliver cyber capabilities with transition to AFLCMC, National Security Agency and U.S. Special Operations Command customers. Research technologies to assist in educating and training the next generation of cyber leaders. Enhance, mature, test, and demonstrate Cyber Agility and defensive cyber deception technologies through exercises and other user-focused venues toward the objective of transition. Integrate new capabilities with existing Intelligence, Surveillance, and Reconnaissance (ISR) systems, and, progress testing with the Cyber Experimentation Environment. ***FY 2018 Plans:*** Continue to develop and demonstrate technologies for the proactive control of cyber defenses, integrating with existing mission assurance framework(s). Demonstrate these technologies in a relevant environment. Continue to integrate new cyber capabilities with existing ISR systems and demonstrate in a relevant environment (such as the Cyber Experimentation Environment).	0.000	5.784	4.084
Title: Resiliency ***Description:*** Integrate and demonstrate a resilient and self-generating information enterprise that dynamically recognizes, characterizes, and understand novel cyber attacks and reconfigures and self-optimizes to resist new attacks. ***FY 2016 Accomplishments:*** For FY 2016, the work for this effort originally was performed under Project 635320, Assured Worldwide Connectivity in an effort of the same name. ***FY 2017 Plans:*** Develop effective red teaming techniques that sufficiently assess detection capabilities for mission-level critical events. Continue development of mission monitoring components, analytics engine, and C2 technology integration. Develop and rapidly evolve	0.000	3.737	6.997

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
capabilities and Concept of Operations (CONOPS) for active guidance and automated processes addressing cyber survivability using an operational system laboratory to host of modular RDT&E, including autonomous cyber survivability capabilities and CONOPS. Schedule to complete advanced technology demonstration for cyber-based mission assurance on trust enhanced hardware. ***FY 2018 Plans:*** Continue to develop and evolve software capabilities and CONOPS 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 C2 technology integration.			
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 2016 Accomplishments:*** For FY 2016, the work for this effort originally was performed under Project 635322, Knowledge Management and Computing in an effort of the same name. ***FY 2017 Plans:*** Test the Agile Condor embedded computing pod in the field on test platform with real-time processing and communication concepts. Develop a runtime environment that can monitor and maintain a trusted and resilient envelope of operation. This runtime environment may consist of monitors that are generated right along with formally verified code during the formal code generation process to monitor/ensure that the high level specifications are maintained through execution. ***FY 2018 Plans:*** Develop and demonstrate real-time neuromorphic computing architecture simulation framework. Conduct the first spiral demonstration of the inherently trusted & 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.	0.000	3.325	2.663
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.	0.000	1.782	1.225

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
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 2016	FY 2017	FY 2018
FY 2016 Accomplishments: For FY 2016, the work for this effort originally was performed under Project 635322, Knowledge Management and Computing. ***FY 2017 Plans:*** Continue development and transition of advanced cross domain solutions (CDS). Demonstrate and integrate into CDS a virtual detonation chamber filter to detect malicious/abnormal behavior. Demonstrate advanced CDS command and control capabilities to improve insight into cross domain service health and status and provide tools to manage CDS risk based upon changes in mission and threat. Continue robust protocol-to-CDS interfaces and techniques to enforce CDS compliance with machine to machine (M2M) interface specifications to make cross-domain enablement of M2M communications more robust and cost effective. Continue to improve the usability of multi-level security (MLS) access solutions with a focus on adding secure foundations to commercial-off-the-shelf mobile technologies as the basis for secure multi-level collaboration. ***FY 2018 Plans:*** Continue development and prototype development of advanced cross domain solutions. Refine interfaces and techniques to enforce CDS compliance with M2M interface specifications to enable cross-domain enablement of M2M communications more robust and effective. Demonstrate and prototype MLS access solutions, including commercial-off-the-shelf mobile technologies as the basis for secure multi-level collaboration.			
Accomplishments/Planned Programs Subtotals	0.000	20.519	18.210

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-	-

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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