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**Department of Defense
Fiscal Year (FY) 2017 President's Budget Submission**

February 2016



Air Force

Justification Book Volume 1 of 3

Research, Development, Test & Evaluation, Air Force

Vol-I

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Air Force • President's Budget Submission FY 2017 • RDT&E Program

Volume 1 Table of Contents

Introduction and Explanation of Contents.....Volume 1 - iii
Comptroller Exhibit R-1..... Volume 1 - v
Master Program Element Table of Contents (by Budget Activity then Line Item Number)..... Volume 1 - xxi
Master Program Element Table of Contents (Alphabetically by Program Element Title)..... Volume 1 - xxxvii
Classified PEs..... Volume 1 - xlix
Exhibit R-2's..... Volume 1 - 1

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**Fiscal Year (FY) 2017 President's Budget
RDT&E Descriptive Summaries
Scientific and Technology Budget Activities
February 2016**

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 2017 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 2017 RDT&E program with the exception of classified program elements. The format and contents of this document are in accordance to the guidelines and requirements of the Congressional committees in so far as possible.
 - b) The "Other Program Funding Summary portion of the R-2 includes, in addition to RDT&E 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 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

Appropriation	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Research, Development, Test & Eval, AF	23,619,928	25,194,457	17,100	25,211,557	28,112,251	32,905	28,145,156
Total Research, Development, Test & Evaluation	23,619,928	25,194,457	17,100	25,211,557	28,112,251	32,905	28,145,156

UNCLASSIFIED

UNCLASSIFIED

Department of Defense
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

Summary Recap of Budget Activities	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Basic Research	538,586	530,253		530,253	500,024		500,024
Applied Research	1,090,419	1,240,141		1,240,141	1,260,152		1,260,152
Advanced Technology Development	606,365	710,377		710,377	725,805		725,805
Advanced Component Development & Prototypes	1,362,546	1,561,351		1,561,351	2,847,833		2,847,833
System Development & Demonstration	3,516,726	3,907,650		3,907,650	4,075,804	425	4,076,229
Management Support	1,495,139	1,184,667		1,184,667	1,245,577		1,245,577
Operational Systems Development	15,010,147	16,060,018	17,100	16,077,118	17,457,056	32,480	17,489,536
Total Research, Development, Test & Evaluation	23,619,928	25,194,457	17,100	25,211,557	28,112,251	32,905	28,145,156
Summary Recap of FYDP Programs							
Strategic Forces	458,400	606,099		606,099	636,723		636,723
General Purpose Forces	1,504,009	1,608,728	300	1,609,028	2,203,903		2,203,903
Intelligence and Communications	1,634,882	1,568,630		1,568,630	1,850,451	4,715	1,855,166
Mobility Forces	223,007	303,822		303,822	505,020		505,020
Research and Development	8,505,587	8,808,727		8,808,727	9,680,261	425	9,680,686
Central Supply and Maintenance	89,056	111,467		111,467	105,997		105,997
Training Medical and Other	2,538	3,272		3,272	3,114		3,114
Administration and Associated Activities	108,250	110,346		110,346	30,441		30,441
Support of Other Nations	3,790	2,315		2,315	4,784		4,784
Classified Programs	11,090,409	12,071,051	16,800	12,087,851	13,091,557	27,765	13,119,322
Total Research, Development, Test & Evaluation	23,619,928	25,194,457	17,100	25,211,557	28,112,251	32,905	28,145,156

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
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 (Dollars in Thousands)

27 Jan 2016

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

Line No	Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	S e c
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1	0601102F	Defense Research Sciences	01	382,332	374,721		374,721	340,812		340,812	U
2	0601103F	University Research Initiatives	01	142,752	141,754		141,754	145,044		145,044	U
3	0601108F	High Energy Laser Research Initiatives	01	13,502	13,778		13,778	14,168		14,168	U
		Basic Research		538,586	530,253		530,253	500,024		500,024	
4	0602102F	Materials	02	114,302	133,734		133,734	126,152		126,152	U
5	0602201F	Aerospace Vehicle Technologies	02	101,053	122,969		122,969	122,831		122,831	U
6	0602202F	Human Effectiveness Applied Research	02	95,727	110,221		110,221	111,647		111,647	U
7	0602203F	Aerospace Propulsion	02	168,628	185,926		185,926	185,671		185,671	U
8	0602204F	Aerospace Sensors	02	118,654	152,175		152,175	155,174		155,174	U
9	0602601F	Space Technology	02	96,425	109,122		109,122	117,915		117,915	U
10	0602602F	Conventional Munitions	02	86,328	99,851		99,851	109,649		109,649	U
11	0602605F	Directed Energy Technology	02	126,189	115,105		115,105	127,163		127,163	U
12	0602788F	Dominant Information Sciences and Methods	02	146,951	169,183		169,183	161,650		161,650	U
13	0602890F	High Energy Laser Research	02	36,162	41,855		41,855	42,300		42,300	U
		Applied Research		1,090,419	1,240,141		1,240,141	1,260,152		1,260,152	
14	0603112F	Advanced Materials for Weapon Systems	03	38,262	46,665		46,665	35,137		35,137	U
15	0603199F	Sustainment Science and Technology (S&T)	03	14,900	18,378		18,378	20,636		20,636	U
16	0603203F	Advanced Aerospace Sensors	03	34,100	42,001		42,001	40,945		40,945	U
17	0603211F	Aerospace Technology Dev/Demo	03	86,275	100,622		100,622	130,950		130,950	U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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

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18	0603216F	Aerospace Propulsion and Power Technology	03	126,729	178,594		178,594	94,594		94,594	U
19	0603270F	Electronic Combat Technology	03	45,548	46,946		46,946	58,250		58,250	U
20	0603401F	Advanced Spacecraft Technology	03	65,207	61,813		61,813	61,593		61,593	U
21	0603444F	Maui Space Surveillance System (MSSS)	03	13,185	12,853		12,853	11,681		11,681	U
22	0603456F	Human Effectiveness Advanced Technology Development	03	21,142	25,448		25,448	26,492		26,492	U
23	0603601F	Conventional Weapons Technology	03	41,385	43,036		43,036	102,009		102,009	U
24	0603605F	Advanced Weapons Technology	03	33,681	35,195		35,195	39,064		39,064	U
25	0603680F	Manufacturing Technology Program	03	51,613	52,630		52,630	46,344		46,344	U
26	0603788F	Battlespace Knowledge Development and Demonstration	03	34,338	46,196		46,196	58,110		58,110	U
		Advanced Technology Development		606,365	710,377		710,377	725,805		725,805	
27	0603260F	Intelligence Advanced Development	04	5,408	5,032		5,032	5,598		5,598	U
28	0603438F	Space Control Technology	04	5,799	4,057		4,057	7,534		7,534	U
29	0603742F	Combat Identification Technology	04	10,606	21,790		21,790	24,418		24,418	U
30	0603790F	NATO Research and Development	04	2,309	4,736		4,736	4,333		4,333	U
31	0603791F	International Space Cooperative R&D	04	806							U
32	0603830F	Space Security and Defense Program	04	30,592	30,771		30,771	32,399		32,399	U
33	0603851F	Intercontinental Ballistic Missile - Dem/Val	04	30,388	39,765		39,765	108,663		108,663	U
34	0603859F	Pollution Prevention - Dem/Val	04	965							U
35	0604015F	Long Range Strike - Bomber	04	883,363	736,228		736,228	1,358,309		1,358,309	U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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

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36	0604257F	Advanced Technology and Sensors	04					34,818		34,818	U
37	0604317F	Technology Transfer	04	4,683	7,612		7,612	3,368		3,368	U
38	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	04		54,637		54,637	74,308		74,308	U
39	0604422F	Weather System Follow-on	04	30,890	56,044		56,044	118,953		118,953	U
40	0604425F	Space Situation Awareness Systems	04					9,901		9,901	U
41	0604776F	Deployment & Distribution Enterprise R&D	04					25,890		25,890	U
42	0604857F	Operationally Responsive Space	04	20,000	18,437		18,437	7,921		7,921	U
43	0604858F	Tech Transition Program	04	79,887	266,514		266,514	347,304		347,304	U
44	0605230F	Ground Based Strategic Deterrent	04		75,166		75,166	113,919		113,919	U
45	0201184F	Counter Narco-Terrorism Program Office	04	650							U
46	0207110F	Next Generation Air Dominance	04	18,224	8,830		8,830	20,595		20,595	U
47	0207455F	Three Dimensional Long-Range Radar (3DELRR)	04	85,832	8,139		8,139	49,491		49,491	U
48	0305164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04	152,144	141,861		141,861	278,147		278,147	U
49	0305236F	Common Data Link Executive Agent (CDL EA)	04					42,338		42,338	U
50	0306250F	Cyber Operations Technology Development	04		81,732		81,732	158,002		158,002	U
51	0306415F	Enabled Cyber Activities	04					15,842		15,842	U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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

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52	0901410F	Contracting Information Technology System	04					5,782		5,782	U
		Advanced Component Development & Prototypes		1,362,546	1,561,351		1,561,351	2,847,833		2,847,833	
53	0604233F	Specialized Undergraduate Flight Training	05	12,903							U
54	0604270F	Electronic Warfare Development	05	7,815	843		843	12,476		12,476	U
55	0604281F	Tactical Data Networks Enterprise	05	30,282	59,996		59,996	82,380		82,380	U
56	0604287F	Physical Security Equipment	05	3,926	5,973		5,973	8,458		8,458	U
57	0604329F	Small Diameter Bomb (SDB) - EMD	05	66,374	29,083		29,083	54,838		54,838	U
58	0604421F	Counterspace Systems	05	22,654	24,134		24,134	34,394	425	34,819	U
59	0604425F	Space Situation Awareness Systems	05	9,031	29,288		29,288	23,945		23,945	U
60	0604426F	Space Fence	05	191,708	240,692		240,692	168,364		168,364	U
61	0604429F	Airborne Electronic Attack	05	26,555	8,358		8,358	9,187		9,187	U
62	0604441F	Space Based Infrared System (SBIRS) High EMD	05	308,788	291,510		291,510	181,966		181,966	U
63	0604602F	Armament/Ordnance Development	05	28,667	37,654		37,654	20,312		20,312	U
64	0604604F	Submunitions	05	2,543	2,506		2,506	2,503		2,503	U
65	0604617F	Agile Combat Support	05	41,857	56,178		56,178	53,680		53,680	U
66	0604618F	Joint Direct Attack Munition	05					9,901		9,901	U
67	0604706F	Life Support Systems	05	14,697	8,187		8,187	7,520		7,520	U
68	0604735F	Combat Training Ranges	05	9,812	11,795		11,795	77,409		77,409	U
69	0604800F	F-35 - EMD	05	566,937	586,953		586,953	450,467		450,467	U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

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70	0604853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05	225,600	227,784		227,784	296,572		296,572	U
71	0604932F	Long Range Standoff Weapon	05	3,438	16,143		16,143	95,604		95,604	U
72	0604933F	ICBM Fuze Modernization	05	57,893	142,551		142,551	189,751		189,751	U
73	0605030F	Joint Tactical Network Center (JTNC)	05					1,131		1,131	U
74	0605213F	F-22 Modernization Increment 3.2B	05	163,877	140,640		140,640	70,290		70,290	U
75	0605214F	Ground Attack Weapons Fuze Development	05	5,177	3,598		3,598	937		937	U
76	0605221F	KC-46	05	763,224	592,364		592,364	261,724		261,724	U
77	0605223F	Advanced Pilot Training	05	8,201	10,395		10,395	12,377		12,377	U
78	0605229F	CSAR HH-60 Recapitalization	05	100,000	156,085		156,085	319,331		319,331	U
79	0605278F	HC/MC-130 Recap RDT&E	05	4,497							U
80	0605431F	Advanced EHF MILSATCOM (SPACE)	05	294,455	228,095		228,095	259,131		259,131	U
81	0605432F	Polar MILSATCOM (SPACE)	05	99,788	71,867		71,867	50,815		50,815	U
82	0605433F	Wideband Global SATCOM (SPACE)	05	28,345	52,185		52,185	41,632		41,632	U
83	0605458F	Air & Space Ops Center 10.2 RDT&E	05	83,245	47,629		47,629	28,911		28,911	U
84	0605931F	B-2 Defensive Management System	05	95,440	271,961		271,961	315,615		315,615	U
85	0101125F	Nuclear Weapons Modernization	05	148,281	212,121		212,121	137,909		137,909	U
86	0207171F	F-15 EPAWSS	05		180,681		180,681	256,669		256,669	U
87	0207701F	Full Combat Mission Training	05	8,831	18,082		18,082	12,051		12,051	U
88	0305176F	Combat Survivor Evader Locator	05		993		993	29,253		29,253	U
89	0307581F	JSTARS Recap	05	70,879	44,343		44,343	128,019		128,019	U

UNCLASSIFIED

UNCLASSIFIED

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 FY 2017 President's Budget
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90	0401319F	Presidential Aircraft Replacement (PAR)	05	11,006	82,420		82,420	351,220		351,220	U
91	0701212F	Automated Test Systems	05		14,563		14,563	19,062		19,062	U
		System Development & Demonstration		3,516,726	3,907,650		3,907,650	4,075,804	425	4,076,229	
92	0604256F	Threat Simulator Development	06	24,318	23,844		23,844	21,630		21,630	U
93	0604759F	Major T&E Investment	06	45,985	73,302		73,302	66,385		66,385	U
94	0605101F	RAND Project Air Force	06	31,164	34,918		34,918	34,641		34,641	U
95	0605502F	Small Business Innovation Research	06	324,371							U
96	0605712F	Initial Operational Test & Evaluation	06	8,916	10,476		10,476	11,529		11,529	U
97	0605807F	Test and Evaluation Support	06	691,977	683,308		683,308	661,417		661,417	U
98	0605860F	Rocket Systems Launch Program (SPACE)	06	33,420	21,792		21,792	11,198		11,198	U
99	0605864F	Space Test Program (STP)	06	20,552	28,143		28,143	27,070		27,070	U
100	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	06	46,955	40,518		40,518	134,111		134,111	U
101	0605978F	Facilities Sustainment - Test and Evaluation Support	06	32,965	27,895		27,895	28,091		28,091	U
102	0606017F	Requirements Analysis and Maturation	06	18,673	22,507		22,507	29,100		29,100	U
103	0606116F	Space Test and Training Range Development	06	22,724	18,940		18,940	18,528		18,528	U
104	0606392F	Space and Missile Center (SMC) Civilian Workforce	06	166,727	176,196		176,196	176,666		176,666	U
105	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	06	4,912	3,841		3,841	4,410		4,410	U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
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106	0702806F	Acquisition and Management Support	06	16,115	15,357		15,357	14,613		14,613	U
107	0804731F	General Skill Training	06	1,425	1,315		1,315	1,404		1,404	U
108	0909999F	Financing for Cancelled Account Adjustments	06	150							U
109	1001004F	International Activities	06	3,790	2,315		2,315	4,784		4,784	U
		Management Support		1,495,139	1,184,667		1,184,667	1,245,577		1,245,577	
110	0603423F	Global Positioning System III - Operational Control Segment	07	334,631	349,181		349,181	393,268		393,268	U
111	0604233F	Specialized Undergraduate Flight Training	07		8,565		8,565	15,427		15,427	U
112	0604445F	Wide Area Surveillance	07	2,000	22,577		22,577	46,695		46,695	U
114	0604618F	Joint Direct Attack Munition	07	2,389							U
115	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	07	45,250	31,344		31,344	10,368		10,368	U
116	0605024F	Anti-Tamper Technology Executive Agency	07	33,775	26,718		26,718	31,952		31,952	U
117	0605117F	Foreign Materiel Acquisition and Exploitation	07		41,689		41,689	42,960		42,960	U
118	0605278F	HC/MC-130 Recap RDT&E	07		10,807		10,807	13,987		13,987	U
119	0101113F	B-52 Squadrons	07	41,072	74,520		74,520	78,267		78,267	U
120	0101122F	Air-Launched Cruise Missile (ALCM)	07	450	451		451	453		453	U
121	0101126F	B-1B Squadrons	07	4,208	2,245		2,245	5,830		5,830	U
122	0101127F	B-2 Squadrons	07	112,691	108,183		108,183	152,458		152,458	U
123	0101213F	Minuteman Squadrons	07	116,344	166,729		166,729	182,958		182,958	U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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

Line No	Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	S e c
---	-----	----	---	-----	-----	-----	-----	-----	-----	-----	-
124	0101313F	Strat War Planning System - USSTRATCOM	07	31,046	28,358		28,358	39,148		39,148	U
125	0101314F	Night Fist - USSTRATCOM	07		87		87				U
126	0101316F	Worldwide Joint Strategic Communications	07		5,315		5,315	6,042		6,042	U
128	0102110F	UH-1N Replacement Program	07					14,116		14,116	U
129	0102326F	Region/Sector Operation Control Center Modernization Program	07	1,229				10,868		10,868	U
130	0105921F	Service Support to STRATCOM - Space Activities	07	3,079	8,090		8,090	8,674		8,674	U
131	0205219F	MQ-9 UAV	07	141,528	122,731		122,731	151,373		151,373	U
132	0205671F	Joint Counter RCIED Electronic Warfare	07			300	300				U
133	0207131F	A-10 Squadrons	07		16,200		16,200	14,853		14,853	U
134	0207133F	F-16 Squadrons	07	130,376	166,297		166,297	132,795		132,795	U
135	0207134F	F-15E Squadrons	07	233,898	205,979		205,979	356,717		356,717	U
136	0207136F	Manned Destructive Suppression	07	14,413	14,860		14,860	14,773		14,773	U
137	0207138F	F-22A Squadrons	07	146,291	231,599		231,599	387,564		387,564	U
138	0207142F	F-35 Squadrons	07	39,275	53,921		53,921	153,045		153,045	U
139	0207161F	Tactical AIM Missiles	07	28,820	43,360		43,360	52,898		52,898	U
140	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	79,767	46,160		46,160	62,470		62,470	U
141	0207171F	F-15 EPAWSS	07	37,726							U
142	0207224F	Combat Rescue and Recovery	07	5,095	412		412				U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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

Line No	Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	S e c
---	-----	----	---	-----	-----	-----	-----	-----	-----	-----	-
143	0207227F	Combat Rescue - Pararescue	07	856	657		657	362		362	U
144	0207247F	AF TENCAP	07	6,974	31,428		31,428	28,413		28,413	U
145	0207249F	Precision Attack Systems Procurement	07	835	1,105		1,105	649		649	U
146	0207253F	Compass Call	07	16,480	14,187		14,187	13,723		13,723	U
147	0207268F	Aircraft Engine Component Improvement Program	07	93,160	103,942		103,942	109,859		109,859	U
148	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	07	12,414	9,793		9,793	30,002		30,002	U
149	0207410F	Air & Space Operations Center (AOC)	07	25,661	21,102		21,102	37,621		37,621	U
150	0207412F	Control and Reporting Center (CRC)	07		557		557	13,292		13,292	U
151	0207417F	Airborne Warning and Control System (AWACS)	07	172,785	131,812		131,812	86,644		86,644	U
152	0207418F	Tactical Airborne Control Systems	07	3,650	6,001		6,001	2,442		2,442	U
154	0207431F	Combat Air Intelligence System Activities	07	7,291	6,793		6,793	10,911		10,911	U
155	0207444F	Tactical Air Control Party-Mod	07	4,616	12,411		12,411	11,843		11,843	U
156	0207448F	C2ISR Tactical Data Link	07	1,699	1,674		1,674	1,515		1,515	U
157	0207452F	DCAPES	07	806	16,723		16,723	14,979		14,979	U
158	0207590F	Seek Eagle	07	23,472	21,564		21,564	25,308		25,308	U
159	0207601F	USAF Modeling and Simulation	07	11,687	24,945		24,945	16,666		16,666	U
160	0207605F	Wargaming and Simulation Centers	07	5,749	6,035		6,035	4,245		4,245	U
161	0207697F	Distributed Training and Exercises	07	3,251	4,358		4,358	3,886		3,886	U
162	0208006F	Mission Planning Systems	07	58,782	55,835		55,835	71,785		71,785	U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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

Line No	Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	S e c
---	-----	----	---	-----	-----	-----	-----	-----	-----	-----	-
163	0208059F	Service Support to Other Core Missions - STRATCOM (CYBERCOM Activities)	07	64,751							U
164	0208087F	AF Offensive Cyberspace Operations	07	12,928	12,874		12,874	25,025		25,025	U
165	0208088F	AF Defensive Cyberspace Operations	07	5,436	7,681		7,681	29,439		29,439	U
168	0301017F	Global Sensor Integrated on Network (GSIN)	07		5,974		5,974	3,470		3,470	U
169	0301112F	Nuclear Planning and Execution System (NPES)	07					4,060		4,060	U
175	0301400F	Space Superiority Intelligence	07	10,697	12,315		12,315	13,880		13,880	U
176	0302015F	E-4B National Airborne Operations Center (NAOC)	07	24,963	76,760		76,760	30,948		30,948	U
177	0303001F	Family of Advanced BLoS Terminals (FAB-T)	07		3,895		3,895	42,378		42,378	U
178	0303131F	Minimum Essential Emergency Communications Network (MEECN)	07	87,240	74,712		74,712	47,471		47,471	U
179	0303140F	Information Systems Security Program	07	64,972	46,303		46,303	46,388		46,388	U
180	0303141F	Global Combat Support System	07	692				52		52	U
181	0303142F	Global Force Management - Data Initiative	07		2,470		2,470	2,099		2,099	U
182	0303601F	MILSATCOM Terminals	07	57,930							U
184	0304260F	Airborne SIGINT Enterprise	07	72,910	112,775		112,775	90,762		90,762	U
187	0305099F	Global Air Traffic Management (GATM)	07	4,157	4,217		4,217	4,354		4,354	U
188	0305110F	Satellite Control Network (SPACE)	07	18,806	7,861		7,861	15,624		15,624	U
189	0305111F	Weather Service	07	19,404	29,826		29,826	19,974		19,974	U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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

Line No	Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	S e c
---	-----	----	---	-----	-----	-----	-----	-----	-----	-----	-
190	0305114F	Air Traffic Control, Approach, and Landing System (ATCALs)	07	25,309	19,392		19,392	9,770		9,770	U
191	0305116F	Aerial Targets	07	8,537	2,515		2,515	3,051		3,051	U
194	0305128F	Security and Investigative Activities	07		472		472	405		405	U
195	0305145F	Arms Control Implementation	07	13,222	9,137		9,137	4,844		4,844	U
196	0305146F	Defense Joint Counterintelligence Activities	07	40	361		361	339		339	U
199	0305173F	Space and Missile Test and Evaluation Center	07	3,490	3,152		3,152	3,989		3,989	U
200	0305174F	Space Innovation, Integration and Rapid Technology Development	07	1,999	1,543		1,543	3,070	4,715	7,785	U
201	0305179F	Integrated Broadcast Service (IBS)	07	8,592	7,860		7,860	8,833		8,833	U
202	0305182F	Spacelift Range System (SPACE)	07	10,134	6,881		6,881	11,867		11,867	U
203	0305202F	Dragon U-2	07	5,511	34,471		34,471	37,217		37,217	U
204	0305205F	Endurance Unmanned Aerial Vehicles	07	20,000	5,000		5,000				U
205	0305206F	Airborne Reconnaissance Systems	07	37,649	60,142		60,142	3,841		3,841	U
206	0305207F	Manned Reconnaissance Systems	07	14,116	13,245		13,245	20,975		20,975	U
207	0305208F	Distributed Common Ground/Surface Systems	07	26,993	22,686		22,686	18,902		18,902	U
208	0305220F	RQ-4 UAV	07	241,828	188,053		188,053	256,307		256,307	U
209	0305221F	Network-Centric Collaborative Targeting	07	11,096	19,587		19,587	22,610		22,610	U
210	0305236F	Common Data Link Executive Agent (CDL EA)	07	32,015	43,796		43,796				U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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

Line No	Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	S e c
211	0305238F	NATO AGS	07	232,851	138,400		138,400	38,904		38,904	U
212	0305240F	Support to DCGS Enterprise	07	17,115	28,336		28,336	23,084		23,084	U
213	0305258F	Advanced Evaluation Program	07					116,143		116,143	U
214	0305265F	GPS III Space Segment	07	204,864	180,359		180,359	141,888		141,888	U
215	0305600F	International Intelligence Technology and Architectures	07	2,270	2,298		2,298	2,360		2,360	U
216	0305614F	JSPOC Mission System	07	83,277	80,669		80,669	72,889		72,889	U
217	0305881F	Rapid Cyber Acquisition	07	3,959	3,149		3,149	4,280		4,280	U
218	0305906F	NCCM - TW/AA System	07					4,951		4,951	U
219	0305913F	NUDET Detection System (SPACE)	07	20,405	14,403		14,403	21,093		21,093	U
220	0305940F	Space Situation Awareness Operations	07	11,017	20,016		20,016	35,002		35,002	U
221	0306250F	Cyber Operations Technology Development	07	7,768	11,980		11,980				U
222	0308699F	Shared Early Warning (SEW)	07	1,119	849		849	6,366		6,366	U
223	0401115F	C-130 Airlift Squadron	07		33,962		33,962	15,599		15,599	U
224	0401119F	C-5 Airlift Squadrons (IF)	07	31,772	22,864		22,864	66,146		66,146	U
225	0401130F	C-17 Aircraft (IF)	07	72,566	48,807		48,807	12,430		12,430	U
226	0401132F	C-130J Program	07	26,715	25,010		25,010	16,776		16,776	U
227	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	07	4,672	6,802		6,802	5,166		5,166	U
228	0401219F	KC-10s	07	2,714	1,799		1,799				U
229	0401314F	Operational Support Airlift	07	27,783	46,453		46,453	13,817		13,817	U
230	0401318F	CV-22	07	37,698	27,776		27,776	16,702		16,702	U

UNCLASSIFIED

UNCLASSIFIED

Department of the Air Force
 FY 2017 President's Budget
 Exhibit R-1 FY 2017 President's Budget
 Total Obligational Authority
 (Dollars in Thousands)

27 Jan 2016

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

Line No	Element Number	Item	Act	FY 2015 (Base & OCO)	FY 2016 Base Enacted	FY 2016 OCO Enacted	FY 2016 Total Enacted	FY 2017 Base	FY 2017 OCO	FY 2017 Total	S e c
231	0408011F	Special Tactics / Combat Control	07	8,081	7,929		7,929	7,164		7,164	U
232	0702207F	Depot Maintenance (Non-IF)	07	1,407	1,525		1,525	1,518		1,518	U
233	0708610F	Logistics Information Technology (LOGIT)	07	56,325	67,915		67,915	61,676		61,676	U
234	0708611F	Support Systems Development	07	15,209	12,107		12,107	9,128		9,128	U
235	0804743F	Other Flight Training	07	987	1,836		1,836	1,653		1,653	U
236	0808716F	Other Personnel Activities	07	126	121		121	57		57	U
237	0901202F	Joint Personnel Recovery Agency	07	2,523	5,911		5,911	3,663		3,663	U
238	0901218F	Civilian Compensation Program	07	2,418	3,604		3,604	3,735		3,735	U
239	0901220F	Personnel Administration	07	6,381	4,598		4,598	5,157		5,157	U
240	0901226F	Air Force Studies and Analysis Agency	07	1,346	1,103		1,103	1,523		1,523	U
241	0901279F	Facilities Operation - Administrative	07	3,666							U
242	0901538F	Financial Management Information Systems Development	07	91,766	95,130		95,130	10,581		10,581	U
9999	9999999999	Classified Programs		11,090,409	12,071,051	16,800	12,087,851	13,091,557	27,765	13,119,322	U
		Operational Systems Development		15,010,147	16,060,018	17,100	16,077,118	17,457,056	32,480	17,489,536	
Total Research, Development, Test & Eval, AF				23,619,928	25,194,457	17,100	25,211,557	28,112,251	32,905	28,145,156	

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
1	01	0601102F	Defense Research Sciences.....	Volume 1 - 1
2	01	0601103F	University Research Initiatives.....	Volume 1 - 17
3	01	0601108F	High Energy Laser Research Initiatives.....	Volume 1 - 21

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
4	02	0602102F	Materials.....	Volume 1 - 25
5	02	0602201F	Aerospace Vehicle Technologies.....	Volume 1 - 41
6	02	0602202F	Human Effectiveness Applied Research.....	Volume 1 - 55
7	02	0602203F	Aerospace Propulsion.....	Volume 1 - 73
8	02	0602204F	Aerospace Sensors.....	Volume 1 - 97
9	02	0602601F	Space Technology.....	Volume 1 - 121
10	02	0602602F	Conventional Munitions.....	Volume 1 - 139

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
11	02	0602605F	Directed Energy Technology.....	Volume 1 - 149
12	02	0602788F	Dominant Information Sciences and Methods.....	Volume 1 - 157
13	02	0602890F	High Energy Laser Research.....	Volume 1 - 185

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
14	03	0603112F	Advanced Materials for Weapon Systems.....	Volume 1 - 191
15	03	0603199F	Sustainment Science and Technology (S&T).....	Volume 1 - 203
16	03	0603203F	Advanced Aerospace Sensors.....	Volume 1 - 209
17	03	0603211F	Aerospace Technology Dev/Demo.....	Volume 1 - 219
18	03	0603216F	Aerospace Propulsion and Power Technology.....	Volume 1 - 227
19	03	0603270F	Electronic Combat Technology.....	Volume 1 - 245
20	03	0603401F	Advanced Spacecraft Technology.....	Volume 1 - 257
21	03	0603444F	Maui Space Surveillance System (MSSS).....	Volume 1 - 277
22	03	0603456F	Human Effectiveness Advanced Technology Development.....	Volume 1 - 281
23	03	0603601F	Conventional Weapons Technology.....	Volume 1 - 293

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
24	03	0603605F	Advanced Weapons Technology.....	Volume 1 - 299
25	03	0603680F	Manufacturing Technology Program.....	Volume 1 - 305
26	03	0603788F	Battlespace Knowledge Development and Demonstration.....	Volume 1 - 309

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
27	04	0603260F	Intelligence Advanced Development.....	Volume 2 - 1
28	04	0603438F	Space Control Technology.....	Volume 2 - 21
29	04	0603742F	Combat Identification Technology.....	Volume 2 - 29
30	04	0603790F	NATO Research and Development.....	Volume 2 - 53
31	04	0603791F	International Space Cooperative R&D.....	Volume 2 - 61
32	04	0603830F	Space Security and Defense Program.....	Volume 2 - 67
33	04	0603851F	Intercontinental Ballistic Missile - Dem/Val.....	Volume 2 - 77
34	04	0603859F	Pollution Prevention - Dem/Val.....	Volume 2 - 115
35	04	0604015F	Long Range Strike - Bomber.....	Volume 2 - 121
36	04	0604257F	Advanced Technology and Sensors.....	Volume 2 - 127

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
37	04	0604317F	Technology Transfer.....	Volume 2 - 149
38	04	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program.....	Volume 2 - 155
39	04	0604422F	Weather System Follow-on.....	Volume 2 - 165
40	04	0604425F	Space Situation Awareness Systems.....	Volume 2 - 173
41	04	0604776F	Deployment & Distribution Enterprise R&D.....	Volume 2 - 179
42	04	0604857F	Operationally Responsive Space.....	Volume 2 - 211
43	04	0604858F	Tech Transition Program.....	Volume 2 - 221
44	04	0605230F	Ground Based Strategic Deterrent.....	Volume 2 - 235
45	04	0201184F	Counter Narco-Terrorism Program Office.....	Volume 2 - 245
46	04	0207110F	Next Generation Air Dominance.....	Volume 2 - 251
47	04	0207455F	Three Dimensional Long-Range Radar (3DELRR).....	Volume 2 - 261
48	04	0305164F	NAVSTAR Global Positioning System (User Equipment) (SPACE).....	Volume 2 - 271
49	04	0305236F	Common Data Link Executive Agent (CDL EA).....	Volume 2 - 283
50	04	0306250F	Cyber Operations Technology Development.....	Volume 2 - 293
51	04	0306415F	Enabled Cyber Activities.....	Volume 2 - 303
52	04	0901410F	Contracting Information Technology System.....	Volume 2 - 309

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
53	05	0604233F	Specialized Undergraduate Flight Training.....	Volume 2 - 317
54	05	0604270F	Electronic Warfare Development.....	Volume 2 - 333
55	05	0604281F	Tactical Data Networks Enterprise.....	Volume 2 - 341
56	05	0604287F	Physical Security Equipment.....	Volume 2 - 361
57	05	0604329F	Small Diameter Bomb (SDB) - EMD.....	Volume 2 - 373
58	05	0604421F	Counterspace Systems.....	Volume 2 - 385
59	05	0604425F	Space Situation Awareness Systems.....	Volume 2 - 405
60	05	0604426F	Space Fence.....	Volume 2 - 425
61	05	0604429F	Airborne Electronic Attack.....	Volume 2 - 433
62	05	0604441F	Space Based Infrared System (SBIRS) High EMD.....	Volume 2 - 441
63	05	0604602F	Armament/Ordnance Development.....	Volume 2 - 467
64	05	0604604F	Submunitions.....	Volume 2 - 491
65	05	0604617F	Agile Combat Support.....	Volume 2 - 499
66	05	0604618F	Joint Direct Attack Munition.....	Volume 2 - 515
67	05	0604706F	Life Support Systems.....	Volume 2 - 521
68	05	0604735F	Combat Training Ranges.....	Volume 2 - 529

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
69	05	0604800F	F-35 - EMD.....	Volume 2 - 543
70	05	0604853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD.....	Volume 2 - 575
71	05	0604932F	Long Range Standoff Weapon.....	Volume 2 - 591
72	05	0604933F	ICBM Fuze Modernization.....	Volume 2 - 599
73	05	0605030F	Joint Tactical Network Center (JTNC).....	Volume 2 - 609
74	05	0605213F	F-22 Modernization Increment 3.2B.....	Volume 2 - 615
75	05	0605214F	Ground Attack Weapons Fuze Development.....	Volume 2 - 625
76	05	0605221F	KC-46.....	Volume 2 - 633
77	05	0605223F	Advanced Pilot Training.....	Volume 2 - 645
78	05	0605229F	CSAR HH-60 Recapitalization.....	Volume 2 - 653
79	05	0605278F	HC/MC-130 Recap RDT&E.....	Volume 2 - 661
80	05	0605431F	Advanced EHF MILSATCOM (SPACE).....	Volume 2 - 669
81	05	0605432F	Polar MILSATCOM (SPACE).....	Volume 2 - 689
82	05	0605433F	WIDEBAND GLOBAL SATCOM (SPACE).....	Volume 2 - 697
83	05	0605458F	Air & Space Ops Center 10.2 RDT&E.....	Volume 2 - 713
84	05	0605931F	B-2 Defensive Management System.....	Volume 2 - 723
85	05	0101125F	Nuclear Weapons Modernization.....	Volume 2 - 731
86	05	0207171F	F-15 EPAWSS.....	Volume 2 - 743

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
87	05	0207701F	Full Combat Mission Training.....	Volume 2 - 751
88	05	0305176F	Combat Survivor Evader Locator.....	Volume 2 - 769
89	05	0307581F	JSTARS Recap.....	Volume 2 - 775
90	05	0401319F	Presidential Aircraft Replacement (PAR).....	Volume 2 - 783
91	05	0701212F	Automated Test Systems.....	Volume 2 - 791

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
92	06	0604256F	Threat Simulator Development.....	Volume 2 - 799
93	06	0604759F	Major T&E Investment.....	Volume 2 - 809
94	06	0605101F	RAND Project Air Force.....	Volume 2 - 819
95	06	0605502F	Small Business Innovation Research.....	Volume 2 - 825
96	06	0605712F	Initial Operational Test & Evaluation.....	Volume 2 - 827
97	06	0605807F	Test and Evaluation Support.....	Volume 2 - 837
98	06	0605860F	Rocket Systems Launch Program (SPACE).....	Volume 2 - 843
99	06	0605864F	Space Test Program (STP).....	Volume 2 - 847

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
100	06	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support.....	Volume 2 - 853
101	06	0605978F	Facilities Sustainment - Test and Evaluation Support.....	Volume 2 - 857
102	06	0606017F	Requirements Analysis and Maturation.....	Volume 2 - 861
103	06	0606116F	Space Test and Training Range Development.....	Volume 2 - 869
104	06	0606392F	Space and Missile Center (SMC) Civilian Workforce.....	Volume 2 - 873
105	06	0308602F	ENTEPRISE INFORMATION SERVICES (EIS).....	Volume 2 - 877
106	06	0702806F	Acquisition and Management Support.....	Volume 2 - 881
107	06	0804731F	General Skill Training.....	Volume 2 - 891
108	06	0909999F	Financing for Cancelled Account Adjustments.....	Volume 2 - 893
109	06	1001004F	International Activities.....	Volume 2 - 895

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
110	07	0603423F	Global Positioning System III - Operational Control Segment.....	Volume 3a - 1
111	07	0604233F	Specialized Undergraduate Flight Training.....	Volume 3a - 19
112	07	0604445F	Wide Area Surveillance.....	Volume 3a - 49

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
114	07	0604618F	Joint Direct Attack Munition.....	Volume 3a - 63
115	07	0605018F	AF Integrated Personnel and Pay System (AF-IPPS).....	Volume 3a - 69
116	07	0605024F	Anti-Tamper Technology Executive Agency.....	Volume 3a - 77
117	07	0605117F	Foreign Materiel Acquisition and Exploitation.....	Volume 3a - 87
118	07	0605278F	HC/MC-130 Recap RDT&E.....	Volume 3a - 89
119	07	0101113F	B-52 SQUADRONS.....	Volume 3a - 97
120	07	0101122F	Air-Launched Cruise Missile (ALCM).....	Volume 3a - 149
121	07	0101126F	B-1B Squadrons.....	Volume 3a - 157
122	07	0101127F	B-2 SQUADRONS.....	Volume 3a - 167
123	07	0101213F	Minuteman Squadrons.....	Volume 3a - 191
124	07	0101313F	Strat War Planning System - USSTRATCOM.....	Volume 3a - 251
125	07	0101314F	Night Fist - USSTRATCOM.....	Volume 3a - 275
126	07	0101316F	Worldwide Joint Strategic Communications.....	Volume 3a - 281
128	07	0102110F	UH-1N Replacement Program.....	Volume 3a - 289
129	07	0102326F	Region/Sector Operation Control Center Modernization Program.....	Volume 3a - 297
130	07	0105921F	Service Support to STRATCOM - Space Activities.....	Volume 3a - 305
131	07	0205219F	MQ-9 UAV.....	Volume 3a - 327
132	07	0205671F	Joint Counter RCIED Electronic Warfare.....	Volume 3a - 355

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
133	07	0207131F	A-10 Squadrons.....	Volume 3a - 361
134	07	0207133F	F-16 Squadrons.....	Volume 3a - 369
135	07	0207134F	F-15E Squadrons.....	Volume 3a - 383
136	07	0207136F	Manned Destructive Suppression.....	Volume 3a - 403
137	07	0207138F	F-22A Squadrons.....	Volume 3a - 411
138	07	0207142F	F-35 Squadrons.....	Volume 3a - 435
139	07	0207161F	Tactical AIM Missiles.....	Volume 3a - 459
140	07	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM).....	Volume 3a - 473
141	07	0207171F	F-15 EPAWSS.....	Volume 3a - 483
142	07	0207224F	Combat Rescue and Recovery.....	Volume 3a - 491
143	07	0207227F	Combat Rescue - Pararescue.....	Volume 3a - 497
144	07	0207247F	AF TENCAP.....	Volume 3a - 503
145	07	0207249F	Precision Attack Systems Procurement.....	Volume 3a - 511
146	07	0207253F	Compass Call.....	Volume 3a - 517
147	07	0207268F	Aircraft Engine Component Improvement Program.....	Volume 3a - 525
148	07	0207325F	Joint Air-to-Surface Standoff Missile (JASSM).....	Volume 3a - 545
149	07	0207410F	Air & Space Operations Center (AOC).....	Volume 3a - 563
150	07	0207412F	Control and Reporting Center (CRC).....	Volume 3a - 595

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
151	07	0207417F	Airborne Warning and Control System (AWACS).....	Volume 3a - 603
152	07	0207418F	Tactical Airborne Control Systems.....	Volume 3a - 615
154	07	0207431F	Combat Air Intelligence System Activities.....	Volume 3a - 623
155	07	0207444F	Tactical Air Control Party-Mod.....	Volume 3a - 637
156	07	0207448F	C2ISR Tactical Data Link.....	Volume 3a - 647
157	07	0207452F	DCAPES.....	Volume 3a - 657
158	07	0207590F	Seek Eagle.....	Volume 3a - 673
159	07	0207601F	USAF Modeling and Simulation.....	Volume 3a - 683
160	07	0207605F	Wargaming and Simulation Centers.....	Volume 3a - 697
161	07	0207697F	Distributed Training and Exercises.....	Volume 3a - 709
162	07	0208006F	Mission Planning Systems.....	Volume 3a - 717
163	07	0208059F	Service Support to Other Core Missions - STRATCOM (CYBERCOM Activities).....	Volume 3a - 753
164	07	0208087F	AF Offensive Cyberspace Operations.....	Volume 3a - 761
165	07	0208088F	AF Defensive Cyberspace Operations.....	Volume 3a - 771
168	07	0301017F	Global Sensor Integrated on Network (GSIN).....	Volume 3b - 1
169	07	0301112F	Nuclear Planning and Execution System (NPES).....	Volume 3b - 11
175	07	0301400F	Space Superiority Intelligence.....	Volume 3b - 19
176	07	0302015F	E-4B National Airborne Operations Center (NAOC).....	Volume 3b - 27

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
177	07	0303001F	Family of Advanced BLoS Terminals (FAB-T).....	Volume 3b - 37
178	07	0303131F	Minimum Essential Emergency Communications Network (MEECN).....	Volume 3b - 45
179	07	0303140F	Information Systems Security Program.....	Volume 3b - 71
180	07	0303141F	Global Combat Support System.....	Volume 3b - 99
181	07	0303142F	Global Force Management - Data Initiative.....	Volume 3b - 107
182	07	0303601F	MILSATCOM Terminals.....	Volume 3b - 115
184	07	0304260F	Airborne SIGINT Enterprise.....	Volume 3b - 123
187	07	0305099F	Global Air Traffic Management (GATM).....	Volume 3b - 151
188	07	0305110F	Satellite Control Network (SPACE).....	Volume 3b - 159
189	07	0305111F	Weather Service.....	Volume 3b - 169
190	07	0305114F	Air Traffic Control, Approach, and Landing System (ATCAL).....	Volume 3b - 183
191	07	0305116F	Aerial Targets.....	Volume 3b - 197
194	07	0305128F	Security and Investigative Activities.....	Volume 3b - 211
195	07	0305145F	Arms Control Implementation.....	Volume 3b - 219
196	07	0305146F	Defense Joint Counterintelligence Activities.....	Volume 3b - 227
199	07	0305173F	Space and Missile Test and Evaluation Center.....	Volume 3b - 233
200	07	0305174F	Space Innovation, Integration and Rapid Technology Development.....	Volume 3b - 241
201	07	0305179F	Integrated Broadcast Service (IBS).....	Volume 3b - 251

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
202	07	0305182F	Spacelift Range System (SPACE).....	Volume 3b - 261
203	07	0305202F	Dragon U-2.....	Volume 3b - 269
204	07	0305205F	Endurance Unmanned Aerial Vehicles.....	Volume 3b - 277
205	07	0305206F	Airborne Reconnaissance Systems.....	Volume 3b - 285
206	07	0305207F	Manned Reconnaissance Systems.....	Volume 3b - 327
207	07	0305208F	Distributed Common Ground/Surface Systems.....	Volume 3b - 337
208	07	0305220F	RQ-4 UAV.....	Volume 3b - 355
209	07	0305221F	Network-Centric Collaborative Targeting.....	Volume 3b - 403
210	07	0305236F	Common Data Link Executive Agent (CDL EA).....	Volume 3b - 421
211	07	0305238F	NATO AGS.....	Volume 3b - 431
212	07	0305240F	Support to DCGS Enterprise.....	Volume 3b - 439
213	07	0305258F	Advanced Evaluation Program.....	Volume 3b - 453
214	07	0305265F	GPS III Space Segment.....	Volume 3b - 459
215	07	0305600F	International Intelligence Technology and Architectures.....	Volume 3b - 477
216	07	0305614F	JSPOC Mission System.....	Volume 3b - 483
217	07	0305881F	Rapid Cyber Acquisition.....	Volume 3b - 503
218	07	0305906F	NCMC - TW/AA System.....	Volume 3b - 511
219	07	0305913F	NUDET Detection System (SPACE).....	Volume 3b - 517

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
220	07	0305940F	Space Situation Awareness Operations.....	Volume 3b - 525
221	07	0306250F	Cyber Operations Technology Development.....	Volume 3b - 541
222	07	0308699F	Shared Early Warning (SEW).....	Volume 3b - 551
223	07	0401115F	C-130 Airlift Squadron.....	Volume 3b - 561
224	07	0401119F	C-5 Airlift Squadrons (IF).....	Volume 3b - 575
225	07	0401130F	C-17 Aircraft (IF).....	Volume 3b - 591
226	07	0401132F	C-130J Program.....	Volume 3b - 603
227	07	0401134F	Large Aircraft IR Countermeasures (LAIRCM).....	Volume 3b - 617
228	07	0401219F	KC-10s.....	Volume 3b - 629
229	07	0401314F	Operational Support Airlift.....	Volume 3b - 635
230	07	0401318F	CV-22.....	Volume 3b - 641
231	07	0408011F	Special Tactics / Combat Control.....	Volume 3b - 651
232	07	0702207F	Depot Maintenance (Non-IF).....	Volume 3b - 661
233	07	0708610F	Logistics Information Technology (LOGIT).....	Volume 3b - 669
234	07	0708611F	Support Systems Development.....	Volume 3b - 705
235	07	0804743F	Other Flight Training.....	Volume 3b - 731
236	07	0808716F	Other Personnel Activities.....	Volume 3b - 739
237	07	0901202F	Joint Personnel Recovery Agency.....	Volume 3b - 745

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Line #	Budget Activity	Program Element Number	Program Element Title	Page
238	07	0901218F	Civilian Compensation Program.....	Volume 3b - 753
239	07	0901220F	Personnel Administration.....	Volume 3b - 759
240	07	0901226F	Air Force Studies and Analysis Agency.....	Volume 3b - 769
241	07	0901279F	Facilities Operation - Administrative.....	Volume 3b - 775
242	07	0901538F	Financial Management Information Systems Development.....	Volume 3b - 783

UNCLASSIFIED

UNCLASSIFIED

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UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

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

Program Element Title	Program Element Number	Line #	BA	Page
A-10 Squadrons	0207131F	133	07.....	Volume 3a - 361
AF Defensive Cyberspace Operations	0208088F	165	07.....	Volume 3a - 771
AF Integrated Personnel and Pay System (AF-IPPS)	0605018F	115	07.....	Volume 3a - 69
AF Offensive Cyberspace Operations	0208087F	164	07.....	Volume 3a - 761
AF TENCAP	0207247F	144	07.....	Volume 3a - 503
Acquisition and Management Support	0702806F	106	06.....	Volume 2 - 881
Advanced Aerospace Sensors	0603203F	16	03.....	Volume 1 - 209
Advanced EHF MILSATCOM (SPACE)	0605431F	80	05.....	Volume 2 - 669
Advanced Evaluation Program	0305258F	213	07.....	Volume 3b - 453
Advanced Materials for Weapon Systems	0603112F	14	03.....	Volume 1 - 191
Advanced Medium Range Air-to-Air Missile (AMRAAM)	0207163F	140	07.....	Volume 3a - 473
Advanced Pilot Training	0605223F	77	05.....	Volume 2 - 645
Advanced Spacecraft Technology	0603401F	20	03.....	Volume 1 - 257
Advanced Technology and Sensors	0604257F	36	04.....	Volume 2 - 127
Advanced Weapons Technology	0603605F	24	03.....	Volume 1 - 299
Aerial Targets	0305116F	191	07.....	Volume 3b - 197
Aerospace Propulsion	0602203F	7	02.....	Volume 1 - 73

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
Aerospace Propulsion and Power Technology	0603216F	18	03.....	Volume 1 - 227
Aerospace Sensors	0602204F	8	02.....	Volume 1 - 97
Aerospace Technology Dev/Demo	0603211F	17	03.....	Volume 1 - 219
Aerospace Vehicle Technologies	0602201F	5	02.....	Volume 1 - 41
Agile Combat Support	0604617F	65	05.....	Volume 2 - 499
Air & Space Operations Center (AOC)	0207410F	149	07.....	Volume 3a - 563
Air & Space Ops Center 10.2 RDT&E	0605458F	83	05.....	Volume 2 - 713
Air Force Studies and Analysis Agency	0901226F	240	07.....	Volume 3b - 769
Air Traffic Control, Approach, and Landing System (ATCALs)	0305114F	190	07.....	Volume 3b - 183
Air-Launched Cruise Missile (ALCM)	0101122F	120	07.....	Volume 3a - 149
Airborne Electronic Attack	0604429F	61	05.....	Volume 2 - 433
Airborne Reconnaissance Systems	0305206F	205	07.....	Volume 3b - 285
Airborne SIGINT Enterprise	0304260F	184	07.....	Volume 3b - 123
Airborne Warning and Control System (AWACS)	0207417F	151	07.....	Volume 3a - 603
Aircraft Engine Component Improvement Program	0207268F	147	07.....	Volume 3a - 525
Anti-Tamper Technology Executive Agency	0605024F	116	07.....	Volume 3a - 77
Armament/Ordnance Development	0604602F	63	05.....	Volume 2 - 467
Arms Control Implementation	0305145F	195	07.....	Volume 3b - 219
Automated Test Systems	0701212F	91	05.....	Volume 2 - 791

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
B-1B Squadrons	0101126F	121	07.....	Volume 3a - 157
B-2 Defensive Management System	0605931F	84	05.....	Volume 2 - 723
B-2 SQUADRONS	0101127F	122	07.....	Volume 3a - 167
B-52 SQUADRONS	0101113F	119	07.....	Volume 3a - 97
Battlespace Knowledge Development and Demonstration	0603788F	26	03.....	Volume 1 - 309
C-130 Airlift Squadron	0401115F	223	07.....	Volume 3b - 561
C-130J Program	0401132F	226	07.....	Volume 3b - 603
C-17 Aircraft (IF)	0401130F	225	07.....	Volume 3b - 591
C-5 Airlift Squadrons (IF)	0401119F	224	07.....	Volume 3b - 575
C2ISR Tactical Data Link	0207448F	156	07.....	Volume 3a - 647
CSAR HH-60 Recapitalization	0605229F	78	05.....	Volume 2 - 653
CV-22	0401318F	230	07.....	Volume 3b - 641
Civilian Compensation Program	0901218F	238	07.....	Volume 3b - 753
Combat Air Intelligence System Activities	0207431F	154	07.....	Volume 3a - 623
Combat Identification Technology	0603742F	29	04.....	Volume 2 - 29
Combat Rescue - Pararescue	0207227F	143	07.....	Volume 3a - 497
Combat Rescue and Recovery	0207224F	142	07.....	Volume 3a - 491
Combat Survivor Evader Locator	0305176F	88	05.....	Volume 2 - 769
Combat Training Ranges	0604735F	68	05.....	Volume 2 - 529

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
Common Data Link Executive Agent (CDL EA)	0305236F	49	04.....	Volume 2 - 283
Common Data Link Executive Agent (CDL EA)	0305236F	210	07.....	Volume 3b - 421
Compass Call	0207253F	146	07.....	Volume 3a - 517
Contracting Information Technology System	0901410F	52	04.....	Volume 2 - 309
Control and Reporting Center (CRC)	0207412F	150	07.....	Volume 3a - 595
Conventional Munitions	0602602F	10	02.....	Volume 1 - 139
Conventional Weapons Technology	0603601F	23	03.....	Volume 1 - 293
Counter Narco-Terrorism Program Office	0201184F	45	04.....	Volume 2 - 245
Counterspace Systems	0604421F	58	05.....	Volume 2 - 385
Cyber Operations Technology Development	0306250F	50	04.....	Volume 2 - 293
Cyber Operations Technology Development	0306250F	221	07.....	Volume 3b - 541
DCAPES	0207452F	157	07.....	Volume 3a - 657
Defense Joint Counterintelligence Activities	0305146F	196	07.....	Volume 3b - 227
Defense Research Sciences	0601102F	1	01.....	Volume 1 - 1
Deployment & Distribution Enterprise R&D	0604776F	41	04.....	Volume 2 - 179
Depot Maintenance (Non-IF)	0702207F	232	07.....	Volume 3b - 661
Directed Energy Technology	0602605F	11	02.....	Volume 1 - 149
Distributed Common Ground/Surface Systems	0305208F	207	07.....	Volume 3b - 337
Distributed Training and Exercises	0207697F	161	07.....	Volume 3a - 709

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
Dominant Information Sciences and Methods	0602788F	12	02.....	Volume 1 - 157
Dragon U-2	0305202F	203	07.....	Volume 3b - 269
E-4B National Airborne Operations Center (NAOC)	0302015F	176	07.....	Volume 3b - 27
ENTEPRISE INFORMATION SERVICES (EIS)	0308602F	105	06.....	Volume 2 - 877
Electronic Combat Technology	0603270F	19	03.....	Volume 1 - 245
Electronic Warfare Development	0604270F	54	05.....	Volume 2 - 333
Enabled Cyber Activities	0306415F	51	04.....	Volume 2 - 303
Endurance Unmanned Aerial Vehicles	0305205F	204	07.....	Volume 3b - 277
Evolved Expendable Launch Vehicle Program (SPACE) - EMD	0604853F	70	05.....	Volume 2 - 575
F-15 EPAWSS	0207171F	86	05.....	Volume 2 - 743
F-15 EPAWSS	0207171F	141	07.....	Volume 3a - 483
F-15E Squadrons	0207134F	135	07.....	Volume 3a - 383
F-16 Squadrons	0207133F	134	07.....	Volume 3a - 369
F-22 Modernization Increment 3.2B	0605213F	74	05.....	Volume 2 - 615
F-22A Squadrons	0207138F	137	07.....	Volume 3a - 411
F-35 - EMD	0604800F	69	05.....	Volume 2 - 543
F-35 Squadrons	0207142F	138	07.....	Volume 3a - 435
Facilities Operation - Administrative	0901279F	241	07.....	Volume 3b - 775
Facilities Restoration and Modernization - Test and Evaluation Support	0605976F	100	06.....	Volume 2 - 853

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
Facilities Sustainment - Test and Evaluation Support	0605978F	101	06.....	Volume 2 - 857
Family of Advanced BLoS Terminals (FAB-T)	0303001F	177	07.....	Volume 3b - 37
Financial Management Information Systems Development	0901538F	242	07.....	Volume 3b - 783
Financing for Cancelled Account Adjustments	0909999F	108	06.....	Volume 2 - 893
Foreign Materiel Acquisition and Exploitation	0605117F	117	07.....	Volume 3a - 87
Full Combat Mission Training	0207701F	87	05.....	Volume 2 - 751
GPS III Space Segment	0305265F	214	07.....	Volume 3b - 459
General Skill Training	0804731F	107	06.....	Volume 2 - 891
Global Air Traffic Management (GATM)	0305099F	187	07.....	Volume 3b - 151
Global Combat Support System	0303141F	180	07.....	Volume 3b - 99
Global Force Management - Data Initiative	0303142F	181	07.....	Volume 3b - 107
Global Positioning System III - Operational Control Segment	0603423F	110	07.....	Volume 3a - 1
Global Sensor Integrated on Network (GSIN)	0301017F	168	07.....	Volume 3b - 1
Ground Attack Weapons Fuze Development	0605214F	75	05.....	Volume 2 - 625
Ground Based Strategic Deterrent	0605230F	44	04.....	Volume 2 - 235
HC/MC-130 Recap RDT&E	0605278F	79	05.....	Volume 2 - 661
HC/MC-130 Recap RDT&E	0605278F	118	07.....	Volume 3a - 89
Hard and Deeply Buried Target Defeat System (HDBTDS) Program	0604327F	38	04.....	Volume 2 - 155
High Energy Laser Research	0602890F	13	02.....	Volume 1 - 185

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
High Energy Laser Research Initiatives	0601108F	3	01.....	Volume 1 - 21
Human Effectiveness Advanced Technology Development	0603456F	22	03.....	Volume 1 - 281
Human Effectiveness Applied Research	0602202F	6	02.....	Volume 1 - 55
ICBM Fuze Modernization	0604933F	72	05.....	Volume 2 - 599
Information Systems Security Program	0303140F	179	07.....	Volume 3b - 71
Initial Operational Test & Evaluation	0605712F	96	06.....	Volume 2 - 827
Integrated Broadcast Service (IBS)	0305179F	201	07.....	Volume 3b - 251
Intelligence Advanced Development	0603260F	27	04.....	Volume 2 - 1
Intercontinental Ballistic Missile - Dem/Val	0603851F	33	04.....	Volume 2 - 77
International Activities	1001004F	109	06.....	Volume 2 - 895
International Intelligence Technology and Architectures	0305600F	215	07.....	Volume 3b - 477
International Space Cooperative R&D	0603791F	31	04.....	Volume 2 - 61
JSPOC Mission System	0305614F	216	07.....	Volume 3b - 483
JSTARS Recap	0307581F	89	05.....	Volume 2 - 775
Joint Air-to-Surface Standoff Missile (JASSM)	0207325F	148	07.....	Volume 3a - 545
Joint Counter RCIED Electronic Warfare	0205671F	132	07.....	Volume 3a - 355
Joint Direct Attack Munition	0604618F	66	05.....	Volume 2 - 515
Joint Direct Attack Munition	0604618F	114	07.....	Volume 3a - 63
Joint Personnel Recovery Agency	0901202F	237	07.....	Volume 3b - 745

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
Joint Tactical Network Center (JTNC)	0605030F	73	05.....	Volume 2 - 609
KC-10s	0401219F	228	07.....	Volume 3b - 629
KC-46	0605221F	76	05.....	Volume 2 - 633
Large Aircraft IR Countermeasures (LAIRCM)	0401134F	227	07.....	Volume 3b - 617
Life Support Systems	0604706F	67	05.....	Volume 2 - 521
Logistics Information Technology (LOGIT)	0708610F	233	07.....	Volume 3b - 669
Long Range Standoff Weapon	0604932F	71	05.....	Volume 2 - 591
Long Range Strike - Bomber	0604015F	35	04.....	Volume 2 - 121
MILSATCOM Terminals	0303601F	182	07.....	Volume 3b - 115
MQ-9 UAV	0205219F	131	07.....	Volume 3a - 327
Major T&E Investment	0604759F	93	06.....	Volume 2 - 809
Manned Destructive Suppression	0207136F	136	07.....	Volume 3a - 403
Manned Reconnaissance Systems	0305207F	206	07.....	Volume 3b - 327
Manufacturing Technology Program	0603680F	25	03.....	Volume 1 - 305
Materials	0602102F	4	02.....	Volume 1 - 25
Maui Space Surveillance System (MSSS)	0603444F	21	03.....	Volume 1 - 277
Minimum Essential Emergency Communications Network (MEECN)	0303131F	178	07.....	Volume 3b - 45
Minuteman Squadrons	0101213F	123	07.....	Volume 3a - 191
Mission Planning Systems	0208006F	162	07.....	Volume 3a - 717

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Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
NATO AGS	0305238F	211	07.....	Volume 3b - 431
NATO Research and Development	0603790F	30	04.....	Volume 2 - 53
NAVSTAR Global Positioning System (User Equipment) (SPACE)	0305164F	48	04.....	Volume 2 - 271
NCMC - TW/AA System	0305906F	218	07.....	Volume 3b - 511
NUDET Detection System (SPACE)	0305913F	219	07.....	Volume 3b - 517
Network-Centric Collaborative Targeting	0305221F	209	07.....	Volume 3b - 403
Next Generation Air Dominance	0207110F	46	04.....	Volume 2 - 251
Night Fist - USSTRATCOM	0101314F	125	07.....	Volume 3a - 275
Nuclear Planning and Execution System (NPES)	0301112F	169	07.....	Volume 3b - 11
Nuclear Weapons Modernization	0101125F	85	05.....	Volume 2 - 731
Operational Support Airlift	0401314F	229	07.....	Volume 3b - 635
Operationally Responsive Space	0604857F	42	04.....	Volume 2 - 211
Other Flight Training	0804743F	235	07.....	Volume 3b - 731
Other Personnel Activities	0808716F	236	07.....	Volume 3b - 739
Personnel Administration	0901220F	239	07.....	Volume 3b - 759
Physical Security Equipment	0604287F	56	05.....	Volume 2 - 361
Polar MILSATCOM (SPACE)	0605432F	81	05.....	Volume 2 - 689
Pollution Prevention - Dem/Val	0603859F	34	04.....	Volume 2 - 115
Precision Attack Systems Procurement	0207249F	145	07.....	Volume 3a - 511

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Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
Presidential Aircraft Replacement (PAR)	0401319F	90	05.....	Volume 2 - 783
RAND Project Air Force	0605101F	94	06.....	Volume 2 - 819
RQ-4 UAV	0305220F	208	07.....	Volume 3b - 355
Rapid Cyber Acquisition	0305881F	217	07.....	Volume 3b - 503
Region/Sector Operation Control Center Modernization Program	0102326F	129	07.....	Volume 3a - 297
Requirements Analysis and Maturation	0606017F	102	06.....	Volume 2 - 861
Rocket Systems Launch Program (SPACE)	0605860F	98	06.....	Volume 2 - 843
Satellite Control Network (SPACE)	0305110F	188	07.....	Volume 3b - 159
Security and Investigative Activities	0305128F	194	07.....	Volume 3b - 211
Seek Eagle	0207590F	158	07.....	Volume 3a - 673
Service Support to Other Core Missions - STRATCOM (CYBERCOM Activities)	0208059F	163	07.....	Volume 3a - 753
Service Support to STRATCOM - Space Activities	0105921F	130	07.....	Volume 3a - 305
Shared Early Warning (SEW)	0308699F	222	07.....	Volume 3b - 551
Small Business Innovation Research	0605502F	95	06.....	Volume 2 - 825
Small Diameter Bomb (SDB) - EMD	0604329F	57	05.....	Volume 2 - 373
Space Based Infrared System (SBIRS) High EMD	0604441F	62	05.....	Volume 2 - 441
Space Control Technology	0603438F	28	04.....	Volume 2 - 21
Space Fence	0604426F	60	05.....	Volume 2 - 425
Space Innovation, Integration and Rapid Technology Development	0305174F	200	07.....	Volume 3b - 241

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
Space Security and Defense Program	0603830F	32	04.....	Volume 2 - 67
Space Situation Awareness Operations	0305940F	220	07.....	Volume 3b - 525
Space Situation Awareness Systems	0604425F	40	04.....	Volume 2 - 173
Space Situation Awareness Systems	0604425F	59	05.....	Volume 2 - 405
Space Superiority Intelligence	0301400F	175	07.....	Volume 3b - 19
Space Technology	0602601F	9	02.....	Volume 1 - 121
Space Test Program (STP)	0605864F	99	06.....	Volume 2 - 847
Space Test and Training Range Development	0606116F	103	06.....	Volume 2 - 869
Space and Missile Center (SMC) Civilian Workforce	0606392F	104	06.....	Volume 2 - 873
Space and Missile Test and Evaluation Center	0305173F	199	07.....	Volume 3b - 233
Spacelift Range System (SPACE)	0305182F	202	07.....	Volume 3b - 261
Special Tactics / Combat Control	0408011F	231	07.....	Volume 3b - 651
Specialized Undergraduate Flight Training	0604233F	53	05.....	Volume 2 - 317
Specialized Undergraduate Flight Training	0604233F	111	07.....	Volume 3a - 19
Strat War Planning System - USSTRATCOM	0101313F	124	07.....	Volume 3a - 251
Submunitions	0604604F	64	05.....	Volume 2 - 491
Support Systems Development	0708611F	234	07.....	Volume 3b - 705
Support to DCGS Enterprise	0305240F	212	07.....	Volume 3b - 439
Sustainment Science and Technology (S&T)	0603199F	15	03.....	Volume 1 - 203

UNCLASSIFIED

UNCLASSIFIED

Air Force • President's Budget Submission FY 2017 • RDT&E Program

Program Element Title	Program Element Number	Line #	BA	Page
Tactical AIM Missiles	0207161F	139	07.....	Volume 3a - 459
Tactical Air Control Party-Mod	0207444F	155	07.....	Volume 3a - 637
Tactical Airborne Control Systems	0207418F	152	07.....	Volume 3a - 615
Tactical Data Networks Enterprise	0604281F	55	05.....	Volume 2 - 341
Tech Transition Program	0604858F	43	04.....	Volume 2 - 221
Technology Transfer	0604317F	37	04.....	Volume 2 - 149
Test and Evaluation Support	0605807F	97	06.....	Volume 2 - 837
Threat Simulator Development	0604256F	92	06.....	Volume 2 - 799
Three Dimensional Long-Range Radar (3DELRR)	0207455F	47	04.....	Volume 2 - 261
UH-1N Replacement Program	0102110F	128	07.....	Volume 3a - 289
USAF Modeling and Simulation	0207601F	159	07.....	Volume 3a - 683
University Research Initiatives	0601103F	2	01.....	Volume 1 - 17
WIDEBAND GLOBAL SATCOM (SPACE)	0605433F	82	05.....	Volume 2 - 697
Wargaming and Simulation Centers	0207605F	160	07.....	Volume 3a - 697
Weather Service	0305111F	189	07.....	Volume 3b - 169
Weather System Follow-on	0604422F	39	04.....	Volume 2 - 165
Wide Area Surveillance	0604445F	112	07.....	Volume 3a - 49
Worldwide Joint Strategic Communications	0101316F	126	07.....	Volume 3a - 281

UNCLASSIFIED

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

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 1: <i>Basic Research</i>	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	382.332	374.721	340.812	0.000	340.812	344.609	350.264	359.395	366.191	Continuing	Continuing
613001: <i>Physics and Electronics</i>	-	116.113	111.598	100.067	0.000	100.067	101.181	102.843	105.523	107.519	Continuing	Continuing
613002: <i>Aerospace, Chemical and Material Sciences</i>	-	122.110	119.000	105.484	0.000	105.484	106.660	108.409	111.236	113.339	Continuing	Continuing
613003: <i>Mathematics, Information and Life Sciences</i>	-	113.159	113.081	101.258	0.000	101.258	102.386	104.066	106.779	108.798	Continuing	Continuing
613004: <i>Education and Outreach</i>	-	30.950	31.042	34.003	0.000	34.003	34.382	34.946	35.857	36.535	Continuing	Continuing

Note

Realigned funding in PE0601102F to project 613004 to put more emphasis on educational outreach.

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

This program 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)

	<u>FY 2015</u>	<u>FY 2016</u>	<u>FY 2017 Base</u>	<u>FY 2017 OCO</u>	<u>FY 2017 Total</u>
Previous President's Budget	389.979	329.721	337.648	0.000	337.648
Current President's Budget	382.332	374.721	340.812	0.000	340.812
Total Adjustments	-7.647	45.000	3.164	0.000	3.164
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	45.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-7.647	0.000			
• Other Adjustments	0.000	0.000	3.164	0.000	3.164

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>
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Congressional Add Details (\$ in Millions, and Includes General Reductions)

	FY 2015	FY 2016
Project: 613001: <i>Physics and Electronics</i> Congressional Add: <i>Program Increase</i>		
Congressional Add Subtotals for Project: 613001	23.782	15.666
Project: 613002: <i>Aerospace, Chemical and Material Sciences</i> Congressional Add: <i>Program Increase</i>		
Congressional Add Subtotals for Project: 613002	26.424	11.167
Project: 613003: <i>Mathematics, Information and Life Sciences</i> Congressional Add: <i>Program Increase</i>		
Congressional Add Subtotals for Project: 613003	18.041	11.167
Project: 613004: <i>Education and Outreach</i> Congressional Add: <i>Program Increase</i>		
Congressional Add Subtotals for Project: 613004	7.250	7.000
Congressional Add Totals for all Projects	75.497	45.000

Change Summary Explanation

Increase in FY 2017 due to DoD cost factor adjustment.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 1					R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>				Project (Number/Name) 613001 / <i>Physics and Electronics</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
613001: <i>Physics and Electronics</i>	-	116.113	111.598	100.067	0.000	100.067	101.181	102.843	105.523	107.519	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 2015	FY 2016	FY 2017
Title: Complex Electronics and Fundamental Quantum Processes	42.390	44.043	40.491
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 2015 Accomplishments: Air Force Research Laboratory joined with the University of Hawaii at Manoa quantum computing research group to explore the frontiers of theoretical and experimental quantum physics. This technology advanced a wide-range of applications including Atom interferometry for precision navigation in GPS-denied environments. 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 2016 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 2017 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-			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613001 / <i>Physics and Electronics</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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.				
<p>Title: Plasma Physics and High Energy Density Non-Equilibrium Processes</p> <p>Description: Scientific focus areas are plasma, electro-energetic physics and space sciences.</p> <p>FY 2015 Accomplishments: Co-funded research to develop a simple, inexpensive way to alter the thermal conductivity of the widely used material lead zirconate titanate (PZT) at room temperature with application for signal processing, which span many dimensions, spatial, temporal, and frequency. 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.</p> <p>FY 2016 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.</p> <p>FY 2017 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. Included space weather, plasma discharges, RF propagation, RF-plasma interaction, and high-power, beam-driven microwave devices.</p>		18.596	19.321	20.856
<p>Title: Lasers and Optics, Electromagnetics, Communication and Signal Processing</p> <p>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.</p> <p>FY 2015 Accomplishments: Funded the creation of a magnetic-free, small (75x reduction) and more efficient radio wave circulator for use in wireless device at double the current bandwidth. This smaller size can be easily integrated into circuit boards of modern communications devices, providing cost savings due to weight reduction. 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.</p>		31.345	32.568	38.720

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613001 / <i>Physics and Electronics</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Included the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals.</p> <p>FY 2016 Plans: Explore all aspects of producing and receiving electromagnetic and electro-optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Continue to investigate aspects of the phenomenology of lasers including high energy lasers, non-linear optics, and ultra-short pulse laser science. Includes the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals.</p> <p>FY 2017 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.</p>			
Accomplishments/Planned Programs Subtotals	92.331	95.932	100.067

	FY 2015	FY 2016
Congressional Add: Program Increase	23.782	15.666
FY 2015 Accomplishments: Conducted congressionally directed effort.		
FY 2016 Plans: Conduct Congressionally directed effort.		
Congressional Adds Subtotals	23.782	15.666

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 1					R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>				Project (Number/Name) 613002 / <i>Aerospace, Chemical and Material Sciences</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
613002: <i>Aerospace, Chemical and Material Sciences</i>	-	122.110	119.000	105.484	0.000	105.484	106.660	108.409	111.236	113.339	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 2015	FY 2016	FY 2017
Title: Aero Structure Interactions and Control	27.543	31.041	31.105
Description: Scientific focus areas are high temperature aerospace materials, hypersonics, aerothermodynamics and turbulence, and flow interactions and control.			
FY 2015 Accomplishments: Supported a wind tunnel test to better understand the vortex ring state, a well-known problem in helicopter descent. This research will lead to techniques to avoid severe loss of lift in small-scale aerial 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 2016 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 2017 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613002 / <i>Aerospace, Chemical and Material Sciences</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, high-performance structures, and thermodynamics.				
<p>Title: Energy, Power, and Propulsion</p> <p>Description: Scientific focus areas are thermal control, theoretical chemistry, molecular dynamics, space power and propulsion, and combustion and diagnostics.</p> <p>FY 2015 Accomplishments: Supported a Hall thruster experiment onboard the X-37B reusable space plane. The experiment will enable in-space characterization of Hall thruster design modifications intended to improve performance relative to current state-of-the-art units. This results in increased payload carrying capacity and a greater number of on-orbit maneuvers for a spacecraft versus using traditional rocket engines. 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.</p> <p>FY 2016 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.</p> <p>FY 2017 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.</p>		33.645	37.916	33.513
<p>Title: Complex Materials and Structures</p> <p>Description: Scientific focus areas are mechanics of multifunctional materials and microsystems, multi-scale mechanics and prognosis, low density materials, and polymer chemistry.</p> <p>FY 2015 Accomplishments: Supported the development of a next-generation lithium-ion battery made using Kevlar membrane that demonstrated a 20% increase in storage capacity. 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</p>		34.498	38.876	40.866

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613002 / <i>Aerospace, Chemical and Material Sciences</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>space systems, with a key goal of increasing functionality while decreasing weight and volume. Explored 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.</p> <p>FY 2016 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.</p> <p>FY 2017 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.</p>			
Accomplishments/Planned Programs Subtotals	95.686	107.833	105.484

	FY 2015	FY 2016
Congressional Add: Program Increase	26.424	11.167
FY 2015 Accomplishments: Conducted Congressionally directed effort.		
FY 2016 Plans: Conduct Congressionally directed effort.		
Congressional Adds Subtotals	26.424	11.167

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

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613002 / <i>Aerospace, Chemical and Material Sciences</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 1					R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>				Project (Number/Name) 613003 / <i>Mathematics, Information and Life Sciences</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
613003: <i>Mathematics, Information and Life Sciences</i>	-	113.159	113.081	101.258	0.000	101.258	102.386	104.066	106.779	108.798	Continuing	Continuing

A. Mission Description and Budget Item Justification

Basic research in the Mathematics, Information, and Life Sciences Project seeks to enable revolutionary advances and expand the fundamental knowledge supporting technologies critical to the future of the Air Force. Research stresses high-risk, far-term, game-changing capability breakthroughs essential for future leaps in warfighter system performance, functionality, reliability, and survivability while simultaneously reducing component and system power, size, mass, and life cycle costs. Major areas being investigated in this project are information and complex networks, decision making, dynamical systems, optimization and control, and natural materials and systems. While the following are specific sub-areas within this project, there is a continuing interest to explore novel ideas to bridge projects within this program.

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

	FY 2015	FY 2016	FY 2017
Title: Information and Complex Networks	25.867	27.715	25.825
Description: Scientific focus areas are systems and software, information operations and security, information fusion, and complex networks.			
FY 2015 Accomplishments: Supported the development of efficient and intelligent algorithms for multifunctional reconfigurable antennas that can adapt to better detect a signal's direction, frequency and polarization. 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 2016 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 2017 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613003 / <i>Mathematics, Information and Life Sciences</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
information processing. Sub-areas include system and network performance prediction, design and analysis, and modeling of human-machine systems.				
<p>Title: Decision Making</p> <p>Description: Scientific focus areas are mathematical modeling of cognition and decision making, trust between humans and autonomous agents, and mixed human-machine decision making.</p> <p>FY 2015 Accomplishments: Transitioned university research effort on cultural and organizational factors that affect trust of and reliance on automated systems to Program 0602202, Human Effectiveness Applied Research. 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.</p> <p>FY 2016 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.</p> <p>FY 2017 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.</p>		18.590	19.918	20.140
<p>Title: Dynamical Systems, Optimization, and Control</p> <p>Description: Scientific focus areas are computational mathematics, dynamics and control, and optimization and discrete mathematics.</p> <p>FY 2015 Accomplishments: Funded the development of a dynamic multi-robot control algorithm that fuels a tablet-based control system. 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</p>		27.010	28.941	26.575

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613003 / <i>Mathematics, Information and Life Sciences</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2016 Plans: Develop new scientific concepts supported by rigorous analysis for advancing the science of autonomy and promoting the understanding necessary to analyze and design complex multi-scale systems as well as provide guaranteed levels of performance. Develop novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments.</p> <p>FY 2017 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. The 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.</p>			
<p>Title: Natural Materials and Systems</p> <p>Description: Scientific focus areas are renewable energy, natural materials and nature inspired systems.</p> <p>FY 2015 Accomplishments: Supported the successful fabrication of the first organic quantum dot light-emitting diodes (LEDs) by using a 3-D printer. The proof of concept activity is a significant step toward using 3-D printing to create on-demand, simple parts and devices. 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.</p> <p>FY 2016 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.</p> <p>FY 2017 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.</p>	23.651	25.340	28.718
Accomplishments/Planned Programs Subtotals	95.118	101.914	101.258

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613003 / <i>Mathematics, Information and Life Sciences</i>

	FY 2015	FY 2016
Congressional Add: Program Increase	18.041	11.167
FY 2015 Accomplishments: Conducted Congressionally directed effort.		
FY 2016 Plans: Conduct Congressionally directed effort.		
Congressional Adds Subtotals	18.041	11.167

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 1					R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>				Project (Number/Name) 613004 / <i>Education and Outreach</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
613004: <i>Education and Outreach</i>	-	30.950	31.042	34.003	0.000	34.003	34.382	34.946	35.857	36.535	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 2015	FY 2016	FY 2017
Title: Outreach to International S&T Community	10.292	10.440	11.978
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 2015 Accomplishments: Established a new international partnership that allows Australian scientists to participate in research efforts at the Air Force Research Laboratory and affiliated U.S. universities. Leveraged international expertise and support international technology liaison missions to identify and maintain awareness of foreign science and technology developments. Explored current foreign investments and influence 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 provide primary interface to coordinate international S&T participation among DoD organizations.			
FY 2016 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 2017 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / <i>Defense Research Sciences</i>	Project (Number/Name) 613004 / <i>Education and Outreach</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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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	13.408	13.602	22.025
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Description: Strengthen science, mathematics, and engineering research and infrastructure in the U.S., thereby strengthening current and future Air Force S&T capabilities.

FY 2015 Accomplishments:

Awarded 57 grants to 43 research institutions 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 2016 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 2017 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.

Accomplishments/Planned Programs Subtotals	23.700	24.042	34.003
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	FY 2015	FY 2016
Congressional Add: Program Increase	7.250	7.000
FY 2015 Accomplishments: Conducted Congressionally directed effort.		
FY 2016 Plans: Conduct Congressionally directed effort.		
Congressional Adds Subtotals	7.250	7.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force Date: February 2016

Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)
3600 / 1	PE 0601102F / <i>Defense Research Sciences</i>	613004 / <i>Education and Outreach</i>

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 1: <i>Basic Research</i>					R-1 Program Element (Number/Name) PE 0601103F / <i>University Research Initiatives</i>							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	142.752	141.754	145.044	0.000	145.044	147.923	150.158	154.054	157.135	Continuing	Continuing
615094: <i>University Research Initiatives</i>	-	142.752	141.754	145.044	0.000	145.044	147.923	150.158	154.054	157.135	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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	147.079	141.754	145.044	0.000	145.044
Current President's Budget	142.752	141.754	145.044	0.000	145.044
Total Adjustments	-4.327	0.000	0.000	0.000	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-4.327	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>	R-1 Program Element (Number/Name) PE 0601103F / <i>University Research Initiatives</i>
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Congressional Add Details (\$ in Millions, and Includes General Reductions)	FY 2015	FY 2016
Project: 615094: <i>University Research Initiatives</i>		
Congressional Add: <i>Program Increase</i>	20.000	-
Congressional Add Subtotals for Project: 615094	20.000	-
Congressional Add Totals for all Projects	20.000	-

C. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Title: Multidisciplinary University Research Initiative</p> <p>Description: Promote fundamental, multi- and interdisciplinary science and engineering research projects involving multiple principle investigators.</p> <p>FY 2015 Accomplishments: Selected eight 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.</p> <p>FY 2016 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.</p> <p>FY 2017 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.</p>	68.129	78.676	82.207
<p>Title: Science and Engineering Education</p> <p>Description: Support post-graduate, graduate, and undergraduate education in science and engineering disciplines at U.S. universities.</p> <p>FY 2015 Accomplishments:</p>	40.753	47.062	48.337

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>		R-1 Program Element (Number/Name) PE 0601103F / <i>University Research Initiatives</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>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 under the Awards to Stimulate and Support Undergraduate Research Experiences (ASSURE) program. Continued funding for awards initiated under prior year DoD programs.</p> <p>FY 2016 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.</p> <p>FY 2017 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.</p>				
<p>Title: Research Instrumentation</p> <p>Description: Enhance scientific and engineering research through advanced education infrastructure and instrumentation at U.S. universities.</p> <p>FY 2015 Accomplishments: Selected 43 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.</p> <p>FY 2016 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.</p> <p>FY 2017 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.</p>		13.870	16.016	14.500
Accomplishments/Planned Programs Subtotals		122.752	141.754	145.044
		FY 2015	FY 2016	
Congressional Add: Program Increase		20.000	-	

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>	R-1 Program Element (Number/Name) PE 0601103F / <i>University Research Initiatives</i>
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	FY 2015	FY 2016
FY 2015 Accomplishments: Conducted congressionally directed effort.		
Congressional Adds Subtotals	20.000	-

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: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>					R-1 Program Element (Number/Name) PE 0601108F / <i>High Energy Laser Research Initiatives</i>							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	13.502	13.778	14.168	0.000	14.168	14.417	14.615	14.906	15.204	Continuing	Continuing
615097: <i>High Energy Laser Research Initiatives</i>	-	13.502	13.778	14.168	0.000	14.168	14.417	14.615	14.906	15.204	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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	13.950	13.778	14.168	0.000	14.168
Current President's Budget	13.502	13.778	14.168	0.000	14.168
Total Adjustments	-0.448	0.000	0.000	0.000	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-0.448	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

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

Project: 615097: *High Energy Laser Research Initiatives*

Congressional Add: *Program Increase*

Congressional Add Subtotals for Project: 615097

	FY 2015	FY 2016
	1.021	-
	1.021	-

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force		Date: February 2016	
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>		R-1 Program Element (Number/Name) PE 0601108F / <i>High Energy Laser Research Initiatives</i>	
Congressional Add Details (\$ in Millions, and Includes General Reductions)		FY 2015	FY 2016
Congressional Add Totals for all Projects		1.021	-
C. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Title: HEL Devices</p> <p>Description: Improve the fundamental understanding of HEL sources, to include solid state, fiber, and gas laser technologies.</p> <p>FY 2015 Accomplishments: Continued research on innovative laser technologies in diode-pumped alkali, short-pulse, free electron, fiber and solid state laser technologies. Continued overseas efforts to leverage international technology advancements.</p> <p>FY 2016 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.</p> <p>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.</p>	6.425	6.438	6.728
<p>Title: HEL Beam Control</p> <p>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.</p> <p>FY 2015 Accomplishments: Continued research on innovative beam control architectures. Continued overseas efforts to leverage international technology advancements.</p> <p>FY 2016 Plans: Continue research on innovative beam control architectures. Continue overseas efforts to leverage international technology advancements.</p> <p>FY 2017 Plans: Continue research on innovative beam control architectures. Continue overseas efforts to leverage international technology advancements.</p>	5.166	6.240	6.240
<p>Title: HEL Education</p> <p>Description: Fund educational grants intended to stimulate interest in HELs among students.</p>	0.890	1.100	1.200

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 1: Basic Research</i>	R-1 Program Element (Number/Name) PE 0601108F / <i>High Energy Laser Research Initiatives</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> 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.</p> <p><i>FY 2016 Plans:</i> 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.</p> <p><i>FY 2017 Plans:</i> 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.</p>			
Accomplishments/Planned Programs Subtotals	12.481	13.778	14.168

	FY 2015	FY 2016
<i>Congressional Add:</i> Program Increase	1.021	-
<i>FY 2015 Accomplishments:</i> Conducted Congressionally-directed effort.		
Congressional Adds Subtotals	1.021	-

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

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>					R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	114.302	133.734	126.152	0.000	126.152	129.016	129.860	132.539	131.030	Continuing	Continuing
624347: <i>Materials for Structures, Propulsion, and Subsystems</i>	-	35.119	55.665	46.444	0.000	46.444	47.094	49.233	50.271	47.597	Continuing	Continuing
624348: <i>Materials for Electronics, Optics, and Survivability</i>	-	34.541	34.530	32.866	0.000	32.866	33.146	34.395	35.091	35.666	Continuing	Continuing
624349: <i>Materials Technology for Sustainment</i>	-	44.642	43.539	46.842	0.000	46.842	48.776	46.232	47.177	47.767	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 (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.

B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	110.680	125.234	127.175	0.000	127.175
Current President's Budget	114.302	133.734	126.152	0.000	126.152
Total Adjustments	3.622	8.500	-1.023	0.000	-1.023
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	8.500			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	5.385	0.000			
• SBIR/STTR Transfer	-1.763	0.000			
• Other Adjustments	0.000	0.000	-1.023	0.000	-1.023

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>
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Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 624347: *Materials for Structures, Propulsion, and Subsystems*
 Congressional Add: *Air Force Educational and Outreach Program*

Congressional Add Subtotals for Project: 624347

	FY 2015	FY 2016
	-	8.500
	-	8.500

Project: 624348: *Materials for Electronics, Optics, and Survivability*
 Congressional Add: *Nanotechnology Research*

Congressional Add Subtotals for Project: 624348

	5.000	-
	5.000	-
	5.000	8.500

Congressional Add Totals for all Projects

Change Summary Explanation

Increase in FY 2015 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Decrease in FY 2017 due to higher DoD priorities.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>				Project (Number/Name) 624347 / <i>Materials for Structures, Propulsion, and Subsystems</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
624347: <i>Materials for Structures, Propulsion, and Subsystems</i>	-	35.119	55.665	46.444	0.000	46.444	47.094	49.233	50.271	47.597	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 2015	FY 2016	FY 2017
Title: Ceramics and Composites	20.720	27.803	27.378
Description: Develop ceramic, ceramic matrix composite, and hybrid materials technologies for performance and supportability improvement in propulsion systems and high temperature aerospace structures.			
FY 2015 Accomplishments: Demonstrated new advanced processing methods, coating technologies, and behavior and life prediction for higher temperature capable organic and ceramic matrix composites. Validated severe environment durability of advanced composite materials for aerospace structures. Continued to advance the development of new ceramic and organic matrix composite materials and processes with higher temperature capability for propulsion systems and aerospace structures. Assessed novel electromagnetic and laser protection materials and processes concepts for suitability for aerospace structures.			
FY 2016 Plans: Continue to demonstrate new advanced processing methods, coating technologies, and behavior and life prediction for higher temperature capable organic and ceramic matrix composites. Demonstrate severe environment durability of advanced composite systems via mechanical testing. Continue to advance the development and validate new ceramic and organic matrix 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624347 / <i>Materials for Structures, Propulsion, and Subsystems</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>development and certification of advanced composite materials. Demonstrate multi-functional materials and processes for applications requiring advanced electromagnetic and laser protection for aerospace structures.</p> <p>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 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 to demonstrate multi-functional materials and processes for applications requiring advanced electromagnetic and laser protection for aerospace structures.</p>				
<p>Title: Metals</p> <p>Description: Develop lightweight and high temperature metallics, life prediction, and metals processing technologies for increased affordability, durability, and reliability.</p> <p>FY 2015 Accomplishments: Demonstrated repeatability of advanced computation methods to support material development and characterization modeling. Demonstrated 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. Demonstrated analysis techniques for understanding, mitigating, and utilizing residual stress in nickel-base superalloys for turbine engines. Continued development of integrated material/manufacturing and component analysis for life management and development of structural materials innovative research. Continued development of next generation turbine engine disk.</p> <p>FY 2016 Plans: Validate repeatability 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 demonstration of analysis techniques for understanding and mitigating residual stress in nickel-base superalloys. Continue development of integrated material/manufacturing and component analysis for life management and development of structural materials innovative research focusing on affordable metals. Continue to advance development of next generation turbine engine disk.</p> <p>FY 2017 Plans:</p>		10.887	14.580	14.357

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016	
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624347 / <i>Materials for Structures, Propulsion, and Subsystems</i>	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016
Implement 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 repeatability of analysis techniques for understanding and mitigating residual stress in nickel-base superalloys. Continue development of integrated material/manufacturing and component analysis 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.			
Title: Thermal Protection Materials		3.512	4.782
Description: Develop lightweight and high temperature metallics, life prediction, and metals processing technologies for increased affordability, durability, and reliability.			4.709
FY 2015 Accomplishments: Worked towards refining and improving processing methods to fabricate structurally integrated thermal protection systems for expendable hypersonic applications. Developed unique experimental techniques to assess mechanical properties and time-dependent behavior. Validated material properties and performance meets design needs for control surfaces, leading edges and acreage. Developed computational models to assess environmental degradation of materials in a hypersonic environment.			
FY 2016 Plans: Continue to refine and improve processing methods to fabricate structurally integrated thermal protection systems for expendable hypersonic applications. Continue development of unique experimental techniques to assess mechanical properties and time-dependent behavior. Assess material properties and performance against requirements for control surfaces, leading edges and acreage. Validate 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 structurally integrated thermal protection systems 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.			
Accomplishments/Planned Programs Subtotals		35.119	47.165
		46.444	
		FY 2015	FY 2016
Congressional Add: Air Force Educational and Outreach Program		-	8.500

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624347 / <i>Materials for Structures, Propulsion, and Subsystems</i>
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	FY 2015	FY 2016
FY 2016 Plans: Conduct congressionally directed effort		
Congressional Adds Subtotals	-	8.500

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>				Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
624348: <i>Materials for Electronics, Optics, and Survivability</i>	-	34.541	34.530	32.866	0.000	32.866	33.146	34.395	35.091	35.666	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 (LO) 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 2015	FY 2016	FY 2017
Title: Infrared Detector Materials	9.749	11.364	10.846
Description: Develop infrared (IR) detector materials and processes technologies for performance, affordability, and operational capability of surveillance, tracking, targeting, and situational awareness systems.			
FY 2015 Accomplishments: Validated and continue to develop materials for use in high resolution IR focal plane arrays for various uses in airborne ISR. Demonstrated materials to support and provide persistent air and space ISR. Demonstrated models of materials optical/IR behavior for LO, ISR, and other applications. Validated nanoscale materials for use in producing detectors. Validated and continue to utilize computational materials science to improve performance prediction models. Demonstrate quantum materials for aerospace applications. Continue to advance the development of short wave IR detector materials and hyperspectral long wave IR materials. Continue to advance the development of Radio Frequency (RF)/IR photonics for air vehicle applications.			
FY 2016 Plans: Continue to develop materials for use in high resolution MWIR applications. Continue to develop materials to support and provide persistent air and space ISR. Demonstrate models of materials optical/IR behavior for LO, ISR, and other applications. Demonstrate nanoscale materials for use in producing detectors. Continue to utilize computational materials science to improve performance prediction models. Demonstrate quantum materials for aerospace applications. Continue development of short			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>wave IR detector materials and hyperspectral long wave IR materials. Continue development of RF/IR photonics for air vehicle applications. Develop nanostructured materials for components to enable agile RF capability.</p> <p>FY 2017 Plans: Continue to develop and demonstrate materials for use in high resolution MWIR applications. Continue to develop and demonstrate materials to support and provide persistent air and space ISR. Demonstrate models of materials optical/IR behavior for LO, ISR, and other applications. Demonstrate nanoscale materials 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 short wave IR detector materials and hyperspectral long wave IR materials. Continue development of RF/IR photonics for air vehicle applications. Demonstrate nanostructured materials for components to enable agile RF capability.</p>				
<p>Title: Directed Energy Hardened Materials</p> <p>Description: Develop and demonstrate technologies to enhance the safety, survivability, and mission effectiveness of aircrews, sensors, viewing systems, and related assets.</p> <p>FY 2015 Accomplishments: Continued to demonstrate repeatability of materials and technologies to protect against directed energy threats. Projects included optimized nonlinear optical limiter materials for damage protection, robust in-band optical limiter materials, enhanced photorefractive hybrid materials concepts, tunable/switchable materials and concepts, and passive optical coating technology for advanced applications in airborne, space, and personnel systems. Validated materials for high energy laser interactions. Utilized computational materials science to enhance multi-scale modeling. Demonstrated materials and processes for hardening and optical materials applications. Continued development of photonic enabled RF phased arrays and tunable inductors/large area films.</p> <p>FY 2016 Plans: Continue to demonstrate repeatability of materials and technologies to protect against directed energy threats. Projects include optimized nonlinear optical limiter materials for damage protection, robust in-band optical limiter materials, enhanced photorefractive hybrid materials concepts, tunable/switchable materials and concepts, and passive optical coating technology for advanced applications in airborne, space, and personnel systems. Continue to validate materials for high energy laser interactions. Develop approaches for integration of multi-modal hardening into structures and devices. Continue to utilize computational materials science to employ multi-scale modeling for design of robust, reliable integrated protection. Continue to demonstrate materials and processes for hardening materials applications.</p> <p>FY 2017 Plans:</p>		11.226	13.017	12.160

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Continue to demonstrate repeatability of materials and technologies to protect against directed energy threats. Projects include optimized nonlinear optical limiter materials for damage protection, robust in-band optical limiter materials, enhanced photorefractive hybrid materials concepts, tunable/switchable materials and concepts, and passive optical coating technology for advanced applications in airborne, space, and personnel systems. Assess response of new materials for high energy laser interactions. Develop approaches for integration of multi-modal hardening into structures and devices. Validate repeatability and continue to utilize computational materials science to enhance multi-scale modeling for design of robust, reliable integrated protection. Continue to demonstrate materials and processes for hardening materials applications.</p>			
<p>Title: Laser Source Materials</p> <p>Description: Develop materials to enable higher performance high power laser sources (quasi-Continuous Wave to Continuous Wave) with emphasis on laser output in the mid-infrared spectral region (2-5 microns).</p> <p>FY 2015 Accomplishments: Produced crystal fiber waveguides using adhesive free bonding methods for high power lasing as a pump source for nonlinear elements. Developed quasi-phase-matched nonlinear structures and wavelength conversion to the MWIR region.</p> <p>FY 2016 Plans: Refine and demonstrate material and growth processes for fabricating phase-matched crystals with record low optical absorption and high laser damage threshold. Improve design and fabrication of crystal fiber waveguides for higher power pump lasing, using improved waveguide confinement designs for single mode output. Investigate power limitations of lasing of crystal fiber waveguide structures and performance limitations. Continue investigation of quasi-phase-matched materials and develop processes to reduce absorption, model and produce optical confinement designs, and demonstrate increased power per pulse in the mid-infrared spectral region.</p> <p>FY 2017 Plans: Continue development of both phase-matched crystals and crystal fiber waveguides sufficiently to demonstrate subsystem capability. And generate band-IV MWIR spectral output with average power exceeding one kilowatt and energy per pulse exceeding one Joule.</p>	1.181	1.425	1.315
<p>Title: Nanostructured and Biological Materials</p> <p>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.</p> <p>FY 2015 Accomplishments: Continued to develop nano and biological engineering methods for complex hybrid materials addressing unique requirements of Air Force sensors and electronic components. Continued to advance the use of computational materials science to model</p>	7.385	8.724	8.545

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>

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

	FY 2015	FY 2016	FY 2017
<p>material development and to enable rapid in-situ experimental data acquisition. Validated reliable materials and processes to optimize components for compact, lightweight, flexible, multi-functional devices for use in unique Air Force autonomy and human performance monitoring applications. Developed methods to assess microbial interactions with material to establish risk for property degradation like microbially influenced corrosion. Demonstrated materials and processes for developing robust hybrid electronic packages on varied flexible and stretchable substrates, and the development of structurally resilient architectures and nanostructures with embedded energy and/or communications for use in sustainment, munitions and remotely piloted aircraft (RPAs). Developed methods to assess reliability of nano and bio materials and processes for Air Force applications. Support Flexible Hybrid Electronics Institute for Manufacturing Innovation and the NanoBio Manufacturing Consortiums.</p> <p>FY 2016 Plans: Continue to validate nano and biological engineering methods for complex hybrid materials addressing unique requirements of Air Force sensors and electronic components. Continue to advance the use of computational materials science to model material development and to enable rapid in-situ experimental data acquisition. Validate reliable materials and processes to optimize components for compact, flexible, multi-functional devices for use in unique Air Force autonomy and human performance monitoring applications. Develop methods to assess microbial interactions with material to establish risk for property degradation. Demonstrate materials and processes for developing robust hybrid electronic packages on varied flexible and stretchable substrates with embedded energy and/or comm for use in sustainment, munitions and RPAs. Focused material and process develop for integration of flexible components into multi-modal platform. Initiate investigation of materials and processes for strain resilient electronics. Develop methods to assess reliability of nano and bio materials and processes for Air Force applications and demonstrate computational techniques and models to characterize failure modes. Support Flexible Hybrid Electronics Institute for Manufacturing Innovation and the NanoBio Manufacturing Consortiums.</p> <p>FY 2017 Plans: Continue to validate nano and biological engineering methods for complex hybrid materials addressing unique requirements of Air Force sensors and electronic components. Demonstrate the use of computational materials science and rapid in-situ experimental data acquisition to lead nano-bio material development. Continue to validate reliable materials and processes to optimize components for compact, flexible, multi-functional devices for use in unique Air Force autonomy and human performance monitoring applications. Develop methods to assess microbial interactions with material to establish risk for property degradation. Continue to demonstrate materials and processes for developing robust hybrid electronic packages on varied flexible and stretchable substrates with embedded energy and/or comm for use in sustainment, munitions and RPAs. Demonstrate material and processes for integration of flexible components into multi-modal platform. Continue to demonstrate materials and processes for strain resilient electronics. Continue to develop methods to assess reliability of nano and bio materials and processes for Air</p>			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624348 / <i>Materials for Electronics, Optics, and Survivability</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Force applications and demonstrate computational techniques and models to characterize failure modes. Support Flexible Hybrid Electronics Institute for Manufacturing Innovation and the NanoBio Manufacturing Consortiums.			
Accomplishments/Planned Programs Subtotals	29.541	34.530	32.866

	FY 2015	FY 2016
Congressional Add: Nanotechnology Research	5.000	-
FY 2015 Accomplishments: Conducted Congressionally-directed effort.		
Congressional Adds Subtotals	5.000	-

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

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

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

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>				Project (Number/Name) 624349 / <i>Materials Technology for Sustainment</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
624349: <i>Materials Technology for Sustainment</i>	-	44.642	43.539	46.842	0.000	46.842	48.776	46.232	47.177	47.767	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 2015	FY 2016	FY 2017
Title: Sensing Technologies	16.964	16.503	16.255
Description: Develop sensing and life prediction technologies to identify damage and characterize the health of aging structures, propulsion systems, and low-observable (LO) materials and structures.			
FY 2015 Accomplishments: Continued to improve and validate nondestructive evaluation modeling capabilities and use these competences to drive improvements in capability to detect and characterize damage in realistic aerospace structures and engine components. Began to develop approaches to address the variability inherent in aerospace systems and materials and begin to quantify the impact of that variability on nondestructive inspection capability and reliability. Validated advanced sensing technologies to detect and characterize changes in material properties, damage evolution, and other factors that detrimentally affect aerospace systems. Initiated development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Assessed repeatability and functionality of innovative LO inspection methods to enable rapid assessment of LO material performance. Initiated development of advanced methods to monitor and evaluate LO material state awareness. Demonstrated enhanced metals performance in aerospace systems. Initiated development of risk-based life management approaches for turbine engine structural materials.			
FY 2016 Plans: Demonstrate nondestructive 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624349 / <i>Materials Technology for Sustainment</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>nondestructive inspection capability and reliability. Demonstrate advanced sensing technologies to detect and characterize changes in material properties, damage evolution, and other factors that detrimentally affect aerospace systems. Continue development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Continue development of advanced methods to monitor and evaluate LO 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.</p> <p>FY 2017 Plans: Continue to demonstrate nondestructive 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 nondestructive 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.</p>				
<p>Title: Production and Repair Technologies</p> <p>Description: Develop support capabilities, information, and processes to resolve problems with materials in the production and repair of systems components and structures.</p> <p>FY 2015 Accomplishments: Continued to validate and demonstrate advanced materials and processes technology to repair and extend the life of Air Force legacy systems. Developed improved lifecycle prediction test methods and techniques to understand effects of service environments, corrosion, residual stresses, and material processes on structural and functional materials. Assessed advanced materials, processes and designs for improved repair and maintainability and life cycle cost of outer-moldline coatings, access panel treatments, and multifunctional systems. Initiated LO affordability technologies and processes to reduce maintenance costs of LO materials.</p> <p>FY 2016 Plans: Demonstrate nondestructive 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 nondestructive inspection capability and reliability. Demonstrate advanced sensing technologies to detect and characterize</p>		12.053	11.862	12.261

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624349 / <i>Materials Technology for Sustainment</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>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 LO 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.</p> <p>FY 2017 Plans: Continue to demonstrate nondestructive 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 nondestructive 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 LO 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.</p>				
<p>Title: Failure Analysis Technologies</p> <p>Description: Develop support capabilities, information, and processes to resolve materials problems and provide electronic and structural failure analysis of components.</p> <p>FY 2015 Accomplishments: Performed quick response failure analyses and materials investigations. Continued to investigate improved analysis techniques to determine root cause materials failure/degradation. Continued to provide advanced materials solutions to ensure critical warfighter system availability and safety of flight. Continued development of functional materials and Micro Electromechanical Systems (MEMS) failure analysis capabilities. Continued to validate advanced electrostatic discharge protection technologies and procedures for emerging avionics subsystems. Continued to transition advanced test methods for analyzing electrical and structural failures of emerging materials. Initiated development on new, more durable materials and protection for high power wiring technologies for Air Force weapon systems. Continued research to provide advanced materials to improve systems sustainment in field and Air Force Program Offices.</p> <p>FY 2016 Plans: Continue to perform quick response failure analyses and materials investigations. Continue to investigate improved analysis techniques to determine root cause materials failure/degradation. Continue to provide advanced materials solutions to ensure critical warfighter system availability and safety of flight. Continue development of functional materials and MEMS failure analysis</p>		15.625	15.174	18.326

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / <i>Materials</i>	Project (Number/Name) 624349 / <i>Materials Technology for Sustainment</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>capabilities. Continue to 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 on new, more durable materials and protection for high power wiring technologies for Air Force weapon systems. Continue research to provide advanced materials to improve systems sustainment in field and Air Force Program Offices.</p> <p><i>FY 2017 Plans:</i> Continue to perform 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 critical warfighter system availability and safety of flight. Continue development of functional materials and MEMS 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 in field and Air Force Program Offices.</p>			
Accomplishments/Planned Programs Subtotals	44.642	43.539	46.842

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: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	101.053	122.969	122.831	0.000	122.831	125.042	129.566	135.530	135.135	Continuing	Continuing
622401: <i>Structures</i>	-	31.230	52.112	41.103	0.000	41.103	44.739	45.579	46.444	47.259	Continuing	Continuing
622403: <i>Flight Controls and Pilot-Vehicle Interface</i>	-	28.305	27.447	28.516	0.000	28.516	29.827	30.418	30.922	31.412	Continuing	Continuing
622404: <i>Aeromechanics and Integration</i>	-	26.080	28.553	34.470	0.000	34.470	28.281	28.875	29.476	29.981	Continuing	Continuing
622405: <i>High Speed Systems Technology</i>	-	15.438	14.857	18.742	0.000	18.742	22.195	24.694	28.688	26.483	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.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>
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B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	105.673	123.438	122.766	0.000	122.766
Current President's Budget	101.053	122.969	122.831	0.000	122.831
Total Adjustments	-4.620	-0.469	0.065	0.000	0.065
• Congressional General Reductions	0.000	-0.469			
• 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	-2.750	0.000			
• SBIR/STTR Transfer	-1.870	0.000			
• Other Adjustments	0.000	0.000	0.065	0.000	0.065

Change Summary Explanation

Decrease in FY 2015 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 622401 / <i>Structures</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
622401: <i>Structures</i>	-	31.230	52.112	41.103	0.000	41.103	44.739	45.579	46.444	47.259	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 2015	FY 2016	FY 2017
<p>Title: Aircraft Service Life Technologies</p> <p>Description: Develop an economic service life analysis capability comprised of analysis tools, methodologies, and structural health monitoring technologies.</p> <p>FY 2015 Accomplishments: Completed technology development concepts for risk informed decision-making. Completed technology efforts for condition-based maintenance of structural integrity. Initiated 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.</p> <p>FY 2016 Plans: Continue development of engineered residual stress methods for airframe life extension. Continue the technology development of failure criteria methods and tools for advanced aircraft composite and metallic components. Continue efforts in certification of advanced composite for aircraft structures. 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.</p> <p>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.</p>	23.772	23.652	21.431
<p>Title: Vehicle Design Technologies</p> <p>Description: Develop methodologies to reduce the cost and time involved from design to full-scale testing of structural concepts and aircraft systems.</p>	3.486	15.665	12.047

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622401 / <i>Structures</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> Completed high fidelity multidisciplinary design methods to enable efficient supersonic air vehicle technologies. Completed development of multi-disciplinary methodologies that will allow for lower cost advanced structures. Continued the development of advanced high fidelity aircraft design analysis tools. Initiated design methods for innovative control of supersonic tailless aircraft. Initiated parametric modeling methods for integrated multidiscipline collaborative design.</p> <p><i>FY 2016 Plans:</i> Continue the development of advanced high fidelity aircraft design analysis tools. Continue design methods for innovative control of supersonic tailless aircraft. Continue parametric modeling methods for integrated multidiscipline collaborative design. Continue high-fidelity technology assessment and design of next generation mobility concepts. Initiate the development of design methods for low cost attritable aircraft concepts.</p> <p><i>FY 2017 Plans:</i> 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.</p>				
<p><i>Title:</i> Structural Concepts</p> <p><i>Description:</i> Develop design methods, processes, and lightweight, adaptive, and multifunctional structural concepts to capitalize on new materials, multi-role considerations, and technology integration into aircraft systems.</p> <p><i>FY 2015 Accomplishments:</i> Continued innovative energy efficient conformal load bearing antenna structural concepts. Initiated development of lightweight, adaptive, and efficient structural concepts for mobility and special operations. Initiated low cost airframe design and manufacturing methods.</p> <p><i>FY 2016 Plans:</i> Continue innovative energy efficient conformal load bearing antenna structural concepts. Continue development of lightweight, adaptive, and efficient structural concepts for mobility and special operations. Continue low cost airframe design and manufacturing methods.</p> <p><i>FY 2017 Plans:</i> 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</p>		3.972	12.795	7.625

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622401 / <i>Structures</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
manufacturing methods. Initiate verification of low cost attritable airframe manufacturing methods. Initiate development of lightweight aircraft structural concepts to support Air Superiority 2030 requirements.			
Accomplishments/Planned Programs Subtotals	31.230	52.112	41.103

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 622403 / <i>Flight Controls and Pilot-Vehicle Interface</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
622403: <i>Flight Controls and Pilot-Vehicle Interface</i>	-	28.305	27.447	28.516	0.000	28.516	29.827	30.418	30.922	31.412	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 flight 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 2015	FY 2016	FY 2017
Title: Advanced Flight Controls Technologies	10.414	11.438	12.307
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 2015 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; developing new methods and expanding to include more aircraft systems. Completed assessment of single pilot operations for mobility aircraft. Continue the development of adaptive guidance and control technologies for small-scale hypersonic air vehicles.			
FY 2016 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. Initiate development of advanced automation capabilities for large aircraft. Complete 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.			
Title: Manned and Unmanned Teaming Technologies	12.768	9.581	11.506

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622403 / <i>Flight Controls and Pilot-Vehicle Interface</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Description: Develop technology for flight control systems that will permit safe interoperability between manned and remotely piloted aircraft and effective teaming in adverse and contested environments.</p> <p>FY 2015 Accomplishments: Continued the 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. Completed demonstration and assessment of on-aircraft technology options for autonomous operations in a terminal airspace environment. Continue development of airborne control of UAS in preparation for flight test activities.</p> <p>FY 2016 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. Initiate development of robust, affordable Unmanned Air Systems (UAS) operations in a terminal airspace environment. Complete development of airborne control of UAS in preparation for flight test activities.</p> <p>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.</p>				
<p>Title: Flight Controls Technologies Modeling and Simulation</p> <p>Description: Develop tools and methods for capitalizing on simulation-based research and development of future aerospace vehicles.</p> <p>FY 2015 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 mission environments, initiating development of testbed for emerging technologies. Continued trade studies of vehicle concepts for strike, mobility and reconnaissance. Completed autonomy in mobility testbed and began mobility evaluations.</p> <p>FY 2016 Plans:</p>		5.123	6.428	4.703

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622403 / <i>Flight Controls and Pilot-Vehicle Interface</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>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. Complete manned-unmanned teaming testbed. Complete mobility evaluations.</p> <p>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.</p>				
Accomplishments/Planned Programs Subtotals		28.305	27.447	28.516
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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 622404 / <i>Aeromechanics and Integration</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
622404: <i>Aeromechanics and Integration</i>	-	26.080	28.553	34.470	0.000	34.470	28.281	28.875	29.476	29.981	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 2015	FY 2016	FY 2017
<p>Title: Aerodynamic Systems Technologies</p> <p>Description: Develop aerodynamic assessment prediction methods centered on expanding the design capabilities of future air vehicles.</p> <p>FY 2015 Accomplishments: Continued to develop and assess aerodynamic technologies that enable future revolutionary manned and unmanned air vehicles. Continued to develop and assess advanced aircraft configurations for future mobility and air superiority requirements. Completed technology assessments on air superiority vehicle concepts. Initiated technology assessments on next generation tanker systems.</p> <p>FY 2016 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 mobility. Continue to develop and assess advanced aircraft configurations for future air superiority. Continue technology assessments on next generation tanker systems. Initiate development and assessment of low cost attritable unmanned air systems concepts.</p> <p>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 UAV concepts.</p>	9.792	8.652	9.117
<p>Title: Next Generation Aerodynamic Technologies</p> <p>Description: Develop and assess technologies for the next generation of multi-role large aircraft.</p> <p>FY 2015 Accomplishments:</p>	9.490	11.367	10.988

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622404 / <i>Aeromechanics and Integration</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Continued development of high fidelity aerodynamic analysis and method development for Mobility and future Air Superiority requirements. Continued development of practical laminar flow technologies for highly swept wings. Initiated aerodynamics technologies to enable control of supersonic tailless aircraft.</p> <p>FY 2016 Plans: Continue development of high fidelity aerodynamic analysis and method development for Mobility and future Air Superiority 2030. Continue development of practical laminar flow technologies for highly swept wings. Continue development of aerodynamics technologies to enable control of supersonic tailless aircraft. Initiate development of flow control techniques to increase the efficiency of practical laminar flow technologies for highly swept wings.</p> <p>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.</p>				
<p>Title: Aircraft Integration Technologies</p> <p>Description: Develop enabling technologies to allow efficient and effective integration of propulsion, weapons, and subsystems into current and future air vehicles.</p> <p>FY 2015 Accomplishments: Developed aerodynamic and propulsion integration technologies that enable future mobility and fighter aircraft. Developed analyses and experiments to investigate propulsion integration flow control to enhance mobility and future air superiority vehicle performance. Developed innovative aerodynamic design methods for integrating high bypass propulsion for future mobility aircraft. Developed advanced kinetic and directed energy weapons integration technologies for future air superiority requirements.</p> <p>FY 2016 Plans: Continue to develop aerodynamic and propulsion integration technologies that enable future mobility and fighter aircraft. Complete analyses and experiments to investigate propulsion integration flow control to enhance mobility and future air superiority vehicle performance. Initiate advanced inlet and exhaust systems subscale tests for air superiority. Continue development of advanced kinetic and directed energy weapons integration technologies for future air superiority requirements. Complete innovative aerodynamic design methods for integrating high bypass propulsion for future mobility aircraft.</p> <p>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</p>		6.798	8.534	14.365

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622404 / <i>Aeromechanics and Integration</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
directed energy weapons integration technologies for future air superiority. Initiate analysis of innovative propulsion integration technologies that enable low cost attritable aircraft.				
Accomplishments/Planned Programs Subtotals		26.080	28.553	34.470
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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>				Project (Number/Name) 622405 / <i>High Speed Systems Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
622405: <i>High Speed Systems Technology</i>	-	15.438	14.857	18.742	0.000	18.742	22.195	24.694	28.688	26.483	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 2015	FY 2016	FY 2017
Title: High Speed/Hypersonics Structures	8.115	8.315	10.896
Description: Develop high speed, high temperature structural analysis methods and technologies for extreme operating conditions in current and future air vehicles.			
FY 2015 Accomplishments: Initiated development of innovative structural concepts for high speed/hypersonic air vehicles. Initiated development of analytical methods for predicting structural response needed for design and evaluation of hot primary structure for hypersonic vehicles. Initiate the impact of path dependent structural behavior on the service life prediction for hot structures encountering extreme environments. Initiated the development and integrate model uncertainty methods into multi-disciplinary simulations and quantify its impact on the structural margin. Initiated development of structural analysis methods and technology for hot structure concepts under extreme environment loading conditions. Initiated the assessment of the aerospace community to quantify the structural margins for extreme environment hot structure through experimental validation of ground test articles. Completed fabrication and initiated testing of representative vehicle structures for combined aero, thermal, and acoustic loads.			
FY 2016 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.			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622405 / <i>High Speed Systems Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Complete testing of representative vehicle structures for combined aero, thermal, and acoustic loads. Validate combined loads methodology to predict structural response.</p> <p>FY 2017 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. Initiate development of structural life prediction methodology for extreme environment structures and thermal protection systems.</p>				
<p>Title: High Speed Vehicle Aeromechanics and Integration</p> <p>Description: Develop new and improved components, concepts, and designs for sustained flight of high-speed/hypersonic expendable and re-useable vehicles. Conduct analyses of high speed/hypersonic vehicles to enable revolutionary capabilities.</p> <p>FY 2015 Accomplishments: Matured critical technologies for high speed/hypersonic flight. Initiated 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. Continued performance and operability ground testing of advanced high contraction ratio inlets. Initiated development of high speed system concepts that provide revolutionary capabilities. Investigated aeromechanic technologies to reduce drag and enable robust stability & control at low dynamic pressure flight conditions. Initiated efforts to characterize high-speed phenomena and develop and validate fundamental high-speed technologies through experimental testing. As part of international collaborative effort, conducted flight tests boundary layer transition experiment. Developed design of multi-functional terminal sensor integrated flight experiment. Assessed mission-level effectiveness and refined definition of preferred high speed weapon alternatives. Developed campaign-level modeling and simulation of high speed weapon alternatives. Assessed campaign-level benefits of preferred high speed weapon alternatives</p> <p>FY 2016 Plans: Continue maturation of 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. Complete performance and operability ground testing of advanced high contraction ratio inlets. Continue development of high speed system concepts that provide revolutionary capabilities. Investigate aeromechanic technologies to reduced drag and enable robust stability and control at low dynamic</p>		7.323	6.542	7.846

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / <i>Aerospace Vehicle Technologies</i>	Project (Number/Name) 622405 / <i>High Speed Systems Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>pressure flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed technologies through experimental testing. As part of an international collaborative effort, continue flight tests of Mach 6 adaptive guidance and control flight experiment. Continue assessment of mission-level effectiveness and refinement of definition of preferred high speed weapon alternatives and limited life hypersonic intelligence, surveillance, and reconnaissance vehicles. Continue assessment of campaign-level benefits of preferred high speed weapon alternatives.</p> <p>FY 2017 Plans: Continue to mature critical technologies for high speed/hypersonic flight. Continue development of design/analysis techniques/tools and experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary capabilities. Continue investigation of aeromechanic technologies to reduced drag and enable robust 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.</p>			
Accomplishments/Planned Programs Subtotals	15.438	14.857	18.742

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

N/A

Remarks

N/A

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	101.157	95.727	110.221	111.647	0.000	111.647	114.704	117.454	119.877	121.458	Continuing	Continuing
621123: <i>Learning and Operational Readiness</i>	11.971	16.385	24.546	23.329	0.000	23.329	23.687	21.582	22.021	22.319	Continuing	Continuing
625328: <i>Human Dynamics Evaluation</i>	25.692	16.919	26.812	26.174	0.000	26.174	26.215	26.690	27.253	27.586	Continuing	Continuing
625329: <i>Sensory Evaluation and Decision Science</i>	37.267	37.443	32.246	31.539	0.000	31.539	31.739	32.840	33.516	33.921	Continuing	Continuing
627757: <i>Bioeffects</i>	26.227	24.980	26.617	30.605	0.000	30.605	33.063	36.342	37.087	37.632	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program conducts applied research in the area of airmen training, airmen system interfaces, bioeffects, and understanding and shaping adversarial behavior. The Learning and Operational Readiness project conducts research to measure, accelerate, and expand the cognitive skills necessary to improve airmen training and mission performance. The Human Dynamics Evaluation project conducts research to advance machine intelligence and operator-aiding technologies by developing and applying airman-focused research for advanced intelligence, surveillance, and reconnaissance (ISR) capabilities and detecting and exploiting human signatures. The Sensory Evaluation and Decision Science project conducts research to revolutionize the manner in which airmen optimize the capabilities of Air Force systems, including remotely piloted aircraft (RPA) and adaptive teams of airmen and machines. The Bioeffects project conducts research on the effects of human exposure to potentially toxic, operational and advanced chemicals and materials (including nanomaterials), electromagnetic (EM) energy (radio frequency to optical), scalable directed energy weapons, and non-lethal weapons. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>
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B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	96.894	100.530	109.280	0.000	109.280
Current President's Budget	95.727	110.221	111.647	0.000	111.647
Total Adjustments	-1.167	9.691	2.367	0.000	2.367
• Congressional General Reductions	0.000	-0.309			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	10.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.167	0.000			
• Other Adjustments	0.000	0.000	2.367	0.000	2.367

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

Project: 621123: *Learning and Operational Readiness*

Congressional Add: *Program Increase*

Congressional Add Subtotals for Project: 621123

Project: 625328: *Human Dynamics Evaluation*

Congressional Add: *Program Increase*

Congressional Add Subtotals for Project: 625328

Project: 625329: *Sensory Evaluation and Decision Science*

Congressional Add: *Program Increase*

Congressional Add Subtotals for Project: 625329

Project: 627757: *Bioeffects*

Congressional Add: *Program Increase*

Congressional Add Subtotals for Project: 627757

Congressional Add Totals for all Projects

	FY 2015	FY 2016
	0.000	3.334
	0.000	3.334
	0.000	3.333
	0.000	3.333
	10.000	3.333
	10.000	3.333
	5.000	-
	5.000	-
	15.000	10.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>
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Change Summary Explanation

Increase in FY 2017 due to increased emphasis by DoD in Aerospace Physiology and Toxicology

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>				Project (Number/Name) 621123 / <i>Learning and Operational Readiness</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
621123: <i>Learning and Operational Readiness</i>	11.971	16.385	24.546	23.329	0.000	23.329	23.687	21.582	22.021	22.319	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 2015	FY 2016	FY 2017
Title: Continuous Learning	16.385	21.212	21.102
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 2015 Accomplishments: Completed development of an analyst readiness research testbed for ISR and cyber operators. Extended learning assessment and management tools to support undergraduate pilot training. Evaluated different methods for secure, credible LVC training and rehearsal for fourth and fifth generation fighters. Created and documented standards for tactical LVC training and readiness. Validated methods to quickly generate rule sets for security applications in C2 and ISR domains. Developed methods to generate realistic representations of adversary tactics for LVC training. Evaluated methods to rapidly reconfigure training environments for different scenarios and mission sets. Initiated work to develop agents to manage training activities in LVC. Began requirements definition for LVC training applications to support enhancing warfighting in contested environments.			
FY 2016 Plans: Begin to implement multiple agents as synthetic white forces for cost reduction in Air Support Operations Center training. Demonstrate adaptive ISR training in training research exercise. Complete evaluations and develop specifications for in-theater C2 trainer. Demonstrate integrated RPA, C2, and joint terminal attack controller (JTAC) training and assessment in routine DMO events. Demonstrate autonomous agents for asset management in RPA operations. Continue research to create autonomous cognitive models to function in contested environments. Complete development of common scenario generation and readiness assessment methods for joint and coalition distributed training and exercise.			
FY 2017 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 621123 / <i>Learning and Operational Readiness</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Integrate and evaluate government off-the-shelf computer-generated forces in an LVC testbed. Complete the development of the Distributed Common Ground Station (DCGS) Weapons Systems Trainer (DWST). Conduct initial training effectiveness study to evaluate the transfer of training using the DWST. Complete multi-role training effectiveness study and deliver results to government customers and partners. Complete and accredit a cross domain solution ruleset. Continue to develop specifications for secure fifth generation LVC operations to include executing a fourth and fifth generation platform study. Initiate designs for outyear studies to execute fourth to fifth generation realistic, secure training and rehearsal events. Begin evaluations of identified training gaps and potential solutions to gaps for the integration of the fifth generation aircraft into a close air support environment. Integrate cyber intelligence training testbed into training research exercises.</p> <p>For FY 2017 and beyond, Cognitive Modeling work accomplished under this effort will be reported under the Cognitive Modeling effort.</p> <p>Title: Cognitive Modeling</p> <p>Description: Research explores application of cognitive science for performance improvement by enhancing training in mission-relevant environments (e.g., flight simulators).</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort was originally performed in the Continuous Learning effort.</p> <p>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.</p>		0.000	0.000	2.227
Accomplishments/Planned Programs Subtotals		16.385	21.212	23.329

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 621123 / <i>Learning and Operational Readiness</i>
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	FY 2015	FY 2016
Congressional Add: Program Increase	0.000	3.334
FY 2015 Accomplishments: N/A		
FY 2016 Plans: Conduct Congressionally-Directed Effort		
Congressional Adds Subtotals	0.000	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.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>				Project (Number/Name) 625328 / <i>Human Dynamics Evaluation</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
625328: <i>Human Dynamics Evaluation</i>	25.692	16.919	26.812	26.174	0.000	26.174	26.215	26.690	27.253	27.586	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 2015	FY 2016	FY 2017
Title: Human Analyst Augmentation	7.672	5.172	10.269
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 2015 Accomplishments: Researched and developed human centric approaches to enhance ISR analysts' ability to attend to relevant intelligence data when coupled with autonomous systems and agents.			
FY 2016 Plans: Apply cognitive systems engineering research methods to airman-centered challenges surrounding contested environments to develop solutions for Air Force ISR analysts. Explore 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.			
Title: Human Trust and Interaction	4.692	9.084	8.188

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625328 / <i>Human Dynamics Evaluation</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Description: Conduct research in cross-cultural communication and automated speech translation tools for Air Force missions. Conduct research to address important aspects of trust in airman-machine teams including investigating how an airman knows an autonomous or semiautonomous system is safe to use and whether the system, data, conclusions, and decision recommendations can be trusted.</p> <p>FY 2015 Accomplishments: Developed guidelines for calibrated trust for symbiotic human-machine teaming. Developed work aids that enable analysts to think more deeply and methodically about their problem space by accounting for contextual factors including culture, religion, governance, and economy.</p> <p>FY 2016 Plans: Experiment with guidelines for calibrated trust for symbiotic airman-machine teaming. Identify and study appropriate levels of transparency between airmen and automated systems. Experiment with multiple language processing algorithms simultaneously to optimize system performance. Evaluate current advances in machine processing for new militarily-relevant languages.</p> <p>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.</p>			
<p>Title: Human Signatures</p> <p>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.</p> <p>FY 2015 Accomplishments: Developed algorithms capable of reliably detecting and characterizing human signatures by leveraging multiple sensing modalities, from multiple platforms, for human threat situation awareness. Developed sensors for novel molecular signatures for increased threat detection in an operational environment and human performance assessment.</p> <p>FY 2016 Plans: Develop advanced molecular and genetic diagnostic methodologies to better assess airman performance. Develop algorithm capable of reliably detecting and characterizing anthropometric signatures.</p> <p>FY 2017 Plans:</p>	4.555	9.223	7.717

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625328 / <i>Human Dynamics Evaluation</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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.			
Accomplishments/Planned Programs Subtotals	16.919	23.479	26.174

	FY 2015	FY 2016
Congressional Add: Program Increase	0.000	3.333
FY 2015 Accomplishments: N/A		
FY 2016 Plans: Conduct Congressionally-Directed Effort		
Congressional Adds Subtotals	0.000	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.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
625329: <i>Sensory Evaluation and Decision Science</i>	37.267	37.443	32.246	31.539	0.000	31.539	31.739	32.840	33.516	33.921	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 2015	FY 2016	FY 2017
<p>Title: Applied Neuroscience</p> <p>Description: Develop technologies to enhance airman performance, airman-airman, and airman-machine collaboration, and system interaction in distributed decision-making environments. Conduct research to predict physiological impacts of high-stress/extreme environments.</p> <p>FY 2015 Accomplishments: Investigated individual and team state sensing and assessment algorithms and methods to examine augmentation mitigation strategies leading to improved warfighter performance. Developed team workload and trust models for autonomy, increased human performance monitoring, and performance improvement. Identified stress-driven metrics and processes that influence human performance. Defined neurophysiological, psychological, and genetic mechanisms and processes for developing guidelines to enhance warfighter cognitive resiliency and performance. Applied physiology computational modeling methods to predict high-stress/extreme environmental effects on the human. Developed augmentation techniques for improving performance in operational environments that include human-machine teaming. Investigated interface technologies and exposure design criteria to protect operators and mitigate injury and performance risks in current and future weapon systems. Developed contamination sensor technology for on-board oxygen generation systems for hypoxia vulnerability risk mitigation. Investigated new technologies for aircraft next generation on-board oxygen generation system.</p> <p>FY 2016 Plans:</p>	11.800	12.515	15.642

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Explore novel airman performance sensor and material solutions to increase sensing and assessing capabilities. Mature team workload and trust models for autonomy, increased airman performance monitoring, and performance improvement. Utilize knowledge of stress-driven metrics and processes to optimize airman performance. Apply neurophysiological, psychological, and genetic mechanisms and processes for developing guidelines to enhance airman performance and cognitive resiliency. Explore additional augmentation techniques such as supplementation and physical training for improving performance in operational environments that include airman-machine teaming. Apply interface technologies and exposure design criteria to protect airmen and mitigate injury and performance risks in current and future weapon systems. Refine physiology computational modeling methods to predict high-stress/extreme environmental effects on airmen. Continue contamination sensor technology development for on-board oxygen generation systems for hypoxia vulnerability risk mitigation. Evaluate new technologies for aircraft next generation on-board oxygen generation system.</p> <p>FY 2017 Plans: Begin development of an optimized sense and access suite of tools for enhanced airman performance in a laboratory environment. Begin design of an adaptive aiding tool for team workload balancing for enhanced team performance. Investigate distributed team mechanisms, techniques, and metrics for initial augmentation technology development. Define target biomarkers and associated sampling techniques for the development of real-time biomarker sensor technology for human performance assessment. Develop behavioral model of mechanisms of cognitive augmentation and stress resilience. Begin development of full crewmember human response model to enhance aircrew performance in extreme stressor environments. Investigate next generation aircraft injury exposure criteria for multi-axial injury model development for improved aircrew protection. Investigate on-board oxygen generating system performance vulnerabilities affecting oxygen production. Explore new ion transport membrane technologies for next generation on-board oxygen generating system.</p>			
<p>Title: Human Role in Semiautonomous Systems</p> <p>Description: Research new control/display concepts and technologies (e.g., information portrayal, control devices, decision-aiding algorithms). Identify best design to direct operator attention.</p> <p>FY 2015 Accomplishments: Demonstrated and quantified the use of selected automation technologies and various tools to enable choices between courses of action for the command and control of multiple RPAs. Integrated advanced visualization concepts and interaction methods for managing information from on- and off-board sources to support RPA operator decision-making into high-fidelity simulations for test and evaluation. Performed advanced simulation of adjustable, adaptive levels of automation to support flexible control of unmanned systems depending on mission and environmental context.</p> <p>FY 2016 Plans:</p>	5.580	6.456	3.180

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Integrate the current states of the platform, mission, environment, and airman operator into a global state database. Develop guidelines for interface design based upon computational problem solving method. Investigate ways to represent autonomous system competency against the current task/situation. Explore airman-autonomy teaming methods and metrics for Air Force applications. Perform advanced simulation of adjustable and adaptive automation to support flexible control of autonomous systems depending on mission and environmental context.</p> <p>FY 2017 Plans: Demonstrate effective deliberative-reactive control interaction methods of dynamic mission planning of heterogeneous multi-vehicle systems. Integrate agent architecture to perform sense-making of human, vehicle, and environmental factors to enhance task performance and mission effectiveness. Demonstrate real time adaptive airman-machine teaming and task allocation methods. Develop and demonstrate communication-compensated distributed control methods for RPA and flexible weapon concepts. Research and develop predictive, look-ahead tools for effects-based mission planning and execution. Develop retrospective methods with integrated machine learning for personalized decision support.</p>				
<p>Title: Battlespace Visualization</p> <p>Description: Advances science and technology associated with collecting, optimizing, displaying, and assimilating sensory information to enhance warfighter decision-making.</p> <p>FY 2015 Accomplishments: Evaluated image enhancement and fusion techniques for improving human perception and performance. Assessed visual analytics techniques for visualizing large, disparate data sets. Investigated cyber operations visualization techniques for transforming numerical data into actionable information. Explored decision aids for multisource fusion methods.</p> <p>FY 2016 Plans: Create cyber operations visualization techniques for transforming numerical data into actionable information. Develop and evaluate cyber operator system interfaces. Design decision aids for multisource fusion methods. Develop experimental test bed for more effective visualization of current and future sensor technologies. Prototype 3-D spatial viewers for mobile devices.</p> <p>FY 2017 Plans: Assess cyber operations visualization techniques for transforming numerical data into actionable information. Continue the development and perform assessments of new cyber interfaces and visualization work aids for cyber defense, offense, and network health. Test and evaluate decision aids for multisource fusion. Assess preliminary geospatial viewers on mobile devices for improved operator performance by evaluating how to best present and interact with Special Operations data. Initiate probabilistic human-centric visual target detection and recognition models.</p>		6.391	6.973	8.474
<p>Title: Battlespace Acoustics</p>		3.672	2.969	4.243

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016																
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>																
B. Accomplishments/Planned Programs (\$ in Millions)																		
Description: Conducts research on advanced auditory and communication technologies that mitigate effects of noise and enhance performance in operational environments.																		
FY 2015 Accomplishments: Validated auditory interfaces that enable the human operator to respond to cyber attacks through persistent auditory displays. Optimized the use of multimodal displays and visualizations to communicate time critical information to distributed teams. Validated the combined effectiveness of audio displays and multimodal interaction techniques to support human decision-making.																		
FY 2016 Plans: Evaluate auditory interfaces that enable airmen to respond to cyber attacks through persistent auditory displays. Validate the use of multimodal displays and visualizations to communicate time-critical information to distributed teams. Enhance the combined effectiveness of audio displays and multimodal interaction techniques to support airman decision-making. Develop communication metrics of intent of communicators compared to receivers' understanding. Develop metrics of airman-machine communication to incorporate emotional context.																		
FY 2017 Plans: Operationally demonstrate multimodal displays and visualizations to communicate time-critical information to distributed teams. Assess the combined effectiveness of audio displays and multimodal interaction techniques to support airman decision-making. Customize automatic speech recognition and generation models in developing interface technology for engagement with autonomous systems. Optimize communication metrics of intent of communicators compared to receivers' understanding. Optimize metrics of airman-machine communication to incorporate emotional context.																		
Accomplishments/Planned Programs Subtotals			27.443 28.913 31.539															
			<table border="1"> <tr> <td></td> <td>FY 2015</td> <td>FY 2016</td> </tr> <tr> <td>Congressional Add: Program Increase</td> <td align="center">10.000</td> <td align="center">3.333</td> </tr> <tr> <td>FY 2015 Accomplishments: Conducted Congressionally-directed effort.</td> <td></td> <td></td> </tr> <tr> <td>FY 2016 Plans: Conduct Congressionally-directed effort</td> <td></td> <td></td> </tr> <tr> <td>Congressional Adds Subtotals</td> <td align="center">10.000</td> <td align="center">3.333</td> </tr> </table>		FY 2015	FY 2016	Congressional Add: Program Increase	10.000	3.333	FY 2015 Accomplishments: Conducted Congressionally-directed effort.			FY 2016 Plans: Conduct Congressionally-directed effort			Congressional Adds Subtotals	10.000	3.333
	FY 2015	FY 2016																
Congressional Add: Program Increase	10.000	3.333																
FY 2015 Accomplishments: Conducted Congressionally-directed effort.																		
FY 2016 Plans: Conduct Congressionally-directed effort																		
Congressional Adds Subtotals	10.000	3.333																
C. Other Program Funding Summary (\$ in Millions)																		
N/A																		
Remarks																		

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 625329 / <i>Sensory Evaluation and Decision Science</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>				Project (Number/Name) 627757 / <i>Bioeffects</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
627757: <i>Bioeffects</i>	26.227	24.980	26.617	30.605	0.000	30.605	33.063	36.342	37.087	37.632	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 2015	FY 2016	FY 2017
Title: Optical Radiation Bioeffects	4.990	8.181	8.991
Description: Conduct laboratory experiments and field research on laser bioeffects, enabling military exploitation of laser technology while providing countermeasures for optical hazards/threats.			
FY 2015 Accomplishments: Integrated components of engagement-level simulations for laser bioeffects into broader DoD modeling and simulation products for the purpose of mission-level and campaign level models. Initiated studies to evaluate bioeffects, protection needs, and collateral effects of emerging directed energy systems concepts. Completed data collection for currently identified optical radiation damage and transient vision effects for use in next-generation of standardized personnel vulnerability models.			
FY 2016 Plans: Complete development of scalable effects simulation tool. Complete new standardized methodology for evaluation of laser devices that cause glare effects in multiple environments. Integrate probabilistic model of individual observer within overall modeling and simulation architecture for evaluating laser collateral effects. Complete 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. Complete 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:			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 627757 / <i>Bioeffects</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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 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.				
<p>Title: Radio Frequency Bioeffects</p> <p>Description: Conduct laboratory experiments and field research to enable safe exploitation of directed energy technologies for communication, target identification, and weapons development.</p> <p>FY 2015 Accomplishments: Conducted empirical laboratory tests on the human behavioral response to combined effects of directed energy sources. Investigated high peak power human performance effects. Explored whole-body biological effects of directly applied ultra-short pulses. Determined effects of RF overexposure on neurological tissue.</p> <p>FY 2016 Plans: Determine the impact of fast thermal gradients on neurological cells. Conduct empirical studies to verify computational tool for radio frequency-induced bio-thermal response. Validate radio frequency dosimetry suite for broad power and frequency range to support next generation high peak power dose determinations. Perform empirical and modeling studies to investigate the feasibility of using short pulse radio frequency energy for standoff membrane poration.</p> <p>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.</p>		4.665	9.225	10.131
<p>Title: Molecular Bioeffects</p> <p>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.</p> <p>FY 2015 Accomplishments: Advanced toxicity and nanotoxicity research; investigated/established toxicity impacts to selected organ systems in the body of advanced fuels, materials, and chemicals used to support existing and future weapon systems. Defined and pursued modulation of major cell pathways affecting human performance using in vitro and in vivo models and modeling and support human studies</p>		10.325	9.211	11.483

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 627757 / <i>Bioeffects</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>of the same. Conducted research to define toxicity issues in current and future aircraft environments. Began development of models incorporating toxicity data and mechanisms of action to inform sensor development and development of real-time sensing of pilot and hazard protection of ground crews. Conducted research to understand novel mechanisms of fundamental interaction of nanomaterials in a biological system.</p> <p>FY 2016 Plans: Conduct research to define toxicity issues in current and future aircraft environments. Pursue development and application capabilities of biomarkers for short-and long-term exposure modeling for existing and emerging militarily-relevant chemicals and materials. Conduct and develop novel research studies to elucidate mechanisms of fundamental interaction of nanomaterials in biological systems. Continue 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.</p> <p>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.</p>			
Accomplishments/Planned Programs Subtotals	19.980	26.617	30.605

	FY 2015	FY 2016
Congressional Add: Program Increase	5.000	-
FY 2015 Accomplishments: Conducted Congressionally-directed effort.		
Congressional Adds Subtotals	5.000	-

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

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / <i>Human Effectiveness Applied Research</i>	Project (Number/Name) 627757 / <i>Bioeffects</i>

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force / BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	168.628	185.926	185.671	0.000	185.671	196.053	199.133	204.116	202.690	Continuing	Continuing
623012: <i>Advanced Propulsion Technology</i>	-	17.250	19.670	27.095	0.000	27.095	29.673	29.612	30.686	28.566	Continuing	Continuing
623048: <i>Combustion and Mechanical Systems</i>	-	11.753	11.652	10.574	0.000	10.574	10.872	11.073	11.287	11.471	Continuing	Continuing
623066: <i>Turbine Engine Technology</i>	-	55.773	63.712	52.519	0.000	52.519	56.151	56.785	57.572	58.584	Continuing	Continuing
623145: <i>Aerospace Power Technology</i>	-	28.769	28.213	34.703	0.000	34.703	34.943	36.590	38.090	36.636	Continuing	Continuing
624847: <i>Rocket Propulsion Technology</i>	-	50.277	57.832	56.278	0.000	56.278	59.781	60.357	61.671	62.544	Continuing	Continuing
625330: <i>Aerospace Fuel Technology</i>	-	4.806	4.847	4.502	0.000	4.502	4.633	4.716	4.810	4.889	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 management 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.

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>
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B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	172.550	182.326	174.471	0.000	174.471
Current President's Budget	168.628	185.926	185.671	0.000	185.671
Total Adjustments	-3.922	3.600	11.200	0.000	11.200
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	3.600			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-0.147	0.000			
• SBIR/STTR Transfer	-3.775	0.000			
• Other Adjustments	0.000	0.000	11.200	0.000	11.200

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

Project: 624847: *Rocket Propulsion Technology*

Congressional Add: *Program Increase*

	FY 2015	FY 2016
	-	3.600
Congressional Add Subtotals for Project: 624847	-	3.600
Congressional Add Totals for all Projects	-	3.600

Change Summary Explanation

Decrease in FY 2015 reflects reprogramming to support Research and Development Projects

Increase in FY 2017 Other Adjustments is due to higher DoD priorities for increased emphasis in hypersonics.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
623012: <i>Advanced Propulsion Technology</i>	-	17.250	19.670	27.095	0.000	27.095	29.673	29.612	30.686	28.566	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 2015	FY 2016	FY 2017
Title: Hypersonic Scramjet Technologies	17.250	19.670	27.095
Description: Develop robust hydrocarbon fueled scramjet engine components and technologies to improve performance, operability, durability, and scalability for future platforms.			
FY 2015 Accomplishments: 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). Completed assessment of distortion impact on isolator operability. Continued to develop low internal drag flame stabilization devices and flight test engine components. Continued fabrication of heavyweight direct connect scramjet combustors in medium scale (ten times). Initiated direct connect testing of first performing contractor medium scale (ten times) scramjet combustors from Mach 3.5 to Mach 7. Continue fabrication of second performing contractor medium scale scramjet combustor.			
FY 2016 Plans: 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. Test advanced materials for application to scramjet engines. Continue to fabricate heavyweight direct connect scramjet combustors in medium scale (ten times). Complete direct connect testing of first performing contractor medium scale (ten times) scramjet combustor from Mach 3.5 to Mach 7. Complete fabrication of second performing contractor medium scale scramjet combustor.			
FY 2017 Plans: 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.			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623012 / <i>Advanced Propulsion Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Continue testing advanced materials for application to scramjet engines. Complete direct connect testing of second performing contractor medium scale (ten times) scramjet combustor from Mach 3.5 to Mach 7.			
Accomplishments/Planned Programs Subtotals	17.250	19.670	27.095

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 623048 / <i>Combustion and Mechanical Systems</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
623048: <i>Combustion and Mechanical Systems</i>	-	11.753	11.652	10.574	0.000	10.574	10.872	11.073	11.287	11.471	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 2015	FY 2016	FY 2017
Title: Combustion Technologies	4.559	4.520	4.402
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 2015 Accomplishments: Developed combustor, augmentor and constant volume combustion or pressure gain combustion technologies such as rotational detonation engines (RDEs) to enable the next generation of gas turbine engines, new engine cycles, and combined-cycles. Explored the interactions and effects of compressor and turbine components on the combustor and combustor materials, to reduce engine weight and increase efficiency. 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. Transitioned ultra-compact combustor technology to performing contractor. Designed full annular High G Ultra Compact Combustor. Demonstrated RDE and turbine integration. Demonstrated gaseous heavy fuel detonation in RDE.			
FY 2016 Plans: Continue development of combustor, augmentor, constant volume combustion and pressure gain combustion technologies such as 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. 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623048 / <i>Combustion and Mechanical Systems</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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 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.				
Title: Diagnostic Technologies Description: Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary propulsion technologies. FY 2015 Accomplishments: Continued development and demonstration of diagnostic systems for high-bandwidth kilo-hertz to mega-hertz (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. Applied to laboratory flame test rigs, engine test cells, and fielded systems. FY 2016 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. Initiate providing sufficient data to support CFD combustion model development. 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.		0.865	0.900	0.700
Title: Lubricant Technologies		3.057	3.030	2.701

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623048 / <i>Combustion and Mechanical Systems</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Description: Develop, test, and qualify advanced turbine engine lubricants. Generate and maintain military specifications for aviation engine lubricants.</p> <p>FY 2015 Accomplishments: Executed plan for transitioning Enhanced Ester (EE) oils into the fleet. Developed transition plans for mechanical system health monitoring system technologies. Continued investigating advanced lube system thermal management technologies for fuel efficient and hi-mach engine applications.</p> <p>FY 2016 Plans: Demonstrate EE oils in F119 and F135 Component Improvement Program (CIP) Accelerated Maturation Testing (AMT) engines in preparation for transition to F-22 & F-35. Begin developing Grade 4 oil Phase-out plan (F-22 & F-35). Plan for F-22 & F-35 flight tests of EE oils. Initiate Research and Development (R&D) investigation of novel ionic fluids as potential lubricants for extreme environments (i.e., hi-Mach).</p> <p>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.</p>			
<p>Title: Bearing Technologies</p> <p>Description: Develop and test advanced bearing material technology and bearing concepts for small, intermediate, and large-scale turbine engine applications.</p> <p>FY 2015 Accomplishments: Continued full-scale bearing rig testing in support of adaptive, fuel efficient engines. Continued oil-free, foil bearing R&D in support of supersonic expendable engines and remotely piloted aircraft. Continued developing improved bearing material life model. Continued maturing active bearing thrust control system and fuse with engine prognostics health monitoring system for future fuel efficient engines.</p> <p>FY 2016 Plans: Complete full-scale bearing rig testing in support of adaptive, fuel efficient engines. Complete oil-free, foil bearing R&D in support of supersonic expendable engines and remotely piloted aircraft. Experimentally validate improved bearing material life model. Investigate failure mechanisms of advanced bearing alloys. Continue maturing active bearing thrust control system and fuse with</p>	3.272	3.202	2.771

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623048 / <i>Combustion and Mechanical Systems</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
engine prognostics health monitoring system for future efficient engines. Initiate 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/prognostic health management (PHM) system for large man-rated and medium-scale propulsion.				
Accomplishments/Planned Programs Subtotals		11.753	11.652	10.574
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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
623066: <i>Turbine Engine Technology</i>	-	55.773	63.712	52.519	0.000	52.519	56.151	56.785	57.572	58.584	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 2015	FY 2016	FY 2017
Title: Turbofan/Turbojet Engine Core Technologies	27.187	31.057	23.523
Description: Develop core turbofan/turbojet engine components (i.e., compressors, combustors, and turbines) for fighters, bombers, sustained supersonic/hypersonic cruise vehicles, and transports.			
FY 2015 Accomplishments: Continued developing 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 combustor and turbine components operating in a realistic engine environment. Continued to develop improved compressor aerodynamic design tools to extend engine operability and efficiency. Completed conceptual design, and initiated detailed design of efficient, very high pressure ratio core component technologies			
FY 2016 Plans: Complete development of modeling and simulation tools for advanced components including coupled aerothermal models; highly loaded, low emissions combustion systems; and turbine durability designs. Perform structural assessment research of mechanical and turbine components operating in a realistic engine environment. Continue development of improved compressor aerodynamic design tools to extend engine operability and efficiency. Complete detailed design of efficient, very high pressure ratio core component technologies.			
FY 2017 Plans:			

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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.				
<p>Title: Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies</p> <p>Description: Develop turbofan/turbojet engine components (i.e., fans, nozzles, etc.) used in engines for fighters, bombers, sustained supersonic strike and hypersonic cruise vehicles, and transports.</p> <p>FY 2015 Accomplishments: Initiated adaptive engine conceptual designs to reduce specific fuel consumption reduction by up to 35% for embedded high bypass turbofans, and for sustained supersonic strike applications. Continued to develop modeling and simulation tools, including methods to predict behavior of serpentine inlets and nozzles. Conducted bench and rig tests to validate modeling and simulation tools to predict fan/inlet interaction for both podded and embedded propulsion systems. Conducted bench and rig tests to validate probabilistic ignition prediction tool for advanced augmentor design system. Developed models to validate function and durability of high temperature electronics for engine control.</p> <p>FY 2016 Plans: Complete 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. Continue development of modeling and simulation tools, including methods to predict behavior of serpentine inlets and nozzles. Initiate rig tests to validate modeling and simulation tools to predict fan/inlet interaction for both podded and embedded propulsion systems. Complete rig tests to validate probabilistic ignition prediction tool for advanced augmentor design system. Validate models for function and durability of high temperature electronics for engine control.</p> <p>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. Continue rig tests to validate modeling and simulation tools to predict fan/inlet interaction for both podded and embedded propulsion systems.</p>		23.128	26.283	23.589
<p>Title: Missile and Remotely Piloted Aircraft Engine Technologies</p> <p>Description: Develop limited life engine components for missile and remotely piloted aircraft (RPA) applications, including long-range supersonic and hypersonic vehicles.</p> <p>FY 2015 Accomplishments:</p>		4.424	5.054	4.424

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Continued to develop and apply advanced modeling and simulation tools for variable cycle component design, advanced cooling concepts, compact augmentors, and composite structures. Continued to demonstrate advanced designs in rig testing. Utilized validation data to develop improved test protocol for small engine augmentor designs.</p> <p>FY 2016 Plans: Complete development of advanced modeling and simulation tools for variable cycle component design, advanced cooling concepts, compact augmentors, and composite structures. Continue to demonstrate advanced component designs in rig testing. Utilize validation data to develop improved test protocol for small engine augmentor designs.</p> <p>FY 2017 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. 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.</p>				
<p>Title: Turboshaft/Turboprop and Small Turbofan Engine Technologies</p> <p>Description: Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports.</p> <p>FY 2015 Accomplishments: Continued to refine and develop and apply advanced modeling and simulation tools for advanced cooling concepts, high efficiency gearboxes, and high performance airfoils. Continued to develop advanced vibration and temperature sensors for use in demonstration of engine durability requirements.</p> <p>FY 2016 Plans: Continue to refine and apply advanced modeling and simulation tools for advanced cooling concepts, high efficiency gearboxes, and high performance airfoils. Demonstrate advanced vibration and temperature sensors for use in engine durability testing.</p> <p>FY 2017 Plans: Develop and validate modeling and simulation tools to achieve very high levels of loading for advanced low pressure turbine components.</p>		1.034	1.318	0.983
Accomplishments/Planned Programs Subtotals		55.773	63.712	52.519
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623066 / <i>Turbine Engine Technology</i>

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.

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 623145 / <i>Aerospace Power Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
623145: <i>Aerospace Power Technology</i>	-	28.769	28.213	34.703	0.000	34.703	34.943	36.590	38.090	36.636	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops electrical and thermal management technologies 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 2015	FY 2016	FY 2017
Title: High Power System Technologies	28.769	28.213	34.703
Description: Develop integrated system architecture 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 2015 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. Initiated integrated ground demonstration of adaptive power and thermal management system for next generation air platforms. Initiated development of advanced, safe energy storage, power distribution, and management systems to include Silicon Carbide applications and batteries.			
FY 2016 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. Complete integrated ground demonstration of adaptive power and thermal management system for next generation air platforms. Complete power, thermal and propulsion architecture study for future air platforms. Continue development of advanced, safe energy storage, power distribution, and management systems to include Silicon Carbide applications and batteries. Initiate power and thermal development toward demonstration of tactical aircraft high-power payload capability, e.g. laser weapon system.			
FY 2017 Plans:			

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 623145 / <i>Aerospace Power Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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 power and thermal development toward demonstration of tactical aircraft high-power payload capability, e.g. laser weapon system. Complete design of laser weapon system demonstration architecture.			
Accomplishments/Planned Programs Subtotals	28.769	28.213	34.703

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.

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
624847: <i>Rocket Propulsion Technology</i>	-	50.277	57.832	56.278	0.000	56.278	59.781	60.357	61.671	62.544	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 2015	FY 2016	FY 2017
Title: Fuel Technologies	6.414	6.427	6.854
Description: Develop, characterize, and test advanced hydrocarbons, energetics, solid propellants, and monopropellants to increase space launch payload capability and refine new synthesis methods.			
FY 2015 Accomplishments: Scaled up methods for removing components from fuels that adversely affect fuel coking in rocket engine environments. Evaluated scaled-up propellants in advanced combustion devices to determine materials compatibility and performance to include supporting large-scale motor tests. Developed advanced binder systems to enable use of advance solid propellant ingredients with significant improvements over state of the art. Acquired 60-liter pilot plant and "large-scale" continuous flow micro reactor for the on-demand and on-site production of common and new propellant ingredients. Continued development and characterization of next generation ionic liquid propellants for use in spacecraft and missile defense applications.			
FY 2016 Plans: Complete scale up methods for removing components from fuels that adversely affect fuel coking in rocket engine environments. Continue to evaluate scaled-up propellants in advanced combustion devices to determine materials compatibility and performance to include supporting large-scale motor tests. Continue to develop advanced binder systems to enable use of advance solid propellant ingredients with significant improvements over state-of-the-art. Continue to utilize 60-liter batch reactor to supplement micro continuous flow technology for the production of propellant ingredients. Continue development and characterization of			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>next generation ionic liquid propellants for use in spacecraft and missile defense applications. Evaluate the effects of ingredient variability on solid propellant properties and ageing characteristics.</p> <p>FY 2017 Plans: Complete scale-up methods for removing components from fuels that cause fuel coking in rocket engines. 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 of next generation 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.</p>				
<p>Title: Liquid Engine Combustion Technologies</p> <p>Description: Develop advanced liquid engine combustion technology for improved performance, while preserving chamber lifetime and reliability needs for engine uses in heavy lift space vehicles.</p> <p>FY 2015 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 performing contractor for use in Hydrocarbon Boost (HCB), a rocket engine ground demonstration. Continued hot fire tests in combustion stability rig and fed data to HCB to influence supporting design efforts. Continued combustion stability modeling critical to supporting HCB Demonstration and all future hydrocarbon fueled liquid rocket engines. Released beta version of analysis/design code to rocket community. Completed characterization of novel cooling channels and transfer info to HCB to influence rocket engine thrust chamber design. Acquired first available fuel lubricity and wear data in support of high performance engine turbomachinery lifetime and operability goals. 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. Designed advanced high heat flux rig to test fuels using orders of magnitude less fuel and time to determine feasibility of fuel for further use/consideration. Continued to evaluate and develop advanced material solutions for high temperature components in rocket engines. Continued to develop and demonstrate in-house, moderate scale liquid rocket component testing capability; began testing a sub-scale preburner in the facility to provide additional risk reduction for future engine designs. Continued to develop high performance compact liquid rocket engine technologies. Completed modeling and simulation of fuel film cooling flow under conditions relevant to liquid rocket engines and demonstrated the significance of unsteadiness on the film cooling effectiveness.</p> <p>FY 2016 Plans: Continue evaluation of injector concepts in hot fire conditions. Continue efforts looking at multi-injector designs and control effectors. Continue transition of candidate injector technologies to performing contractor for use in HCB, a rocket engine</p>		5.344	6.319	6.837

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>ground demonstration. Continue hot fire tests in combustion stability rig and feed data to HCB to influence supporting design efforts. Continue combustion stability modeling critical to supporting HCB Demonstration and all future hydrocarbon fueled liquid rocket engines. Develop reduced chemical kinetic mechanism for fuel combustion implementable in CFD simulations (first & second phase: 1 to 80 atmospheres of pressure). Experimentally evaluate novel cooling channel designs developed via additive manufacturing. Extend modeling and simulation of fuel film cooling to include additional physical effects in order to close gaps with experimental data. Continue 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. Complete a test article that will enable heat transfer tests at conditions relevant to full scale boost engines in a laboratory environment, and conduct testing. Continue to evaluate and develop advanced material solutions for high temperature components in rocket engines. Continue to develop and demonstrate in-house, moderate scale liquid rocket component testing capability; continue testing a sub-scale preburner in the facility to provide additional risk reduction for future engine designs. Continue to develop high performance compact liquid rocket engine technologies.</p> <p>FY 2017 Plans: Continue evaluation of injector concepts in hot-fire conditions. Continue examination of multi-injector designs and control effectors. Provide direct customer support to evaluate and troubleshoot injector designs and issues for HCB. Deliver high-fidelity injector simulations that compliment experimental data. Continue hot fire tests in combustion stability rig and feed data to HCB to influence supporting design efforts. Continue combustion stability modeling critical to supporting HCB Demonstration and all future hydrocarbon fueled liquid rocket engines. Deliver combustion stability codes to rocket community, enabling more robust and stable engine designs. Develop fundamental physics of fuel film cooling. Deliver validated and verified film fuel cooling modeling and simulation codes. 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. Test survivability and effectiveness of thermal barrier coatings for advanced hydrocarbon boost engine thrust chambers.</p>			
<p>Title: Advanced Liquid Engine Technologies</p> <p>Description: Develop advanced liquid engine technologies for improved performance, while increasing life and reliability needs for engine uses in expendable and reusable launch vehicles.</p> <p>FY 2015 Accomplishments: Continued to develop enabling hydrocarbon boost technology for future spacelift concepts and continue risk reduction activities for the development of HCB technologies such as subscale turbopump assembly and thrust chamber assembly. Completed Preliminary Design Reviews for the Preburner and Turbopump.</p> <p>FY 2016 Plans:</p>	15.917	17.517	17.906

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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<p>Continue to develop enabling HCB technology for future spacelift concepts and continue risk reduction activities for the development of HCB technologies (turbopump assembly, thrust chamber assembly). Complete Critical Design Review for the full-scale Preburner. Complete Preliminary and Critical Design Review for the full-scale Preburner and Thrust Chamber. Complete fabrication of the Preburner and begin testing. Begin fabrication of the Thrust Chamber. Begin exploring engine concepts for next generation, beyond 2035, launch vehicles and concepts to effect cost reductions. Also explore changing facility needs and requirements to support characterization of components and research demonstrators.</p> <p>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.</p>			
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<p>Title: On-Orbit Propulsion Technologies</p> <p>Description: Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for station-keeping, repositioning, and orbit transfer for satellites and satellite constellations.</p> <p>FY 2015 Accomplishments: Conducted scale-up of advanced monopropellants and evaluated advanced ignition schemes and chamber concepts. Continued development of next generation high power electric spacecraft propulsion. Continued advanced modeling and simulation tool developments to improve design and analysis tools for a wide range of spacecraft propulsion concepts/technologies, incorporating concepts/technologies and accurately model the physics. Continued transition of new thruster modeling framework to spacecraft industry for use in future designs. Explored and developed new generation of chemical spacecraft thruster technologies. Continued support of future NASA flight of Air Force Research Lab's (AFRL) non-toxic monopropellant.</p> <p>FY 2016 Plans: Conduct scale-up of advanced monopropellants and evaluate advanced ignition schemes and chamber concepts, including integration of advanced plume diagnostic capabilities. Continue development of next generation high power electric spacecraft propulsion for increased efficiency, operability, and flexibility. Continue advanced modeling and simulation tool developments to improve design and analysis tools for a wide range of spacecraft propulsion concepts/technologies, incorporating concepts/technologies and accurately model the physics. Transition new thruster/plume modeling framework to spacecraft industry for use in future designs. Release initial version of code to industry partners. Explore and develop new generation of chemical spacecraft thruster technologies. Complete support of NASA flight of AFRL non-toxic monopropellant (replaces toxic monopropellant currently used in spacecraft).</p> <p>FY 2017 Plans:</p>	13.895	12.317	13.190
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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Complete 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, incorporating concepts/technologies and accurately model the physics. 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 chemical spacecraft thruster technologies.			
<p>Title: Space Access and Strike Applications</p> <p>Description: Develop missile propulsion and boost technologies for space access and strike applications.</p> <p>FY 2015 Accomplishments: Continued development of 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.</p> <p>FY 2016 Plans: Continue to develop advanced tactical propulsion. Continue development and evaluation of next generation of updated, physics-based modeling, simulation, and analysis tools for missile propulsion components and applications. Continue to develop advanced component technologies for missile propulsion applications for strategic and strike systems helping to ensure their long-term sustainment. Continue propellant development efforts including long-life propellants.</p> <p>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. Use 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 between Air Force, Navy, and Missile Defense Agency needs for this technology. Continue propellant development efforts including long-life propellants.</p>	5.171	7.094	7.146
<p>Title: Ballistic Missile Technologies</p> <p>Description: Develop missile propulsion technologies and aging and surveillance technologies for ballistic missiles.</p> <p>FY 2015 Accomplishments: Continued application of 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</p>	3.536	4.558	4.345

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 624847 / <i>Rocket Propulsion Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
data acquisition and reduced uncertainty in ballistic missile life predictions. Supported transition of previous tools, models, data management system to user.			
<i>FY 2016 Plans:</i> 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 development efforts to further improve data acquisition and reduce uncertainty in ballistic missile life predictions. Support transition of previous tools, models, data management system to user. Improve the fidelity and precision of non-destructive evaluation tools, improving capability to determine flaw size, orientation, and location. Begin long-term validation of tools through long-term aging of sub-scale motors. Sub-scale motors will be periodically dissected to validate the sensor and analytical analysis of each motor.			
<i>FY 2017 Plans:</i> 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. Sub-scale motors will be periodically dissected to validate the sensor and analytical analysis of each motor.			
Accomplishments/Planned Programs Subtotals	50.277	54.232	56.278

	FY 2015	FY 2016
<i>Congressional Add:</i> Program Increase	-	3.600
<i>FY 2016 Plans:</i> Conduct Congressionally directed efforts		
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.

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>				Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
625330: <i>Aerospace Fuel Technology</i>	-	4.806	4.847	4.502	0.000	4.502	4.633	4.716	4.810	4.889	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 2015	FY 2016	FY 2017
<p>Title: Alternative Fuels</p> <p>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.</p> <p>FY 2015 Accomplishments: Evaluated alternative fuels being considered for addition to commercial aviation jet fuel, which Air Force will use due to conversion to new fuel standards.</p> <p>FY 2016 Plans: Continue to evaluate advanced cellulosic alternative fuels being considered for addition to commercial aviation jet fuel, which Air Force will use due to conversion to new fuel standards.</p> <p>FY 2017 Plans: Continue to evaluate advanced alternative fuels being considered for addition to commercial aviation jet fuel, which Air Force will use due to conversion to new fuel standards.</p>	0.193	0.194	0.100
<p>Title: Integrated Thermal and Energy Management</p> <p>Description: Develop and demonstrate advanced components and conduct performance assessments of advanced aircraft integrated thermal and energy management systems for engines and aircraft.</p> <p>FY 2015 Accomplishments: Developed and evaluated nano-catalysts/nano-additives for enhancing heat sink and reducing coking.</p> <p>FY 2016 Plans:</p>	1.450	1.463	1.401

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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Evaluate fuel-based closed-loop liquid precooler systems for tactical air platforms. Optimize the composition of next generation endothermic fuel for use with catalysts for maximum heat sink and reduced coking.			
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<p>FY 2017 Plans: Continue to develop fuel and catalyst approaches to improve endothermic fuel heat sink and minimize coking.</p>			
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<p>Title: Fuel Logistics</p>	1.450	1.463	1.401
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<p>Description: Study and evaluate low-cost approaches to reduce fuel logistics footprint to reduce cost. Study fuel logistics vulnerabilities and develop detection and mitigation technologies.</p>			
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<p>FY 2015 Accomplishments: Evaluated anti-microbial peptides and biological active control for mitigating biological growth an aviation fuels.</p>			
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<p>FY 2016 Plans: Evaluate AF capability to reduce/eliminate additives from F-24 (commercial Jet A + additives).</p>			
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<p>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.</p>			
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<p>Title: Combustion Emissions and Performance</p>	1.713	1.727	1.600
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<p>Description: Develop and test advanced emissions diagnostic techniques for airbreathing propulsion systems. Conduct evaluations of the combustion and emissions characteristics of aviation fuels.</p>			
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<p>FY 2015 Accomplishments: Evaluated advanced diagnostics to assess combustor engine emissions and combustion characteristics.</p>			
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<p>FY 2016 Plans: Initiate combustor/hot section materials durability study as a function of fuel composition.</p>			
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<p>FY 2017 Plans: Evaluate fuel composition effects on operability and emissions of advanced developmental combustors and engines.</p>			
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Accomplishments/Planned Programs Subtotals	4.806	4.847	4.502
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C. Other Program Funding Summary (\$ in Millions)			
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N/A			
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Remarks			
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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force Date: February 2016

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / <i>Aerospace Propulsion</i>	Project (Number/Name) 625330 / <i>Aerospace Fuel Technology</i>
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D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research	R-1 Program Element (Number/Name) PE 0602204F I Aerospace Sensors
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	118.654	152.175	155.174	0.000	155.174	162.992	164.291	167.682	169.931	Continuing	Continuing
622002: <i>Electronic Component Technology</i>	-	27.194	38.234	41.326	0.000	41.326	41.991	42.115	42.927	43.495	Continuing	Continuing
622003: <i>EO Sensors & Countermeasures Tech</i>	-	27.387	26.805	21.535	0.000	21.535	26.813	26.979	27.556	27.974	Continuing	Continuing
622005: <i>Cyber Technology</i>	-	0.000	0.000	10.200	0.000	10.200	6.520	6.649	6.788	6.855	Continuing	Continuing
626095: <i>Sensor Fusion Technology</i>	-	24.037	27.359	35.322	0.000	35.322	35.655	36.262	37.044	37.544	Continuing	Continuing
627622: <i>RF Sensors and Countermeasures Tech</i>	-	40.036	59.777	46.791	0.000	46.791	52.013	52.286	53.367	54.063	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) 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 sensors; 4) technologies to manage and fuse on-board sensor information for timely, comprehensive situational awareness; and 5) technology for reliable, all-weather surveillance, reconnaissance, and precision strike RF sensors and electronic combat 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.

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>
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B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	118.321	147.291	173.838	0.000	173.838
Current President's Budget	118.654	152.175	155.174	0.000	155.174
Total Adjustments	0.333	4.884	-18.664	0.000	-18.664
• Congressional General Reductions	0.000	-0.116			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	5.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	1.524	0.000			
• SBIR/STTR Transfer	-1.191	0.000			
• Other Adjustments	0.000	0.000	-18.664	0.000	-18.664

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

Project: 627622: *RF Sensors and Countermeasures Tech*

Congressional Add: *Program Increase*

Congressional Add Subtotals for Project: 627622

Congressional Add Totals for all Projects

	FY 2015	FY 2016
	-	5.000
	-	5.000
	-	5.000

Change Summary Explanation

Increase in FY 2015 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358

Decrease in FY 2017 due to higher DoD priorities.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>				Project (Number/Name) 622002 / <i>Electronic Component Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
622002: <i>Electronic Component Technology</i>	-	27.194	38.234	41.326	0.000	41.326	41.991	42.115	42.927	43.495	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project focuses on generating, controlling, receiving, and processing electronic signals for RF sensor aerospace 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 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 electronic component technologies. The project aims to demonstrate significantly improved military sensors of smaller size, lower weight, lower cost, lower power dissipation, higher reliability, and improved performance. The device and component 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 2015	FY 2016	FY 2017
Title: Multifunction Sensor Subsystems	8.120	9.222	9.961
Description: Develop, analyze, demonstrate, and perform engineering trade studies for technologies for compact, affordable, multi-function subsystems for aerospace sensors.			
FY 2015 Accomplishments: Developed, refined and demonstrated advanced trade space and prediction tools for emerging devices. Completed engineering trade analysis for baseline sensing system technologies. Continued development of trade space models for advanced system of systems sensing and electronic warfare simulations.			
FY 2016 Plans: Complete baseline trade space models for use in advanced system of systems simulations. Complete advanced trade space tools for emerging technologies. Continue development of advanced prediction tools. Initiate next level of fidelity models for advanced future multifunction subsystem concepts. Initiate prototype multi-function demonstrations of concepts determined through analysis and design tools.			
FY 2017 Plans: Complete development of next generation advanced prediction tools. Refine fidelity of models for multifunction subsystem concepts. Continue to develop and optimize multi-function prototypes.			
Title: Microelectronic/Optoelectronic Technologies	9.061	10.145	10.987

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622002 / <i>Electronic Component Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Description: Develop and assess new microelectronic/optoelectronic material, device and fabrication technologies for next generation imaging, precision strike, and battlespace access across all Air Force domains.</p> <p>FY 2015 Accomplishments: Completed device concept baseline for multi-use (sense environments and counter threat) applications. Continued the identification and evaluation of concepts for compact, high performance devices and components. Demonstrated projected gains through characterization of test articles in relevant environments. Continued development of tools and methods to design and analyze game-changing components.</p> <p>FY 2016 Plans: Complete identification and evaluation of innovative concepts for generation after next compact, high performance devices and components. Demonstrate prototype of a highly integrated microsystem. Continue to refine tools and methods to design, build and analyze game changing component technologies. Initiate evaluation of emerging component technologies against device concept baseline for multi-use applications.</p> <p>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 next generation device concepts exploiting breakthrough materials discovery.</p>			
<p>Title: Antennas</p> <p>Description: Design and develop antenna subsystems and components for airborne and space-based surveillance. Develop novel and advanced antennas for lightweight, conformal arrays.</p> <p>FY 2015 Accomplishments: Continued fabrication and characterization of innovative devices to extend bandwidth, reconfigurability, tunability, and trustworthiness. Continued demonstrations of multi-wavelength, agile and affordable advanced detectors and arrays with emphasis on integrated filtering. Continued the design and fabrication of high-brightness and agile waveform sources to integrate into microsystems and subsystems.</p> <p>FY 2016 Plans: Continue to explore and evaluate innovative devices for increase bandwidth and tunability. Continue demonstrations of multi-wavelength, agile and affordable advanced detectors and arrays. Complete characterization and evaluation of novel high-brightness and agile waveform source.</p> <p>FY 2017 Plans:</p>	4.763	5.417	5.851

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622002 / <i>Electronic Component Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Continue to explore and evaluate innovative materials and devices for reduced cost, size, weight and power consumption. Initiate identification of novel device concepts exploiting new material discoveries. Complete demonstration of current advanced multi-wavelength, agile and affordable advanced detector and array.				
<p>Title: Trusted Systems for ISR and Avionics Systems</p> <p>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, Electro-Optical/Infrared (EO/IR) sources, EO/IR detectors, beam control and waveguides, and trusted and reliable electronics.</p> <p>FY 2015 Accomplishments: Continued the identification of COTS and GOTS technologies nearly ready or ready for integration into microsystem and subsystem demonstration. Developed, matured and demonstrated solutions utilizing COTS/GOTS technology that enable cyber-hardness, rad-hardness and resistance to tampering.</p> <p>FY 2016 Plans: Demonstrate trusted sensing and electronic warfare subsystem technologies utilizing the integration of low-cost commercially available electronics with exquisite emerging military electronics. Initiate vulnerability model and simulation capability to assess cost and liability of trust in electronics.</p> <p>FY 2017 Plans: Demonstrate latest ability to determine trust in design and trust in fabrication of highly integrated microsystems. Continue modeling and simulation architecture development to inform and predict mission assurance for highly integrated microsystems, devices and materials.</p>		5.250	6.190	6.686
<p>Title: Advanced Components for Electronic Warfare</p> <p>Description: Develop, mature, and demonstrate critical electronic technologies to enable revolutionary electronic warfare subsystems.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: For FY 2015, the work for this effort originally was performed in Project 622003, EO Sensors & Countermeasures Tech, under the effort EO/IR Sensors and Threat Countermeasures Technologies.</p>		0.000	7.260	7.841

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622002 / <i>Electronic Component Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Develop, mature and demonstrate critical electronics technologies to enable highly agile, closed loop sense, learn and adapt revolutionary electronic warfare subsystems. Demonstrate advancements in real time hardware configurability and the integration at the microsystem level of electrons and photons. <i>FY 2017 Plans:</i> Continue to develop, mature and demonstrate technologies critical to advanced cognitive and networked electronic warfare subsystems and components. Identify and exploit advanced devices and microsystems to enable highly miniature and affordable Electronic Warfare (EW) systems. Continue to demonstrate advancements of real time hardware configurability through integration of electrons and photons at the microsystem level.			
Accomplishments/Planned Programs Subtotals	27.194	38.234	41.326

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>				Project (Number/Name) 622003 / <i>EO Sensors & Countermeasures Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
622003: <i>EO Sensors & Countermeasures Tech</i>	-	27.387	26.805	21.535	0.000	21.535	26.813	26.979	27.556	27.974	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

	FY 2015	FY 2016	FY 2017
<p>Title: Non-cooperative Detection and Identification Technologies</p> <p>Description: Develop innovative optical sensing technology for non-cooperative detection and identification of airborne and ground-based targets.</p> <p>FY 2015 Accomplishments: Evaluated, via modeling and simulation, innovative sensor concepts to increase long range image quality for passive electro-optical and infrared reconnaissance sensors for high altitude platforms. Advanced longwave infrared hyperspectral imaging and determined operationally useful radiometric sensitivity and area coverage rate for a sensor system that is practical and affordable.</p> <p>FY 2016 Plans: In FY 2016 and beyond, work accomplished under this effort will be reported under the effort Passive EO/IR Sensing in Contested Environments.</p> <p>FY 2017 Plans: N/A</p>	11.864	0.000	0.000
<p>Title: EO/IR Sensors and Threat Countermeasure Technologies</p> <p>Description: Develop optical and infrared sensors for airborne and space situational awareness and threat warning. Develop countermeasure technologies for use against infrared and electro-optical guided missile threats.</p> <p>FY 2015 Accomplishments:</p>	7.791	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622003 / <i>EO Sensors & Countermeasures Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Initiated synthetic aperture ladar (SAL) techniques based on modeling and simulation previously conducted to enhance spatial resolution beyond the diffraction limit of conventional optics through the coherent collection and processing of laser illuminated scene radiance. Advanced research to improve system capabilities and provide high confidence target identification at standoff ranges for both reconnaissance and targeting platforms.</p> <p>FY 2016 Plans: In FY 2016 and beyond, work accomplished under this effort will be reported under the effort Laser Radar Sensing in Contested Environments and in project 622002, Electronic Component Technology, under the effort Advanced Components for Electronic Warfare.</p> <p>FY 2017 Plans: N/A</p>				
<p>Title: Optical Technologies</p> <p>Description: Develop optical spectrum transmitter, detector and agile aperture technologies capable of sensing multiple target characteristics for robust non-cooperative target identification and future infrared countermeasure systems.</p> <p>FY 2015 Accomplishments: Initiated research in the use of vibrometry and range-Doppler sensing technology to aid in target identification and decoy discrimination at ranges at which the imaging performance is insufficient. Supported phenomenology understanding, signature collection, sensor product visualization, and automatic target recognition in collaboration with other Air Force Research Laboratory directorates. Continued prototyping of a flexible, next generation long wave infrared hyperspectral imaging spectrometer.</p> <p>FY 2016 Plans: In FY 2016 and beyond, work accomplished under this effort will be reported under the effort Passive EO/IR Sensing in Contested Environments.</p> <p>FY 2017 Plans: N/A</p>		7.732	0.000	0.000
<p>Title: Passive EO/IR Sensing in Contested Environments</p> <p>Description: Develop innovative passive optical sensing technology to support surveillance and reconnaissance in contested environments. Develop high performance focal planes, aperture technologies and imaging techniques capable of long range target detection and characterization for ISR.</p> <p>FY 2015 Accomplishments:</p>		0.000	8.917	7.178

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622003 / <i>EO Sensors & Countermeasures Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
N/A				
<p>FY 2016 Plans: For FY 2015, the work for this effort originally was performed under the effort Optical Technologies.</p> <p>Evaluate, via modeling and simulation, innovative sensor concepts to increase long range image quality for high altitude passive electro-optical and infrared reconnaissance sensors at twice the current operational range. Conduct initial demonstrations of the effectiveness of computational image restoration and noise reduction. Refine and demonstrate candidate component technologies for jitter mitigation and restoration in the presence of deep turbulence. Investigate system-level impacts of image restoration technology using a commercial reconnaissance sensor and platform. Determine the utility of non-traditional sensor architectures in improving image quality and the operational range of passive imagers. Mature longwave infrared hyperspectral imaging to achieve operationally useful radiometric sensitivity, detection performance, and area coverage rates at far off nadir viewing geometries. Continue prototyping of a flexible, next generation long wave infrared hyperspectral imaging spectrometer. Complete evaluations of prototype Silicon-Gallium (SiGa) long wave infrared detectors at high operating temperatures. Continue investigation of high performance long wave infrared detectors for hyperspectral imaging. Initiate technology developments for next generation infrared search and track (IRST) components and systems focused on performance in clutter using staring focal planes and reduced complexity implementations. Adapt passive sensing models to support IRST technology trade analyses.</p> <p>FY 2017 Plans: Evaluate, via modeling and simulation, innovative sensor concepts to increase long range image quality for high altitude passive electro-optical and infrared reconnaissance sensors at twice the current operational range. Test prototype systems and subsystems as appropriate to assess progress towards goals. Continue and advance demonstrations of the effectiveness of computational image restoration and noise reduction. Refine and demonstrate 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 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. Demonstrate technologies and components supporting longwave infrared hyperspectral imaging at operationally useful radiometric sensitivity, detection performance, and area coverage rates at far off nadir viewing geometries. Continue prototyping of a flexible, next generation long wave infrared hyperspectral imaging spectrometer. Continue investigation of high performance long wave infrared detectors for hyperspectral imaging. Continue technology and architecture developments for next generation IRST components and systems focused on performance in clutter using novel optical concepts, staring focal planes, and reduced complexity implementations. Adapt passive sensing models to support IRST technology trade analyses. Explore concepts for merging IRST sensing with other sensing modalities.</p>				
Title: Laser Radar Sensing in Contested Environments		0.000	17.888	14.357

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622003 / <i>EO Sensors & Countermeasures Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Description: Develop innovative laser sensing technology for non-cooperative detection and 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.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: For FY 2015, the work for this effort originally was performed under the effort EO/IR Sensors and Threat Countermeasure Technologies.</p> <p>Develop synthetic aperture lidar (SAL) techniques based on modeling and simulation previously conducted to enhance spatial resolution beyond the diffraction limit of conventional optics. Research the problem of improving system capabilities to provide high confidence target identification at standoff ranges for both reconnaissance and targeting platforms. Continue fabrication and characterization of critical components for a long range SAL demonstration system. Design and fabricate next generation long range holographic aperture lidar imaging testbed focused on progression to platform compatible configurations. Continue research in the use of remote laser vibrometry and range-Doppler sensing technology to aid in target identification and decoy discrimination at ranges at which the imaging performance is insufficient. Research will also support phenomenology understanding, signature collection, sensor product visualization, and automatic target recognition in collaboration with other Air Force Research Laboratory Technology Directorates. Conduct laboratory testing of initial foundry runs of focal planes optimized for three dimensional and holographic imaging. Increase emphasis on applications for long range air-to-air lidar updating modeling and simulation, phenomenology measurement capabilities and to support utility analysis and system design and evaluations.</p> <p>FY 2017 Plans: Advance developing SAL techniques to enhance spatial resolution beyond the diffraction limit of conventional optics. 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. Complete fabrication and characterization of critical components for a long range SAL demonstration system. Design, fabricate, test, and explore limitations of next generation long range holographic aperture lidar imaging testbed focused on progression to platform compatible configurations. Continue research in the use of remote laser vibrometry and range-Doppler sensing technology to aid in target identification and decoy discrimination at ranges at which the imaging performance is insufficient. Research will also support Phenomenology understanding, signature collection, sensor product visualization, and automatic target recognition in collaboration with other</p>			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622003 / <i>EO Sensors & Countermeasures Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
AFRL Directorates. Complete laboratory testing of initial foundry runs of focal planes optimized for three dimensional and holographic imaging. 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. Explore concepts for merging air-to-air sensing with other sensing modalities.			
Accomplishments/Planned Programs Subtotals	27.387	26.805	21.535

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
622005: <i>Cyber Technology</i>	-	0.000	0.000	10.200	0.000	10.200	6.520	6.649	6.788	6.855	Continuing	Continuing

A. Mission Description and Budget Item Justification

Project 622005, Cyber Technology is new for 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 to develop adaptable and resilient hardware 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 2015	FY 2016	FY 2017
<p>Title: Malware Detection</p> <p>Description: Develop tools and capabilities to detect and classify malware in avionics software and firmware to preclude their introduction into avionics systems and, in the event of a system breach, develop capabilities to operate in the presence of the threat. Activities in this area are focused on developing a feature set indicative of deceptive or malicious behavior that will be used in conjunction with machine learning algorithms to detect zero-day attacks on avionics systems.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort was performed in Project 627622, RF Sensors and Countermeasures Tech, under the effort RF Sensor Technologies.</p> <p>Develop deception/malware detection tools for x86-based hardware malware, and expand capability by using file size and instruction frequency to include additional feature sets. The selected feature set will be used in conjunction with existing machine learning algorithms to determine the detection rate and classification accuracy of these algorithms using known malware samples.</p>	0.000	0.000	4.453
<p>Title: Adaptive Cyber Protections</p> <p>Description: Develop adaptable and resilient hardware for real-time avionics cyber-attack pattern recognition and mitigation. This activity will take a two-pronged approach to developing adaptable hardware required to support rapid avionics cyber-attack pattern recognition and build self-protecting avionics systems.</p>	0.000	0.000	5.747

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 622005 / <i>Cyber Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> N/A</p> <p><i>FY 2016 Plans:</i> N/A</p> <p><i>FY 2017 Plans:</i> For FY 2015 and FY 2016, the work for this effort was performed in Project 627622, RF Sensors and Countermeasures Tech, under the effort RF Sensor Technologies.</p> <p>This will investigate the use of evolvable hardware to perform pattern recognition. Demonstrate whether evolvable hardware in conjunction with evolvable mathematical algorithms can achieve advantage over existing pattern recognition algorithms and are applicable to avionics cyber protections.</p>			
Accomplishments/Planned Programs Subtotals	0.000	0.000	10.200

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.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>				Project (Number/Name) 626095 / <i>Sensor Fusion Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
626095: <i>Sensor Fusion Technology</i>	-	24.037	27.359	35.322	0.000	35.322	35.655	36.262	37.044	37.544	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 2015	FY 2016	FY 2017
Title: Automatic Target Recognition Technologies	10.051	0.000	0.000
Description: Develop automatic target recognition (ATR), sensor management, and sensor fusion technologies for target detection, tracking, and identification in ISR, and combat identification applications.			
FY 2015 Accomplishments: Developed advanced object recognition methods which correlate data from multiple sensors from air, space and cyber domains. Continued to assess and enhance physics-based techniques to meet the autonomous target detection and identification, sensor management, and sensor fusion requirements for intelligence, surveillance, and reconnaissance applications, combat identification applications, and Planning and Direction, Collection, Processing and Exploitation, Analysis and Production, and Dissemination - Experimentation (PCPAD-X) applications in contested and uncontested environments. Continued to assess and develop capabilities to represent and utilize sensor parameters and errors to improved fused geo-location accuracy.			
FY 2016 Plans: In FY 2016 and beyond, work accomplished under this effort will be reported under the effort Distributed Sensing for ATR.			
FY 2017 Plans: N/A			
Title: Target Signature Modeling	4.080	3.814	4.919

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 626095 / <i>Sensor Fusion Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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Description: Develop, evaluate, and demonstrate target signature models to support sensor exploitation algorithm development and testing for reconnaissance and strike mission applications.

FY 2015 Accomplishments:

Continued development of all-source target models for emerging threat systems in contested environments. Created and assessed methods for validating all-source signature models. Continued to mature target signature models for signature exploitation of multi-spectral systems and signals intelligence sensors. Matured promising approaches to develop a single target model for application to all parts of the spectrum.

FY 2016 Plans:

Continue development of all-source target models for emerging threat systems in contested environments. Demonstrate maturing methods for validating all-source signature models. Continue maturing promising approaches to develop a single target model for application to all parts of the spectrum. Develop ground clutter modeling and reduced feature-set target signature prediction techniques for radio frequency sensors. Initiate controlled data collections and high resolution feature database for emerging sensors. Initiate 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. Demonstrate maturing methods for validating all-source signature models. Improve efficient target modeling representation to enable more rapid model development and reduce database storage requirements. 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

6.500	5.817	7.504
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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 2015 Accomplishments:

Developed novel techniques for analysis of large sensor data sets to discover, characterize, and identify threatening activities in contested environments. Continued development of sensor resource optimization enablers for autonomous sensor employment. Continued development and validation of performance models for sensor exploitation technologies. Demonstrate application of sensor and algorithm performance models in the PCPAD-X integrative and virtual environments. Continued to enhance development of an integrated, unified ATR methodology through industry and university outreach.

FY 2016 Plans:

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 626095 / <i>Sensor Fusion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Initiate 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. Continue to demonstrate application of sensor and algorithm performance models in PCPAD-X. Continue to enhance development of an integrated, unified ATR methodology through industry and university outreach.</p> <p>FY 2017 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. Develop target classification techniques through deep learning methods and state of the art neural network methods.</p>				
<p>Title: Trusted Sensing Technologies</p> <p>Description: Develop, evaluate, and demonstrate methodologies, techniques, and strategies to instill trust in distributed, heterogeneous sensing systems within air, space, and cyber domains.</p> <p>FY 2015 Accomplishments: Initiated research in trusted exploitation algorithms and tools for PC-PAD, defining and quantifying metrics. Built upon previous work in PCPAD-X to research application of trust metrics in the evaluation of COTS, GOTS, and contractor owned exploitation algorithms and tools to assure the mission.</p> <p>FY 2016 Plans: In FY 2016 and beyond, work accomplished under this effort will be reported under the effort Sensor Management for ATR.</p> <p>FY 2017 Plans: N/A</p>		3.406	0.000	0.000
<p>Title: Sensor Management for ATR</p> <p>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.</p>		0.000	13.861	17.910

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 626095 / <i>Sensor Fusion Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> N/A</p> <p><i>FY 2016 Plans:</i> For FY15, the work for this effort was performed under the effort Trusted Sensing Technologies.</p> <p>Develop exploration of multi-sensor inference and control approaches for autonomous operations. Develop metrics for assessing multi-sensor control techniques with regard to assured threat avoidance and optimal sensor positioning. Initiate size-weight-power-constrained processing assessment approaches for future platform on-board processing of multi-sensor data. Define and develop multi-sensor performance assessment approaches for inclusion in PCPAD-X.</p> <p><i>FY 2017 Plans:</i> Develop exploration of multisensory inference and control approaches for autonomous operations. Develop metrics for assessing multi-sensor control techniques with regard to assured threat avoidance and optimal sensor positioning. Initiate 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.</p>				
<p><i>Title:</i> Distributed Sensing for ATR</p> <p><i>Description:</i> Develop techniques and metrics for adaptive, penetrating, distributed RF exploitation in contested environments.</p> <p><i>FY 2015 Accomplishments:</i> N/A</p> <p><i>FY 2016 Plans:</i> For FY15, the work for this effort was performed under the effort Automatic Target Recognition Technologies.</p> <p>Develop bi-static phenomenology models. Design new waveforms to exploit bi-static RF phenomenology. Develop a systems theory for incorporating identification (ID) uncertainty in ATR algorithms. Develop distributed exploitation algorithms. Design a closed loop sensor mode controller for adaptive transmit and receive.</p> <p><i>FY 2017 Plans:</i> Develop bi-static phenomenology models. Design new waveforms to exploit bi-static RF phenomenology. Develop a systems theory for incorporating ID uncertainty in ATR algorithms. Develop distributed exploitation algorithms. Design a closed -loop sensor mode controller for adaptive transmit and receive.</p>		0.000	3.867	4.989
Accomplishments/Planned Programs Subtotals		24.037	27.359	35.322

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force Date: February 2016

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

N/A

Remarks

D. Acquisition Strategy

N/A

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>				Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
627622: <i>RF Sensors and Countermeasures Tech</i>	-	40.036	59.777	46.791	0.000	46.791	52.013	52.286	53.367	54.063	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and assesses affordable, reliable all weather 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 2015	FY 2016	FY 2017
Title: Hybrid Sensor Technologies	7.939	12.082	10.329
Description: Develop hybrid sensor solutions to be responsive to needs and detect difficult targets. Develop jam-resistant time, position, and velocity sensors.			
FY 2015 Accomplishments: Matured GPS augmentation technologies that take advantage of distributed platforms relaying Global Navigation Satellite Systems (GNSS) signals and georeferenced real-time imaging to improve GPS accuracy in GPS sparse or denied environments. Developed technologies that expand the ability to incorporate GNSS signals into the Global Positioning System (GPS) user equipment as a means to improve navigation signal reliability and availability.			
FY 2016 Plans: Develop technologies to ensure robust and accurate navigation in GPS contested and denied environments. Mature 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. Continue to work with allied nations (Australia,			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Canada, and the United Kingdom) to augment GPS capability through the use of GNSS for precise positioning, navigation, and timing information.			
<p>Title: RF Sensor Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments: Continued research and development of agile waveforms, adaptive spectrum utilization techniques, and electromagnetic forensics sensing of the signal environment for robust adaptive RF sensing in contested spectrums and persistent stand-in RF sensing in denied environments. Continued research and development of RF sensor technology, including: signals intelligence (SIGINT) hardware, algorithms, and techniques, passive radar techniques, and advanced receive array antenna technology with wideband and high dynamic range, for passive multimode radars and efficient combat identification capabilities.</p> <p>FY 2016 Plans: Initiate research on fully polarimetric bistatic RF ground target and clutter phenomenology and relevant ground vehicle dynamics for RF sensing. Continue research and development of RF sensor technologies, including antennas, electromagnetic structures, propagation in plasma medium, electromagnetic modeling & simulation, and prototype experimentation for efficient combat identification capabilities. Develop agile, spectrally efficient, radar waveforms and robust distributed sensing techniques for dominance in non-traditional RF environments. Initiate development of electromagnetics forensics techniques for passive RF sensing and EW applications.</p> <p>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.</p> <p>Continue research and development of fully polarimetric persistent representation of critical mobile targets and bistatic phenomenology with realistic low grazing angle. Develop electromagnetics based modelling, simulation, and measurement tools for propagation, scattering, and radiation application to improve RF sensors capabilities. Continue development of agile, spectrally efficient, radar waveforms and robust distributed sensing techniques for dominance in non-traditional RF environments. Continue development of advanced electromagnetic forensics techniques for passive RF and EW applications.</p>	11.942	16.016	13.655

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Continue to explore novel and advanced sensing technologies for use in demanding environments for future platform capability. Develop methods to electronically attack passive sensing systems used by red forces to degrade this capability.				
<p>Title: Optimize RF Sensing Technology</p> <p>Description: Develop technology to reduce size, weight, and power of RF sensors. Develop technology to enable affordable upgrades and optimally control RF and multi-intelligence sensors.</p> <p>FY 2015 Accomplishments: Conducted Electro-Magnetic/Electronic Warfare Battle Management (EM/EWBM) research to optimize use of EW assets against current and future integrated air defense systems and RF threats. Identified, developed and integrated improved electronics that reduce cost, size, weight and power of current EW systems to facilitate development of distributed EW jammers/sensor systems. Developed new approaches to protection of aircraft avionics systems and on-board data networks.</p> <p>FY 2016 Plans: In FY 2016 and beyond, work accomplished under this effort will be reported under the effort Sensor Resource Management.</p> <p>FY 2017 Plans: N/A</p>		5.195	0.000	0.000
<p>Title: Multi-Band/Multi-Beam Technologies</p> <p>Description: Develop multi-band and multi-beam forming technologies. Address technologies for antenna array operations in dynamic sensor networks.</p> <p>FY 2015 Accomplishments: Identified advanced RF/EO subsystem concepts to refine and update trade space capability. Completed the Multiple-Input Multiple-Output (MIMO) and waveform-diverse models for system and system of systems analysis. Initiated concept exploration for highly integrated, mostly digital microsystems for reconfigurable and tunable capabilities.</p> <p>FY 2016 Plans: Continue research in advanced RF/EO subsystem concepts to support expendable RF systems configurations. Develop and demonstrate concepts to support expendable RF ISR sensors (Radar, SIGINT, Electronic Support, and Combat ID). Develop conformal RF antenna concepts from C Band to Ka-Band. Develop advanced geo-location algorithms for single and multiple platform operations. Continue research in highly integrated digital microsystems for reconfigurable and tunable capabilities.</p> <p>FY 2017 Plans: Develop test-bed vehicle for static and dynamic testing of RF/EO sensors and algorithms. Continue research and development of conformal RF antenna concepts from C-Band to Ka-Band. Expand concepts to support expendable RF ISR sensors (Radar,</p>		5.616	10.928	9.342

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>SIGINT, Electronic Support, and Combat ID), demonstrate these capabilities for next-generation attritable platforms, and continue development of advanced geo-location algorithms for single and multiple platform operations. Continue research in highly integrated digital microsystems for reconfigurable and tunable capabilities.</p> <p>In conjunction with development of multi-band, multi-beam technology for sensing capability, develop methods to detect use of this technique and countermeasures to mitigate its use for sensing blue force platforms.</p>				
<p>Title: Counter RF Threat Technologies</p> <p>Description: Develop aerospace platform jamming technologies and techniques to counter advanced radio-frequency (RF) threats associated with current and future aerospace weapons systems.</p> <p>FY 2015 Accomplishments: Developed multi-faceted approaches to countering RF threats. Efforts included development of machine learning, autonomous systems to identify frequency agile and changing waveforms. Developed counter-countermeasures to digital radio frequency memory (DRFM) based jammers. Developed EM/EWBM tools, and distributed EW techniques to counter state-of-the-art integrated air defense systems. Developed novel disruptive technologies that leverage cyber, directed energy, and machine learning to counter RF, EO/IR threats.</p> <p>FY 2016 Plans: For FY 2016 and beyond, work accomplished under this effort will be reported under the effort Sensor Resource Management.</p> <p>FY 2017 Plans: N/A</p>		9.344	0.000	0.000
<p>Title: Sensor Resource Management</p> <p>Description: Develop technology to enable optimization of sensor resources in contested environments on own-ship and multi-ship in manned, unmanned and manned/unmanned teaming concepts.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: For FY 2015, the work for this effort originally was performed under the efforts, Optimize RF Sensing Technology and Counter RF Threat Technologies.</p>		0.000	15.751	13.465

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Develop distributed sensor management techniques utilizing an Open Mission Systems (OMS) context and Service Oriented Architecture (SOA) common set of messages and data models. Use Electronic Warfare and Communications as first functional disciplines to initiate SOA constructs. Initiate layered effects analyses on next generation RF based threats, counters and perform vulnerability assessments. Initiate operational architecture and mission services through common mission control center constructs. Continue research of advanced Electronic Support (ES) concepts and exploration of adaptable Electronic Attack (EA) EA/ES capabilities.</p> <p>FY 2017 Plans: 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. 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 threats. Develop robust modeling and simulation capability to study the efficiency versus effectiveness of distributed electronic warfare assets. Continue research into effective management of electronic warfare assets in operational environments focusing on a multi-ship strike package employment. Refine and augment open mission standards (OMS) to facilitate electronic warfare capability. Solidify protocol messaging to enable introduction of new technologies into avionics systems without encroaching on platform flight certification.</p>			
Accomplishments/Planned Programs Subtotals	40.036	54.777	46.791

	FY 2015	FY 2016
Congressional Add: Program Increase	-	5.000
FY 2016 Plans: Conduct Congressionally directed effort		
Congressional Adds Subtotals	-	5.000

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

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / <i>Aerospace Sensors</i>	Project (Number/Name) 627622 / <i>RF Sensors and Countermeasures Tech</i>

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>					R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	96.425	109.122	117.915	0.000	117.915	121.663	119.560	127.134	128.856	Continuing	Continuing
621010: <i>Space Survivability & Surveillance</i>	-	34.637	42.970	39.163	0.000	39.163	40.361	28.878	33.706	34.408	Continuing	Continuing
624846: <i>Spacecraft Payload Technologies</i>	-	14.905	12.478	15.732	0.000	15.732	16.034	16.530	16.634	16.543	Continuing	Continuing
625018: <i>Spacecraft Protection Technology</i>	-	8.143	15.049	19.411	0.000	19.411	21.971	26.355	27.768	28.216	Continuing	Continuing
628809: <i>Spacecraft Vehicle Technologies</i>	-	38.740	38.625	43.609	0.000	43.609	43.297	47.797	49.026	49.689	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Program Element 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. 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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	98.229	116.122	108.936	0.000	108.936
Current President's Budget	96.425	109.122	117.915	0.000	117.915
Total Adjustments	-1.804	-7.000	8.979	0.000	8.979
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	-7.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-0.304	0.000			
• SBIR/STTR Transfer	-1.500	0.000			
• Other Adjustments	0.000	0.000	8.979	0.000	8.979

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force Date: February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>
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Change Summary Explanation

Decrease in FY 2016 due to Congressional Directed Reduction for excess to need.

Increase in FY 2017 is due to increased emphasis by DoD in space environment research and advanced navigation technology development.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>				Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
621010: <i>Space Survivability & Surveillance</i>	-	34.637	42.970	39.163	0.000	39.163	40.361	28.878	33.706	34.408	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 2015	FY 2016	FY 2017
Title: Space Environment Research	5.231	14.795	13.606
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 2015 Accomplishments: Took delivery of unique pulsed electroacoustic sensor to measure charging inside materials and began testing capability to research material susceptibility to internal charging while exploiting continued material aging research. Exploited new on-orbit data sources to enhance energetic space environment models. Initiated research on methods for remote measurement of spacecraft material properties. Began researching novel techniques for solar energetic particle forecast.			
FY 2016 Plans: Initiate research program to quantify/predict internal charging for new and aged materials. Continue developing models to predict the generation and transport of solar energetic particles. Begin developing predictive model for observable and dielectric spacecraft material property changes. Continue exploitation of new on-orbit data sources to enhance energetic space environment models supporting spacecraft design and mission planning. Develop global magnetic field models of the Sun, allowing determination of solar wind conditions used for forecasting solar radiation conditions at Earth. Prior work on solar energetic particles will be assessed for incorporation into predictive space environment model that forecast effects of particle radiation environment on satellites. Techniques for improving the predictions of the timing/magnitude of geomagnetic storms driven by solar eruptions will be investigated. Develop a suite of codes that will be used for attribution of satellite communication interference. Deliver block upgrades to address future needs of the DoD satellite communication user community. Develop models for error corrections caused by ionospheric disturbances to Over the Horizon Radar (OTHR). Provide upgrades to the state of the art model currently used for those corrections, focusing on a newly discovered phenomena called traveling ionospheric disturbances, which causes objects located by OTHR to apparently shift in location. Assess future signature			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>packages that should be added to the hypersonics flow solver. Continue the assessment of new geometry and material impacts on mission success for strategic systems. In FY2016 and beyond, Ionospheric Research effort has been combined with this effort to better align technical efforts.</p> <p>FY 2017 Plans: Continue developing predictive model for observable and dielectric spacecraft material property changes. Begin utilizing property change results in development of new design standards. Continue exploitation of on-orbit data sources to validate energetic space environment models supporting spacecraft design and mission planning. Select improved solar magnetic field and energetic particle models for further development as transition candidates for incorporation into future spirals of anomaly attribution tools. Begin analyzing and exploiting data from the on-orbit radiation remediation proof-of-concept experiment, as well as existing on-orbit spacecraft. Pursue ionosonde auto scaling technologies, as well as real-time characterization of OTHR performance. Assess impacts of the arctic ionosphere on OTHR availability. Create integrated version of space environment impact on space-ground radio frequency links attribution tool meeting space operations requirements for scintillation and solar impacts on satellite communications, command, and control systems. Using data from a new weather satellite constellation, evaluate and refine Global Positioning System (GPS) radio frequency exploitation algorithms for global scintillation specification. Integrate new data into existing baseline model based on ground-based measurements. Improve state-of-the-art solar magnetic flux transport model for more reliable forecast of solar radio and extreme ultraviolet flux levels, key parameters for Air Force space weather models and forecasts. Derive an advanced ionosphere-thermosphere model using these parameters and evaluate the performance.</p>			
<p>Title: Surveillance Technologies</p> <p>Description: Develop advanced target detection techniques, spectral signature libraries, and decision aids for space-based sensors and surveillance systems.</p> <p>FY 2015 Accomplishments: Evaluated hyper temporal imaging (HTI) data processing methods and target detection algorithms for space-based, early missile warning. Delivered space-based HTI sensor performance trade studies for optimal early missile detection. Explored and evaluated new innovative HTI detection methods for concealed activity monitoring.</p> <p>FY 2016 Plans: Expand evaluation of HTI data processing methods and target detection algorithms to wider range of real-world and simulated target-background scenes of missile warning scenarios as well as to space-based imagery data that is compressed to reduce satellite downlink problems. Deliver 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. Initiate</p>	9.392	8.358	7.990

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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.				
<p>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 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.</p>				
<p>Title: Ionospheric Research</p> <p>Description: Develop techniques, forecasting tools, and sensors for ionospheric specification and forecasting, space-based geolocation demonstrations, and determination of potential radar degradation.</p> <p>FY 2015 Accomplishments: Continued investigations for physics-based space weather specification and forecast models related to impacts on DoD systems. Validated improved modeling capabilities for scintillation impacts on communications, GPS and remote sensing, and for environmentally-induced satellite anomalies. Began development of next model increments. Integrated and quantitatively assessed environmental models and system impact data across the solar, magnetosphere, and ionosphere domains to expand capabilities for actionable attribution and forecast of environmentally-caused anomalies on DoD satellites and environmental interference with electromagnetic wave propagation. Incorporated advanced ionospheric sounding techniques and traveling ionospheric disturbance effects into simulation model for next generation radar systems. Conducted application-specific trade studies for model components and data types. Demonstrated high frequency radio geolocation coordinate registration capability.</p> <p>FY 2016 Plans: In FY 2016 and beyond, this effort is combined with the Space Environment Research effort in the same project to better align technical efforts.</p> <p>FY 2017 Plans: N/A</p>		6.590	0.000	0.000
<p>Title: Radiation Remediation Research</p>		3.476	4.756	3.946

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: Validated RBR end-to-end model version 2.0 using ground and space-based measurements with the very low frequency particle mapper and satellite experiments. Conducted fielded RBR capability assessments to determine rough order fielded system requirements.</p> <p>FY 2016 Plans: Validate RBR end-to-end model version 3.0 using ground and space-based measurements with satellite and terrestrial experiments. Conduct fielded RBR capability assessments to determine rough order fielded system requirements.</p> <p>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.</p>				
<p>Title: Seismic Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments: Assessed relative utility of different scientific and computational advances for improving the accuracy of three-dimensional seismic wave propagation models. Explored use of details of seismic signals in three-dimensional models for discrimination of explosions from earthquakes. Extended coverage and increased resolution of unified model.</p> <p>FY 2016 Plans: Deliver discrimination capabilities using full seismic waveforms based on three-dimensional models to fill critical capability gaps. Use three-dimensional attenuation models to improve signal loss prediction for seismic signals used in discrimination. Investigate the use of modern high speed computing capabilities and massive data archives to automate the detection, location, and discrimination of seismic events.</p> <p>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</p>		5.213	7.532	6.565

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>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.</p> <p>Title: Alternative Navigation Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments: Continued to advance the development of compact atomic clocks with improved accuracy and stability to replace legacy atomic clocks. Testing commenced on National Institute of Standards and Technology atomic clock. Continued construction of a free space, cold atom 3-axis gyroscope/accelerometer that would enable GPS-free precision navigation. Tested a completed free space, cold atom single-axis gyroscope/accelerometer to learn about its strengths and limitations. Continued development of a confined cold atom gyroscope with reduced size and weight over free space cold atom gyroscopes to expand GPS-free navigation to a larger number of Air Force platforms.</p> <p>FY 2016 Plans: Continue to advance the development of compact atomic clocks with improved accuracy and stability to replace legacy atomic clocks. Continue construction of a free space, cold atom 3-axis gyroscope/accelerometer that would enable GPS-free precision navigation. Complete further tests of free space, cold atom single-axis gyroscope/accelerometer to learn about its strengths and limitations. Develop 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.</p> <p>FY 2017 Plans: 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.</p>	4.735	7.529	7.056
Accomplishments/Planned Programs Subtotals	34.637	42.970	39.163

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

N/A

Remarks

D. Acquisition Strategy

N/A

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 621010 / <i>Space Survivability & Surveillance</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>				Project (Number/Name) 624846 / <i>Spacecraft Payload Technologies</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
624846: <i>Spacecraft Payload Technologies</i>	-	14.905	12.478	15.732	0.000	15.732	16.034	16.530	16.634	16.543	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 2015	FY 2016	FY 2017
Title: Space-Based Detector Technologies	0.963	2.289	3.379
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 2015 Accomplishments: Continued to develop and mature an alternative sensor material system to include: increased operating temperature, reduced non-uniformity, and reduced cost. Explored novel detector enhancement methodologies (radiation hardening techniques, detector architectures, etc.) to mainstream visible-long wavelength infrared focal plane array developments.			
FY 2016 Plans: Continue 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. Complete laboratory demonstration of tunable detector technology and validate basic functionality over a militarily significant range of wavelengths. Initiate development of radiation tolerant detectors to achieve dim object tracking for next-generation space situational awareness systems. Complete support for novel cloud-penetrating missile warning experiment. Continue 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. Continue development and verification of first-principle-based model to predict detector degradation in a natural space environment.			
Title: Space Situational Awareness Sensing (SSA) Research	3.041	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 624846 / <i>Spacecraft Payload Technologies</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: Began execution of experiment campaign to measure satellite components to verify and validate predictive modeling capabilities against laboratory and field measurements. Began systems analysis to establish performance requirements under validated threat scenarios. Initiated next-generation analysis of sensing methods and phenomena to exploit for space protection.</p> <p>FY 2016 Plans: 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.</p> <p>FY 2017 Plans: N/A</p>				
<p>Title: Space Electronics Research</p> <p>Description: Develop technologies for space-based payload components such as radiation-hardened electronic devices, micro-electro-mechanical system devices, and advanced electronics packaging.</p> <p>FY 2015 Accomplishments: Completed development of integrated modules using three-dimensional techniques to increase throughput while reducing size, weight, and, especially, power. Explored new transistor designs that are compatible with current manufacturing techniques but more efficient and radiation tolerant at ultra-small feature sizes (e.g., 7 nanometers). Expanded on-going electronic device reliability research into other failure modes (e.g., hot carrier injection) to understand defects responsible for reduced lifetimes in small feature-size electronic devices. Continued exploration of successful integration techniques for system-on-chip integrated circuits.</p> <p>FY 2016 Plans: Continue research into advanced transistor types for use at ultra-submicron technology nodes. Document initial small-feature-size reliability findings and transition results to device development community to improve spacecraft electronic lifetime predictions. Complete investigation of advanced electronic circuit technology and begin transition, if applicable, to development phase. Initiate 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. Initiate development of path for trusted electronics as it applies to space electronics.</p> <p>FY 2017 Plans:</p>		3.612	2.224	2.659

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 624846 / <i>Spacecraft Payload Technologies</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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. Continue radiation effects research on advanced technologies for space application. Initiate development of three-dimensional electronics to extend technology node density.				
<p>Title: Modeling and Simulation Tools for Space Applications</p> <p>Description: Develop modeling and simulation tools for space-based ground surveillance systems, rendezvous and proximity operations, imaging of space systems, disaggregated satellite architecture, and space control payloads.</p> <p>FY 2015 Accomplishments: Continued to develop spacecraft and mission simulations in close conjunction with customers across the DoD. Continued to integrate state-of-the-art system performance and mission planning algorithms into modeling and simulation software tools. Revised flight tools based on recent flight program experience. Supported technology development and maturation through capability and mission utility studies and size, weight, and power-cost trade studies.</p> <p>FY 2016 Plans: Continue to develop spacecraft and mission simulations in close conjunction with customers across the DoD and other government agencies. Continue to integrate state-of-the-art system performance and mission planning algorithms into modeling and simulation tools. Revise flight tools based on recent flight program experience. Support technology maturation through capability and mission utility studies, size, weight, and power-cost trade studies, and wargaming activities. Provide utility analysis to future flight experiments.</p> <p>FY 2017 Plans: Support technology maturation through capability assessment and mission utility studies; size, weight, and power-cost trade studies; and wargaming activities. Provide utility analysis to future flight experiments and support refinement of mission parameters. Develop spacecraft and mission simulations in close conjunction with customers across the DoD and other government agencies, as necessary. Integrate state-of-the-art system performance and mission planning algorithms into modeling and simulation tools.</p>		4.364	4.129	5.054
<p>Title: Alternative Positioning, Navigation, and Timing Technology</p> <p>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.</p>		2.925	3.836	4.640

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 624846 / <i>Spacecraft Payload Technologies</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> Conducted experiments to establish the sensitivity of PNT payload units/sub-units to off-nominal operating conditions and to establish laboratory readiness for incorporation of experimental hardware from other, on-going PNT technology developments. Conducted studies to identify alternative and innovative technology options for PNT payloads.</p> <p><i>FY 2016 Plans:</i> Continue experiments establishing 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.</p> <p><i>FY 2017 Plans:</i> Incorporate advanced amplifiers into in-house PNT payload laboratory testbed. Continue experiments establishing 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.</p>			
Accomplishments/Planned Programs Subtotals	14.905	12.478	15.732

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>				Project (Number/Name) 625018 / <i>Spacecraft Protection Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
625018: <i>Spacecraft Protection Technology</i>	-	8.143	15.049	19.411	0.000	19.411	21.971	26.355	27.768	28.216	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 2015	FY 2016	FY 2017
Title: Threat Warning Research	8.143	15.049	19.411
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 2015 Accomplishments: Down selected and matured next generation proximity detection sensor technologies and sensor suite integration. Provided technology support for the next Joint Space Operations Center (JSpOC) Mission Systems upgrade. Completed instantiation of JSpOC Mission Systems (JMS) space situational awareness testbed. Developed SSA closed loop simulation showing automated threat detection and response actions. Evaluated technologies to enable better monitoring of space objects in geosynchronous orbit.			
FY 2016 Plans: Complete experimental measurements of satellite components to verify and validate predictive modeling capabilities. Continue analysis of next-generation sensing methods and phenomena to exploit for space protection. Complete assessments of proximity sensor options and transition findings, as appropriate, to satellite system developers. Begin 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. Initiate development of advanced algorithms for satellite threat detection and response for both ground-based and space-based implementations. Continue development of capabilities to increase satellite autonomy and perform closed loop demonstration showing threat detection and responsive courses of action.			
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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 625018 / <i>Spacecraft Protection Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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 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.			
Accomplishments/Planned Programs Subtotals	8.143	15.049	19.411

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>				Project (Number/Name) 628809 / <i>Spacecraft Vehicle Technologies</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
628809: <i>Spacecraft Vehicle Technologies</i>	-	38.740	38.625	43.609	0.000	43.609	43.297	47.797	49.026	49.689	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 2015	FY 2016	FY 2017
<p>Title: Space Power/Thermal Research</p> <p>Description: Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts.</p> <p>FY 2015 Accomplishments: Continued to examine new solid state, zero vibration cryocooler methods. Performed studies on how new solid state technologies may be integrated directly to a focal plane array to show representative thermal loading. Continued development of greater than 40% efficient solar cell approaches. Investigated advanced photon management approaches. Continued optimizing flexible solar array for mass and volume efficiency.</p> <p>FY 2016 Plans: Complete solid state refrigeration research and document low-temperature semiconductor materials findings. Focus development of greater than 40% efficient solar cells by demonstrating increased photocurrent using nano-enhanced cells. Continue to investigate advanced photon management approaches to increase efficiency and radiation hardness. Complete Flex-Array initial development for 60 kW/m3 power density performance. Initiate follow-on development for achieving 70-80 kW/m3 array performance.</p> <p>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.</p>	4.419	4.496	4.933
<p>Title: Space Structures and Controls Research</p> <p>Description: Develop revolutionary and enabling technologies, including lighter weight, lower cost, high performance structures for space platforms; guidance, navigation, and controls hardware and software for next generation of space superiority systems.</p> <p>FY 2015 Accomplishments:</p>	7.758	8.886	10.911

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 628809 / <i>Spacecraft Vehicle Technologies</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Improved and refined collaborative autonomous spacecraft guidance, navigation, and control efforts supporting distributed spacecraft missions. Continued efforts to integrate guidance, navigation, and control methods with advanced spacecraft autonomy decision architectures. Integrated multi-spacecraft and autonomous spacecraft efforts to establish multiple autonomous spacecraft technology capability. Developed improved constitutive models for composite materials. Continued research to improve the fabrication and manufacture of precision and high tolerance composite structures. Performed research in thermal management technologies for heat dissipation of high power and high energy density electronics. Delivered and transitioned analytic and numerical tools and demonstrate multi-physics optimization of satellite structures.</p> <p>FY 2016 Plans: Continue advanced guidance and navigation algorithms integration into advanced autonomous spacecraft software. Continue collaborative autonomous multi-spacecraft algorithms in laboratory and high-fidelity simulations/breadboards including embedded processor implementations. Begin reactive maneuver strategies for spacecraft resiliency in laboratory simulation. Develop alternative GPS technologies for contested environments. Transition methods to improve the fabrication and manufacture of precision and high tolerance composite structures to spacecraft prime contractors. Initiate development of technologies to increase the resiliency and affordability of spacecraft structures through the development and test of new, actively-controlled thermal technologies. Continue 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. Explore new meta-material technologies to improve the electromagnetic interaction characteristics of Air Force spacecraft structures.</p> <p>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.</p>				
<p>Title: Space Experiments</p> <p>Description: Develop flight experiments to improve the capabilities of existing operational space systems and to enable new transformational space capabilities.</p> <p>FY 2015 Accomplishments:</p>		20.612	17.208	18.423

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 628809 / <i>Spacecraft Vehicle Technologies</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Continued pre-launch preparations of the on-orbit radiation remediation proof-of-concept experiment. Completed science payload designs and long lead procurement for maneuverable geosynchronous space vehicle experiment. Verified system design for science data collections. Verified payload subsystem hardware and software after component/subsystem delivery. Prepared for component/subsystem tests, completed experiment planning for maneuverable geosynchronous experimental platform design payload configurations, and began to prepare for final spacecraft integration and test. Completed very low frequency particle mapper space vehicle assembly integration and test.</p> <p>FY 2016 Plans: Complete final integration, testing, 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 one year experimental operations. Complete development and continue 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. Complete 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. Assess technology readiness and risks for a space based integrated demonstration of an advanced GPS payload for contested environments. Develop mission science objectives and on orbit data collection/analysis requirements to support an integrated experiment in the FY2021-2023 timeframe.</p> <p>FY 2017 Plans: Complete on-orbit early checkout for radiation remediation proof-of-concept experiment and complete one year of experimental activities. Continue satellite experimental operations to investigate remediation techniques for enhanced space radiation. Initiate on-orbit 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. Complete 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. 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.</p>				
<p>Title: Space Communication Technologies</p> <p>Description: Develop technologies for next-generation space communications terminals and equipment and methods/techniques to enable future space system operational command and control concepts.</p> <p>FY 2015 Accomplishments:</p>		5.951	8.035	9.342

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / <i>Space Technology</i>	Project (Number/Name) 628809 / <i>Spacecraft Vehicle Technologies</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Continued applied research and development efforts (modeling, simulation, and laboratory testing) to reduce component technical risks and to meet technology needs. Specifically, worked to develop a propagation flight experiment to characterize the W and V frequency bands for future military satellite communications. Began evaluation of optical communication links with small spacecraft.</p> <p>FY 2016 Plans: Complete design phase of W and V frequency band flight experiment. Establish Continental U.S. ground station receiver network and verify connectivity. Initiate development of science and experiment plans. Continue development of models, simulations, and laboratory testing to support the flight experiment. Continue investigations of optical communications options.</p> <p>FY 2017 Plans: Complete experimental payload build and ground receiver installation and testing for the W and V frequency band flight experiment. Complete breadboard testing of prototype modem concepts to support W and V frequency band terminals. Perform fabrication and testing of a multi-beam reflector antenna to support W and V frequency band satellite terminals. Initiate development of a laboratory testbed for a smart-radio network concept for satellite communication to mitigate impacts from spectrum congestion and interference.</p>			
Accomplishments/Planned Programs Subtotals	38.740	38.625	43.609

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	86.328	99.851	109.649	0.000	109.649	114.114	116.214	123.950	131.390	Continuing	Continuing
622068: <i>Advanced Guidance Technology</i>	-	40.317	46.822	52.733	0.000	52.733	56.056	49.982	62.079	70.211	Continuing	Continuing
622502: <i>Ordnance Technology</i>	-	46.011	53.029	56.916	0.000	56.916	58.058	66.232	61.871	61.179	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. 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.

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)

	<u>FY 2015</u>	<u>FY 2016</u>	<u>FY 2017 Base</u>	<u>FY 2017 OCO</u>	<u>FY 2017 Total</u>
Previous President's Budget	87.387	99.851	101.043	0.000	101.043
Current President's Budget	86.328	99.851	109.649	0.000	109.649
Total Adjustments	-1.059	0.000	8.606	0.000	8.606
• 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	-0.118	0.000			
• SBIR/STTR Transfer	-0.941	0.000			
• Other Adjustments	0.000	0.000	8.606	0.000	8.606

Change Summary Explanation

Increase in FY 2017 due to increased emphasis on technologies for distributed, low-cost seekers and weapon guidance.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>				Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
622068: <i>Advanced Guidance Technology</i>	-	40.317	46.822	52.733	0.000	52.733	56.056	49.982	62.079	70.211	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

	FY 2015	FY 2016	FY 2017
Title: Seeker Technologies	9.000	11.500	13.582
Description: Develops seeker technologies for air-delivered munitions to provide high confidence target discrimination and classification, precise target location, and robust terminal tracking.			
FY 2015 Accomplishments: Completed an experimental initial proof-of-concept wide-field-of-view seeker based on bio-inspired research activities which increased options for countermeasure resistance and alternate navigation concepts and concurrently reduced design complexity. Developed adverse weather and high-speed applications that simplify, increase the flexibility, and reduce the cost of advanced seekers. Developed algorithmic approaches to integrate weapons into the kill chain and enable flexible targeting with or without an operator in the loop. Developed mathematical techniques that enable distributed seeker imaging and targeting.			
FY 2016 Plans: Continue to refine wide-field-of-view seeker proof-of-concept with emphasis on high-resolution sensors, particularly with bio-inspired and high-rate processing characteristics to allow precise munition terminal guidance in degraded, contested environments. Continue to develop technologies that simplify, increase the flexibility, and reduce the cost of advanced seekers (passive and active electro-optical, infrared, and radar munition) with focus on combat operations in adverse weather and in high-speed applications. Continue to develop algorithmic approaches to integrate weapons into the kill chain and enable flexible targeting with or without an operator in the loop. Continue to develop mathematical techniques that enable distributive seeker imaging and targeting. Explore terminal seeker technologies that enable innovative air-to-air engagements for fifth generation aircraft and beyond. Explore incorporation of open architecture principles to reduce cost and 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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 subsystems. Develop distributed, low-cost seeker technology hardware. Conduct research on integrated processing techniques to enable networked systems.				
Title: Aerodynamics, Navigation and Control Technologies		23.560	26.212	24.891
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 2015 Accomplishments: Completed hardware-in-the-loop tests of an adaptive autopilot for a boosted penetrator concept. Completed flight experiments demonstrating navigation using optical aiding. Developed linked aero-structural-thermal computational tools to predict flight performance of hypersonic weapons and tools to develop prototype concepts for further analysis. Developed algorithms for guidance and control of advanced weapons concepts in a contested electromagnetic environment. Matured technologies for precision weapon navigation in the absence of GPS. Demonstrated navigation in GPS jamming scenarios, geo-locating, and homing on emitting ground targets.				
FY 2016 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 in contested electromagnetic spectrum and under GPS-degraded and GPS-denied conditions. Continue to develop weapon navigation and control networking technologies that provide enhanced mission capability in denied or anti-access environments, facilitate agile and maneuverable weapons, foster autonomy, trust, and networking, and enable precise munition control and actuation. Integrate technologies for weapon-platform interfaces, including advanced high capacity carriage and release technology to enable flexible, reprogrammable load-outs and achieve hardware and software modularity. Integrate algorithms to support distributed, multi-strategy weapon concept-of-operations to defeat enemy defenses. Develop airframe and control technologies that enable innovative air-to-air engagements.				
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 navigation under GPS-degraded and GPS-denied conditions. Continue development of weapon-platform interfaces, including				

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>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 using optical aiding techniques. 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 experiments to characterize 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.</p>			
<p>Title: Guidance Technologies</p> <p>Description: Develops guidance subsystem integration and evaluation technologies to provide open and closed loop ground testing, flight test risk reduction, and digital simulation of novel concepts.</p> <p>FY 2015 Accomplishments: Developed technologies for precision weapon navigation independent of GPS availability. Demonstrated navigation techniques for contested electromagnetic environment scenarios, including geolocation/homing on ground based systems. Conducted joint flight experiments demonstrating optical aided navigation. Conducted hardware-in-the-loop tests of an adaptive autopilot that expands the flight envelope for penetrator applications. Developed integrated computational tools to predict performance of hypersonic weapons used to shape concepts for further analysis. Developed algorithms and analysis tools to explore collaboration and autonomy concepts in advanced threat environments.</p> <p>FY 2016 Plans: Continue to develop technologies for precision weapon navigation independent of GPS availability to include celestial navigation and optical aiding techniques. Continue to develop integrated computational tools to predict performance of hypersonic weapons used to shape concepts for further analysis. Continue to develop algorithms and analysis tools to explore distributed collaboration and autonomy concepts in advanced threat environments. Develop improved simulation technologies that evaluate innovative air-to-air engagements. Develop a real-time radar/millimeter wave signature generation capability for testing algorithms in real-time software and hardware in-the-loop environments. Develop simulation technologies that evaluate cooperative, flexible munition target engagements. Develop a modular radio-frequency hardware-in-the-loop capability to support munitions concepts with high speed target engagement. Develop new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems.</p> <p>FY 2017 Plans: Continue to develop and conduct experiments leading to demonstration of precision navigation using celestial aiding. Continue to develop and conduct demonstrations of weapons navigation using optical aiding techniques. Continue to develop and conduct experiments demonstrating autonomy algorithms to implement distributed/collaboration/coordination behaviors of multiple</p>	7.757	9.110	14.260

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
weapons. 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	40.317	46.822	52.733

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>				Project (Number/Name) 622502 / <i>Ordnance Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
622502: <i>Ordnance Technology</i>	-	46.011	53.029	56.916	0.000	56.916	58.058	66.232	61.871	61.179	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 2015	FY 2016	FY 2017
Title: Energetic Materials Technology	10.000	10.300	11.081
Description: Investigates and develops energetic materials technology that can maximize weapon lethality, while applying appropriate safety and security features.			
FY 2015 Accomplishments: Transitioned energetic material with multi-Service applications. Demonstrated improved Insensitive Munition (IM) performance for energetic material formulations for penetration and general purpose bomb applications. Developed material formulations designed to reduced shipping/storage costs while reducing risk of catastrophic damage in event of accident. Scaled-up technologies for producing new novel energetic formulations for hard target applications.			
FY 2016 Plans: Continue to investigate energetic formulations that increase thermal and vibration tolerance required for very long range, high speed munitions, and hard target applications. Continue to emphasize development of novel energetic materials, including reactive cases, that improve performance and reduce bomb and missile size so as to increase loadout and increase shipping/storage safety. Develop concepts for distributed and multi-point fuzing. Develop a virtual design tool for use in material design activities.			
FY 2017 Plans: Continue to investigate novel materials to increase energy density over traditional explosives while maintaining lethality for mass and volume constrained applications. Continue to experiment on energetic fills for high temperature applications to mitigate environmental challenges to energetic materials' survivability, initiation, dynamic, and mechanical properties. Continue initiative to develop 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. Investigate liner technologies to improve IM performance. Implement additive manufacturing techniques to increase the design space for kinetic weapon lethality.			
Title: Fuze Technologies	13.000	14.729	11.698

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622502 / <i>Ordnance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Description: Investigates and develops fuzes for air-delivered weapon applications to develop novel energetic initiation concepts, penetration fuzing, point burst fuzes, and develop predictive models.</p> <p>FY 2015 Accomplishments: 2015 Completed ground-breaking research for fundamental understanding of the initiation process which will provide increased fuze reliability. Developed unique test capability and completed testing to evaluate the performance of advanced fuze algorithms in high speed scenarios. Quantified the fuze environment during representative penetration scenarios and provided data to multiple organizations for modeling and simulation (M&S) activities.</p> <p>FY 2016 Plans: Continue to develop M&S and test capabilities for penetration scenarios. Develop fuzing system technologies to employ ground profiling radar for miniature ordnance packaging to enable more lethal forward-firing effects with low collateral damage. Investigate the capability to predict and measure fuze performance during munition penetration at high impact speeds. Investigate alternative optimized fuzing technologies that facilitate tailored lethal effects. Develop distributed and multi-point fuzing concepts.</p> <p>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.</p>				
<p>Title: Warhead Technologies</p> <p>Description: Investigates and develops innovative warhead kill mechanisms, such as adaptable warheads, directional-control fragmenting warheads, and reactive metals.</p> <p>FY 2015 Accomplishments: Implemented new models into multiphase physics codes which improved simulation capability. Enhanced the weapon penetration predictions codes. Conducted numerous tests to provide phenomenological understanding and data for code validation. Performed studies for weapon concept assessments. Developed small, multi-output warhead technologies primarily for soft surface targets, but with limited penetration capability for hardened, shallow structures.</p> <p>FY 2016 Plans: Continue to develop small, multi-output warhead technologies primarily for soft surface targets, but with limited penetration capability for hardened, shallow structures. Explore novel warhead technologies and materials that increase lethality in innovative</p>		12.381	15.000	17.462

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622502 / <i>Ordnance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>air-to-air engagements. Develop small, multi-output penetrator technologies that address penetrator stability through novel nose shapes and increased survivability through internal structures for high-speed impacts into hard and deeply buried targets.</p> <p>FY 2017 Plans: Continue refining small, multi-output warhead technologies primarily for soft surface targets but with limited penetration capability of hardened structures. Continue to experiment with novel materials and determine their mechanical response under high-rate and high-pressure loading conditions. Implement additive manufacturing techniques for novel warhead designs. Develop technologies for high speed penetration applications into challenging targets. Develop air-to-air missile warhead concepts for legacy fighters and the air targets in near-peer engagement scenarios.</p>				
<p>Title: Ordnance Technologies</p> <p>Description: Using a system approach, investigates and develops ordnance concepts by making technology trades between fuzes, warheads, and explosives and by improving weapon carriage, release, and dispensing.</p> <p>FY 2015 Accomplishments: Conducted numerous tests to provide phenomenological understanding and data for code validation. Performed studies for weapon concept assessments. Enhanced the weapon penetration prediction codes and released a new version with ten times increase in problem size and twenty times reduction in run time. Implemented new ordnance models into multiphase physics codes which improved the simulation capability. Developed inventive ordnance concepts that increase the capacity and capability of fifth generation and beyond aircraft.</p> <p>FY 2016 Plans: Continue to develop multiphase physics models analyzing the detonation of a warhead and the dispersal of either a neutralizer or fuel. Continue to develop inventive ordnance concepts that increase the capacity and capability of fifth generation and beyond aircraft. Develop mission-level simulation architecture capability to enable weapon system and weapon technology assessments. Explore general purpose warhead concepts that allow technology refresh matching the pace of technology discovery in an affordable, sustainable design. Develop technologies for low-cost, long-range munition concepts.</p> <p>FY 2017 Plans: Continue to develop validated modeling and simulation (M&S) tools for computational physics sciences with emphasis on the development of computational techniques for addressing physics issues that occur below the macroscopic scale. Continue to develop mission-level simulation architecture capability to enable weapon system and weapon technology assessments. Continue to explore general purpose warhead concepts that allow technology refresh matching the pace of technology discovery in an affordable, sustainable design. Continue to develop technologies for low-cost, long-range munition concepts. Develop predictive techniques for munition effectiveness tools used in concept development and assessment as well as studies involving</p>		10.630	13.000	16.675

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>	Project (Number/Name) 622502 / <i>Ordnance Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
analysis of alternatives. Develop test capability and M&S tools to characterize lethality survivability, performance of advanced energetics, and ordnance systems.			
Accomplishments/Planned Programs Subtotals	46.011	53.029	56.916

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: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research	R-1 Program Element (Number/Name) PE 0602605F I Directed Energy Technology
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	126.189	115.105	127.163	0.000	127.163	120.059	121.530	124.018	125.791	Continuing	Continuing
624866: Lasers & Imaging Technology	-	77.529	75.988	92.445	0.000	92.445	85.160	85.986	87.750	89.018	Continuing	Continuing
624867: Advanced Weapons & Survivability Technology	-	48.660	39.117	34.718	0.000	34.718	34.899	35.544	36.268	36.773	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 lasers 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.

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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	125.866	115.604	118.401	0.000	118.401
Current President's Budget	126.189	115.105	127.163	0.000	127.163
Total Adjustments	0.323	-0.499	8.762	0.000	8.762
• Congressional General Reductions	0.000	-0.499			
• 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	2.772	0.000			
• SBIR/STTR Transfer	-2.449	0.000			
• Other Adjustments	0.000	0.000	8.762	0.000	8.762

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

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

R-1 Program Element (Number/Name)
PE 0602605F / *Directed Energy Technology*

Change Summary Explanation

Increase in FY 2015 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

In FY2017 increase due to increased priority of high energy laser research.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>				Project (Number/Name) 624866 / <i>Lasers & Imaging Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
624866: <i>Lasers & Imaging Technology</i>	-	77.529	75.988	92.445	0.000	92.445	85.160	85.986	87.750	89.018	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 2015	FY 2016	FY 2017
Title: High Energy Laser Technologies and Directed Energy Assessments	47.220	48.285	65.570
Description: Develop and demonstrate high energy laser (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 2015 Accomplishments: Continued to conduct research supporting a joint Air Force/DARPA ground demonstration of a high power solid state laser with a beam control system. Used effects testing to establish system requirements and validate modeling efforts. Evaluated subscale turret beam control technologies. Updated and used Integrated Weapons Environment for Analysis (IWEA) to analyze directed and kinetic energy weapons in a common environment to help plan weapons investments. Used intelligence information to evaluate foreign HEL threats and provide weapon system and technology developers with tools and criteria to help protect US systems. Began integration of beam control technologies and monolithic fiber amplifier for ground to air field tests. Continued design of laser system for aircraft self-protection.			
FY 2016 Plans: Complete beam control and monolithic fiber amplifier integration and ground tests. Conduct effects testing to establish system requirements and validate modeling efforts. Perform airborne tests of turret beam control technologies. Begin integration of beam control and low power laser technologies for aircraft self-protection. Complete IWEA Build 1 and conduct assessments of concepts for laser weapon systems to help users plan weapons investments. Model and characterize foreign HEL threats to blue systems			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>	Project (Number/Name) 624866 / <i>Lasers & Imaging Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
and provide assessments to developers for hardening materials and designs. Complete 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 and conduct assessments of concepts for laser weapon systems. Model and characterize foreign HEL threats.			
Title: Optical Space Situational Awareness and Satellite Vulnerability 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 2015 Accomplishments: Developed dynamic telescope control to keep track of potential threat objects in space. Demonstrated data analysis techniques to understand characteristics of potential space threats and satellite anomalies. Demonstrated capabilities for significantly extending existing techniques into 24-hour operations. Evaluated concepts for persistent monitoring of space events and concepts to image and search the local space around our high-value satellite assets, including those in geosynchronous orbits. FY 2016 Plans: Begin 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. Perform comparison of capabilities for extending telescope operation into daylight hours to provide Air Force Space Command programs with technology options for their requested products. Demonstrate 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 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. Implement 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.	30.309	27.703	26.875
Accomplishments/Planned Programs Subtotals	77.529	75.988	92.445

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force Date: February 2016

Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)
3600 / 2	PE 0602605F / <i>Directed Energy Technology</i>	624866 / <i>Lasers & Imaging Technology</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>				Project (Number/Name) 624867 / <i>Advanced Weapons & Survivability Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
624867: <i>Advanced Weapons & Survivability Technology</i>	-	48.660	39.117	34.718	0.000	34.718	34.899	35.544	36.268	36.773	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 2015	FY 2016	FY 2017
Title: HPEM and Unconventional Weapon Technologies	29.697	19.711	15.921
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 2015 Accomplishments: Completed, in collaboration with the Navy, the first phase of the ultra-short pulsed laser atmospheric propagation studies by constructing the world's largest controlled turbulence beam line. Conducted effects studies on electronics based on the assessments from FY14. Developed compact 50 kilovolt solid state switch. Developed designs for 100 megavolt test facility accelerator. Continued development of technologies leading to more efficient, smaller, lighter, and more powerful HPEM systems.			
FY 2016 Plans: Refine ultra-short pulsed laser atmospheric propagation studies. Conduct effects studies on electronics based on the assessments from FY15. Complete compact 50 kilovolt solid state switch. Complete designs for 100 megavolt test facility accelerator. Begin design of smaller, higher power, source technology for the Next Generation High Power Microwave (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. Complete compact 50 kilovolt solid state switch and package it in a militarily relevant platform. Complete design of smaller, higher power, source technology for the Next Generation HPM demonstration.			
Title: HPEM Effects and Mitigation Research	18.963	19.406	18.797

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>	Project (Number/Name) 624867 / <i>Advanced Weapons & Survivability Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: Developed source for effects testing that operates in three microwave bands. Completed integration of software into DE High Performance Computing Software Applications Institute, 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. Used intelligence information to evaluate foreign HPEM threats and provide weapon system and technology developers with tools and criteria to help protect US systems.</p> <p>FY 2016 Plans: Complete source for effects testing that operates in three microwave bands. Test and validate DE High Performance Computing Software Applications Institute software, which allows modeling of DE sources and propagation that involves plasmas. Assess potential improvements to US weapons systems from employing HPEM weapons technologies for platform protection and target prosecution. Conduct assessments of HPEM and kinetic energy weapon concepts in a common environment to help users plan weapons investments. Model and characterize HPEM threats to blue systems and provide assessments developers for hardening materials and designs.</p> <p>FY 2017 Plans: Test and validate 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. Conduct further assessments of HPEM and kinetic energy 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. Model and characterize current and projected HPEM threats to blue systems and provide assessments to developers for hardening materials and designs.</p>			
Accomplishments/Planned Programs Subtotals	48.660	39.117	34.718

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

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>	Project (Number/Name) 624867 / <i>Advanced Weapons & Survivability Technology</i>

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	146.951	169.183	161.650	0.000	161.650	159.214	166.251	169.690	171.865	Continuing	Continuing
625315: <i>Connectivity and Protection Tech</i>	-	64.217	77.129	31.228	0.000	31.228	31.456	32.266	31.579	31.699	Continuing	Continuing
625316: <i>Info Mgt and Computational Tech</i>	-	28.814	31.138	12.966	0.000	12.966	12.528	14.150	13.982	13.274	Continuing	Continuing
625317: <i>Information Decision Making Tech</i>	-	13.035	20.462	14.770	0.000	14.770	14.585	15.865	15.695	16.860	Continuing	Continuing
625318: <i>Operational Awareness Tech</i>	-	20.407	19.198	21.246	0.000	21.246	22.731	23.753	24.246	24.900	Continuing	Continuing
625319: <i>Cyberspace Dominance Technology</i>	-	0.000	0.000	59.712	0.000	59.712	56.815	58.695	62.226	62.739	Continuing	Continuing
620MMS: <i>Research Site Support</i>	-	20.478	21.256	21.728	0.000	21.728	21.099	21.522	21.962	22.393	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.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>
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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.

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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	147.749	164.909	163.132	0.000	163.132
Current President's Budget	146.951	169.183	161.650	0.000	161.650
Total Adjustments	-0.798	4.274	-1.482	0.000	-1.482
• Congressional General Reductions	0.000	-0.226			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	4.500			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	1.000	0.000			
• SBIR/STTR Transfer	-1.798	0.000			
• Other Adjustments	0.000	0.000	-1.482	0.000	-1.482

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

Project: 625315: *Connectivity and Protection Tech*

Congressional Add: *Program Increase*

Congressional Add Subtotals for Project: 625315

Congressional Add Totals for all Projects

	FY 2015	FY 2016
	-	4.500
	-	4.500
	-	4.500

Change Summary Explanation

Increase in FY 2015 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Decrease in FY 2017 is due to higher DoD priorities.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>				Project (Number/Name) 625315 / <i>Connectivity and Protection Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
625315: <i>Connectivity and Protection Tech</i>	-	64.217	77.129	31.228	0.000	31.228	31.456	32.266	31.579	31.699	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 2015	FY 2016	FY 2017
Title: Advanced Connectivity Technologies	22.348	28.122	31.228
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 2015 Accomplishments:			
Completed an accelerated waveform development process and associated tools. Demonstrated the digital portion of a 32 by 32 multiple input, multiple output (MIMO) system. Continued the 81 to 86 gigahertz (GHz) Traveling Wave Tube Amplifier (TWTA) development. Completed bench-top demonstration of quantum key distribution (QKD) in concert with a multi-access lasercom system. Initiated research to investigate the use of autonomy on small unmanned aircraft system platforms to support (semi-)autonomous distributed cooperative airborne tactics using airborne networks. Initiated 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 architectures. Developed a waveform starter kit for multi-mission communications and radar. Performed dual site diversity radiometric testing for mitigating weather limitations. Continued development of automated process to port communication models to real-time hardware in the loop. Continued both development of secure video distribution over tactical internets on demand and design of distributed, cross-layer protocols for cognitive radio ad hoc networks with decentralized control. Continued the development of a modular			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>Connectivity and Protection Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>airborne network bridge for the creation of an air-air/air-ground secure tactical intranet. Continued the development of wideband, long range, rapidly deployable aerial backbone network for command, control, intelligence, surveillance, and reconnaissance (C2ISR) dissemination.</p> <p>FY 2016 Plans: Perform a field demonstration of the 32 by 32 MIMO system. Demonstrate a three node QKD multi-access laser communications system. Plan a 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. Develop a software implementation of a low-bandwidth protocol for network situational awareness and management across heterogeneous networks. Derive an Air Force specification and S&T strategy for next-generation directional capabilities. Continue development of an automated process to port communication models to a real-time hardware in the loop simulation. Continue the development and integration of waveform components, tools, and hardware into an innovative ecosystem for affordable rapid waveform development over a continuum of COTS/GOTS software defined radio frequency (SDRF) architectures. Continue 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. Continue the development of a modular airborne network bridge for the creation of an air-air/air-ground secure tactical intranet. Continue the development of wideband, long range, rapidly deployable aerial backbone network for C2ISR dissemination. Continue research to advance autonomy in unmanned air vehicles to support distributed cooperative airborne tactics using advanced communications techniques.</p> <p>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 RF capability. Demonstrate TWTAs at 81 to 86 GHz continuous power of approximately 45 watts. Demonstrate a multi-access optical link at 30 kilometers.</p>				
<p>Title: Cyber Defense Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments:</p>		17.860	20.906	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>Connectivity and Protection Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Initiated research in Cyber ISR technologies to support integrated Signals Intelligence (SIGINT)-Cyber operations. Initiated development of innovative embedded system security techniques that protect critical high-value resources; initial use-case focus is command and control functions of unmanned aerial systems. Continued interaction with the University Center of Excellence (UCoE) in Assured Cloud Computing and collect performance results for a framework to assess cloud trustworthiness. Initiated research for enhanced cyber situational awareness through the automated assessment of mission execution through the analysis of network traffic flows.</p> <p>FY 2016 Plans: Continue development of embedded and resilient technologies; develop an initial prototype with separation, monitoring service and cryptographic key management. Continue enhancement, maturation, testing, and demonstration of Cyber Agility technologies through exercises and other user-focused venues toward the objective of transition. Continue 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). Continue interaction with UCoE in Assured Cloud Computing. Continue research for an innovative approach to mission awareness by making mission model, information, and behavioral analytical assessments of mission execution status and mission phase changes.</p> <p>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.</p>				
<p>Title: Cyber Offense Technologies</p> <p>Description: Develop offensive cyber operations technologies to access, maintain presence on, and deliver effects to adversary systems.</p> <p>FY 2015 Accomplishments: Continued development in software-defined radio (SDR) hardware, software, frameworks and interfaces matched with dynamic waveform techniques and cyberspace capabilities to detect, identify, locate and attack adversaries in anti-access area-denial (A2AD) environments. Continued state of the art (SOTA) multi-channel, tactical transceiver technology as well as modular and hardware-flexible SDR components to operate over the entire electromagnetic spectrum (EMS) & Cyberspace Continuum including SIGINT, Electronic Warfare (EW), Cyber and Communications in a horizontally and vertically-scalable fashion. Researched and developed concepts for how the behaviors of living organisms (i.e. flocking, herding, swarming) could be advantageously applied to the enterprise operations realm. Researched next generational operating systems and computer-based systems of interest for advancing cyber operation based capabilities. Developed prototype, proof of concept based</p>		18.380	18.291	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>Connectivity and Protection Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>capabilities. Transitioned Cyber Mission Framework Prototype (Alpha) to the 67th Cyberspace Operations Group (Air Force Space Command) in San Antonio for evaluation.</p> <p>FY 2016 Plans: Continue development of existing capabilities to exploit and mitigate adversary threats in the EMS. Continue closed-loop learning techniques for applying EW and Cyberspace operations in composite fashion based on near-real-time feedback loops. Continue to mature SDR hardware and software at national-level exercises and pursue technology transfer/transition to Joint platforms and Programs of Record. Continue 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. Continue development of technologies to remain current with new waveforms and signals. Continue Service Oriented Architecture (SOA) mission component development for use in the Air Force Life Cycle Management Center Cyber Mission Platform (CMP). Transition components, including mission reporting, for use in CMP. Continue red-teaming new components to improve security.</p> <p>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.</p>				
<p>Title: Survivability Technologies</p> <p>Description: Develop methods and technologies for controlled operation of information systems during attacks and fault conditions, minimizing vulnerabilities of cyber attacks, and guaranteeing the accuracy and correctness of data and codes.</p> <p>FY 2015 Accomplishments: Initiated 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.</p> <p>FY 2016 Plans: Continue 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. Focus effort on hiding mission essential functions (MEFs) in the cloud and rapidly recovering MEFs using the vast computing cloud resources.</p> <p>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 Survivability Technologies.</p>		0.235	0.803	0.000
<p>Title: Cyber Technologies for Spectrum Warfare</p>		5.394	4.507	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>Connectivity and Protection Tech</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: Initiated development of methods to improve the identification, collection and geo-location, analysis and correlation of parametric data and information. These methods will maximize the information that can be extracted to include: source of the communication, location of the transmitter, function of the transmitter, Radio Frequency (RF) and other technical characteristics of the transmission.</p> <p>FY 2016 Plans: Continue development of methods to improve the identification, collection and geo-location, analysis and correlation of parametric data and information. These methods will maximize 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.</p> <p>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.</p>			
Accomplishments/Planned Programs Subtotals	64.217	72.629	31.228

	FY 2015	FY 2016
Congressional Add: Program Increase	-	4.500
FY 2016 Plans: Conduct Congressionally directed effort.		
Congressional Adds Subtotals	-	4.500

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

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625315 / <i>Connectivity and Protection Tech</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>				Project (Number/Name) 625316 / <i>Info Mgt and Computational Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
625316: <i>Info Mgt and Computational Tech</i>	-	28.814	31.138	12.966	0.000	12.966	12.528	14.150	13.982	13.274	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 2015	FY 2016	FY 2017
Title: Dissemination Technologies	9.152	9.406	12.966
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 2015 Accomplishments: Completed development of information management services embedded with the sensor that will boost the effective communication bandwidth available to tactical users and link pilots, remotely piloted aircraft (RPA), and ground assets in the field. 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. Initiated 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. Initiated the development of information management capabilities that			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625316 / <i>Info Mgt and Computational Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2016 Plans: Continue research into scalable mission responsive data systems by mapping mission requirements to information flows. Continue 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. Continue development of responsive autonomous control for tactical sensor control. Continue 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. Continue the development of 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.</p> <p>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.</p>				
<p>Title: Processing Technologies</p> <p>Description: Develop automatic and dynamically reconfigurable, affordable, scalable, distributed petaflop processing technologies for real-time global information systems.</p> <p>FY 2015 Accomplishments: Continued development of advanced computing techniques, enabling superior information processing for Air Force warfighters through in-house research. Improved on-board processing to include real-time dissemination of three dimensional (3D) situational awareness of the battlespace. Investigated the information management techniques necessary for an operator to publish, query and subscribe to services that enable the information to be provided to only those operators that require it without overloading existing communication links. Investigated the use of neuromorphic neural network techniques for real-time learning about unanticipated events (hypothesis discovery and testing). Initiated 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 Intelligence, Surveillance, and Reconnaissance (ISR) missions in the contested and A2AD environments.</p> <p>FY 2016 Plans:</p>		7.156	6.720	0.000

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625316 / <i>Info Mgt and Computational Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Continue 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 A2AD environments. Develop autonomous methods of discovering salient events by exploiting disparate sensor data via bio-logically inspired neuromorphic learning algorithms. Develop algorithms that automatically make associations of disparately sensed signatures for a given event(s). Develop the algorithms so that they exploit low level information (raw data) from ISR sensors. Fabricate the enhanced Air Force Research Laboratory Secure Processor.</p> <p>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.</p>				
<p>Title: Cross Domain Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments: Developed an innovative approach to malicious code detection by running suspect files within a virtual environment and comparing the execution with normal application behaviors. Developed a secure foundation for mobile devices that will act as a foundation for a multiple levels of security (MLS) mobile device. Developed a cross-domain video teleconference (VTC) capability that allows VTC participants to be on networks of differing classification. Developed automated techniques to correlate network events to cross-domain systems (CDS) policy configurations allowing for automated remediation of attacks.</p> <p>FY 2016 Plans: Develop techniques to allow rapid cross security domain enablement of IT systems. Continue development of a secure MLS mobile foundation. Continue development of malicious code detection techniques based upon runtime performance of applications.</p> <p>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.</p>		4.724	5.772	0.000
<p>Title: Advanced Architectural Technologies</p> <p>Description: Develop the architectural mechanisms that form the basis for predictable software and high assurance systems.</p> <p>FY 2015 Accomplishments:</p>		7.782	9.240	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625316 / <i>Info Mgt and Computational Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Completed creation of a trade space analysis tool used to determine feasibility and scale of autonomy on mobile systems. Completed demonstration of 3D stacking of logic chips on other logic chips while using standard processor fabrication lines. Initiated development of theory and techniques to continuously validate/reestablish trust utilizing mission objectives & warfighter perspectives (environment). Developed a continuous calculus of trust (verification & validation) as the system executes the mission. Initiated research of trusted and resilient systems using evolutionary and formal approaches. Developed automated repairs that are trusted, understandable and maintainable by humans. Initiated research for embedded processor to address the middle range computing requirements and having significant cyber hardening features. Initiated research to develop new, unconventional processing technologies with greater than ten-times conventional processing energy efficiencies to allow efficient co-processing on-board.</p> <p>FY 2016 Plans: Integrate the hardened secure processor with its stacked dynamic random-access memory (DRAM) memory. Package the stacked chipset and test it on a printed circuit board. Continue research on a calculus of trust for measurement and understanding. Develop 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). Develop automated repairs that are trusted, understandable and maintainable by humans.</p> <p>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.</p>			
Accomplishments/Planned Programs Subtotals	28.814	31.138	12.966

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>				Project (Number/Name) 625317 / <i>Information Decision Making Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
625317: <i>Information Decision Making Tech</i>	-	13.035	20.462	14.770	0.000	14.770	14.585	15.865	15.695	16.860	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 2015	FY 2016	FY 2017
Title: Campaign Planning Technologies	6.361	5.918	9.242
Description: Develop advanced monitoring, planning, and assessment technologies enabling aerospace commanders to develop effects-based campaigns.			
FY 2015 Accomplishments: Continued development of robust autonomous control algorithms for heterogeneous and distributed assets capable of learning in dynamic environments. Completed research in cooperative agency and group transfer learning. Initiated research to develop a validation and verification methodology such that an agent acting autonomously will never act outside of a prescribed policy.			
FY 2016 Plans: Initiate 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. Continue development of robust autonomous control algorithms for heterogeneous and distributed assets capable of learning in dynamic environments. Initiate research for robust autonomous system capable of self-adjustment and active learning under unforeseen circumstances. Demonstrate multi-agent autonomous ISR capabilities, given limited communications in Autonomous Test and Evaluation Environment simulations. Continue 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.			
Title: Command and Control System Technologies	6.674	14.544	5.528

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625317 / <i>Information Decision Making Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: Characterized Moving Target Defenses attributes and de-conflicted network and system resources across competing defenses. Completed development of fundamental visualization components that addressed existing and forth coming visualization problems for the Air Force, such as: live video over 3D terrain, radial mission map plots, semantic dataset overview, semantic dataset merging and filtering, thin-client point cloud visualization, server based point cloud distribution and analysis, and structured graph navigation. Initiated research on new concepts for space operations, such as the applicability of crowdsourcing methods in the space C2 domain; designed and implemented an Electromagnetic Spectrum Common Operational Picture.</p> <p>FY 2016 Plans: Continue development of concepts for space operations. 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 command and control. Work 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. Provide final delivery of Attack Surface Reasoning and Characterization of Proactive Defenses integration with local and remote testbeds.</p> <p>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.</p>			
Accomplishments/Planned Programs Subtotals	13.035	20.462	14.770

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

N/A

Remarks

D. Acquisition Strategy

N/A

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625317 / <i>Information Decision Making Tech</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>				Project (Number/Name) 625318 / <i>Operational Awareness Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
625318: <i>Operational Awareness Tech</i>	-	20.407	19.198	21.246	0.000	21.246	22.731	23.753	24.246	24.900	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 2015	FY 2016	FY 2017
Title: Multi-Source Fusion Technologies	10.795	10.699	10.283
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 2015 Accomplishments: Continued 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. Applied advanced reasoning techniques to multi-INT data including SIGINT and space surveillance network (SSN) data to assess space objects and determine significance of activity. Continued the development of on-board technologies that integrate and fuse data from disparate sensors and sources. Integrated on-board passive 3D processing to enhance algorithm performance and provide operators with greatly improved situational awareness. Continued to develop multi-INT fusion for contested environments to aid National Air and Space Intelligence Center (NASIC) & DCGS analysts. Developed automatic optimization of tracking algorithms across sensors, modes, and regions. Migrated tools and data to distributed (cloud) computing to extract additional performance gains. Provided baseline Activity-Based Intelligence (ABI) capabilities and metrics. Developed distributed cross-document co-reference for automated consolidation of information across documents; a flexible and adaptive platform for layered Network analysis.			
FY 2016 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625318 / <i>Operational Awareness Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Complete in-house and university research dealing with the information fusion using 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. Analyze emerging activities across multiple domains in both tactical and strategic timelines. Continue applying advanced reasoning techniques to multi-INT data including SIGINT and SSN data to assess space objects and determine significance of activity. Address 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. Provide advanced ABI tools with built-in optimization tailored against operator objectives. Develop 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.</p> <p>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 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.</p>			
<p>Title: Exploitation Technologies</p> <p>Description: Develop digital information exploitation technologies for electronic communications and special signals intelligence, imagery, and measurement signatures to increase accuracy, correlation, and timeliness of the information.</p> <p>FY 2015 Accomplishments: Investigated novel algorithms for collection, identification, detection and geo-location of modern emitter signals. Experimented with digital hardware solutions for capturing modern emitter signals. Improved feature extraction techniques for performance across multiple data sets, improve modeling efficiency for algorithms, investigate new classifier techniques, and improve performance on cross-platform data. Applied previously developed Level Zero fusion algorithms to recorded data for performance analysis. Derived distributed fusion approach that operates across a network of distributed, multi-modality, sensors. Incorporated machine</p>	6.720	6.085	8.646

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625318 / <i>Operational Awareness Tech</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>learning approaches into event discovery. Continued development of an automated capability to search and retrieve objects of interest in full motion video (FMV) sources and correlate with information from multiple intelligence sources.</p> <p>FY 2016 Plans: Continue 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. Continue algorithmic improvements in signal characterization, detection and mitigation of coding/channel condition effects. Develop improvements for feature extraction methods and performance across multiple data sets. Finalize evaluation of FMV exploitation tools, and select the best of breed. Initiate the development of capabilities for the exploitation of intelligence information using topological mathematical approaches applied to the SIGINT domain.</p> <p>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 for anomaly and/or pattern detection. Continue SIGINT characterization algorithm development and refine methods based on feedback. Develop specialized SIGINT change detection.</p>				
<p>Title: Next Generation Command Technologies</p> <p>Description: Develop modeling and simulation technologies for the next generation of planning, assessment, and execution environments.</p> <p>FY 2015 Accomplishments: Developed a CATALiST (Common Automated Targeting Architecture Linking integrated Solution Threads) framework which includes: data and user management; security and role-based access; integrated and re-configurable workflows linking targeting materials production tasks, tools, and dashboards; dashboards which enable real-time management of targeting material production resources; and several automated tools integrated within the framework to increase product quality, shorten the production time, as well as incorporate cyber, electronic warfare, and kinetic targeting options across classified domains.</p> <p>FY 2016 Plans: Continue to develop a capability that identifies targets with non-kinetic data and propose new workflows for such targets. Work towards illustrating the time saved for Battle Damage Assessment (BDA) by performing assessment with non-geospatial intelligence data. Conduct tests using electromagnetic data.</p> <p>FY 2017 Plans:</p>		2.892	2.414	2.317

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625318 / <i>Operational Awareness Tech</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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.			
Accomplishments/Planned Programs Subtotals	20.407	19.198	21.246

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
625319: <i>Cyberspace Dominance Technology</i>	-	0.000	0.000	59.712	0.000	59.712	56.815	58.695	62.226	62.739	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 2015	FY 2016	FY 2017
Title: Cyber Defense Technologies	0.000	0.000	19.081
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 2015 Accomplishments: N/A			
FY 2016 Plans: N/A			
FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed under Project 625315, Connectivity and Protection Technology in the effort, Cyber Defense Technologies			
Continue development of Decision Engine and tesbed. Initiate demonstration of all system system components, with reduced scale and feature set.			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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 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.				
<p>Title: Cyber Offense Technologies</p> <p>Description: Develop offensive cyber operations technologies to access, maintain presence on, and deliver effects to adversary systems.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed under Project 625315, Connectivity and Protection Technology in the effort, Cyber Offense Technologies</p> <p>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.</p>		0.000	0.000	13.424
<p>Title: Advanced Architectural Technologies</p> <p>Description: Develop the architectural mechanisms that form the basis for predictable software and high assurance systems.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed under Project 625316, Info Management and Computational Technology in the effort, Advanced Architectural Technologies.</p>		0.000	0.000	9.571

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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.				
<p>Title: Processing Technologies</p> <p>Description: Develop automatic and dynamically reconfigurable, scalable, affordable distributed peta-flop processing technologies for real-time global information systems.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed under Project 625316, Info Management and Computational Technology in the effort, Processing Technologies</p>		0.000	0.000	4.979
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.				
<p>Title: Survivability Technologies</p> <p>Description: Develop methods and technologies for controlled operation of information systems during attacks and fault conditions, minimizing vulnerabilities of cyber attacks, and guaranteeing the accuracy and correctness of data and codes.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed under Project 625315, Connectivity and Protection Technology in the effort, Survivability Technologies</p>		0.000	0.000	4.560

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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.				
<p>Title: Cross Domain Technologies</p> <p>Description: Develop secure cross domain discovery services for access to services outside the existing domain. Develop the tools to allow collaboration of workflows required by the Air Force net-centric information management system.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed under Project 625316, Info Management and Computational Technology in the effort, Cross Domain Technologies</p> <p>Continue research on cross domain change detection, cross domain machine to machine mediation layer and multiple levels of security mobile secure foundation technologies.</p>		0.000	0.000	4.488
<p>Title: Cyber Technologies for Spectrum Warfare</p> <p>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.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and 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.</p>		0.000	0.000	3.609

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 625319 / <i>Cyberspace Dominance Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Continue development of active and passive methods to locate, acquire and process data and signals of interest.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	59.712

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>				Project (Number/Name) 62OMMS / <i>Research Site Support</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
62OMMS: <i>Research Site Support</i>	-	20.478	21.256	21.728	0.000	21.728	21.099	21.522	21.962	22.393	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 2015	FY 2016	FY 2017
Title: Rome Research Infrastructure	20.478	21.256	21.728
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 NETWORKX contracts for Continental U.S.), trunk connectivity and wireless communications.			
FY 2015 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 included annual inspection of facilities, master planning, overhead of planning and design, overhead of construction management, and non-Sustainment and Restoration Modernization (SRM) service			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 62OMMS / <i>Research Site Support</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>calls. Provided basic installation communication services, including long haul trunk and telecommunications services. Provided site vehicle lease under GSA for logistics, security, and mission support.</p> <p>FY 2016 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.</p> <p>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.</p>				
Accomplishments/Planned Programs Subtotals		20.478	21.256	21.728
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / <i>Dominant Information Sciences and Methods</i>	Project (Number/Name) 62OMMS / <i>Research Site Support</i>

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>					R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	36.162	41.855	42.300	0.000	42.300	43.049	43.685	44.553	45.443	Continuing	Continuing
625096: <i>High Energy Laser Research</i>	-	36.162	41.855	42.300	0.000	42.300	43.049	43.685	44.553	45.443	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program funds Department of Defense (DoD) high energy laser (HEL) applied research through the HEL Joint Technology Office (JTO). 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. 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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	37.441	42.037	42.300	0.000	42.300
Current President's Budget	36.162	41.855	42.300	0.000	42.300
Total Adjustments	-1.279	-0.182	0.000	0.000	0.000
• Congressional General Reductions	0.000	-0.182			
• 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	-0.030	0.000			
• SBIR/STTR Transfer	-1.249	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

C. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Title: Robust Electric Laser Initiative	5.120	1.540	0.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>		R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Description: Advance solid-state laser development.</p> <p>FY 2015 Accomplishments: Continued the joint high power electric laser product improvement program, as part of the Robust Electric Laser Initiative (RELI) effort. Initiated two additional major efforts for risk reduction and to explore other architectures for scalability. Monitored technical progress of the 60kW and the 30kW lasers and other sources. Monitored preparation for integration onto specific relevant military platforms. Continued analysis of trade space to understand performance and integration issues for other platforms. Performed government-sponsored measurements to validate performance.</p> <p>FY 2016 Plans: Complete a joint high power electric laser product improvement program, as part of the RELI effort. Monitor technical progress of the four efforts and other sources. Monitor performance of the lasers as integrated onto relevant military platforms. Complete analysis of trade space to understand performance, fielding, robustness and integration issues for future platforms. Complete government-sponsored measurements to validate performance.</p> <p>FY 2017 Plans: In FY2016, the RELI effort completes.</p>				
<p>Title: Solid State Laser Technologies</p> <p>Description: Mature technologies that will provide system level performance commensurate with fieldable laser devices.</p> <p>FY 2015 Accomplishments: Developed high reliability, lower cost, efficient and high temperature diode pump sources. Performed scaling of alternate laser wavelengths to militarily relevant power levels. Developed high power delivery fiber technologies. Performed risk reduction analysis for fielding of laser systems. Conducted a reduced Service and Agency call for FY15.</p> <p>FY 2016 Plans: Develop high reliability, lower cost, efficient and high temperature diode pump sources. Scale alternate laser wavelengths to militarily relevant power levels. Investigate high power fiber technologies. Focus efforts on risk reduction for fielding of laser systems.</p> <p>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</p>		5.220	7.107	7.650

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>		R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
military platforms. Conduct analysis of trade space to understand performance, fielding, robustness and integration issues for future platforms.				
<p>Title: Advanced High Energy Laser (HEL) Technologies</p> <p>Description: Investigate new technologies that have revolutionary potential HEL applications.</p> <p>FY 2015 Accomplishments: Explored novel laser technologies to improve efficiency and decrease mass/volume for future laser devices. Evaluated new materials for HEL applications. Continued to improve understanding of short pulse laser technology to include material interaction and propagation. Continued to scale electrically pumped alkali lasers to KW-class power levels. Began efforts to further characterize and understand the physics of HEL propagation in adverse weather conditions such as fog, rain, smoke and dust. Continued development of the Predictive Avoidance and Air Space Deconfliction system and begin initial testing on HEL test range(s). Conducted a reduced Service and Agency call for FY15.</p> <p>FY 2016 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 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 development of the Avoidance and Air Space Deconfliction system and continue early-phase testing on HEL test range(s).</p> <p>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 such as fog, rain, smoke and dust. Continue testing of the Avoidance and Air Space Deconfliction system on HEL test range(s).</p>		4.780	6.210	6.210
<p>Title: Laser Beam Control Technologies</p> <p>Description: Develop technology to support high performance beam control systems and integrated demonstrations.</p> <p>FY 2015 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</p>		14.572	19.638	21.080

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>		R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
control hardware and technologies to improve throughput efficiency through the beam director, decrease component weight, and improve tracking and compensation through the atmosphere. Conducted a Service and Agency call for FY15. FY 2016 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. Further enhance 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 programs for Service specific applications. 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.				
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 2015 Accomplishments: In close coordination with existing HEL models, integrated new lethality data into campaign-level HEL system 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. Supported the 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 2016 Plans: Continue to integrate recent lethality data into campaign-level HEL system models. Conduct laser vulnerability experiments on materials, components, and targets. Complete development of an unmanned air vehicle vulnerability module for integration into the modeling and simulation toolkit. 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 2017 Plans:		3.060	3.720	3.720

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>		R-1 Program Element (Number/Name) PE 0602890F / <i>High Energy Laser Research</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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.				
Title: High Energy Laser (HEL) Modeling		3.410	3.640	3.640
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 2015 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. Updated predictive avoidance modeling into existing HEL toolkit. Continued development of a risk assessment for illumination of objects in space by tactical laser weapons. Continued analysis of scenario conditions to understand relative gains in hardware developments. Continued development and refinement of the requirements for a suite of DEW tools to be used in an environment from which the warfighter can assess mission utility for a given DEW platform and engagement.				
FY 2016 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 predictive avoidance modeling into existing HEL toolkit. Continue development of a risk assessment for illumination of objects in space by tactical laser weapons. Continue 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 predictive avoidance modeling into existing HEL toolkit. Continue development of a risk assessment for illumination of objects in space by tactical laser weapons. Develop Joint Munition Effects Manual (JMEM)-like modeling tools for future HEL weapon systems.				
Accomplishments/Planned Programs Subtotals		36.162	41.855	42.300
D. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
E. Acquisition Strategy				
N/A				

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

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

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

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	38.262	46.665	35.137	0.000	35.137	36.664	36.519	37.778	38.535	Continuing	Continuing
632100: <i>Laser Hardened Materials</i>	-	16.816	15.629	15.472	0.000	15.472	15.343	15.617	15.926	16.245	Continuing	Continuing
633153: <i>Non-Destructive Inspection Development</i>	-	4.251	5.029	6.350	0.000	6.350	6.331	6.423	6.550	6.681	Continuing	Continuing
633946: <i>Materials Transition</i>	-	17.195	26.007	13.315	0.000	13.315	14.990	14.479	15.302	15.609	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 (NDI/E) 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 (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)

	<u>FY 2015</u>	<u>FY 2016</u>	<u>FY 2017 Base</u>	<u>FY 2017 OCO</u>	<u>FY 2017 Total</u>
Previous President's Budget	40.177	37.665	36.284	0.000	36.284
Current President's Budget	38.262	46.665	35.137	0.000	35.137
Total Adjustments	-1.915	9.000	-1.147	0.000	-1.147
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	9.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-1.064	0.000			
• SBIR/STTR Transfer	-0.851	0.000			
• Other Adjustments	0.000	0.000	-1.147	0.000	-1.147

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

Project: 633946: *Materials Transition*

Congressional Add: *Metals Affordability Research*

FY 2015	FY 2016
8.000	9.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>
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Congressional Add Details (\$ in Millions, and Includes General Reductions)

	FY 2015	FY 2016
Congressional Add Subtotals for Project: 633946	8.000	9.000
Congressional Add Totals for all Projects	8.000	9.000

Change Summary Explanation

Decrease in FY 2015 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

Decrease in FY 2017 due to higher DoD priorities.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>				Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
632100: <i>Laser Hardened Materials</i>	-	16.816	15.629	15.472	0.000	15.472	15.343	15.617	15.926	16.245	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 2015	FY 2016	FY 2017
Title: Aerospace Systems Protection	7.904	7.379	7.306
Description: Develop and demonstrate materials technologies that enhance hardening for sensors, avionics, and components to increase survivability and mission effectiveness of aerospace systems.			
FY 2015 Accomplishments: Continued to advance development of protection materials for visual/near-infrared (NIR) Intelligence, Surveillance, and Reconnaissance (ISR) Sensors. Validated and demonstrated the 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 to develop survivable electro-optic sensors that provide full spectrum protection for missile warning. Continued evaluating the performance impact of damage-limiting semiconductor materials designed to harden electro-optic imaging sensors. Continued to develop laser countermeasures for survivability of dynamic electro-optic and infrared (EO/IR) imagers. Validated and 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 2016 Plans: Continue development of protection materials for visual/NIR ISR sensors. Demonstrate use of protection technologies for future ISR sensor designs and strategies to mitigate directed energy damage for visual/NIR, SWIR, and MWIR detectors. Develop survivable electro-optic sensors that provide full spectrum protection for missile warning. Continue evaluating the performance impact of damage-limiting semiconductor materials designed to harden electro-optic imaging sensors. Develop laser countermeasures for survivability of dynamic EO/IR 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. Continue air systems airframe and anti-access munitions hardening assessment.			
FY 2017 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Continue to analyze and develop protection materials for visual/NIR ISR sensors. Continue to demonstrate use of protection technologies for future ISR 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 EO/IR 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. Continue to develop air systems airframe and anti-access munitions hardening assessments.				
Title: Aircrew Protection		8.912	8.250	8.166
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 2015 Accomplishments: Developed and demonstrated laser protection materials and technologies for personnel protection e.g., laser eye protection. Continued development of helmet mounted sensor hardening materials. Continued development of visor based aircrew protection materials. Characterized eye protection technologies using computational materials science tools. Continued to improve functionality and performance of personnel protection technologies in expected operational conditions.				
FY 2016 Plans: Continue to develop and demonstrate laser protection materials and technologies for personnel protection. Validate and continue development of helmet mounted sensor hardening materials. Continue to advance development of visor based aircrew protection materials. 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 2017 Plans: Continue to develop and demonstrate laser protection materials and technologies for personnel protection. Validate and continue development of helmet mounted sensor hardening materials focusing on next generation nighttime sensors. Continue to advance development of visor based aircrew protection materials with agile protection. 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.				
Accomplishments/Planned Programs Subtotals		16.816	15.629	15.472
C. Other Program Funding Summary (\$ in Millions)				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>

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.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>				Project (Number/Name) 633153 / <i>Non-Destructive Inspection Development</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
633153: <i>Non-Destructive Inspection Development</i>	-	4.251	5.029	6.350	0.000	6.350	6.331	6.423	6.550	6.681	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced 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 2015	FY 2016	FY 2017
<p>Title: Advanced Engine Inspection Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments: Continued development of NDI/E approaches to nondestructively 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. Added sonic IR inspection system to the NDE toolkit.</p> <p>FY 2016 Plans: Demonstrate NDI/E approaches to nondestructively 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.</p> <p>FY 2017 Plans: Continue to demonstrate NDI/E approaches to nondestructively 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.</p>	1.063	1.237	1.964
<p>Title: Low-Observable Inspection Technologies</p> <p>Description: Develop and demonstrate advanced inspection technologies supporting low-observable (LO) systems to enhance affordability and ensure full performance and survivability.</p>	0.808	0.939	1.585

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633153 / <i>Non-Destructive Inspection Development</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> 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. Completed and transitioned a hand-held imaging tool.</p> <p><i>FY 2016 Plans:</i> Initiate new and continue 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.</p> <p><i>FY 2017 Plans:</i> Demonstrate 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. Develop tools to improve characterization of specialty multilayer coatings.</p>				
<p><i>Title:</i> Advanced System Monitoring Technologies</p> <p><i>Description:</i> Develop and demonstrate advanced systems status monitoring technologies to provide on-board and embedded sensing to gain continuous awareness of the state of key subsystems.</p> <p><i>FY 2015 Accomplishments:</i> Validated improved field and depot-level nondestructive inspection/evaluation technologies and methodologies for assessing the structural integrity of airframes. Added a sonic IR NDE inspection system to the tool box. Developed analytical methods to assess the location of damage in multi-layered structure based on nondestructive inspection data and results. Continued development of robotic nondestructive inspection methods to minimize disassembly and reduced maintenance burden to perform inspections of aircraft structures. Validated the integration of computational materials science tools with life prediction methods to enable risk-based life management. Validated technologies to analyze materials state awareness and prevent corrosion.</p> <p><i>FY 2016 Plans:</i> Transition improved field and depot-level nondestructive inspection/evaluation technologies and methodologies for assessing the structural integrity of airframes. Continue development of analytical methods to assess the location of damage in multi-layered structure base on nondestructive inspection data and results. Continue development of robotic nondestructive inspection methods to minimize disassembly and reduced maintenance burden to perform inspections of aircraft structures. Initiate 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 nondestructive inspection/evaluation data necessary for improved damage</p>		2.380	2.853	2.801

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633153 / <i>Non-Destructive Inspection Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>detection and characterization. Demonstrate the integration of computational materials science tools with life prediction methods to enable risk-based life management.</p> <p><i>FY 2017 Plans:</i> 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 nondestructive inspection/evaluation 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.</p>			
Accomplishments/Planned Programs Subtotals	4.251	5.029	6.350

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633946 / <i>Materials Transition</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
633946: <i>Materials Transition</i>	-	17.195	26.007	13.315	0.000	13.315	14.990	14.479	15.302	15.609	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 2015	FY 2016	FY 2017
<p>Title: Air Vehicle Materials Technologies</p> <p>Description: Develop and demonstrate materials and processes technologies for air vehicle and subsystems to enhance lift, propulsion, Low-observable performance, power generation management, and affordability of air vehicles.</p> <p>FY 2015 Accomplishments: Validated processing methods and lifing tools for ceramic matrix composites and graded microstructure turbine engine disk concepts. Demonstrated repeatability of magnetoresistive sensing technologies. Continued integration of damage with risk-based life management strategies for turbine engines. Continued development of materials and processes to increase Low-observable materials affordability.</p> <p>FY 2016 Plans: Demonstrate processing methods and lifing tools for ceramic matrix composites and graded microstructure turbine engine disk concepts. Continue developing the repeatability of magnetoresistive sensing technologies. Integrate damage with risk-based life management strategies for turbine engines. Continue development of materials and processes to increase Low-observable materials and metals affordability.</p> <p>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.</p>	7.816	14.524	10.672
<p>Title: High Temperature Material Technologies</p> <p>Description: Develop and demonstrate affordable, novel high temperature materials/structures and thermal management concepts to enable future defense capabilities for prompt global strike concepts.</p>	1.379	2.483	2.643

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633946 / <i>Materials Transition</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> Initiated validation of 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. Continued to develop 2700 degrees Fahrenheit ceramic matrix composites for turbine hot section components. Completed risk reduction enhancements to ensure out year goals are met.</p> <p><i>FY 2016 Plans:</i> 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 metals, and intermetallics. Demonstrate 2700F ceramic matrix composites for turbine hot section components. Initiate development of high temperature materials for next generation turbine engine disks.</p> <p><i>FY 2017 Plans:</i> 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 metals, and intermetallics. Continue to demonstrate and model 2700F ceramic matrix composites for turbine hot section components. Continue to develop high temperature materials for next generation turbine engine disks.</p>			
Accomplishments/Planned Programs Subtotals	9.195	17.007	13.315

	FY 2015	FY 2016
<i>Congressional Add:</i> Metals Affordability Research	8.000	9.000
<i>FY 2015 Accomplishments:</i> Conduct Congressionally directed effort.		
<i>FY 2016 Plans:</i> Conduct congressionally directed effort in low-cost special aerospace metals.		
Congressional Adds Subtotals	8.000	9.000

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

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633946 / <i>Materials Transition</i>

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					PE 0603199F / <i>Sustainment Science and Technology (S&T)</i>							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	14.900	18.378	20.636	0.000	20.636	22.811	23.217	23.680	24.154	Continuing	Continuing
635351: <i>Technology Sustainment</i>	-	14.900	18.378	20.636	0.000	20.636	22.811	23.217	23.680	24.154	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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	15.800	18.378	20.636	0.000	20.636
Current President's Budget	14.900	18.378	20.636	0.000	20.636
Total Adjustments	-0.900	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	-0.450	0.000			
• SBIR/STTR Transfer	-0.450	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>		R-1 Program Element (Number/Name) PE 0603199F / <i>Sustainment Science and Technology (S&T)</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Title: System Health Management/Assessment Technologies</p> <p>Description: Develop, demonstrate, and transition state awareness/system health management technologies. Conduct studies and analyses to design sustainability into future applications.</p> <p>FY 2015 Accomplishments: Continued development and demonstration of diagnostic technology to monitor/assess health of airframe/engine and components. Completed development of sonic infrared inspection capability. Continued health assessment capability development for fielded systems and components. Completed arc mitigation for 270 Volts Direct Current (VDC) systems.</p> <p>FY 2016 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.</p> <p>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.</p>		4.591	5.010	4.952
<p>Title: Prevention/Enhanced Maintainability Technologies</p> <p>Description: Develop, demonstrate, and transition maintenance and sustainment technologies to improve component design, maintenance, replacement, and concepts for performance improvement and reduced maintenance burden.</p> <p>FY 2015 Accomplishments: Completed validation of erosion coating test protocol and flush head fastener inspection technologies for improved component durability, reliability, and safety. Completed friction plug welding for B-1B panel to increase time between maintenance actions and reduce maintenance cost drivers. Continued efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions, including a solid state amplifier replacement for unsupported vacuum tubes used on the B-1 aircraft's ALQ-161, defensive avionics system. Continued airframe/engine/subsystem technology efforts including replacement for honeycomb structures. Continued development of materials and processes to reduce low observable sustainment. Continued integrally bladed rotor repair improvements. Initiated durable structure demonstrations. Initiated C-5 corrosion project. Initiated dust containment and on-aircraft mold mitigation improvements. Initiated demonstration for enhanced ester oil for turbine engines.</p> <p>FY 2016 Plans:</p>		3.983	4.241	5.024

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>		R-1 Program Element (Number/Name) PE 0603199F / <i>Sustainment Science and Technology (S&T)</i>		
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Continue efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions. Continue airframe/engine/subsystem technology efforts including replacement for honeycomb structures. Continue development of materials and processes to reduce low observable Continue solid state amplifier replacement for B-1B. Continue enhanced ester oil and integrally bladed rotor repair modeling. Initiate thermal spray coating process.</p> <p>FY 2017 Plans: Complete first low observable (L/O) articles. Continue efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions. Continue enhanced ester oil and integrally bladed rotor repair modeling.</p>				
<p>Title: Management/Improved Reliability Technologies</p> <p>Description: Develop, demonstrate, and transition technologies to improve existing and new components, fleet management/ decision-making tools, and supply chain/sustainment infrastructure to decrease downtime and costs, and increase reliability.</p> <p>FY 2015 Accomplishments: 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 F-22 canopy efforts. Continued updated spacecraft propulsion model. Continued quantification of life extension prediction of A-10 and T-38 aircraft cold worked holes. Initiated structural/Non-destructive Inspection (NDI) tool verification. Initiated data visualization tool expansion from inspection data to depot maintenance data.</p> <p>FY 2016 Plans: Complete data visualization tool expansion to depot maintenance data. 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.</p> <p>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.</p>		3.968	4.749	4.649
<p>Title: Composite Certification</p> <p>Description: Develop, demonstrate and transition reliability-based design of advanced composites for aircraft structures. This includes studies and analysis of processes and methodologies for application of composites to address sustainment and affordability issues across the force.</p>		2.358	4.378	6.011

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603199F / <i>Sustainment Science and Technology (S&T)</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> Demonstrated accurate prediction of the probability of failure and life of bonded and unitized composite structures. Demonstrated manufacturing processes and manufacturing process control of composite primary structures. Demonstrated feasibility of implementing a damage tolerant design approach for composite structures. Demonstrated feasibility and benefits of a robust process for predicting and addressing the risk elements for safe and affordable certification of composite structures. Demonstrated life extension of a composite primary structure beyond that of the original certified service life.</p> <p><i>FY 2016 Plans:</i> Complete demonstration of accurate prediction of the probability of failure and life of bonded and unitized composite structures. Continue demonstration of manufacturing processes and manufacturing process control of composite primary structures. Continue 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. Initiate assessment and designs of affordable low cost composite manufacturing methods and processes.</p> <p><i>FY 2017 Plans:</i> 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.</p>			
Accomplishments/Planned Programs Subtotals	14.900	18.378	20.636

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

Remarks

E. Acquisition Strategy
N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603199F / <i>Sustainment Science and Technology (S&T)</i>
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F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	34.100	42.001	40.945	0.000	40.945	38.547	38.793	39.565	40.355	Continuing	Continuing
63665A: <i>Advanced Aerospace Sensors Technology</i>	-	14.919	17.443	19.547	0.000	19.547	17.734	18.258	18.620	18.992	Continuing	Continuing
6369DF: <i>Target Attack and Recognition Technology</i>	-	19.181	24.558	21.398	0.000	21.398	20.813	20.535	20.945	21.363	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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	34.334	42.183	40.945	0.000	40.945
Current President's Budget	34.100	42.001	40.945	0.000	40.945
Total Adjustments	-0.234	-0.182	0.000	0.000	0.000
• Congressional General Reductions	0.000	-0.182			
• 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	0.720	0.000			
• SBIR/STTR Transfer	-0.954	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>				Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
63665A: <i>Advanced Aerospace Sensors Technology</i>	-	14.919	17.443	19.547	0.000	19.547	17.734	18.258	18.620	18.992	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 2015	FY 2016	FY 2017
Title: Integrated Navigation Technologies	4.910	4.484	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 2015 Accomplishments: Matured GPS augmentation technologies that take advantage of distributed platforms relaying Global Navigation Satellite Systems (GNSS) signals and geo-referenced real-time imaging to improve GPS accuracy in GPS sparse or denied environments. Developed technologies that expanded the ability to incorporate GNSS signals into GPS user equipment as a means to improved navigation signal reliability and availability.			
FY 2016 Plans: Demonstrate GPS augmentation technologies which include use of GNSS signals with functionality to minimize point source interference while maintaining robust Position, Navigation & Timing (PNT). Continue to develop and mature technologies to incorporate GNSS capability in user equipment to include GPS Modernized Signals. Develop 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	3.174	3.341	2.358

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: 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 contested environments. Characterized, measured, modeled, simulated, and improved system performance of active and passive RF sensing systems in terms of RF sensing geometry, environmental phenomenology, clutter, and interference.</p> <p>FY 2016 Plans: Develop wideband apertures, beamforming networks, signal processing and receiver technology to support passive Electronic Support and Passive Radar modes. Continue research and development of high performance conformal array antenna technology, novel waveforms, MIMO signal processing techniques, and cooperative RF sensing from multiple platforms in contested environments. Characterize, measure, model, simulate, and improve system performance of active and passive RF sensing systems in terms of RF sensing geometry, environmental phenomenology, clutter, and interference.</p> <p>FY 2017 Plans: Continue research and development of wideband apertures, beamforming networks, signal processing and receiver technology to support passive Electronic Support and Passive Radar modes. Demonstrate wideband phased array and antenna technology in a laboratory environment. Demonstrate MIMO waveform characteristics and evaluate performance using laboratory assets. Develop multichannel transmit receive hardware for MIMO applications.</p> <p>For FY 2017 and beyond, the laser radar technology development work will be performed under the Laser Radar for Non-Cooperative Identification effort.</p>				
<p>Title: Passive Radio Frequency (RF) Sensing Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments: Continued research and development of passive multi-mode radar technology, including signal intelligence (SIGINT), airborne moving target indicator (AMTI), ground moving target indicator (GMTI), and synthetic aperture radar (SAR) imaging. Further developed sensor resource management capabilities for sensor time, energy, and waveform management, as well as optimal utilization of non-cooperative signals in the field of regard. Continued development of algorithms and hardware for passive RF</p>		3.884	6.411	4.422

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>sensing applications, with emphasis on both high endurance at long stand-off range, and survivable, covert stand-in RF sensing within contested airspace.</p> <p>FY 2016 Plans: Research and develop an illumination selection manager to support passive radar functions in an anti-access/area denial (A2/AD) environment. Continue research and development of passive multi-mode radar technology, including SIGINT, AMTI, GMTI, and SAR imaging.</p> <p>FY 2017 Plans: Develop concepts for Distributed Passive Geolocation from multiple standoff platforms. Continue development 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.</p> <p>For FY 2017 and beyond, Passive Sensing work accomplished under this effort will be reported under the Passive EO Sensing for Surveillance and Reconnaissance effort.</p>				
<p>Title: Long Range Sensing Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments: Extended GMTI and SAR techniques developed for detection and tracking of dismounts and high value mobile ground targets from high angle, close-in RF sensing scenarios to low angle, long stand-off RF sensing geometric scenarios with A2/AD. Revised and extended prior radar systems engineering and develop improved algorithms and multi-static cooperative radar techniques to address the challenges of long stand-off RF sensing in A2/AD airspace.</p> <p>FY 2016 Plans: Continue to develop improved algorithms for low grazing angle, long stand-off GMTI and SAR. Collect data for testing of algorithms. Revise and extend prior radar systems engineering and develop improved algorithms and multi-static cooperative radar techniques to address the challenges of long stand-off RF sensing in A2/AD airspace. Develop technology to enable multi-function RF systems. Develop simulation models that combine radio frequency and electro-optical/infrared sensors with a sensor resource manager. Continue to demonstrate open architecture constructs that enable rapid technology refresh in RF systems.</p> <p>FY 2017 Plans:</p>		2.951	3.207	2.212

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Design a radar pod for long stand-off sensing that includes advanced GMTI and SAR modes tailored for long stand-off. Include a sensor resource manager and infrared search and track system in the design of the sensor package. Extend open architecture constructs to incorporate electronic warfare and communication functions.</p> <p>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.</p> <p>For FY 2017 and beyond, the laser radar technology development work will be performed under the Laser Radar for Non-Cooperative Identification effort.</p>				
<p>Title: Passive EO Sensing for Surveillance and Reconnaissance Technologies</p> <p>Description: Advance, demonstrate, and transition innovative imaging and non-imaging optical sensing technologies for surveillance and reconnaissance of airborne and ground-based objects of interest in an A2/AD environment. This effort includes the development of systems, subsystems, and components necessary to yield new capabilities.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: In FY 2015 and 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.</p> <p>Advance and refine engineering trades and system optimization, via modeling, simulation, and test, of innovative sensor concepts to increase long range image quality for passive electro-optical and infrared reconnaissance sensors beyond the current state of the art and show connections to documented requirements. 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. Reduce the number of candidate architectures through analysis and measurement, when possible. Prepare and conduct technology demonstrations to advance system, subsystem, and component technology readiness levels (TRL) as required.</p>		0.000	0.000	6.778
Title: Laser Radar for Non-Cooperative Identification		0.000	0.000	3.777

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: In FY 2015 and FY 2016, the work was originally performed under the Persistent Sensing in Contested Environment Technologies effort and the Long Range Sensing Technologies effort.</p> <p>Refine Synthetic Aperture Laser Radar (SAL) technology demonstrators under development based on modeling and simulation to enhance spatial resolution beyond the diffraction limit of conventional optics. 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. Integrate these technologies when sufficiently mature. Fabricate, characterize, and test critical components for a long range SAL demonstration. Refine sensor product visualization and automatic target recognition by applying previous phenomenology research in collaboration with other Air Force Research Laboratory Technology Directorates. Increase emphasis on applications for long range air-to-air ladar, updating modeling and simulation to support system design and analysis of alternatives. Prepare and conduct technology demonstrations to advance system, subsystem, and component TRL as required.</p>			
Accomplishments/Planned Programs Subtotals	14.919	17.443	19.547

<p>C. Other Program Funding Summary (\$ in Millions) N/A</p> <p>Remarks</p> <p>D. Acquisition Strategy N/A</p>

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 63665A / <i>Advanced Aerospace Sensors Technology</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>				Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
6369DF: <i>Target Attack and Recognition Technology</i>	-	19.181	24.558	21.398	0.000	21.398	20.813	20.535	20.945	21.363	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 2015	FY 2016	FY 2017
Title: Integrated Sensor Targeting Technologies	3.570	4.564	3.960
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 2015 Accomplishments: Continued assessing integrated sensor targeting technologies for permissive environments which could serve as candidate solutions for Planning and Direction, Collection, Processing and Exploitation, Analysis and Production, and Dissemination (PCPAD) in contested environments. Created target signature databases from electro-optical, synthetic aperture radar, and multi-source sensor data for targets representing the highest priority threat systems.			
FY 2016 Plans: Demonstrate phenomenology-derived feature toolkit for high resolution characterization of salient RF and EO features for select targets; Initiate development and assessment of reduced feature set target models and update target signature database; Demonstrate salient feature extraction for distributed radar and ladar. Initiate challenge problem development for assessment of reduced target feature sets in PCPAD-experimental (PCPAD-X). Continue development of applications to utilize target signature			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
databases from electro-optical, synthetic aperture radar, and multi-source sensor data for targets representing the highest priority threat systems. FY 2017 Plans: Demonstrate phenomenology-derived feature toolkit for high resolution characterization of salient RF and EO features for select targets. Continue development and assessment of reduced feature set target models and update target signature database. Demonstrate salient feature extraction for distributed radar and ladar. Demonstrate applications to utilize target signature databases from electro-optical, synthetic aperture radar, and multisource sensor data for targets representing the highest priority threat systems.				
Title: Multi-Sensor Target Recognition Description: Develop and assess multi-sensor automatic target recognition for intelligence, surveillance, reconnaissance, strike, and weapon systems. FY 2015 Accomplishments: Continued development of target signature formation techniques from single and multiple cooperating sensors, and sensors and signals of opportunity. Created experiments for demonstrating the contributions of promising technologies to address deficiencies in automatic target recognition for select classes of targets in contested environments. FY 2016 Plans: Initiate development of applications to characterize and suppress clutter in bi-static and passive RF sensors; Initiate development of advanced tracking algorithms for 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 multi-sensor tracking and change detection applications for mobile targets in contested environments. FY 2017 Plans: Continue development of applications to characterize and suppress clutter in bistatic and passive RF sensors. Continue development of advanced tracking algorithms for 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. Develop multi-sensor exploitation and fusion methods for use by analysts.		8.169	10.142	8.800
Title: Wide-Angle, Continuously-Staring Technologies Description: Develop wide angle, continuous staring, multi-sensor/wavelength sensing and automated exploitation technology to detect, track, and identify targets over large areas at low sensor update rates.		7.442	9.852	8.638

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / <i>Advanced Aerospace Sensors</i>	Project (Number/Name) 6369DF / <i>Target Attack and Recognition Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> Continued development of stand-off (air and space) and episodic stand-in sensing capabilities for contested and denied environments. Continued development of exploitation algorithms, phenomenological modeling, image formation, and target and scenario databases necessary to support transition of staring sensing capabilities to the warfighter. Continued to integrate, demonstrate and evaluate enhanced wide angle and wide area sensing and exploitation technologies in conditions representative of contested and denied environments.</p> <p><i>FY 2016 Plans:</i> 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; Continue development of stand-off (air and space) and episodic stand-in sensing capabilities for contested and denied environments.</p> <p><i>FY 2017 Plans:</i> 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. Continue development of stand-off (air and space) and episodic stand-in sensing capabilities for contested and denied environments.</p>			
Accomplishments/Planned Programs Subtotals	19.181	24.558	21.398

<p>C. Other Program Funding Summary (\$ in Millions) N/A</p> <p>Remarks</p> <p>D. Acquisition Strategy N/A</p> <p>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.</p>

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)					PE 0603211F I Aerospace Technology Dev/Demo							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	86.275	100.622	130.950	0.000	130.950	119.280	123.297	102.871	75.348	Continuing	Continuing
634920: Flight Vehicle Tech Integration	-	5.346	25.772	23.873	0.000	23.873	19.734	19.828	26.258	26.783	Continuing	Continuing
634926: High Speed/Hypersonic Intgr and Demo	-	63.496	50.618	92.801	0.000	92.801	82.762	83.914	50.328	21.755	Continuing	Continuing
634927: Flight Systems Control	-	17.433	24.232	14.276	0.000	14.276	16.784	19.555	26.285	26.810	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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	91.037	100.733	63.866	0.000	63.866
Current President's Budget	86.275	100.622	130.950	0.000	130.950
Total Adjustments	-4.762	-0.111	67.084	0.000	67.084
• Congressional General Reductions	0.000	-0.111			
• 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	-2.484	0.000			
• SBIR/STTR Transfer	-2.278	0.000			
• Other Adjustments	0.000	0.000	67.084	0.000	67.084

Change Summary Explanation

Decrease in FY 2015 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force / BA 3: Advanced Technology Development (ATD)</i>	PE 0603211F / <i>Aerospace Technology Dev/Demo</i>

Increase in FY 2017 Other Adjustments is due to increased emphasis in hypersonics.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/ Demo</i>				Project (Number/Name) 634920 / <i>Flight Vehicle Tech Integration</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
634920: <i>Flight Vehicle Tech Integration</i>	-	5.346	25.772	23.873	0.000	23.873	19.734	19.828	26.258	26.783	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 2015	FY 2016	FY 2017
Title: Aerospace Vehicle Technology Integration	1.517	11.242	12.546
Description: Develop, simulate, and demonstrate integrated technologies to improve the performance of aerospace platform capabilities.			
FY 2015 Accomplishments: Initiated C-17 formation flight Advanced Technology Demonstration (ATD). Initiated feasibility flight test of C-17 aircraft with aft body drag reduction devices. Continued 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.			
FY 2016 Plans: Continue development of the C-17 formation flight ATD. Complete feasibility flight test of C-17 aircraft with aft body drag reduction devices. Complete 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. Initiate quiet small unmanned aerospace systems (UAS) integrated flight test. Initiate near-term flight demonstration of an expendable unmanned system.			
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.			
Title: Advanced Aerospace Structure Technologies	3.829	14.530	11.327

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/ Demo</i>	Project (Number/Name) 634920 / <i>Flight Vehicle Tech Integration</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Description: This effort changed from Multi-Role Structure Technologies to Advanced Aerospace Structure Technologies to better reflect the content and objectives. Develop and demonstrate affordable, lightweight, adaptive, and multifunctional structural concepts integrated into aerospace systems.</p> <p>FY 2015 Accomplishments: Completed flight test of directional finding communication antenna integration technology demonstration into load-bearing structures for small unmanned aerospace systems (UAS). Completed flight technology demonstrations of key high altitude persistent Intelligence, Surveillance, and Reconnaissance (ISR) for active flutter suppression, gust load alleviation, and adaptive, multi-purpose wing surfaces.</p> <p>FY 2016 Plans: Initiate an electronic warfare and passive radar flight demonstration of an integrated antenna into load-bearing structures for small remotely piloted aircraft. Initiate a low cost airframe design and manufacturing demonstration. Initiate low cost attributable aircraft flight demonstration designs and analysis.</p> <p>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. Initiate engineered residual stress design methods structural demonstration. Continue low cost airframe design and manufacturing demonstrations. Complete low cost attributable aircraft flight demonstration designs and analysis.</p>			
Accomplishments/Planned Programs Subtotals	5.346	25.772	23.873

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/Demo</i>				Project (Number/Name) 634926 / <i>High Speed/Hypersonic Intgr and Demo</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
634926: <i>High Speed/Hypersonic Intgr and Demo</i>	-	63.496	50.618	92.801	0.000	92.801	82.762	83.914	50.328	21.755	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 2015	FY 2016	FY 2017
Title: High Speed/Hypersonic Vehicle Technologies	63.496	50.618	92.801
Description: Develop, simulate, and demonstrate integrated vehicle technologies to enable and improve the performance of future high-speed and hypersonic systems.			
FY 2015 Accomplishments: Completed preliminary design review of air-breathing weapon concept vehicle. 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.			
FY 2016 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. Complete preliminary design review of boost-glide weapon concept vehicle. Initiate 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. Complete critical design review 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.			
Accomplishments/Planned Programs Subtotals	63.496	50.618	92.801

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
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

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/ Demo</i>				Project (Number/Name) 634927 / <i>Flight Systems Control</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
634927: <i>Flight Systems Control</i>	-	17.433	24.232	14.276	0.000	14.276	16.784	19.555	26.285	26.810	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, 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 2015	FY 2016	FY 2017
Title: Autonomous Systems Control	17.433	24.232	14.276
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 2015 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 safety of flight of analog flight control system hosting of digital flight control algorithms. Initiated demonstration of integrated ground and air collision avoidance. Initiated development and demonstration of robust, adaptive guidance, and control of hypersonic aircraft.			
FY 2016 Plans: Continue development and demonstration of technologies for situational awareness, autonomous control, and survivability for unmanned systems and manned platforms. Continue demonstration of autonomous and safe airspace interoperability for manned and remotely piloted aircraft systems. Continue development and demonstration of airborne control of teams of unmanned aircraft. Continue development and demonstration of improved accuracy, situational awareness, and safety for air drop operations. Complete development and demonstration of robust, adaptive guidance, and control of hypersonic aircraft. Complete 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / <i>Aerospace Technology Dev/ Demo</i>	Project (Number/Name) 634927 / <i>Flight Systems Control</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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 and air collision avoidance.			
Accomplishments/Planned Programs Subtotals	17.433	24.232	14.276

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	126.729	178.594	94.594	0.000	94.594	104.499	112.332	116.482	118.570	Continuing	Continuing
632480: <i>Aerospace Fuels</i>	-	2.144	2.267	2.262	0.000	2.262	2.302	2.358	2.404	2.452	Continuing	Continuing
633035: <i>Aerospace Power Technology</i>	-	13.605	19.296	11.010	0.000	11.010	13.934	20.135	22.337	22.544	Continuing	Continuing
634921: <i>Aircraft Propulsion Subsystems Int</i>	-	51.389	77.791	19.757	0.000	19.757	17.902	18.194	18.539	18.909	Continuing	Continuing
634922: <i>Space & Missile Rocket Propulsion</i>	-	25.004	31.231	24.314	0.000	24.314	28.799	29.484	30.072	30.673	Continuing	Continuing
635098: <i>Advanced Aerospace Propulsion</i>	-	26.301	23.670	25.013	0.000	25.013	28.797	20.346	20.751	21.167	Continuing	Continuing
63681B: <i>Advanced Turbine Engine Gas Generator</i>	-	8.286	24.339	12.238	0.000	12.238	12.765	21.815	22.379	22.825	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 power and thermal management 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.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>

B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	132.681	168.821	94.717	0.000	94.717
Current President's Budget	126.729	178.594	94.594	0.000	94.594
Total Adjustments	-5.952	9.773	-0.123	0.000	-0.123
• Congressional General Reductions	0.000	-0.227			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	10.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-2.071	0.000			
• SBIR/STTR Transfer	-3.881	0.000			
• Other Adjustments	0.000	0.000	-0.123	0.000	-0.123

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

Project: 633035: *Aerospace Power Technology*
 Congressional Add: *Silicon Carbide Research*

	FY 2015	FY 2016
Congressional Add Subtotals for Project: 633035	8.500	10.000
Congressional Add Totals for all Projects	8.500	10.000

Change Summary Explanation

Decrease in FY 2015 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 632480 / <i>Aerospace Fuels</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
632480: <i>Aerospace Fuels</i>	-	2.144	2.267	2.262	0.000	2.262	2.302	2.358	2.404	2.452	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 2015	FY 2016	FY 2017
<p>Title: Fuel-Related Thermal Management</p> <p>Description: Demonstrate thermally stable fuels and fuel system hardware concepts to enhance cooling capacity (performance), minimize fuel coking, and reduce fuel system maintenance.</p> <p>FY 2015 Accomplishments: Demonstrated heat sink and coking performance of advanced producible endothermic fuel.</p> <p>FY 2016 Plans: Demonstrate nano-catalysts/nano-additives for enhancing heat sink and reducing coking.</p> <p>FY 2017 Plans: Investigate adaptable heat sink alternatives for advanced thermal management.</p>	0.594	0.627	0.662
<p>Title: Gas Turbine Combustion, Emissions, and Performance</p> <p>Description: Develop and demonstrate efficacy of low-cost, environmentally friendly fuel approaches to assess and reduce soot/particulate emissions from gas turbine engines.</p> <p>FY 2015 Accomplishments: Demonstrated advanced particulate characterization enabling the identification and quantification of particulates absorbed in volatile and non-volatile hydrocarbon fuels.</p> <p>FY 2016 Plans:</p>	0.594	0.628	0.600

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 632480 / <i>Aerospace Fuels</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Assess 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.				
Title: Fuel Logistics		0.767	0.812	0.800
Description: Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Air Force.				
FY 2015 Accomplishments: Continued bio-contamination, mitigation and risk assessment of aviation fuels. Continued to demonstrate and evaluate commercial conversion impacts and fuel filtration devices with nano-size meshes to mitigate biological growth in aviation fuels.				
FY 2016 Plans: Continue bio-contamination, mitigation and risk assessment of aviation fuels. Demonstrate 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.				
Title: Alternative Jet Fuels		0.189	0.200	0.200
Description: Characterize and demonstrate the use of alternative hydrocarbon jet fuel to comply with Air Force certifications and standards for jet fuels.				
FY 2015 Accomplishments: Approved military use of alternative fuels added to commercial aviation jet fuel specifications. Continued analysis of approaches for evaluating and approving alternative jet fuels added to commercial jet aviation fuel specifications.				
FY 2016 Plans: Continue 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.				
Accomplishments/Planned Programs Subtotals		2.144	2.267	2.262

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 632480 / <i>Aerospace Fuels</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 633035 / <i>Aerospace Power Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
633035: <i>Aerospace Power Technology</i>	-	13.605	19.296	11.010	0.000	11.010	13.934	20.135	22.337	22.544	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 electrical power and thermal management components, controls and systems required to satisfy the 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 provide a two- fold to five-fold improvement in aircraft reliability and maintainability, and a reduction in power system weight. This project integrates into energy optimized aircraft efforts and power and thermal programs.

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

	FY 2015	FY 2016	FY 2017
<p>Title: High Power Aircraft Subsystem Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments: Continued development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Continued demonstration of platform-level hardware-in-the-loop integrated power and thermal management subsystems. Initiated development of actuation technology for applications with power, volume, and thermal limitations.</p> <p>FY 2016 Plans: Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Complete demonstration of platform-level hardware-in-the-loop integrated power and thermal management subsystems. Continue development of actuation technology for applications with power, volume, and thermal limitations. Initiate the development of hybrid-cycle power and thermal management system. Initiate development of advanced power generation and distribution system.</p> <p>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</p>	5.105	9.296	11.010

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 633035 / <i>Aerospace Power Technology</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
advanced power generation and distribution system. Initiate development and demonstration of an integrated power and thermal system for a high-power payload, e.g. laser weapon demonstration.			
Accomplishments/Planned Programs Subtotals	5.105	9.296	11.010

	FY 2015	FY 2016
Congressional Add: Silicon Carbide Research	8.500	10.000
FY 2015 Accomplishments: Conducted Congressionally directed efforts		
FY 2016 Plans: Conduct Congressionally directed efforts		
Congressional Adds Subtotals	8.500	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.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 634921 / <i>Aircraft Propulsion Subsystems Int</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
634921: <i>Aircraft Propulsion Subsystems Int</i>	-	51.389	77.791	19.757	0.000	19.757	17.902	18.194	18.539	18.909	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 concept 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 subsystem 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, and durability for widely varying mission needs.

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

	FY 2015	FY 2016	FY 2017
Title: Missile/Remotely Piloted Aircraft Engine Performance	13.649	20.687	11.757
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 2015 Accomplishments: Completed initial ground testing of demonstration supersonic, long endurance turbine engines at simulated altitude conditions. Completed testing of advanced components for engine technology applicable to missiles and unmanned vehicles. Completed detailed design and begin fabrication and instrumentation of a subsonic small turbine engine technology experimental test.			
FY 2016 Plans: Complete final ground testing of demonstration supersonic, long endurance turbine engines at simulated altitude conditions. Complete fabrication and instrumentation of a subsonic small turbine engine technology experimental test. Complete detailed design of subsonic mid-sized turbine engine technology for remotely piloted aircraft.			
FY 2017 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 634921 / <i>Aircraft Propulsion Subsystems Int</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Conduct ground test of subsonic small turbine engine for missile application. Increase effort in efficient limited-life medium scale propulsion development for future Intelligence, Surveillance, and Reconnaissance (ISR) and strike capability.			
Title: Adaptive Turbine Engine Technologies	37.740	57.104	8.000
Description: Design, fabricate, and demonstrate performance, durability, and operability technologies to mature adaptive turbine engine technologies.			
FY 2015 Accomplishments: Completed preliminary design reviews and initiate detailed design of an adaptive turbine engine with reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. Continued engine technology development activity to support core engine assembly and initial ground testing. Continue to instrument and assemble core experimental adaptive turbine engines.			
FY 2016 Plans: Complete the instrumentation and assembly of core experimental adaptive turbine engines. Initiate and complete ground testing of core experimental adaptive turbine engines. Initiate and 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.			
FY 2017 Plans: Support successful technology transition to potential 6.4 program.			
Accomplishments/Planned Programs Subtotals	51.389	77.791	19.757

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 634922 / <i>Space & Missile Rocket Propulsion</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
634922: <i>Space & Missile Rocket Propulsion</i>	-	25.004	31.231	24.314	0.000	24.314	28.799	29.484	30.072	30.673	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced and innovative low-cost rocket turbo-machinery and components, and low-cost space launch propulsion technologies. Additionally, this project develops technologies for the sustainment of strategic systems (including solid rocket motor boosters and missile propulsion, post boost control, and aging and surveillance efforts) and tactical rockets. Characteristics such as environmental acceptability, affordability, reliability, responsiveness, reduced weight, and reduced operation and launch costs are emphasized. Increased life and performance of propulsion systems are key goals. Technology areas investigated include ground demonstrations of compact, lightweight, advanced propulsion technologies, higher efficiency energy conversion systems (derived from an improved understanding of combustion fundamentals), and high-energy propellants. Technological advances in this program could improve the performance of expendable payload capabilities by approximately twenty to fifty percent and reduce launch, operations, and support costs by approximately thirty percent. Responsiveness and operability of propulsion systems will be enhanced for reusable launch systems. Aging and surveillance efforts for solid rocket motors could reduce lifetime prediction uncertainties for individual motors by fifty percent, enabling motor replacement for cause. The efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire DoD and National Aeronautics and Space Administration (NASA). The project efforts are part of the Rocket Propulsion 21 (RP21) program. The project efforts are reviewed by a DoD level steering committee annually for relevance to DoD missions and achievement of technical goals defined by the RP21 program.

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

	FY 2015	FY 2016	FY 2017
Title: Liquid Rocket Propulsion Technologies	18.451	23.057	17.776
Description: Develop liquid rocket propulsion technology for current and future space launch vehicles.			
FY 2015 Accomplishments: Continued development of hydrocarbon engine components for integration and demonstration in an advanced hydrocarbon engine concept applicable to future expendable and reusable launch vehicles. Completed sub-scale preburner and completed sub-scale turbine component testing to demonstrate hydrocarbon boost technologies. Completed thrust chamber sub-scale development and test device. Continued full-scale pre-burner component development, conducted Preliminary Design Review (PDR), Critical Design Review (CDR), and began fabrication of test article. Conducted PDR on the full-scale turbopump design. Continued design of thrust chamber assembly and conducted PDR of the full-scale design.			
FY 2016 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 634922 / <i>Space & Missile Rocket Propulsion</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Continue development of hydrocarbon engine components for integration and demonstration in an advanced hydrocarbon engine concept applicable to future expendable and reusable launch vehicles. Continue fabrication of full-scale preburner and begin testing the component. Conduct CDR on the Thrust Chamber and begin fabrication.</p> <p>FY 2017 Plans: Continue development of hydrocarbon engine components for integration and demonstration in an advanced hydrocarbon engine concept applicable to future expendable and reusable launch vehicles. Complete CDR for the full-scale Turbopump and begin fabrication. Complete fabrication of the full-scale Thrust Chamber and begin testing. Conduct the PDR for the integrated demonstration engine.</p>				
<p>Title: Ballistic Missile Technologies</p> <p>Description: Develop and demonstrate missile propulsion and post-boost control systems technologies for ballistic missiles.</p> <p>FY 2015 Accomplishments: Continued to develop advanced missile case, insulation, and nozzle technologies. Continued validation of modeling and simulation tools.</p> <p>FY 2016 Plans: Continue to develop advanced missile case, insulation, and nozzle technologies. Continue validation of modeling and simulation tools through upcoming demonstration.</p> <p>FY 2017 Plans: Begin technology demonstration effort on advanced missile case, insulation, and nozzle technologies and validation of physics-based modeling, simulation, and analysis tools. Begin technology demonstration effort of post-boost technologies.</p>		3.991	6.054	4.777
<p>Title: Strategic System Motor Surveillance</p> <p>Description: Develop and demonstrate aging and surveillance technologies for strategic systems to reduce lifetime prediction uncertainty for individual motors, enabling motor replacement for cause.</p> <p>FY 2015 Accomplishments: Continued development of next generation of sensors used for aging and surveillance. Supported transition of previous tools, models, and data management system to user. Continued sub-scale motors dissection to validate the sensor and analytical analysis of each motor.</p> <p>FY 2016 Plans: Apply next generation of chemical and aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, and</p>		2.562	2.120	1.761

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 634922 / <i>Space & Missile Rocket Propulsion</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>non-destructive analysis tools. Continue advanced sensor development efforts to further improve data acquisition and reduce uncertainty in ballistic missile life predictions. Improve the fidelity and precision of non-destructive evaluation tools to increase capability to determine flaw size, orientation, and location. Support transition of previous tools, models, data management system to user. Begin 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.</p> <p>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 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.</p>			
Accomplishments/Planned Programs Subtotals	25.004	31.231	24.314

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 635098 / <i>Advanced Aerospace Propulsion</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635098: <i>Advanced Aerospace Propulsion</i>	-	26.301	23.670	25.013	0.000	25.013	28.797	20.346	20.751	21.167	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 2015	FY 2016	FY 2017
Title: Scramjet Technologies	26.301	23.670	25.013
Description: Develop and demonstrate technologies for a hydrocarbon-fueled scramjet with robust operation up to Mach 7.			
FY 2015 Accomplishments: Continued development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and engine controls. Initiated testing of flight weight ground test engine to demonstrate tactically compliant cold start system. Continued 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. Conducted ground test of flight weight engine components for High Speed Strike Weapon demonstration and supported PDR.			
FY 2016 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. Design flight weight cold start system for demonstration in direct-connect test hardware. Develop scramjet technologies to enhance operability including robust operation during maneuvers. Continue accelerated development and demonstration of tactically-relevant long range high speed strike scramjet engine technologies including ground and flight demonstrations needed for potential follow-on acquisition program. Initiate detailed design of scramjet engine for air breathing weapon concept.			
FY 2017 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 635098 / <i>Advanced Aerospace Propulsion</i>

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

	FY 2015	FY 2016	FY 2017
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 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.			
Accomplishments/Planned Programs Subtotals	26.301	23.670	25.013

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>				Project (Number/Name) 63681B / <i>Advanced Turbine Engine Gas Generator</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
63681B: <i>Advanced Turbine Engine Gas Generator</i>	-	8.286	24.339	12.238	0.000	12.238	12.765	21.815	22.379	22.825	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 Aerospace Propulsion Subsystems Integration (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 2015	FY 2016	FY 2017
Title: Core Engine Technologies	2.827	8.310	5.238
Description: Design, fabricate, and demonstrate performance predictions in core engines, using innovative engine cycles and advanced materials for turbofan and for turbojet engines.			
FY 2015 Accomplishments: Continued fabrication of hardware components enabling increased reliability, maintainability, and affordability for ground engine core demonstration. Completed full annular combustor rig demonstration.			
FY 2016 Plans: Continue instrumentation and assembly of component hardware for rig demonstration and validation of increased reliability, maintainability, and affordability. Complete 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.			
Title: High Pressure Ratio Core Engine Technologies	0.308	0.904	1.900

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 63681B / <i>Advanced Turbine Engine Gas Generator</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Description: Design, fabricate, and demonstrate high overall pressure ratio engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines.</p> <p>FY 2015 Accomplishments: Initiated risk reduction rig tests of components of small efficient engine core concepts with advanced technologies such as high pressure ratios, high temperature capability compressors, high heat release combustors, and high cooling effectiveness turbine with an integrated thermal management system and advanced mechanical systems.</p> <p>FY 2016 Plans: Complete 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.</p> <p>FY 2017 Plans: Complete data reduction of test data for potential follow-on transition to ground engine demonstration or for fielded systems.</p>				
<p>Title: Adaptive Turbine Engine Core Technologies</p> <p>Description: Design, fabricate, and demonstrate adaptive turbine engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines.</p> <p>FY 2015 Accomplishments: Completed detailed design of some engine core technologies and continued others for application to adaptive turbine engine with reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. Initiated hardware procurement and manufacturing of core components and technologies for transition to experimental engine core demonstration.</p> <p>FY 2016 Plans: Complete 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. Initiate experimental engine core demonstration of an adaptive turbine engine and critical component rig tests. Begin conceptual design for air dominance adaptive core demonstrator.</p> <p>FY 2017 Plans: Finish manufacturing and begin assembly of core demonstrator. Begin preliminary design for advanced air dominance adaptive core demonstrator.</p>		5.151	15.125	5.100
Accomplishments/Planned Programs Subtotals		8.286	24.339	12.238

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / <i>Aerospace Propulsion and Power Technology</i>	Project (Number/Name) 63681B / <i>Advanced Turbine Engine Gas Generator</i>

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

Remarks

D. Acquisition Strategy
N/A

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	45.548	46.946	58.250	0.000	58.250	60.851	64.445	61.607	60.800	Continuing	Continuing
633720: <i>EW Quick Reaction Capabilities</i>	-	27.632	27.119	30.912	0.000	30.912	28.107	29.975	30.598	31.282	Continuing	Continuing
63431G: <i>RF Warning & Countermeasures Tech</i>	-	13.774	15.774	19.671	0.000	19.671	20.284	21.237	17.539	15.850	Continuing	Continuing
634335: <i>Cyber Concepts</i>	-	0.000	0.000	2.635	0.000	2.635	7.534	8.376	8.517	8.616	Continuing	Continuing
63691X: <i>EO/IR Warning & Countermeasures Tech</i>	-	4.142	4.053	5.032	0.000	5.032	4.926	4.857	4.953	5.052	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 in four project areas. 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 EW and cyber warfare to rapidly demonstrate a capability for rapid fielding. It also develops and demonstrates advanced technologies for radio-frequency electronic combat suites and advanced warning and countermeasure technologies to defeat electro-optical, infrared, and laser threats to aerospace platforms. 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.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>
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B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	47.508	47.032	54.250	0.000	54.250
Current President's Budget	45.548	46.946	58.250	0.000	58.250
Total Adjustments	-1.960	-0.086	4.000	0.000	4.000
• Congressional General Reductions	0.000	-0.086			
• 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	-0.886	0.000			
• SBIR/STTR Transfer	-1.074	0.000			
• Other Adjustments	0.000	0.000	4.000	0.000	4.000

Change Summary Explanation

Increase in FY 2017 due to increase DoD emphasis on advanced sensors technology.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>				Project (Number/Name) 633720 / <i>EW Quick Reaction Capabilities</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
633720: <i>EW Quick Reaction Capabilities</i>	-	27.632	27.119	30.912	0.000	30.912	28.107	29.975	30.598	31.282	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 2015	FY 2016	FY 2017
Title: Disruptive EW and Countermeasure Technologies	12.457	12.069	13.790
Description: Develop disruptive EW and countermeasure concepts specifically selected for rapidly fieldable, high-impact effects and demonstrate them in an operational environment.			
FY 2015 Accomplishments: Focused research on investigating the use of directed energy and cyber effects for EW use against Radio Frequency (RF) threats. Determined trade space and conducted experiments of these disruptive technologies against surrogate integrated air defense systems and other RF threats. Explored multi-spectral approaches to defend against these threat systems.			
FY 2016 Plans: Leverage 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. Focus research methods to mitigate the determined deficiencies in attack methodology and develop alternative strategies for employment to enable successful suppression of integrated air defense systems.			
FY 2017 Plans: Continue to develop capability to use RF electronic attack (EA) techniques to deliver cyber effects. Directly support the cyber efforts in Project 634335, Cyber Concepts, to model cyber effects on an integrated air defense system and simulate their utility. Develop, integrate and demonstrate required navigation technologies required for distributed EA concepts.			
Title: Threat-to-Countermeasure System of Systems (SoS) Methods	7.020	7.032	8.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 633720 / <i>EW Quick Reaction Capabilities</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Description: Establish and maintain an all-source, physics-based, design-level, red-blue, comparative, threat-to-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.</p> <p>FY 2015 Accomplishments: Improved in-house system of systems analysis capabilities in order to develop new techniques to address multispectral EW threats. Conducted initial systems engineering research on new technology initiatives in order to provide physics based, metric-driven projects that will address threats to countermeasure systems.</p> <p>FY 2016 Plans: Demonstrate improvements in Systems of Systems (SoS) analysis capability through virtual simulation mechanisms. Use metrics to show the value added proposition of multi-spectral techniques to address the threat to countermeasure system performance.</p> <p>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 ISR or strike) in A2/AD scenarios. Continue to develop, integrate and demonstrate required navigation technologies required for SoS operations in A2/AD environments.</p>				
<p>Title: Evaluation of Advanced Countermeasure Concepts</p> <p>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.</p> <p>FY 2015 Accomplishments: Enhanced in-house analysis and assessment capability to include current threat arrays and allow the analysis of distributed EW techniques against these systems. These included hardware-in-the-loop (HWIL) and software-in-the-loop (SWIL) enhancements for EW, electro-optical (EO) / infrared (IR) countermeasures, avionics vulnerability, and positioning, navigation, and timing (PNT).</p> <p>FY 2016 Plans: Demonstrate reconfigurable closed-loop HWIL assessment capability for discovering and evaluating advanced EW techniques, including diverse distributed concepts. The development of advanced techniques will ensure aircraft survivability against future</p>		8.155	8.018	9.122

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 633720 / <i>EW Quick Reaction Capabilities</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>threats with highly agile and adaptable waveform structures. Demonstrate in-house analysis and assessment technologies for countering A2/AD scenarios.</p> <p>FY 2017 Plans: For FY 2015 and 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.</p> <p>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.</p> <p>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.</p> <p>Continue development, integration and demonstration of required navigation technologies required for operations against modern threats.</p>				
Accomplishments/Planned Programs Subtotals		27.632	27.119	30.912
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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>				Project (Number/Name) 63431G / <i>RF Warning & Countermeasures Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
63431G: <i>RF Warning & Countermeasures Tech</i>	-	13.774	15.774	19.671	0.000	19.671	20.284	21.237	17.539	15.850	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 2015	FY 2016	FY 2017
Title: Electronic Attack	13.774	15.774	19.671
Description: Develop aerospace platform jamming technologies and techniques to counter advanced radio-frequency (RF) threats associated with current and future aerospace weapon systems.			
FY 2015 Accomplishments: Developed and conducted laboratory simulation experiments of adaptable EA technique concepts. Developed software prototype algorithms for cognitive jammer system concepts as well as protection of avionics systems to cyberattacks. Continued to develop and demonstrate in laboratory environment advanced Electronic Protection (EP) concepts to defeat next generation RF threats with a major emphasis on penetrating contested, anti-access/area-denial scenarios.			
FY 2016 Plans: Leverage advances in cognitive machine learning to autonomously employ adaptable EA techniques against modern adaptive programmable threats. Develop techniques to ascertain the efficacy of advanced EA methods employed against modern threats to close the loop allowing optimization of the EA technique.			
FY 2017 Plans: For FY 2015 and 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 research into innovative EA techniques including use of distributed assets against integrated air defense networks and adaptable techniques for use against any threats. Utilize over the air observables to alter technique parameters to more			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 63431G / <i>RF Warning & Countermeasures Tech</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
effectively address modern adaptive threats. Develop, integrate and demonstrate required navigation technologies required for distributed EA concepts.			
Accomplishments/Planned Programs Subtotals	13.774	15.774	19.671

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 634335 / <i>Cyber Concepts</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
634335: <i>Cyber Concepts</i>	-	0.000	0.000	2.635	0.000	2.635	7.534	8.376	8.517	8.616	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates fundamental 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 advance the science of avionics cyber vulnerabilities by understanding 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.

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 2015	FY 2016	FY 2017
<p>Title: Avionics Cyber Vulnerabilities</p> <p>Description: Develop methods, techniques, and technical tools to enable, assist, and improve the efficiency of assessments and vulnerability discovery processes. Use developed tools and techniques to assess avionics boxes, systems, busses, and components.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and 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.</p> <p>Develop reverse engineering tools to specifically investigate vulnerabilities in embedded software and analysis tools to help ensure the embedded computer systems do not contain accessible vulnerabilities.</p>	0.000	0.000	1.464
<p>Title: Avionics Cyber Protections</p> <p>Description: Develop advanced automated analysis tools and protection techniques to prevent exploitation of cyber susceptibilities in avionics systems. This strategy would include discovery and mitigation of likely attack vectors, remediation of susceptibilities, and safeguards to assure the integrity of embedded software.</p>	0.000	0.000	1.171

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 634335 / <i>Cyber Concepts</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> N/A</p> <p><i>FY 2016 Plans:</i> N/A</p> <p><i>FY 2017 Plans:</i> For FY 2015 and 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.</p> <p>Investigate development of embedded system protection concepts for ARM-based processors (e.g., real-time attestation, code and data checking, control flow integrity).</p>				
Accomplishments/Planned Programs Subtotals		0.000	0.000	2.635
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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>				Project (Number/Name) 63691X / <i>EO/IR Warning & Countermeasures Tech</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
63691X: <i>EO/IR Warning & Countermeasures Tech</i>	-	4.142	4.053	5.032	0.000	5.032	4.926	4.857	4.953	5.052	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. Develop 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 2015	FY 2016	FY 2017
Title: Advanced Electro-Optical (EO)/Infrared (IR) Warning and Countermeasure Technologies	4.142	4.053	5.032
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 2015 Accomplishments: Developed advanced EO/IR concepts for protection from postulated future threats, including definition of component and subsystem requirements. Concepts addressed contested, anti-access/area-denial threats. Conducted laboratory experiments of surrogate multi-mode EO/IR sensors, processors, and track algorithms and continued to perform advanced proactive infrared countermeasure (PIRCM) search, detect, and countermeasure research.			
FY 2016 Plans: Continue the characterization and exploitation of advanced threat IR guided missiles and EO/IR fire-control systems and sensors. Develop high-fidelity surrogates, scene generation and modeling and simulation for testing and countermeasure development and verification/correlation to hardware in the loop results. Define the requirements for novel countermeasure effects against advanced IR and multispectral threats. Conduct tests with advanced, next generation missile warning, hostile fire indication (HFI) and laser warning technologies.			
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.			
Accomplishments/Planned Programs Subtotals	4.142	4.053	5.032

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force Date: February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / <i>Electronic Combat Technology</i>	Project (Number/Name) 63691X / <i>EO/IR Warning & Countermeasures Tech</i>
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C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force</i> / BA 3: <i>Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	65.207	61.813	61.593	0.000	61.593	60.243	59.110	60.246	61.452	Continuing	Continuing
632181: <i>Spacecraft Payloads</i>	-	11.946	15.555	15.936	0.000	15.936	15.873	16.672	16.853	17.191	Continuing	Continuing
633834: <i>Integrated Space Technology Demonstrations</i>	-	17.512	24.739	22.416	0.000	22.416	23.454	15.994	15.692	16.006	Continuing	Continuing
634400: <i>Space Systems Protection</i>	-	3.654	6.191	8.091	0.000	8.091	7.607	8.644	9.057	9.237	Continuing	Continuing
634950: <i>Space Demonstration</i>	-	11.072	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.072
635021: <i>Space Systems Survivability</i>	-	2.901	2.202	1.849	0.000	1.849	1.846	1.942	1.940	1.979	Continuing	Continuing
635083: <i>Ballistic Missiles Technology</i>	-	7.295	3.913	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.208
63682J: <i>Spacecraft Vehicles</i>	-	10.827	9.213	13.301	0.000	13.301	11.463	15.858	16.704	17.039	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.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>
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B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	68.907	54.897	61.693	0.000	61.693
Current President's Budget	65.207	61.813	61.593	0.000	61.593
Total Adjustments	-3.700	6.916	-0.100	0.000	-0.100
• Congressional General Reductions	0.000	-0.084			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	7.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-1.594	0.000			
• SBIR/STTR Transfer	-2.106	0.000			
• Other Adjustments	0.000	0.000	-0.100	0.000	-0.100

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

Project: 633834: *Integrated Space Technology Demonstrations*

Congressional Add: *Program Increase*

	FY 2015	FY 2016
	-	7.000
Congressional Add Subtotals for Project: 633834	-	7.000
Congressional Add Totals for all Projects	-	7.000

Change Summary Explanation

Decrease in FY 2015 reflects reprogramming to support Research and Development Projects, 10 U.S.C. Section 2358.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 632181 / <i>Spacecraft Payloads</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
632181: <i>Spacecraft Payloads</i>	-	11.946	15.555	15.936	0.000	15.936	15.873	16.672	16.853	17.191	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 2015	FY 2016	FY 2017
Title: Advanced Space Electronics	4.098	4.111	4.834
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 2015 Accomplishments: Continued development of multi-processor components to provide extremely-high-performance, low-power on-orbit processing capability. Continued to develop high-density volatile memory devices. Continued structured application specific circuits development to include development of reconfigurable or structured analog array integrated circuits to meet growing need for mixed-signal space electronics. Continued development of electron-beam (E-Beam) lithography tool. Investigated development of on-shore advanced field programmable gate array (FPGA).			
FY 2016 Plans: Begin development of advanced electronic circuit components to achieve increased memory density with greater resiliency to the space environment. Continue development of mission-enabling advanced processors, memory, analog to digital/digital to analog converters, FPGAs, and E-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 E-Beam transition and trusted FPGA development. Complete development of high density non-volatile memory technologies. Continue development of high-efficiency power conversion devices.			
Title: Advanced Space Modeling and Simulation Tools	0.846	1.262	1.149

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 632181 / <i>Spacecraft Payloads</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Description: Develop modeling, simulation, and analysis tools for space-based surveillance systems, space capability protection technologies, access/mobility technologies, and flight experiments.</p> <p>FY 2015 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.</p> <p>FY 2016 Plans: Update modeling and simulation tools for flight programs using data sets from recent missions. Continue evaluating the military and technical utility of emerging space vehicle technologies and associated software algorithms.</p> <p>FY 2017 Plans: Evaluate the military and technical utility of emerging space vehicle technologies and associated software algorithms. Update modeling and simulation tools for flight programs using data sets from recent missions and current commercial and government owned software.</p>				
<p>Title: Advanced Space Sensors</p> <p>Description: Develop space infrared technology and hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of hot targets, as well as "cold body" objects.</p> <p>FY 2015 Accomplishments: Investigated material system alternative to mercury cadmium telluride for use in wide field of view applications in support of classic intelligence, surveillance, and reconnaissance missile warning applications. Continued to mature radiation hardened visible starrers and/or scanners as well as long wavelength infrared detection in support of Space Situational Awareness (SSA) missions.</p> <p>FY 2016 Plans: Continue 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. Initiate development of long wavelength infrared detector options to enable future satellite characterization and threat warning & assessment capabilities. Continue support to device radiation performance characterization and evaluation.</p> <p>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</p>		2.445	1.804	2.367

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 632181 / <i>Spacecraft Payloads</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
observed. Investigate potential detector materials for long wavelength infrared detection. Deliver a scanning focal planning array for missile warning capability demonstration during laser impingement.				
Title: Positioning, Navigation, and Timing (PNT) Space Payload Technologies		4.557	8.378	7.586
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 2015 Accomplishments: Finalized design and began performance evaluation of advanced technology space qualifiable L-band radio frequency (RF) amplifier(s) for PNT/Global Positioning System (GPS).				
FY 2016 Plans: Develop initial designs and fabricate breadboards of on-orbit reprogrammable digital waveform generator for PNT/GPS. Complete advanced technology space qualifiable L-band RF 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.				
Accomplishments/Planned Programs Subtotals		11.946	15.555	15.936
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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 633834 / <i>Integrated Space Technology Demonstrations</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
633834: <i>Integrated Space Technology Demonstrations</i>	-	17.512	24.739	22.416	0.000	22.416	23.454	15.994	15.692	16.006	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 2015	FY 2016	FY 2017
Title: Integrated Satellite Demonstrations	17.512	17.739	22.416
Description: Develop satellite technologies for integrated, robust, flexible, satellite demonstrations building on previous work and leveraging investments by other organizations.			
FY 2015 Accomplishments: Continued one year of experimental flight operations. Began analyzing science and health and status data. Verified maneuverable geosynchronous experimental platform design. Verified spacecraft subsystem and payload hardware and software post component/ subsystem delivery in preparation for component/subsystem tests and system integration and test.			
FY 2016 Plans: Continue and complete payload integration for geosynchronous spaceflight demonstration and begin launch vehicle integration targeted for launch in FY2017. 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). Develop space and ground segment concepts for integrated demonstration of an advanced GPS payload for contested environments. Determine military utility and define specific goals, scope, technical objectives and concepts of operation. Begin design engineering trade studies for space flight demonstration with target launch of FY2021-2023.			
FY 2017 Plans: Launch and perform initial operations for geosynchronous spaceflight demonstration; conduct experimental flight operations. 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 633834 / <i>Integrated Space Technology Demonstrations</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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 an advanced GPS payload for contested environments with a target launch of FY2021-2023. Refine experiment plans and ground segment concept for experimental operations.			

Accomplishments/Planned Programs Subtotals	17.512	17.739	22.416
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	FY 2015	FY 2016
Congressional Add: Program Increase	-	7.000
FY 2016 Plans: Conduct Congressionally-Directed effort		
Congressional Adds Subtotals	-	7.000

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 634400 / <i>Space Systems Protection</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
634400: <i>Space Systems Protection</i>	-	3.654	6.191	8.091	0.000	8.091	7.607	8.644	9.057	9.237	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 2015	FY 2016	FY 2017
<p>Title: SSA Capability Development</p> <p>Description: Develop tools and technologies that advance space-based proximity awareness capabilities and enable protection and countermeasure courses of action. Efforts will assess a variety of phenomenologies and concepts in response to multiple threat classes and scenarios.</p> <p>FY 2015 Accomplishments: Initiated hardware development on space-based imaging concepts that show viability under the feasibility study. Completed data analysis from the joint threat scenario study to quantify technology return-on-investment metrics. Initiated concept development, modeling, and simulations.</p> <p>FY 2016 Plans: Transition space-based imaging concepts to system development community for further maturation. Begin development of integrated tracking filter incorporating physics-based neutral density drag models for improved SSA.</p> <p>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.</p>	2.533	1.370	1.778
<p>Title: Space Indicators and Warning Research</p> <p>Description: Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites.</p> <p>FY 2015 Accomplishments:</p>	0.278	1.697	2.268

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 634400 / <i>Space Systems Protection</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Continued updating sensor specifications and evaluating additional sensors to compare attributes (size, weight, power, performance, maturity, etc.) of sensor technologies against case uses/scenarios/missions. FY 2016 Plans: Review 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. Identify and review holistic, resilient spacecraft concept technologies. Identify and develop 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.				
Title: Spacecraft Threat Detection Description: Develop active satellite local space awareness technologies and exploitation tools for satellite systems. FY 2015 Accomplishments: Developed components to enable on-board detection, assessment, and resolution of spacecraft anomalies to include co-orbital and directed energy threats. Applied efforts towards geosynchronous spaceflight demonstration as well as extensions to demonstrate multi-asset, space and ground, coordination. Employed system levels concepts to enable cross queuing of assets both on-orbit and on the ground. FY 2016 Plans: Refine capabilities to perform on-board course of action mission planning which will involve tasking of satellite subsystems as well as other space system entities; mature technology through ground and flight demonstration opportunities. Select cross queuing concepts and identify specific candidate technologies to integrate and increase cross coordination between space and ground sensor assets. FY 2017 Plans: Continue and demonstrate 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.		0.843	3.124	4.045
Accomplishments/Planned Programs Subtotals		3.654	6.191	8.091

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 634400 / <i>Space Systems Protection</i>

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

N/A

Remarks

D. Acquisition Strategy

N/A

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 634950 / <i>Space Demonstration</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
<i>634950: Space Demonstration</i>	-	11.072	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.072

A. Mission Description and Budget Item Justification

This project will provide mission design and development, payload integration, launch support, operations planning, and one-year of on-orbit operations for a science and technology space-launch mission. The project will provide a launch opportunity in support of the multi-agency "new entrant" certification strategy and the Air Force Launch Services New Entrant Certification Guide.

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

	FY 2015	FY 2016	FY 2017
Title: S&T Space Launch Integration and Test	11.072	0.000	0.000
Description: Provide mission design and development, payload integration, launch support, operations planning, and one-year of on-orbit operations for a science and technology space-launch mission while supporting the multi-agency "new entrant" certification strategy.			
FY 2015 Accomplishments: Finalized satellite and payload manifest. Completed payload/satellite/launch vehicle integration. In FY 2015, Project 634950, Space Demonstration, and S&T Space Launch Integration and Test effort was completed.			
FY 2016 Plans: N/A			
FY 2017 Plans: N/A			
Accomplishments/Planned Programs Subtotals	11.072	0.000	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.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 635021 / <i>Space Systems Survivability</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635021: <i>Space Systems Survivability</i>	-	2.901	2.202	1.849	0.000	1.849	1.846	1.942	1.940	1.979	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 2015	FY 2016	FY 2017
Title: Spacecraft Survivability/Reliability	2.901	2.202	1.849
Description: Develop technologies to provide improved space radiation and ionospheric hazard specification and forecasting.			
FY 2015 Accomplishments: Continued utilizing on-orbit data to generate tailored space environment hazards for operational systems. Expanded space environment anomaly attribution tool to new orbital domains. Completed assembly and initiated calibration and test of compact space environment sensor. Updated standard radiation belt model with additional new on-orbit data. Began integrating next-generation solar and interplanetary models with anomaly resolution tool to provide predictions of space environment hazards.			
FY 2016 Plans: Enhance computational performance of standard radiation belt model for satellite design while continuing to add new on-orbit data. Transition spiral one of anomaly attribution tool to operational demonstration. Begin optimizing design of compact energetic particle sensor. Evaluate performance of solar and interplanetary models to provide anomaly hazard predictions. Continue exploitation of on-orbit data from wider array of sources to improve understating of system specific space environment effects. Complete 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. Initiate spiral two development for anomaly attribution tool to include additional information for operators and incorporate limited space environment forecast demonstrations. Begin development, assembly, and calibration of energetic particle sensor. Continue evaluating performance of space environment forecast models for incorporation into anomaly attribution tool. Begin exploiting data from on-orbit radiation			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 635021 / <i>Space Systems Survivability</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
remediation mission for inclusion in standard radiation belt model for satellite design. Investigate and improve forecasting of solar radio events that impact Air Force operational systems.			
Accomplishments/Planned Programs Subtotals	2.901	2.202	1.849

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 635083 / <i>Ballistic Missiles Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635083: <i>Ballistic Missiles Technology</i>	-	7.295	3.913	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.208

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 2015	FY 2016	FY 2017
Title: Advanced Navigation Instruments	7.295	3.913	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 2015 Accomplishments: Continued weapons hardening of critical technology elements of Advanced Inertial Measurement Unit (AIMU) system. Built two ground test units with improved design updates for additional testing and integration planning. Investigated and implemented multipath mitigation improvements. Incorporated in militarily relevant hardware and conducted field testing.			
FY 2016 Plans: Complete weapons hardening of solid-state gyroscope sensor. Complete architecture studies to leverage communications links to provide position and time knowledge, and initiate demonstration of performance on hand held military radios.			
FY 2017 Plans: For FY 2017 and beyond, this effort will be combined with the Advanced Alternative Navigation Technologies effort in Project 63682J, Spacecraft Vehicles, to better align advanced navigation technology research and development.			
Accomplishments/Planned Programs Subtotals	7.295	3.913	0.000

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

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 635083 / <i>Ballistic Missiles Technology</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
63682J: <i>Spacecraft Vehicles</i>	-	10.827	9.213	13.301	0.000	13.301	11.463	15.858	16.704	17.039	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 2015	FY 2016	FY 2017
<p>Title: Space Power Technologies</p> <p>Description: Develop power generation space technologies such as multi-junction solar cells, thin-film solar cells, lightweight solar cell arrays, and radiation resistant solar cell modules.</p> <p>FY 2015 Accomplishments: Continued development of approaches for greater than 35% efficient solar cells. Matured module/blanket technologies for increased reliability and resiliency. Matured flexible array technologies.</p> <p>FY 2016 Plans: Select candidate approaches for achieving greater than 35% efficient solar cells and initiate cell performance and radiation optimization for selected method. Continue development of resilient technologies for module/array survivability. Initiate demonstrations of flexible array technology through ground demo and/or flight experiments.</p> <p>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.</p>	1.608	1.159	0.990
<p>Title: Spacecraft Thermal Technologies</p> <p>Description: Develop technologies for long-life, efficient, low-vibration, lightweight mechanical cryocoolers and integration components for space applications.</p> <p>FY 2015 Accomplishments: Continued computer simulations to optimize performance of different cryogenic coolers in support of payload thermal management systems for very large format focal plane arrays for missile warning capability and for industry. Increased manufacturability of space-borne cryocoolers through the implementation of commercial, terrestrial cryocooler technologies, combined with space-like designs.</p> <p>FY 2016 Plans:</p>	1.019	0.254	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Complete 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: 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 2015 Accomplishments: Developed new thermal technologies for heat dissipation of high energy density spacecraft electronics slated for use on Air Force communications and GPS spacecraft. Initiated in-house testing of these technologies and began working the technology transition process to Air Force spacecraft prime contractors. Matured technologies for composite spacecraft deployable structures, solar arrays, electro-optical and radio-frequency apertures, and de-orbit mechanisms. Tested structurally-integrated sensing technologies on satellite structures to provide an improved option for monitoring spacecraft health and potential threats. FY 2016 Plans: Complete contracted efforts and in-house government testing, deliver high-performance heat spreader, compliant thermal interface material, and electronics cooling technologies for spaceflight experiment. Using the International Space Station, test 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. Develop and test deployment of a lightweight baffle and an affordable deployable radio-frequency aperture for communication and high-gain GPS signals. Initiate 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.		2.020	1.159	0.992
Title: On-Orbit Satellite Controls Description: Develop technologies for spacecraft controls and mechanisms for on-orbit applications. FY 2015 Accomplishments:		0.493	0.452	0.423

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Initiated development of advanced low size/weight/power high-precision navigation hardware for geosynchronous SSA missions.</p> <p>FY 2016 Plans: Continue development of advanced low size/weight/power inertial measurement units and high-precision maneuvering technology for geosynchronous SSA missions.</p> <p>FY 2017 Plans: Complete development of advanced low size/weight/power inertial measurement units and high-precision maneuvering technology for geosynchronous SSA missions. Initiate development and testing of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions.</p>				
<p>Title: Space Communication and Control Technologies</p> <p>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.</p> <p>FY 2015 Accomplishments: Continued incremental development of satellite communication flight experiments to support future Air Force satellite systems, particularly reconfigurable/reprogrammable satellite transceivers, space laser communication terminals, and millimeter wave atmospheric propagation experiments. Supported Space and Missile Systems Center Low-Cost User Terminal initiatives.</p> <p>FY 2016 Plans: Complete evaluation of small space-based laser communication terminal and verify technology readiness for transition to the satellite development community. Complete risk reduction activities and initiate assembly, integration and testing work for a satellite communication flight experiment to support next-generation Air Force communications needs. Continue to invest in advanced development projects that address technology gaps identified by Air Force Space Command for future military satellite communication systems.</p> <p>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-data-rate satellite telemetry, command, and control.</p>		4.190	3.291	2.812
<p>Title: Advanced Alternative Navigation Technologies</p> <p>Description: Develop new atomic clock technologies and transition these technologies to industry for potential application to future positioning, navigation, and timing space considerations.</p> <p>FY 2015 Accomplishments:</p>		1.497	2.898	8.084

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Initiated efforts to transition newly-developed atomic clock technology from laboratory experiments to industry for potential space systems application. Designed and began fabricating engineering models of these clocks to meet DoD positioning and timing requirements.</p> <p>FY 2016 Plans: Continue efforts to develop atomic clock technology from laboratory experiments into prototypes to transition to industry. Continue fabrication and development of engineering models of the clocks for testing and integration.</p> <p>FY 2017 Plans: Finalize efforts to develop atomic clock technology from laboratory experiments into prototypes 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 hand held military radios to inform technology development activity.</p> <p>In FY 2015 and FY 2016, the advanced navigation instrumentation work was previously performed in Project 635083, Ballistic Missiles Technology, under the Advanced Navigation Instruments effort.</p>				
Accomplishments/Planned Programs Subtotals		10.827	9.213	13.301
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				
E. Performance Metrics				
Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.				

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity	R-1 Program Element (Number/Name)											
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603444F / <i>Maui Space Surveillance System (MSSS)</i>											
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	13.185	12.853	11.681	0.000	11.681	11.681	11.912	12.147	12.390	Continuing	Continuing
634868: <i>Maui Space Surveillance System</i>	-	13.185	12.853	11.681	0.000	11.681	11.681	11.912	12.147	12.390	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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	14.031	12.853	11.681	0.000	11.681
Current President's Budget	13.185	12.853	11.681	0.000	11.681
Total Adjustments	-0.846	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	-0.475	0.000			
• SBIR/STTR Transfer	-0.371	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

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

	FY 2015	FY 2016	FY 2017
Title: Operate and Upgrade Maui Space Surveillance System (MSSS)	10.156	10.853	9.169
Description: Operate and upgrade the MSSS to support development, demonstration, and integration of ground-based optical SSA technologies.			
FY 2015 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			

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603444F / <i>Maui Space Surveillance System (MSSS)</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>for development and demonstration of ground based optical SSA capabilities in conjunction with customer programs and an operational SSA mission. Completed installation of equipment for upgraded Laser Guidestar system at MSSS.</p> <p>FY 2016 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. Complete testing and demonstration of Laser Guidestar system at MSSS.</p> <p>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.</p>			
<p>Title: Geosynchronous Object Sensor</p> <p>Description: Develop and demonstrate dual-use integrated sensor technology for imaging of geosynchronous objects as well as other long-range applications.</p> <p>FY 2015 Accomplishments: Began integration of low power transceiver hardware prior to low power testing to image objects in geosynchronous orbit.</p> <p>FY 2016 Plans: Conduct 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.</p> <p>FY 2017 Plans: Begin full-power demonstration of laser imaging of objects in geosynchronous orbit.</p>	3.029	2.000	2.512
Accomplishments/Planned Programs Subtotals	13.185	12.853	11.681

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

Remarks

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force Date: February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603444F / <i>Maui Space Surveillance System (MSSS)</i>
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E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	21.142	25.448	26.492	0.000	26.492	22.811	23.470	25.114	25.615	Continuing	Continuing
635323: <i>Directed Energy Bioeffects Parameters</i>	-	3.012	2.439	4.909	0.000	4.909	4.888	5.115	6.393	6.520	Continuing	Continuing
635324: <i>Human Dynamics and Terrain Demonstration</i>	-	8.592	7.149	6.759	0.000	6.759	6.935	7.068	7.209	7.353	Continuing	Continuing
635325: <i>Mission Effective Performance</i>	-	4.345	10.724	10.141	0.000	10.141	6.626	6.846	6.982	7.122	Continuing	Continuing
635327: <i>Warfighter Interfaces</i>	-	5.193	5.136	4.683	0.000	4.683	4.362	4.441	4.530	4.620	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.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>
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B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	21.788	25.448	26.314	0.000	26.314
Current President's Budget	21.142	25.448	26.492	0.000	26.492
Total Adjustments	-0.646	0.000	0.178	0.000	0.178
• 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	-0.062	0.000			
• SBIR/STTR Transfer	-0.584	0.000			
• Other Adjustments	0.000	0.000	0.178	0.000	0.178

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>				Project (Number/Name) 635323 / <i>Directed Energy Bioeffects Parameters</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635323: <i>Directed Energy Bioeffects Parameters</i>	-	3.012	2.439	4.909	0.000	4.909	4.888	5.115	6.393	6.520	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 non-lethal 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 2015	FY 2016	FY 2017
Title: Optical Radiation Bioeffects	1.460	1.622	3.550
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 2015 Accomplishments: Began integration of physiological/behavioral response models into engagement-level simulation capabilities for directed energy weapon threats and concepts. Demonstrated modeling and simulation tools which transition engagement-level simulations to mission and campaign models to evaluate the utility and impact of directed energy systems. Applied these models in the battlespace simulation at tactical levels with contribution of bioeffect human vulnerability models in a DoD standardized format. Continued flight evaluation comparisons of predictive human system integration models to performance and acceptance of military users of these technologies in next-generation aircraft, identifying data gaps and optimizing future acquisitions.			
FY 2016 Plans: Complete 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. Complete initial demonstration of human vulnerability model built within a DoD standardized format and continue additional component development, integrating vision effects along with probability of eye and skin injury. Complete effort to design probabilistic risk assessment tools for lasers. Extend laser eye protection (LEP) evaluations to perform night visor aircrew acceptance testing, including laboratory testing, and ground and flight assessments.			
FY 2017 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635323 / <i>Directed Energy Bioeffects Parameters</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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.				
Title: Radio Frequency Bioeffects		1.552	0.817	1.359
Description: Develop and demonstrate technologies to assess RF bioeffects and collateral hazards from high power RF directed energy systems.				
FY 2015 Accomplishments: Validated predictive capability of models against high average power scenarios and began integration of high peak power models and high average power models into one software suite. Continued integration of RF bioeffects real-time model and control algorithms into RF weapons to optimize non-lethal human effects while minimizing collateral damage from RF weapons.				
FY 2016 Plans: Develop fast (near real-time) anatomy and physiology-based computational tool for RF-induced thermal response. Complete prototype high peak power effects model integration into software suite and begin verification and validation studies. Increase 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.				
Accomplishments/Planned Programs Subtotals		3.012	2.439	4.909
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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>				Project (Number/Name) 635324 / <i>Human Dynamics and Terrain Demonstration</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635324: <i>Human Dynamics and Terrain Demonstration</i>	-	8.592	7.149	6.759	0.000	6.759	6.935	7.068	7.209	7.353	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 2015	FY 2016	FY 2017
<p>Title: Human Analyst Augmentation</p> <p>Description: Develop and demonstrate human-centered design processes and operational tools that optimize ISR information exploitation and analysis.</p> <p>FY 2015 Accomplishments: Developed analytical work environments and toolsets to create advanced situational performance for ISR work roles that span the processing, exploitation, and dissemination process from time-dominated tactical work situations to content-dominated operational and strategic reach back operations.</p> <p>FY 2016 Plans: Demonstrate 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.</p> <p>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.</p>	3.319	5.194	4.215
<p>Title: Human Trust and Interaction</p> <p>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.</p> <p>FY 2015 Accomplishments:</p>	2.103	1.206	2.044

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635324 / <i>Human Dynamics and Terrain Demonstration</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Developed advanced multimedia machine translation and automatic speech recognition tools. Developed 'soft' and 'hard' fusion methodology experiments.</p> <p>FY 2016 Plans: Demonstrate and test advanced multimedia machine translation and automatic speech recognition tools.</p> <p>FY 2017 Plans: Investigate advanced multimedia translation and automatic speech recognition tool applications in military environments for mission focus areas and domains.</p>				
<p>Title: Human Signatures</p> <p>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.</p> <p>FY 2015 Accomplishments: Demonstrated utility of integrated normative anthropometric-based human signatures data sets. Demonstrated wearable wireless monitors for human performance real-time assessment for multiple operational settings.</p> <p>FY 2016 Plans: Investigate integration of normative anthropometric-based human signatures algorithms into sensor system processors.</p> <p>FY 2017 Plans: Integrate human detection algorithm to provide operators with real-time counts of gender and age differentiation into operationally relevant sensor applications.</p>		3.170	0.749	0.500
Accomplishments/Planned Programs Subtotals		8.592	7.149	6.759
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635324 / <i>Human Dynamics and Terrain Demonstration</i>

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>				Project (Number/Name) 635325 / <i>Mission Effective Performance</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635325: <i>Mission Effective Performance</i>	-	4.345	10.724	10.141	0.000	10.141	6.626	6.846	6.982	7.122	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 2015	FY 2016	FY 2017
Title: Continuous Learning	4.345	10.724	10.141
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 2015 Accomplishments: Completed performance-based LVC environment fidelity assessment system. Completed development of automated tools to analyze training utility for alternative ways to accomplish mixes of live and virtual training in and across mission sets. Began development of common scenario, learner performance, and after action review content tagging for training. Developed learning management technologies for undergraduate pilot training. Developed adaptive training and performance measurement system for ISR analysts. Developed low-cost, multiple-platform remotely piloted aircraft (RPA) training system. Initiated adaptive training for Red Flag preparation. Developed deployable LVC capability for manned and unmanned aircraft as well as emergency responders.			
FY 2016 Plans: Complete operational trials of integrated LVC operations training and assessment methods in large force exercise. Demonstrate shareable content and metrics in joint and coalition mission training contexts. Begin development of reusable models for improving adversary realism in distributed mission operations (DMO) and LVC environments. Demonstrate deployable LVC training in integrated manned and unmanned aircraft and ground operations exercise. Begin development of scenario and metrics specifications and standards for deployable LVC operations.			
FY 2017 Plans:			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635325 / <i>Mission Effective Performance</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
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.			
Accomplishments/Planned Programs Subtotals	4.345	10.724	10.141

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>				Project (Number/Name) 635327 / <i>Warfighter Interfaces</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635327: <i>Warfighter Interfaces</i>	-	5.193	5.136	4.683	0.000	4.683	4.362	4.441	4.530	4.620	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 2015	FY 2016	FY 2017
Title: Applied Neuroscience	0.726	0.437	0.995
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 2015 Accomplishments: Finalized design recommendations for an integrated offensive and defensive cyber operator tool set. Integrated neurophysiological sensors and validated biofluid sensors capable of real-time assessment of human cognition, human-machine teaming status, and calibrated trust. Conducted cognitive task analyses and cognitive work analyses in operational cyber and other operational domains to develop technical requirements and make operational recommendations based on findings. Integrated sensors, methodologies, and approaches to assess operator functional state relating to stress, cognition, trust, and human-machine teaming.			
FY 2016 Plans: Verify and validate design recommendations for an integrated offensive and defensive cyber operator tool set. Finalize design of neurophysiological-based airman performance sensor suite. Refresh sensors, methodologies, and approaches to assess operator functional state relating to stress, cognition, trust, and airman-machine teaming.			
FY 2017 Plans: Finalize design of an integrated offensive and defensive cyber operator tool set. Begin development of the neurophysiological-based airman performance sensor suite. Begin to build rapid and agile human-centered and testing capability for cyber operations.			
Title: Battlespace Acoustics	2.801	3.119	1.637

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635327 / <i>Warfighter Interfaces</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: Integrated real-time 3-D acoustic models into mission planning tools. Validated high-fidelity 3-D acoustic models against real-world data obtained from airborne platform measurements in different weather and terrain environments. Validated weather effects, landscape sounds, and geography used in developed acoustic models. Applied human factors and usability engineering methodologies to prototype and test wearable interfaces for seamless integration of data for battlefield airmen.</p> <p>FY 2016 Plans: Validate real-time 3-D acoustic models into mission planning tools. Evaluate high-fidelity 3-D acoustic models against real-world data obtained from airborne platform measurements in different weather and terrain environments. Conduct human panel validation studies of weather effects, landscape sounds, and geography used in developed acoustic models. Initiate applications of physiological sensors, usability engineering methodologies to prototype and test innovative solutions required for battlefield airmen and pararescue jumpers.</p> <p>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. Analyze human panel validation studies of weather effects, landscape sounds, and geography used in developed acoustic models. 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.</p>				
<p>Title: Human Role in Semiautonomous Systems</p> <p>Description: Develop and demonstrate an integrated human-centered interface to control multiple RPAs that have various levels of autonomy and that optimize net-centric information flow.</p> <p>FY 2015 Accomplishments: Demonstrated and evaluated operator interface designs to support decision-making and situation awareness while controlling multiple advanced and legacy RPAs in a dynamic mission environment. Performed initial evaluations of multi-transit control station interface technology to enable a single pilot to simultaneously control multiple RPAs transiting through airspace by using</p>		1.666	1.580	2.051

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / <i>Human Effectiveness Advanced Technology Development</i>	Project (Number/Name) 635327 / <i>Warfighter Interfaces</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>high-fidelity simulations. Evaluated interfaces for a networked RPA collaborative environment using high-fidelity simulations and flight tests, to allow teams of pilot, sensor, and payload operators to work together during various RPA mission phases.</p> <p><i>FY 2016 Plans:</i> Foster 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. Perform 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. Deliver mature prototype of RPA transit operations workstation. Enhance and evaluate 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.</p> <p><i>FY 2017 Plans:</i> 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. Extend transit control into the operations area, factoring in sensor management tasks and other operational drivers.</p>			
Accomplishments/Planned Programs Subtotals	5.193	5.136	4.683

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

Remarks

D. Acquisition Strategy
N/A

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)					R-1 Program Element (Number/Name) PE 0603601F I Conventional Weapons Technology							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	41.385	43.036	102.009	0.000	102.009	155.804	180.370	259.366	204.802	Continuing	Continuing
63670A: <i>Weapon Technology Development</i>	-	41.385	43.036	60.509	0.000	60.509	74.604	76.470	47.366	53.002	Continuing	Continuing
63670B: <i>Weapon Concept Development</i>	-	0.000	0.000	41.500	0.000	41.500	81.200	103.900	212.000	151.800	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. This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and integration of these subsystems and components into system concepts for field experiments and/or tests in a simulated environment. 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.

B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	42.046	48.536	45.401	0.000	45.401
Current President's Budget	41.385	43.036	102.009	0.000	102.009
Total Adjustments	-0.661	-5.500	56.608	0.000	56.608
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	-5.500			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.025	0.000			
• SBIR/STTR Transfer	-0.686	0.000			
• Other Adjustments	0.000	0.000	56.608	0.000	56.608

Change Summary Explanation

Decrease in FY 2016 due to Congressional Directed Reduction for improving funds management: forward financing.

Increase in FY 2017 due to increased emphasis on distributed fuzing technologies, long range strike weapon technology demonstrations, and missile technology demonstrations.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>				Project (Number/Name) 63670A / <i>Weapon Technology Development</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
63670A: <i>Weapon Technology Development</i>	-	41.385	43.036	60.509	0.000	60.509	74.604	76.470	47.366	53.002	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, matures, assesses, and demonstrates advanced/innovative ordnance and guidance component and subsystem technologies for air-launched conventional weapons. The project focuses on maturation of advanced explosives, fuzes, warheads, submunitions, and weapon airframes, carriage and dispensing; as well as innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation.

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

	FY 2015	FY 2016	FY 2017
Title: Ordnance Technologies	9.418	8.252	34.000
Description: Develop advanced ordnance technologies for conventional, air-delivered munitions. Specific technical areas of focus include fuzes, energetic materials, and warheads.			
FY 2015 Accomplishments: Demonstrated precision height-of-burst technologies for tailored fragmentation thereby limiting collateral damage. Quantified lethality through near field barriers, i.e., within a flight vehicle for fragmenting weapons. Developed embedded fuze components to withstand the shock occurring as a result of weapon impact into hardened targets. Developed and assessed ordnance technologies that enable high-speed strike weapon concepts. Designed innovative compartmented weapon to allow directional control of weapon fragments.			
FY 2016 Plans: Continue to mature alternate fuzing technologies to increase the reliability of penetrating weapons. Continue to develop and assess ordnance technologies that enable high-speed strike weapon concepts. Develop ordnance technologies that enable general purpose warheads that are lethal across an ever increasing spectrum of targets with the aim of a simplified family of warheads.			
FY 2017 Plans: Increase emphasis in maturing distributed fuzing concepts for close-controlled strike, area attack, and penetration applications, including assessing long term safety, survivability and functionality over time. Continue to advance ordnance technologies to allow tailored lethality by controlling weapon fragmentation. Increase emphasis in developing and demonstrating ordnance technologies that enable high-speed strike weapon concepts. Develop test capabilities and analysis tools to evaluate ordnance technologies in relevant environments. Develop ordnance technologies for survivability at high speed impacts.			
Title: Guidance Technologies	7.956	11.051	26.509

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>	Project (Number/Name) 63670A / <i>Weapon Technology Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Description: Develop guidance technologies to improve the precision, controlled lethality and flexibility of conventional, air-delivered munitions. Specific technical areas include precision navigation and terminal seekers.</p> <p>FY 2015 Accomplishments: Completed the initial trade study for low cost non-gimbaled seeker for agile engagements of platform threats. Conducted wind tunnel testing to characterize propulsion systems for next generation air-to-air weapons. Applied new in-house developed aero- and structural-thermal tools to high speed conceptual weapon design and assessment. Built government-industry consortium and created beta architecture for open design of weapons that will allow software defined weapons, rapid tech refresh of weapons, and increased innovation. Developed the preliminary concept, interface definition, and performance specifications for a tri-mode scene generation capability which will support the design, development, and analysis of advanced weapon concepts in representative environments.</p> <p>FY 2016 Plans: Continue to develop and assess technologies capable of guiding a high-speed strike weapon characterized by very high terminal speed and high end-game maneuverability. Continue to explore alternative guidance and control concepts that enable an improved air-to-air missile. Continue design and development of seeker subsystem prototypes for platform self-defense.</p> <p>FY 2017 Plans: Conduct wind-tunnel and limited flight experiments to characterize air-to-air guidance and control. Increase emphasis on integrated hardware and software-in-the-loop demonstrations of high speed weapon technologies. Increase emphasis in developing advanced modular and service oriented weapon architectures. Continue design and development of seeker subsystem prototypes for platform self-defense. Develop projector and common scene generator technologies for design, development, and analysis of advanced weapon concepts in representative environments for assets networked and operating in future battle spaces. Develop technologies for precision navigation of weapons.</p>			
<p>Title: Advanced Munition Concept Technologies</p> <p>Description: Demonstrate advanced conventional munitions concepts. These innovative concepts integrate ordnance, guidance, and carriage and release technologies to demonstrate warfighter capability.</p> <p>FY 2015 Accomplishments: Conducted System Requirements Reviews for the demonstration of hypersonic airbreathing and boost-glide weapon concepts. Updated Modeling, Simulation and Analysis tools for guidance, control, and endgame maneuver in hypersonic flight regimes. Developed innovative warhead concepts for hypersonic airframes and initiated structural and lethality analyses. Continued development of concepts for cooperative control of small weapons to increase the capacity and capability of fifth-generation aircraft. Began development of a simulation test bed to validate Open System Architecture interfaces and system designs.</p>	24.011	23.733	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>	Project (Number/Name) 63670A / <i>Weapon Technology Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>Created high-fidelity network simulation for an affordable, compact, and secure weapon data link. Initiated development of testbed for experimentation with cooperative control algorithms. Tested additively manufactured steel fragment flexible weapon warhead liners and warheads to evaluate improvements in fragmentation lethality. Completed analysis (engagement, mission, and campaign-level, as well as lethality, survivability, and logistics) to inform technology development of small weapons concepts.</p> <p>FY 2016 Plans: Continue to conduct relevant long range strike weapon technology demonstration to reduce risk for a potential follow on acquisition program. Continue the development of a munition concept to incorporate technologies for carriage and terminal impact at high speed. Continue investigating concepts for cooperative control of small weapons to produce scalable effects to increase the capacity and capability of fifth generation aircraft. Continue to demonstrate the ability to articulate the trades and synergies of kinetic energy and directed energy weapons by incorporating higher fidelity methodologies into systems level analysis, including joint weapons effectiveness. Demonstrate weapon integration concept for air target engagement.</p> <p>FY 2017 Plans: Starting in FY 2017 and beyond, work accomplished under this effort will be reported in Project 63670B, Weapon Concept Development.</p>			
Accomplishments/Planned Programs Subtotals	41.385	43.036	60.509

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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>	Project (Number/Name) 63670B / <i>Weapon Concept Development</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
63670B: <i>Weapon Concept Development</i>	-	0.000	0.000	41.500	0.000	41.500	81.200	103.900	212.000	151.800	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 2015	FY 2016	FY 2017
<p>Title: Air-to-Air Concept Development</p> <p>Description: Mature, integrate, and demonstrate air-to-air weapon components and systems (ordnance, guidance, and carriage and release technologies) to demonstrate warfighter capability.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed under Project 63670A, Weapon Technology Development, in the effort, Advanced Munition Concept Technologies.</p> <p>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.</p>	0.000	0.000	5.000
<p>Title: Air-to-Ground Concept Development</p> <p>Description: Mature, integrate, and demonstrate air-to-ground weapon components and systems (ordnance, guidance, and carriage and release technologies) to demonstrate warfighter capability.</p>	0.000	0.000	36.500

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603601F / <i>Conventional Weapons Technology</i>	Project (Number/Name) 63670B / <i>Weapon Concept Development</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p><i>FY 2015 Accomplishments:</i> N/A</p> <p><i>FY 2016 Plans:</i> N/A</p> <p><i>FY 2017 Plans:</i> For FY 2015 and FY 2016, the work for this effort originally was performed under Project 63670A, Weapon Technology Development, in the effort, Advanced Munition Concept Technologies.</p> <p>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.</p>			
Accomplishments/Planned Programs Subtotals	0.000	0.000	41.500

<p><u>C. Other Program Funding Summary (\$ in Millions)</u> N/A</p> <p><u>Remarks</u></p> <p><u>D. Acquisition Strategy</u> N/A</p> <p><u>E. Performance Metrics</u> 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.</p>

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	33.681	35.195	39.064	0.000	39.064	38.677	30.238	30.840	31.458	Continuing	Continuing
633151: <i>High Power Solid State Laser Technology</i>	-	16.337	13.385	20.824	0.000	20.824	11.987	12.237	12.480	12.730	Continuing	Continuing
633152: <i>High Power Microwave Development and Integration</i>	-	17.344	21.810	18.240	0.000	18.240	26.690	18.001	18.360	18.728	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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	33.542	30.195	31.064	0.000	31.064
Current President's Budget	33.681	35.195	39.064	0.000	39.064
Total Adjustments	0.139	5.000	8.000	0.000	8.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	5.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.743	0.000			
• SBIR/STTR Transfer	-0.604	0.000			
• Other Adjustments	0.000	0.000	8.000	0.000	8.000

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

Project: 633152: *High Power Microwave Development and Integration*

Congressional Add: *Counter-electronics high power microwave advanced missile*

FY 2015	FY 2016
10.000	5.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>
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Congressional Add Details (\$ in Millions, and Includes General Reductions)

	FY 2015	FY 2016
Congressional Add Subtotals for Project: 633152	10.000	5.000
Congressional Add Totals for all Projects	10.000	5.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>				Project (Number/Name) 633151 / <i>High Power Solid State Laser Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
633151: <i>High Power Solid State Laser Technology</i>	-	16.337	13.385	20.824	0.000	20.824	11.987	12.237	12.480	12.730	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 2015	FY 2016	FY 2017
Title: High Energy Laser/Beam Control	16.337	13.385	20.824
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 2015 Accomplishments: With DARPA, integrated their electric laser with the Air Force beam control system in order to conduct high power lethality testing against various targets including counter-RAM (rockets, artillery, mortar), surface-to-air missiles (SAM) and aircraft. Continued design of a full scale turret with aero-effects mitigation.			
FY 2016 Plans: Complete experiments with the joint DARPA and Air Force high energy laser system against various targets including ground targets and surface-to-air missiles. Document field lethality data, modeling and simulation tools, and lessons learned on the tests. Begin preparation for integration of a moderate power laser system into a pod for aircraft self-protection ground demo. Continue 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-protect demonstration. Complete the integration/verification of the beam control system 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.			
Accomplishments/Planned Programs Subtotals			20.824

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

N/A

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>	Project (Number/Name) 633151 / <i>High Power Solid State Laser Technology</i>

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.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>	Project (Number/Name) 633152 / <i>High Power Microwave Development and Integration</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
633152: <i>High Power Microwave Development and Integration</i>	-	17.344	21.810	18.240	0.000	18.240	26.690	18.001	18.360	18.728	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. It also provides inputs to the susceptibility, vulnerability, and lethality databases.

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

	FY 2015	FY 2016	FY 2017
Title: HPEM Technologies	7.344	16.810	18.240
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 2015 Accomplishments: Began 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.			
FY 2016 Plans: Refine design 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 red directed energy threats on blue assets. Begin initial preparations for the next generation high power microwave (HPM) demonstration.			
FY 2017 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 red directed energy threats on blue assets. Begin the next generation HPM demonstration.			
Accomplishments/Planned Programs Subtotals	7.344	16.810	18.240

	FY 2015	FY 2016
Congressional Add: Counter-electronics high power microwave advanced missile	10.000	5.000

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603605F / <i>Advanced Weapons Technology</i>	Project (Number/Name) 633152 / <i>High Power Microwave Development and Integration</i>
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	FY 2015	FY 2016
FY 2015 Accomplishments: Conducted Congressionally directed effort.		
FY 2016 Plans: Conduct Congressionally directed effort.		
Congressional Adds Subtotals	10.000	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.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity					R-1 Program Element (Number/Name)							
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					PE 0603680F / <i>Manufacturing Technology Program</i>							
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	51.613	52.630	46.344	0.000	46.344	45.386	43.906	44.780	45.675	Continuing	Continuing
635280: <i>Manufacturing Technologies</i>	-	51.613	52.630	46.344	0.000	46.344	45.386	43.906	44.780	45.675	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Manufacturing Technology 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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	52.772	42.630	46.344	0.000	46.344
Current President's Budget	51.613	52.630	46.344	0.000	46.344
Total Adjustments	-1.159	10.000	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	10.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-1.159	0.000			
• Other Adjustments	0.000	0.000	0.000	0.000	0.000

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

Project: 635280: *Manufacturing Technologies*

Congressional Add: *Additive Manufacturing*

FY 2015	FY 2016
10.000	10.000

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603680F / <i>Manufacturing Technology Program</i>			
Congressional Add Details (\$ in Millions, and Includes General Reductions)		FY 2015	FY 2016	
Congressional Add Subtotals for Project: 635280		10.000	10.000	
Congressional Add Totals for all Projects		10.000	10.000	
C. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Title: Sustainment Manufacturing Technologies		11.652	11.841	12.873
Description: Develop and implement cost-effective maintenance, repair, and manufacturing technologies for sustainment of Air Force weapon systems.				
FY 2015 Accomplishments: Continued development of cost effective conventional and low-observable production and repair technologies to enable affordable sustainment of aircraft systems. Aided in the development of Low Observable (LO) imaging tool and adding robotics into the depot. Continued manufacturing technology development for depot maintenance.				
FY 2016 Plans: Continue development of cost effective conventional and LO production and repair technologies to enable affordable sustainment of aircraft systems. Continue manufacturing technology development for depot maintenance.				
FY 2017 Plans: Continue development of cost effective conventional production and low-observable repair technologies to enable affordable sustainment of aircraft systems. Continue agile sustainment manufacturing technology development for depot maintenance.				
Title: Advanced Manufacturing Technologies		29.961	30.789	33.471
Description: Develop and transition pervasive affordability and producibility technologies for weapon systems and processes.				
FY 2015 Accomplishments: Continued development and demonstration of manufacturing capabilities for more affordable advanced turbine engine propulsion technologies, communications technologies, advanced active electronic scanned array (AESA) sensor applications, and Mid-Wave Infrared optics producibility. Developed a slurry dip automated system to keep employees safe. Developed fuel sealant application caps to aid in production. Continued development of agile manufacturing applications and hot structures affordability and continue to mature advanced material development.				
FY 2016 Plans: Continue development and demonstration of manufacturing capabilities for more affordable advanced turbine engine propulsion technologies, communications technologies, advanced AESA sensor applications, and Mid-Wave Infrared optics producibility.				

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force	Date: February 2016
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Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	R-1 Program Element (Number/Name) PE 0603680F / <i>Manufacturing Technology Program</i>
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C. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Continue development of agile manufacturing applications and hot structures affordability and continue to mature advanced material development. FY 2017 Plans: Continue development and demonstration of agile manufacturing capabilities for more affordable advanced turbine engine propulsion technologies, ISR and communications technologies, transparent ceramics producibility, and the producibility of air armaments. Continue development of agile manufacturing applications and structures affordability with a focus on low cost attritable aircrafts and open pod architecture; and continue to mature advanced material manufacturing development and get it to the field.			
Accomplishments/Planned Programs Subtotals	41.613	42.630	46.344

	FY 2015	FY 2016
Congressional Add: Additive Manufacturing	10.000	10.000
FY 2015 Accomplishments: Conducted Congressionally-directed effort.		
FY 2016 Plans: Conduct congressionally directed effort		
Congressional Adds Subtotals	10.000	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: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)	R-1 Program Element (Number/Name) PE 0603788F I Battlespace Knowledge Development and Demonstration
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
Total Program Element	-	34.338	46.196	58.110	0.000	58.110	61.169	63.984	64.044	60.224	Continuing	Continuing
635319: Anticipatory OPS Intent and Response	-	4.265	3.635	3.562	0.000	3.562	3.602	6.144	6.267	6.392	Continuing	Continuing
635320: Assured Worldwide Connectivity	-	18.768	25.190	20.837	0.000	20.837	22.813	19.717	16.636	13.208	Continuing	Continuing
635321: Global Battlespace Awareness	-	7.709	12.165	8.425	0.000	8.425	11.017	12.874	14.616	14.908	Continuing	Continuing
635322: Knowledge Management and Computing	-	3.596	5.206	4.767	0.000	4.767	3.369	3.811	3.676	2.068	Continuing	Continuing
635329: Cyber Battlespace Dev & Demo	-	0.000	0.000	20.519	0.000	20.519	20.368	21.438	22.849	23.648	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.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>

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 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	35.289	46.414	52.042	0.000	52.042
Current President's Budget	34.338	46.196	58.110	0.000	58.110
Total Adjustments	-0.951	-0.218	6.068	0.000	6.068
• Congressional General Reductions	0.000	-0.218			
• 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	-1.116	0.000			
• Other Adjustments	0.165	0.000	6.068	0.000	6.068

Change Summary Explanation

Increase in FY 2017 is due to increased DoD emphasis on high-speed data link technology.

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>				Project (Number/Name) 635319 / <i>Anticipatory OPS Intent and Response</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635319: <i>Anticipatory OPS Intent and Response</i>	-	4.265	3.635	3.562	0.000	3.562	3.602	6.144	6.267	6.392	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 2015	FY 2016	FY 2017
Title: Adaptive Planning and Decision Tools	3.584	3.231	2.606
Description: Develop and demonstrate the integration of planning tools and information-based intelligent agents for adaptive replanning and decision support tools.			
FY 2015 Accomplishments: Designed and developed a set of planning tools and services that proactively build and shape the portion of cyberspace employed in support of mission assurance objectives. Developed a moving target defense specification for integration into a Command and Control (C2) mission assurance framework. Continued development and experimentation of net-centric mission planning and execution concepts to provide a net-enabled dynamic decision support capability for a variety of air, space and cyber missions. Generated optimized means of synchronizing cross-domain effects while respecting hard and soft constraints within and across domains.			
FY 2016 Plans: Prototype 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. Demonstrate 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. Validate 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 C2 framework modernizing JSpOC operations, advanced indications and warning tipping C2 system for proactive countermeasure actions and visualization of the			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635319 / <i>Anticipatory OPS Intent and Response</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
complete electromagnetic spectrum for enhancing Joint Space Operations Center (JSpOC) decision making. Initiate effort for Distributed Operations in a Contested Environment. Create and use scenarios and evaluation metrics for integrated demonstration and testing.				
Title: Next Generation Planning and Assessment Tools		0.681	0.404	0.956
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 2015 Accomplishments: Completed development of tools in machine learning for patterns of life generation. Demonstrated capabilities to rapidly and systematically decompose commander's intent into a set of measurable effects that result from actions taken in multiple domains (air, space, and cyber).				
FY 2016 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.				
FY 2017 Plans: 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.				
Accomplishments/Planned Programs Subtotals		4.265	3.635	3.562
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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635320 / <i>Assured Worldwide Connectivity</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635320: <i>Assured Worldwide Connectivity</i>	-	18.768	25.190	20.837	0.000	20.837	22.813	19.717	16.636	13.208	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 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 2015	FY 2016	FY 2017
Title: Cyber Offense	4.671	5.543	0.000
Description: Develop and demonstrate offensive cyber operations capabilities in a series of experimental technology demonstrations.			
FY 2015 Accomplishments: Continued development and delivery of a capability which processes available cyber observables to deliver operational preparation of the environment information vital to the warfighter. Continued development of a highly configurable cyber simulation environment which produces high fidelity cyber telemetry for analysis. Continued assessment of military objectives for places where non-kinetic solutions can aid kinetic missions and enhance technologies for military relevant environments. Continued development of technologies to remain current with new waveforms and signals.			
FY 2016 Plans: Merge next generation cyber operations technologies with other relevant military programs and demonstrate enhanced capabilities that allow non-kinetic capabilities to aid kinetic missions. Develop technologies to remain current with new waveforms and signals. Continue Service Oriented Architecture component development for use in the Air Force Lifecycle Management			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635320 / <i>Assured Worldwide Connectivity</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Center (AFLCMC) Cyber Mission Platform (CMP). Schedule 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 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 2015 Accomplishments: Continued development of a network level encryption and traffic-aware router, which allow enclaves at different security levels to share a common network. Demonstrated interference-tolerant waveform design, dissemination and utility on portable radio platform. Developed decentralized control algorithms and protocols for radio networks that optimally allocate resources from the bottom to higher layers of the protocol stack. Continued development of key technologies to be demonstrated in the laboratory using the software definable radio testbed. FY 2016 Plans: Continue the development of a network level encryption and traffic-aware router, allowing enclaves at different security levels to share common network. Continue research to push the limits of technologies that improve the Aerial Layer Networks used by the Air Force. Develop optimal universal waveform sets for multipath multi-access communications. Initiate the integration, test & evaluation, and demonstration of an integrated version of the capabilities developed under this program. Perform 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 radio frequency (RF) capability. Initiate the development of high-speed data link technology in line with DoD emphasis areas.		6.742	11.295	20.837
Title: Resiliency		3.011	3.247	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635320 / <i>Assured Worldwide Connectivity</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: Continued the enhancement, maturation, testing, and demonstration of cyber agility technologies through exercises and other user-focused venues. Developed semantic models for discovering and managing conflicts, dependencies, and cascading terminology alterations in DoD-wide Joint Doctrine and U.S. Transportation Command (USTRANSCOM)/JSpoC mission implementations. Developed plans for bridging domain and DoD doctrinal models for information relationships extractions. Demonstrated SecureServe capabilities at the virtual machine (VM) and hypervisor level to the AFLCMC Transition Agent (AFLCMC/HBB). Provided initial research into current state of the art of open source technologies of steganographic and malware-based technologies.</p> <p>FY 2016 Plans: Continue 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. Continue developing mature doctrinal representations for cross-DoD mission ontologies and use cases. Continue developing SecureServe to include updating and enhancing VM communication channels, network monitoring, failover, snapshot, and migration. Integrate the dynamic attestation prototype into the SecureServe baseline. Continue development and evaluation of an agile, modular, and pluggable framework for integration of open source algorithms.</p> <p>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.</p>			
<p>Title: Effects-based Cyber Defense</p> <p>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.</p> <p>FY 2015 Accomplishments: Continued development and performance analysis of new enhancement for insertion into active steganalysis product.</p> <p>FY 2016 Plans:</p>	4.344	5.105	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635320 / <i>Assured Worldwide Connectivity</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Complete the development and demonstration of new enhancements into the active steganalysis product. Initiate research into novel resiliency technologies to package into an adaptive systems solution. Complete the initial prototyping of defensive cyber deception technologies. <i>FY 2017 Plans:</i> 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.			
Accomplishments/Planned Programs Subtotals	18.768	25.190	20.837

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-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>				Project (Number/Name) 635321 / <i>Global Battlespace Awareness</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635321: <i>Global Battlespace Awareness</i>	-	7.709	12.165	8.425	0.000	8.425	11.017	12.874	14.616	14.908	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 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)

Title: Advanced Signal and Data Exploitation Technologies	FY 2015	FY 2016	FY 2017
Description: Demonstrate advanced signal and data exploitation technologies for detection, tracking, identification, and targeting of time-critical targets, and information extraction.	2.284	5.454	3.016
FY 2015 Accomplishments: Developed technologies which enhanced electronic signals intelligence (ELINT) detection and processing capabilities against emerging emitter weapon systems. Explored signals intelligence (SIGINT), communications intelligence (COMINT) and other intelligence signal exploitation for contested environments. Continued the development of speech processing algorithm investigations that improved feature extraction techniques, speed and efficiency of training/testing algorithms, and classifiers that aid in improvements to component technologies. Developed and performed an analysis of new enhancement which were inserted into active steganalysis products. Developed technologies that maintained currency with new waveforms and signals. Researched and developed full motion video object of interest signature detection and exploitation algorithms. Continued development of multi-source intelligence (multi-INT) correlation approaches. Investigated and developed techniques which improved the motion imagery capabilities. Continued the development of automated capabilities which exploited signals of interest.			
FY 2016 Plans: Refine and test technologies to enhance ELINT detection and processing capabilities against emerging emitter weapon systems. Develop strategies for multi-INT exploitation. Investigate algorithms that can improve upon the audio prioritization capabilities, improvements to detection and correction methods, and mitigation techniques for modeling differences. Complete new enhancements and insert them into active steganalysis products. Develop technologies to remain current with new			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635321 / <i>Global Battlespace Awareness</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>waveforms and signals. Integrate full motion video object of interest detection and exploitation algorithms with multi-INT correlation algorithms and demonstrate the capability. Integrate enhanced motion imagery capabilities with existing imagery exploitation tools. Continue the development of automated capabilities to exploit signals of interest.</p> <p>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 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.</p>				
<p>Title: Advanced Data Handling, Visualization and Distributed Data Fusion</p> <p>Description: Develop and demonstrate advanced data handling, event visualization technologies, and distributed data fusion to enable a more effective utilization of data available.</p> <p>FY 2015 Accomplishments: Continued analysis of recorded multi-intelligence test data with developed algorithms. Applied object based processing and activity based intelligence tradecraft to selected domains and intelligence problems. Developed approaches of filtering multi-intelligence data for ingestion into machine learning approaches for the purpose of event discovery. Matured capabilities to provide graph-based approaches for handling large and complex relationships observed across various sources. Delivered automatic optimization of tracking algorithms across sensors, modes, and regions. Migrated tools and data to distributed (cloud) computing to extract additional performance gains. Completed an improved cross domain solution independent file filtering capability within Cross Domain Solution (CDS) systems.</p> <p>FY 2016 Plans: Continue the application of object based processing and activity based intelligence tradecraft to selected domains and intelligence problems. Transition 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. Continue developing, demonstrating, and transitioning technology solutions for automated recognition of indicators to associate potential and emerging threats against Blue assets. Continue developing computational capabilities that automate the decision-making process and that encompass sensing, data mining and analysis, information extraction and understanding, and activity recognition. Continue the development of technologies to create activity based intelligence from motion data.</p> <p>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</p>		1.354	3.092	3.118

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635321 / <i>Global Battlespace Awareness</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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.				
<p>Title: Autonomous Text Exploitation</p> <p>Description: Develop and demonstrate capabilities for reasoning and learning, text understanding, link and group discovery, and advanced analysis for situational awareness and understanding.</p> <p>FY 2015 Accomplishments: Continued the development of cross-document co-reference capability integrated into document processing pipeline. Continued the development of web-based Text Exploitation and Analysis framework.</p> <p>FY 2016 Plans: Continue developing cross-document co-reference capability integrated into document processing pipeline. Continue developing web-based Text Exploitation and Analysis framework. Initiate research and development for plug and play modules for deeper text understanding and large scale, time dependent, network based analytics.</p> <p>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.</p>		1.178	0.724	1.220
<p>Title: Adversary Courses of Action</p> <p>Description: Develop models to provide detailed understanding of the adversary's probable intent and future strategy to identify adversary COAs, the most likely COA, and the COA most dangerous to friendly forces and mission accomplishment.</p> <p>FY 2015 Accomplishments: Continued development of a demonstration of advanced analytical capabilities that integrate kinetic and non-kinetic options for full spectrum targeting. Initiated the development of assessment 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 the addition of targeting capabilities to increase the full range of options available.</p> <p>FY 2016 Plans: Continue 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. Continue developing a demonstration of advanced analytical capabilities that integrate kinetic</p>		2.893	2.895	1.071

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635321 / <i>Global Battlespace Awareness</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
and non-kinetic options for full spectrum targeting. Continue 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. Continue adding targeting capabilities to increase the full range of options available.				
FY 2017 Plans: 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.				
Accomplishments/Planned Programs Subtotals		7.709	12.165	8.425
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-2A, RDT&E Project Justification: PB 2017 Air Force **Date:** February 2016

Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635322 / <i>Knowledge Management and Computing</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635322: <i>Knowledge Management and Computing</i>	-	3.596	5.206	4.767	0.000	4.767	3.369	3.811	3.676	2.068	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 2015	FY 2016	FY 2017
Title: Game Changing Computing Power	0.924	2.695	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 2015 Accomplishments: Continued the design, development and demonstration of affordable, high performance, interactive, parallel data exploitation and massively parallel systems. Developed and demonstrated embedded high performance computing systems and integrated bio-inspired embedded computing hardware that delivers a set of autonomous sensing capabilities for Air Force ISR missions in contested and anti-access/area denial (A2/AD) environments. Initiated the development of trusted resilient legacy systems that continuously and simultaneously assess and re-establish warfighter trust as the resilient system dynamically responds to fight through failures and attacks.			
FY 2016 Plans: Continue designing, developing and demonstrating affordable, high performance, interactive, parallel data exploitation and massively parallel systems. 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			

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635322 / <i>Knowledge Management and Computing</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>A2/AD environments. Continue to develop capabilities to simultaneously assess, maintain or reestablish trust as resiliency actions respond to failures and/or attacks. Continue to develop new approaches to building trusted and resilient systems. Demonstrate trusted and resilient systems in a realistic operational environment. Initiate 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 control for continuous, dynamic autonomous operations. The output will develop a processor capable of universal quantum computation.</p> <p>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.</p>				
<p>Title: Advanced Information Management</p> <p>Description: Demonstrate how a publish, subscribe, and query information management (IM) paradigm can enable vertical and horizontal integration of Air Force information systems.</p> <p>FY 2015 Accomplishments: Developed and delivered a suite of new collaboration capabilities for U.S. and Coalition Multiple Levels of Security (MLS) environments producing four new cross-domain collaboration tools in: Voice over Internet Protocol(VoIP) / Video Teleconferencing; Secure Full Motion Video (FMV) streaming; Automated & resilient data content inspection; and Global trusted remote monitoring & management. Initiated the development of 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.</p> <p>FY 2016 Plans: Continue 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.</p> <p>Initiate 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 situational awareness (SA) and communications.</p> <p>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 situational awareness (SA) across the theater of war for targeting</p>		0.980	2.511	4.767

UNCLASSIFIED

Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635322 / <i>Knowledge Management and Computing</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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 (ST) mission sets so that ST operators can have superior situational awareness (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.				
Title: Agile Information Management Services Description: Demonstrate how agile information management services enable effective information sharing in a tactical environment. FY 2015 Accomplishments: Completed development of information management services embedded with the sensor that will boost the effective communication bandwidth available to tactical users and link pilots, remotely piloted aircraft and ground assets in the field. FY 2016 Plans: Effort terminated due to higher DoD priorities. FY 2017 Plans: N/A		1.692	0.000	0.000
Accomplishments/Planned Programs Subtotals		3.596	5.206	4.767
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.				

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>				Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635329: <i>Cyber Battlespace Dev & Demo</i>	-	0.000	0.000	20.519	0.000	20.519	20.368	21.438	22.849	23.648	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 2015	FY 2016	FY 2017
Title: Cyber Offense	0.000	0.000	6.223
Description: Develop and demonstrate offensive cyber operations capabilities in a series of experimental technology demonstrations.			
FY 2015 Accomplishments: N/A			
FY 2016 Plans: N/A			
FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed under Project 635320, Assured Worldwide Connectivity in an effort of the same name.			
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 Cyber Mission Platform (CMP). Transition components, including Cyber Time and Cyber Mission Planning, for use in CMP. Continue red-teaming new components to improve security.			
Title: Effects-based Cyber Defense	0.000	0.000	6.026

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
<p>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.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed Project 635320, Assured Worldwide Connectivity in an effort of the same name.</p> <p>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 ISR systems, and, progress testing with the Cyber Experimentation Environment.</p>			
<p>Title: Resiliency</p> <p>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.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed Project 635320, Assured Worldwide Connectivity in an effort of the same name.</p> <p>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</p>	0.000	0.000	3.703

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
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.				
<p>Title: Game Changing Computing Power</p> <p>Description: Develop and demonstrate computer architectures with greater capacity and sophistication to enable game-changing computing power to the warfighter anywhere, anytime.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed Project 635322, Knowledge Management and Computing in an effort of the same name.</p> <p>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.</p>		0.000	0.000	3.617
<p>Title: Autonomous, Multi-level Access and Transfer</p> <p>Description: Develop autonomous, secure information access and sharing capabilities required by the Air Force net-centric information enterprise.</p> <p>FY 2015 Accomplishments: N/A</p> <p>FY 2016 Plans: N/A</p> <p>FY 2017 Plans: For FY 2015 and FY 2016, the work for this effort originally was performed Project 635322, Knowledge Management and Computing in an effort of the same name.</p>		0.000	0.000	0.950

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / <i>Battlespace Knowledge Development and Demonstration</i>	Project (Number/Name) 635329 / <i>Cyber Battlespace Dev & Demo</i>

B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
Continue the 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 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.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	20.519

C. Other Program Funding Summary (\$ in Millions)											
<u>Line Item</u>	<u>FY 2015</u>	<u>FY 2016</u>	<u>FY 2017</u> <u>Base</u>	<u>FY 2017</u> <u>OCO</u>	<u>FY 2017</u> <u>Total</u>	<u>FY 2018</u>	<u>FY 2019</u>	<u>FY 2020</u>	<u>FY 2021</u>	<u>Cost To Complete</u>	<u>Total Cost</u>
• 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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