Department of Defense
Fiscal Year (FY) 2016 President's Budget Submission

February 2015

Air Force

Justification Book Volume 1 of 3

Research, Development, Test & Evaluation, Air Force

Vol−I

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Volume 1 Table of Contents

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Fiscal Year (FY) 2016 President's Budget Submission
RDT&E Descriptive Summaries
Scientific and Technology Budget Activities
February 2015

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 2016 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 2015 RDT&E program with the exception of classified program elements. The format sand contents of this document are in accordance to the guidelines and requirements of the Congressional committees in so far as possible.
         b) The "Other Program Funding Summary portion of the R-2 includes, in addition to RDTE& funds, Procurement funds and quantities, Military Construction appropriation funds on specific development programs, Operations and Maintenance appropriation funds where they are essential to the development effort described, and where appropriate, Department of Energy (DOE) costs.

2. (U) CLASSIFICATION
   A. All exhibits contained in Volumes I, II, and III are unclassified. Classified exhibits are not included in the submission due to the level of security classification and necessity of special security clearances.

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Department of Defense
FY 2016 President's Budget
Exhibit R-1 FY 2016 President's Budget
Total Obligational Authority
(Dollars in Thousands)

28 Jan 2015

Appropriation	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Research, Development, Test & Eval, AF	23,823,510	23,630,474	14,706	23,645,180	26,473,669	17,100	26,490,769
Total Research, Development, Test & Evaluation	23,823,510	23,630,474	14,706	23,645,180	26,473,669	17,100	26,490,769

R-1C1: FY 2016 President's Budget (Published Version of PB Position), as of January 28, 2015 at 07:27:29

Department of Defense
FY 2016 President's Budget
Exhibit R-1 FY 2016 President's Budget
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Summary Recap of Budget Activities	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Basic Research	510,830	551,008		551,008	485,253		485,253
Applied Research	1,124,358	1,100,790		1,100,790	1,217,342		1,217,342
Advanced Technology Development	624,332	629,912		629,912	675,785		675,785
Advanced Component Development & Prototypes	936,496	1,407,354		1,407,354	2,062,575		2,062,575
System Development & Demonstration	4,344,992	3,617,103		3,617,103	3,847,791		3,847,791
Management Support	1,418,396	1,178,699		1,178,699	1,174,584		1,174,584
Operational Systems Development	14,864,106	15,145,608	14,706	15,160,314	17,010,339	17,100	17,027,439
Total Research, Development, Test & Evaluation	23,823,510	23,630,474	14,706	23,645,180	26,473,669	17,100	26,490,769

Summary Recap of FYDP Programs							
Strategic Forces	181,376	514,726		514,726	618,422		618,422
General Purpose Forces	1,475,225	1,541,794		1,541,794	1,687,905	300	1,688,205
Intelligence and Communications	1,362,446	1,640,102		1,640,102	1,635,920		1,635,920
Mobility Forces	311,274	241,643		241,643	366,856		366,856
Research and Development	9,095,792	8,343,388		8,343,388	9,105,003		9,105,003
Central Supply and Maintenance	91,235	98,657		98,657	156,778		156,778
Training Medical and Other	1,716	2,538		2,538	3,272		3,272
Administration and Associated Activities	119,003	116,625		116,625	117,056		117,056
Support of Other Nations	3,785	3,790		3,790	2,315		2,315
Classified Programs	11,181,658	11,127,211	14,706	11,141,917	12,780,142	16,800	12,796,942
Total Research, Development, Test & Evaluation	23,823,510	23,630,474	14,706	23,645,180	26,473,669	17,100	26,490,769

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

Line No	Program Element Number	Item	Act	FY 2014 (Base & OCO)	FY 2015 Base Enacted	FY 2015 OCO Enacted	FY 2015 Total Enacted	FY 2016 Base	FY 2016 OCO	FY 2016 Total	Sec
1	0601102F	Defense Research Sciences	01	364,195	389,979		389,979	329,721		329,721	U
2	0601103F	University Research Initiatives	01	133,798	147,079		147,079	141,754		141,754	U
3	0601108F	High Energy Laser Research Initiatives	01	12,837	13,950		13,950	13,778		13,778	U
	Basic	Research		510,830	551,008		551,008	485,253		485,253	
4	0602102F	Materials	02	118,951	110,680		110,680	125,234		125,234	U
5	0602201F	Aerospace Vehicle Technologies	02	117,724	105,673		105,673	123,438		123,438	U
6	0602202F	Human Effectiveness Applied Research	02	101,157	96,894		96,894	100,530		100,530	U
7	0602203F	Aerospace Propulsion	02	193,204	172,550		172,550	182,326		182,326	U
8	0602204F	Aerospace Sensors	02	125,989	118,321		118,321	147,291		147,291	U
9	0602601F	Space Technology	02	100,066	98,229		98,229	116,122		116,122	U
10	0602602F	Conventional Munitions	02	80,804	87,387		87,387	99,851		99,851	U
11	0602605F	Directed Energy Technology	02	110,725	125,866		125,866	115,604		115,604	U
12	0602788F	Dominant Information Sciences and Methods	02	136,885	147,749		147,749	164,909		164,909	U
13	0602890F	High Energy Laser Research	02	38,853	37,441		37,441	42,037		42,037	U
	Applied	Research		1,124,358	1,100,790		1,100,790	1,217,342		1,217,342	
14	0603112F	Advanced Materials for Weapon Systems	03	53,593	40,177		40,177	37,665		37,665	U
15	0603199F	Sustainment Science and Technology (S&T)	03	12,380	15,800		15,800	18,378		18,378	U
16	0603203F	Advanced Aerospace Sensors	03	31,968	34,334		34,334	42,183		42,183	U
17	0603211F	Aerospace Technology Dev/Demo	03	75,029	91,037		91,037	100,733		100,733	U

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18	0603216F	Aerospace Propulsion and Power Technology	03	160,765	132,681		132,681	168,821		168,821	U
19	0603270F	Electronic Combat Technology	03	42,516	47,508		47,508	47,032		47,032	U
20	0603401F	Advanced Spacecraft Technology	03	57,787	68,907		68,907	54,897		54,897	U
21	0603444F	Maui Space Surveillance System (MSSS)	03	25,535	14,031		14,031	12,853		12,853	U
22	0603456F	Human Effectiveness Advanced Technology Development	03	24,508	21,788		21,788	25,448		25,448	U
23	0603601F	Conventional Weapons Technology	03	33,410	42,046		42,046	48,536		48,536	U
24	0603605F	Advanced Weapons Technology	03	18,519	33,542		33,542	30,195		30,195	U
25	0603680F	Manufacturing Technology Program	03	40,221	52,772		52,772	42,630		42,630	U
26	0603788F	Battlespace Knowledge Development and Demonstration	03	48,101	35,289		35,289	46,414		46,414	U
		Advanced Technology Development		624,332	629,912		629,912	675,785		675,785	
27	0603260F	Intelligence Advanced Development	04	3,983	5,408		5,408	5,032		5,032	U
28	0603287F	Physical Security Equipment	04	3,874							U
29	0603438F	Space Control Technology	04	22,862	6,075		6,075	4,070		4,070	U
30	0603742F	Combat Identification Technology	04	12,938	10,980		10,980	21,790		21,790	U
31	0603790F	NATO Research and Development	04	4,561	2,392		2,392	4,736		4,736	U
32	0603791F	International Space Cooperative R&D	04	379	833		833				U
33	0603830F	Space Security and Defense Program	04	23,986	31,613		31,613	30,771		30,771	U
34	0603851F	Intercontinental Ballistic Missile - Dem/Val	04	72,696	30,885		30,885	39,765		39,765	U
35	0603859F	Pollution Prevention - Dem/Val	04	953	998		998				U

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36	0604015F	Long Range Strike	04	348,625	913,728		913,728	1,246,228		1,246,228	U
37	0604317F	Technology Transfer	04	2,531	4,769		4,769	3,512		3,512	U
38	0604327F	Hard and Deeply Buried Target Defeat System (HDBTDS) Program	04	109,602				54,637		54,637	U
39	0604337F	Requirements Analysis and Maturation	04	11,486							U
40	0604422F	Weather System Follow-on	04		39,901		39,901	76,108		76,108	U
41	0604458F	Air & Space Ops Center	04	60,971							U
42	0604618F	Joint Direct Attack Munition	04	2,417							U
43	0604635F	Ground Attack Weapons Fuze Development	04	17,271							U
44	0604857F	Operationally Responsive Space	04	10,000	20,000		20,000	6,457		6,457	U
45	0604858F	Tech Transition Program	04	48,194	79,004		79,004	246,514		246,514	U
46	0605230F	Ground Based Strategic Deterrent	04					75,166		75,166	U
47	0105921F	Service Support to STRATCOM - Space Activities	04	2,685							U
48	0201184F	Counter Narco-Terrorism Program Office	04	510							U
49	0207110F	Next Generation Air Dominance	04		15,722		15,722	8,830		8,830	U
50	0207455F	Three Dimensional Long-Range Radar (3DELRR)	04	52,891	88,825		88,825	14,939		14,939	U
51	0305164F	NAVSTAR Global Positioning System (User Equipment) (SPACE)	04	123,081	156,221		156,221	142,288		142,288	U
52	0306250F	Cyber Operations Technology Development	04					81,732		81,732	U
		Advanced Component Development & Prototypes		936,496	1,407,354		1,407,354	2,062,575		2,062,575	

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53	0603260F	Intelligence Advanced Development	05	977							U
54	0604233F	Specialized Undergraduate Flight Training	05	3,601	13,324		13,324				U
55	0604270F	Electronic Warfare Development	05	1,971	7,815		7,815	929		929	U
56	0604281F	Tactical Data Networks Enterprise	05	41,388	39,059		39,059	60,256		60,256	U
57	0604287F	Physical Security Equipment	05		3,926		3,926	5,973		5,973	U
58	0604329F	Small Diameter Bomb (SDB) - EMD	05	109,580	68,738		68,738	32,624		32,624	U
59	0604421F	Counterspace Systems	05	22,655	23,424		23,424	24,208		24,208	U
60	0604425F	Space Situation Awareness Systems	05	304,380	9,462		9,462	32,374		32,374	U
61	0604426F	Space Fence	05		200,082		200,082	243,909		243,909	U
62	0604429F	Airborne Electronic Attack	05	4,422	30,687		30,687	8,358		8,358	U
63	0604441F	Space Based Infrared System (SBIRS) High EMD	05	322,399	308,788		308,788	292,235		292,235	U
64	0604602F	Armament/Ordnance Development	05	13,661	29,112		29,112	40,154		40,154	U
65	0604604F	Submunitions	05	2,564	2,543		2,543	2,506		2,506	U
66	0604617F	Agile Combat Support	05	16,747	42,840		42,840	57,678		57,678	U
67	0604706F	Life Support Systems	05	7,069	14,854		14,854	8,187		8,187	U
68	0604735F	Combat Training Ranges	05	19,649	10,129		10,129	15,795		15,795	U
69	0604800F	F-35 - EMD	05	616,560	567,889		567,889	589,441		589,441	U
70	0604851F	Intercontinental Ballistic Missile - EMD	05	118,504							U
71	0604853F	Evolved Expendable Launch Vehicle Program (SPACE) - EMD	05	19,431	225,600		225,600	84,438		84,438	U

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72	0604932F	Long Range Standoff Weapon	05	5,000	3,438		3,438	36,643		36,643	U
73	0604933F	ICBM Fuze Modernization	05	76,553	59,826		59,826	142,551		142,551	U
74	0605213F	F-22 Modernization Increment 3.2B	05	88,268	173,647		173,647	140,640		140,640	U
75	0605214F	Ground Attack Weapons Fuze Development	05		5,332		5,332	3,598		3,598	U
76	0605221F	KC-46	05	1,505,476	786,437		786,437	602,364		602,364	U
77	0605223F	Advanced Pilot Training	05		8,201		8,201	11,395		11,395	U
78	0605229F	CSAR HH-60 Recapitalization	05	333,558	100,000		100,000	156,085		156,085	U
79	0605278F	HC/MC-130 Recap RDT&E	05	2,611	4,497		4,497				U
80	0605431F	Advanced EHF MILSATCOM (SPACE)	05	261,554	307,898		307,898	228,230		228,230	U
81	0605432F	Polar MILSATCOM (SPACE)	05	101,401	103,245		103,245	72,084		72,084	U
82	0605433F	Wideband Global SATCOM (SPACE)	05	11,674	31,328		31,328	56,343		56,343	U
83	0605458F	Air & Space Ops Center 10.2 RDT&E	05		85,938		85,938	47,629		47,629	U
84	0605931F	B-2 Defensive Management System	05	248,971	98,768		98,768	271,961		271,961	U
85	0101125F	Nuclear Weapons Modernization	05	33,000	168,357		168,357	212,121		212,121	U
86	0207171F	F-15 EPAWSS	05					186,481		186,481	U
87	0207701F	Full Combat Mission Training	05	4,663	8,831		8,831	18,082		18,082	U
88	0305176F	Combat Survivor Evader Locator	05					993		993	U
89	0307581F	NextGen JSTARS	05		73,088		73,088	44,343		44,343	U
90	0401318F	CV-22	05	46,705							U
91	0401319F	Presidential Aircraft Replacement (PAR)	05					102,620		102,620	U

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92	0701212F	Automated Test Systems	05					14,563		14,563	U
		System Development & Demonstration		4,344,992	3,617,103		3,617,103	3,847,791		3,847,791	
93	0604256F	Threat Simulator Development	06	14,786	24,418		24,418	23,844		23,844	U
94	0604759F	Major T&E Investment	06	31,423	47,232		47,232	68,302		68,302	U
95	0605101F	RAND Project Air Force	06	32,956	30,443		30,443	34,918		34,918	U
96	0605502F	Small Business Innovation Research	06	304,921							U
97	0605712F	Initial Operational Test & Evaluation	06	6,972	10,266		10,266	10,476		10,476	U
98	0605807F	Test and Evaluation Support	06	724,958	689,509		689,509	673,908		673,908	U
99	0605860F	Rocket Systems Launch Program (SPACE)	06	12,755	34,364		34,364	21,858		21,858	U
100	0605864F	Space Test Program (STP)	06	11,642	21,161		21,161	28,228		28,228	U
101	0605976F	Facilities Restoration and Modernization - Test and Evaluation Support	06	44,160	46,955		46,955	40,518		40,518	U
102	0605978F	Facilities Sustainment - Test and Evaluation Support	06	29,743	32,965		32,965	27,895		27,895	U
103	0606017F	Requirements Analysis and Maturation	06		16,350		16,350	16,507		16,507	U
104	0606116F	Space Test and Training Range Development	06		19,512		19,512	18,997		18,997	U
105	0606323F	Multi-Service Systems Engineering Initiative	06	6,682							U
106	0606392F	Space and Missile Center (SMC) Civilian Workforce	06	172,257	176,727		176,727	185,305		185,305	U
107	0308602F	ENTEPRISE INFORMATION SERVICES (EIS)	06		4,938		4,938	4,841		4,841	U

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108	0702806F	Acquisition and Management Support	06	20,525	18,644		18,644	15,357		15,357	U
109	0804731F	General Skill Training	06	304	1,425		1,425	1,315		1,315	U
110	0909999F	Financing for Cancelled Account Adjustments	06	527							U
111	1001004F	International Activities	06	3,785	3,790		3,790	2,315		2,315	U
		Management Support		1,418,396	1,178,699		1,178,699	1,174,584		1,174,584	
112	0603423F	Global Positioning System III - Operational Control Segment	07	361,381	299,060		299,060	350,232		350,232	U
113	0604233F	Specialized Undergraduate Flight Training	07					10,465		10,465	U
114	0604445F	Wide Area Surveillance	07	4,836	2,000		2,000	24,577		24,577	U
116	0604618F	Joint Direct Attack Munition	07		2,469		2,469				U
117	0605018F	AF Integrated Personnel and Pay System (AF-IPPS)	07	33,114	60,019		60,019	69,694		69,694	U
118	0605024F	Anti-Tamper Technology Executive Agency	07	25,733	34,815		34,815	26,718		26,718	U
119	0605278F	HC/MC-130 Recap RDT&E	07					10,807		10,807	U
121	0101113F	B-52 Squadrons	07	16,481	49,457		49,457	74,520		74,520	U
122	0101122F	Air-Launched Cruise Missile (ALCM)	07	983	450		450	451		451	U
123	0101126F	B-1B Squadrons	07	14,355	4,353		4,353	2,245		2,245	U
124	0101127F	B-2 Squadrons	07	80,225	116,580		116,580	108,183		108,183	U
125	0101213F	Minuteman Squadrons	07		139,109		139,109	178,929		178,929	U
126	0101313F	Strat War Planning System - USSTRATCOM	07	32,077	32,014		32,014	28,481		28,481	U

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127	0101314F	Night Fist - USSTRATCOM	07					87		87	U
128	0101316F	Worldwide Joint Strategic Communications	07					5,315		5,315	U
130	0102326F	Region/Sector Operation Control Center Modernization Program	07	1,570	1,272		1,272				U
131	0105921F	Service Support to STRATCOM - Space Activities	07		3,134		3,134	8,090		8,090	U
132	0205219F	MQ-9 UAV	07	104,000	148,598		148,598	123,439		123,439	U
133	0205671F	Joint Counter RCIED Electronic Warfare	07						300	300	U
134	0207131F	A-10 Squadrons	07	11,435							U
135	0207133F	F-16 Squadrons	07	109,887	133,105		133,105	148,297		148,297	U
136	0207134F	F-15E Squadrons	07	227,098	241,969		241,969	179,283		179,283	U
137	0207136F	Manned Destructive Suppression	07	10,724	14,831		14,831	14,860		14,860	U
138	0207138F	F-22A Squadrons	07	266,431	146,299		146,299	262,552		262,552	U
139	0207142F	F-35 Squadrons	07	3,000	40,092		40,092	115,395		115,395	U
140	0207161F	Tactical AIM Missiles	07	12,376	29,739		29,739	43,360		43,360	U
141	0207163F	Advanced Medium Range Air-to-Air Missile (AMRAAM)	07	68,564	82,195		82,195	46,160		46,160	U
142	0207171F	F-15 EPAWSS	07		38,944		38,944				U
143	0207224F	Combat Rescue and Recovery	07	2,582	5,095		5,095	412		412	U
144	0207227F	Combat Rescue - Pararescue	07	350	883		883	657		657	U
145	0207247F	AF TENCAP	07	114,816	5,812		5,812	31,428		31,428	U
146	0207249F	Precision Attack Systems Procurement	07	2,000	1,081		1,081	1,105		1,105	U

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147	0207253F	Compass Call	07	10,745	14,315		14,315	14,249		14,249	U
148	0207268F	Aircraft Engine Component Improvement Program	07	86,467	94,177		94,177	103,942		103,942	U
149	0207325F	Joint Air-to-Surface Standoff Missile (JASSM)	07	6,202	12,897		12,897	12,793		12,793	U
150	0207410F	Air & Space Operations Center (AOC)	07	18,332	25,662		25,662	21,193		21,193	U
151	0207412F	Control and Reporting Center (CRC)	07	6,435				559		559	U
152	0207417F	Airborne Warning and Control System (AWACS)	07	143,404	180,804		180,804	161,812		161,812	U
153	0207418F	Tactical Airborne Control Systems	07	719	3,754		3,754	6,001		6,001	U
155	0207431F	Combat Air Intelligence System Activities	07	5,780	7,891		7,891	7,793		7,793	U
156	0207444F	Tactical Air Control Party-Mod	07	8,816	5,850		5,850	12,465		12,465	U
157	0207448F	C2ISR Tactical Data Link	07	1,373	1,744		1,744	1,681		1,681	U
158	0207449F	Command and Control (C2) Constellation	07	7,418							U
159	0207452F	DCAPES	07	9,769	821		821	16,796		16,796	U
160	0207581F	Joint Surveillance/Target Attack Radar System (JSTARS)	07	27,308							U
161	0207590F	Seek Eagle	07	22,046	23,844		23,844	21,564		21,564	U
162	0207601F	USAF Modeling and Simulation	07	8,439	12,034		12,034	24,994		24,994	U
163	0207605F	Wargaming and Simulation Centers	07	5,326	5,956		5,956	6,035		6,035	U
164	0207697F	Distributed Training and Exercises	07	3,600	3,357		3,357	4,358		4,358	U
165	0208006F	Mission Planning Systems	07	55,432	60,679		60,679	55,835		55,835	U

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166	0208059F	Cyber Command Activities	07	36,824	67,057		67,057				U
167	0208087F	AF Offensive Cyberspace Operations	07	13,610	13,355		13,355	12,874		12,874	U
168	0208088F	AF Defensive Cyberspace Operations	07	5,853	5,576		5,576	7,681		7,681	U
171	0301017F	Global Sensor Integrated on Network (GSIN)	07					5,974		5,974	U
177	0301400F	Space Superiority Intelligence	07	10,697	10,697		10,697	13,815		13,815	U
178	0302015F	E-4B National Airborne Operations Center (NAOC)	07	12,816	25,852		25,852	80,360		80,360	U
179	0303001F	Family of Advanced BLoS Terminals (FAB-T)	07					3,907		3,907	U
180	0303131F	Minimum Essential Emergency Communications Network (MEECN)	07	18,981	80,882		80,882	75,062		75,062	U
181	0303140F	Information Systems Security Program	07	61,687	69,727		69,727	46,599		46,599	U
182	0303141F	Global Combat Support System	07	725	692		692				U
183	0303142F	Global Force Management - Data Initiative	07					2,470		2,470	U
184	0303601F	MILSATCOM Terminals	07	125,924	54,678		54,678				U
186	0304260F	Airborne SIGINT Enterprise	07	83,972	74,072		74,072	112,775		112,775	U
189	0305099F	Global Air Traffic Management (GATM)	07	4,027	4,157		4,157	4,235		4,235	U
190	0305103F	Cyber Security Initiative	07	1,979							U
191	0305105F	DoD Cyber Crime Center	07	279							U
192	0305110F	Satellite Control Network (SPACE)	07	34,488	20,806		20,806	7,879		7,879	U
193	0305111F	Weather Service	07	19,950	20,102		20,102	29,955		29,955	U

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194	0305114F	Air Traffic Control, Approach, and Landing System (ATCALS)	07	31,920	26,087		26,087	21,485		21,485	U
195	0305116F	Aerial Targets	07	10,616	8,639		8,639	2,515		2,515	U
198	0305128F	Security and Investigative Activities	07	189				472		472	U
199	0305145F	Arms Control Implementation	07	1,430	13,222		13,222	12,137		12,137	U
200	0305146F	Defense Joint Counterintelligence Activities	07	10	40		40	361		361	U
203	0305173F	Space and Missile Test and Evaluation Center	07	3,584	3,674		3,674	3,162		3,162	U
204	0305174F	Space Innovation, Integration and Rapid Technology Development	07	2,409	2,071		2,071	1,543		1,543	U
205	0305179F	Integrated Broadcast Service (IBS)	07	6,954	8,592		8,592	7,860		7,860	U
206	0305182F	Spacelift Range System (SPACE)	07	11,909	13,318		13,318	6,902		6,902	U
207	0305202F	Dragon U-2	07	13,700	5,511		5,511	34,471		34,471	U
208	0305205F	Endurance Unmanned Aerial Vehicles	07	1,000	20,000		20,000				U
209	0305206F	Airborne Reconnaissance Systems	07	47,059	37,652		37,652	50,154		50,154	U
210	0305207F	Manned Reconnaissance Systems	07	13,491	13,516		13,516	13,245		13,245	U
211	0305208F	Distributed Common Ground/Surface Systems	07	6,321	26,994		26,994	22,784		22,784	U
212	0305219F	MQ-1 Predator A UAV	07	760				716		716	U
213	0305220F	RQ-4 UAV	07	120,180	241,828		241,828	208,053		208,053	U
214	0305221F	Network-Centric Collaborative Targeting	07	7,413	11,096		11,096	21,587		21,587	U

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215	0305236F	Common Data Link Executive Agent (CDL EA)	07	33,896	32,015		32,015	43,986		43,986	U
216	0305238F	NATO AGS	07	221,589	232,851		232,851	197,486		197,486	U
217	0305240F	Support to DCGS Enterprise	07	19,309	17,118		17,118	28,434		28,434	U
218	0305265F	GPS III Space Segment	07	195,950	211,907		211,907	180,902		180,902	U
219	0305600F	International Intelligence Technology and Architectures	07		2,270		2,270				U
220	0305614F	JSPOC Mission System	07	56,523	73,779		73,779	81,911		81,911	U
221	0305881F	Rapid Cyber Acquisition	07	2,151	4,102		4,102	3,149		3,149	U
222	0305913F	NUDET Detection System (SPACE)	07	42,506	20,405		20,405	14,447		14,447	U
223	0305940F	Space Situation Awareness Operations	07	11,911	11,408		11,408	20,077		20,077	U
224	0306250F	Cyber Operations Technology Development	07		4,938		4,938				U
225	0308699F	Shared Early Warning (SEW)	07	1,060	1,157		1,157	853		853	U
226	0401115F	C-130 Airlift Squadron	07	47,700				33,962		33,962	U
227	0401119F	C-5 Airlift Squadrons (IF)	07	48,617	38,773		38,773	42,864		42,864	U
228	0401130F	C-17 Aircraft (IF)	07	97,134	82,948		82,948	54,807		54,807	U
229	0401132F	C-130J Program	07	22,443	26,715		26,715	31,010		31,010	U
230	0401134F	Large Aircraft IR Countermeasures (LAIRCM)	07	4,116	4,672		4,672	6,802		6,802	U
231	0401219F	KC-10s	07		2,714		2,714	1,799		1,799	U
232	0401314F	Operational Support Airlift	07	38,538	27,784		27,784	48,453		48,453	U
233	0401318F	CV-22	07		38,719		38,719	36,576		36,576	U

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234	0401319F	Presidential Aircraft Replacement (PAR)	07		11,006		11,006				U
235	0408011F	Special Tactics / Combat Control	07	6,021	8,312		8,312	7,963		7,963	U
236	0702207F	Depot Maintenance (Non-IF)	07	1,605	1,407		1,407	1,525		1,525	U
237	0708610F	Logistics Information Technology (LOGIT)	07	58,532	62,894		62,894	112,676		112,676	U
238	0708611F	Support Systems Development	07	10,573	15,712		15,712	12,657		12,657	U
239	0804743F	Other Flight Training	07	1,347	987		987	1,836		1,836	U
240	0808716F	Other Personnel Activities	07	65	126		126	121		121	U
241	0901202F	Joint Personnel Recovery Agency	07	1,046	2,603		2,603	5,911		5,911	U
242	0901218F	Civilian Compensation Program	07	2,296	1,589		1,589	3,604		3,604	U
243	0901220F	Personnel Administration	07	8,322	5,026		5,026	4,598		4,598	U
244	0901226F	Air Force Studies and Analysis Agency	07	760	1,394		1,394	1,103		1,103	U
245	0901279F	Facilities Operation - Administrative	07	632	3,798		3,798				U
246	0901538F	Financial Management Information Systems Development	07	105,420	102,215		102,215	101,840		101,840	U
9999	9999999999	Classified Programs		11,181,658	11,127,211	14,706	11,141,917	12,780,142	16,800	12,796,942	U
		Operational Systems Development		14,864,106	15,145,608		15,160,314	17,010,339	17,100	17,027,439	
Total Research, Development, Test & Eval, AF				23,823,510	23,630,474		23,645,180	26,473,669	17,100	26,490,769	

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Budget Activity 03: Advanced Technology Development (ATD)
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Budget Activity 04: Advanced Component Development & Prototypes (ACD&P)
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Budget Activity 04: Advanced Component Development & Prototypes (ACD&P)
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Budget Activity 04: Advanced Component Development & Prototypes (ACD&P)
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Budget Activity 05: System Development & Demonstration (SDD)
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Budget Activity 06: RDT&E Management Support
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Budget Activity 07: Operational Systems Development
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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
0605798F	ANALYSIS SUPPORT GROUP

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PROGRAM ELEMENT COMPARISON SUMMARY

PROGRAM ELEMENT (BY BUDGET ACTIVITY)

Remarks

BUDGET ACTIVITY #1: BASIC RESEARCH (Volume 1)

None

BUDGET ACTIVITY #2: APPLIED RESEARCH (Volume 1)

None

BUDGET ACTIVITY #3: ADVANCED TECHNOLOGY DEVELOPMENT (Volume 1)

None

BUDGET ACTIVITY #4: ADVANCED COMPONENT DEVELOPMENT AND PROTOTYPE (Volume 2)

0306250F	CYBER OPERATIONS TECHNOLOGY DEVELOPMENT	In FY 2016, funding in PECs 0208059F and 0306250F, Project 676002 Cyber Systems Modernization, BA 07, was transferred to PE 0306250F, Cyber Operations Technology Development, Project 646008, US Cyber Command Technology Development, BA 04 in order to align efforts.
0603742F	COMBAT IDENTIFICATION TECHNOLOGY	In FY 2016, Project 642597 Non-cooperative Identification Subsystems includes new start efforts for Radio ID (RID).
0603790F	NATO RESEARCH AND DEVELOPMENT	In FY 2016, PE 0603791F, International Space Cooperative Research & Development, Project 645035, International Space Coop R&D, efforts were transferred to PE 0603790, NATO Research and Development, Project 64NATO, NATO Coop R&D, in order to consolidate international cooperative research and development activities.

PROGRAM ELEMENT COMPARISON SUMMARY

PROGRAM ELEMENT (BY BUDGET ACTIVITY)

0603791F	INTERNATIONAL SPACE COOPERATIVE R&D	In FY 2016, PE 0603791F, International Space Cooperative Research & Development, Project 645035, International Space Coop R&D, efforts were transferred to PE 0603790, NATO Research and Development, Project 64NATO, NATO Coop R&D, in order to consolidate international cooperative research and development activities.
0603859F	POLLUTION PREVENTION - DEM/VAL	In FY 2016, Project Number 644852 Pollution Prevention was terminated.
0605230F	GROUND BASED STRATEGIC DETERRENT	In FY 2016, PE 0605230F, Project 641025, Ground Based Strategic Deterrent (GBSD), efforts were transferred from the Solid Rocket Motor Modernization (SRMM) and Guidance Modernization Program (GMP)efforts in PE 0101213F, Project 672987, MM Ops Equipment

BUDGET ACTIVITY #5: SYSTEM DEVELOPMENT AND DEMONSTRATION (SDD) (Volume 2)

0207171F	F-15 EPAWSS	In FY 2016, PE 0207171F, F-15 EPAWSS, Project 676038 was transferred to PE 0207171F, F-15 EPAWSS, Project 657108 BA05 to align BA with stage of development.
0305176F	COMBAT SURVIVOR EVADER LOCATOR	In FY 2016, Project 654522 CSAR EMD, includes new start efforts for CSEL Crypto.
0401319F	PRESIDENTIAL AIRCRAFT REPLACEMENT (PAR)	In the FY 2016, PE 0401319 Presidential Aircraft Recap (PAR), Project 655250 Presidential Aircraft Recapitalization, was transferred to PE 0401319 Presidential Aircraft Recap (PAR), Project 655250 Presidential Aircraft Recapitalization, BA07 to align BA with stage of development.
0604233F	SPECIALIZED UNDERGRADUATE FLIGHT TRAINING	In FY 2016 PE 0604233F Specialized Undergraduate Flight Training, Project 654102 JPATS was transferred to BA07 to align activities for upgrades to fielded weapon system.
0604421F	COUNTERSPACE SYSTEMS	In FY 2016, Project 65A013 Bounty Hunter is a new start effort.

PROGRAM ELEMENT COMPARISON SUMMARY

PROGRAM ELEMENT (BY BUDGET ACTIVITY)

0604706F	LIFE SUPPORT SYSTEMS	In FY 2016 project 65412A Life Support Systems New Start projects for Personal Radio Communications (PRC) and Aircrew Safety Improvements.
0604853F	EELVP (SPACE) - EMD	In FY 2016, Project 650006, Next Generation Rocket Engine, includes new start efforts for the Evolved Expendable Launch Vehicle program.
0605278F	HC/MC-130 RECAP RDT&E	In FY 2016, PE 0605278F, HC/MC-130 Recap RDTE, Project 655249 HC-130Recap, efforts were transferred to PE 0605278F, HC/MC-130 Recap RDTE, Project 655249, HC/MC-130 Recap, BA 07 as the program achieved full rate production.
0701212F	AUTOMATED TEST SYSTEMS	In FY 2016, Project 6506TE, Test and Evaluation Support Budget Authority, includes a new start effort for Automated Bomber Test Systems.

BUDGET ACTIVITY #6: RDT&E MANAGEMENT SUPPORT (Volume 2)

0606017F	REQUIREMENTS ANALYSIS AND MATURATION	In FY 2016, Project 666158, Integrated Simulation and Analysis includes new start efforts to improve organic Air Force analysis and assessment capabilities.

BUDGET ACTIVITY #7: OPERATIONAL SYSTEMS DEVELOPMENT (Volume 3)

0101113F	B-52 SQUADRONS	In FY 2016, Project 675055, GPS-IU, includes new start effort for Global Positioning System (GPS)-Interface Unit (IU) Replacement. In FY 2016, Project 675039, B-52 System Improvements, includes new start effort(s) for potential engineering studies & analysis and test & evaluation.
0101127F	B-2 SQUADRONS	In FY 2016 Project 675345, B-2 Modernization, includes new start effort for B-2 strategic communication.

PROGRAM ELEMENT COMPARISON SUMMARY

PROGRAM ELEMENT (BY BUDGET ACTIVITY)

0101213F	MINUTEMAN SQUADRONS	In FY 2016, Project 672984, MM III Baseline Support, includes new start efforts for LGM-30G Cadmium Replacement Program (CaDRP) and LGM-30G Squadron Data Simulator (SDS). In FY 2016, Project 672985, MM Support Equip, the LGM-30G Payload Transporter Replacement (PTR) program was re-established and transferred from PE 0604851F, ICBM - EMD, Project 655037, Support Equipment, in order to consolidate ICBM efforts. In FY 2016, Project 672987, MM Ops Equipment, the two ongoing efforts will be transferred into PE 0605230F, Ground Based Strategic Deterrent (GBSD), Project 641025. The efforts being transferred are Guidance Modernization Program (GMP) and Solid Rocket Motor Modernization (SRMM). In FY 2016, Project 672985, MM Support Equip, includes a new start effort for LGM-30G Performance Assessment Data Systems Communications Equipment Interface Unit (PADS CEIU).
0101313F	STRAT WAR PLANNING SYSTEM - USSTRATCOM	In FY 2016, PE 0101313F, Strategic War Planning System, Project 675368, Global Sensor Integrated on Network, efforts were transferred to PE 0301017F, Global Sensor Integrated on Network, Project 675368, Global Sensor Integrated on Network, in order to provide improved transparency.
0101316F	WORLDWIDE JOINT STRATEGIC COMMUNICATIONS	In FY 2016, Project 671820, Strategic Automated Command and Control System (SACCS), includes a new start effort for SACCS Replacement.
0105921F	SVC SPT TO STRATCOM - SPACE ACTIVITIES	In FY 2016 Project 670373 DCIP and Project 67A011 Space Analysis and Application Development are new starts
0207171F	F-15 EPAWSS	In FY 2016, PE 0207171F, F-15 EPAWSS, Project 676038 was transferred to PE 0207171F, F-15 EPAWSS, Project 657108 BA05 to align BA with stage of development.
0207224F	COMBAT RESCUE AND RECOVERY	In FY 2016, Project 676016, Avionics Development and Integration will complete.
0207412F	CONTROL AND REPORTING CENTER (CRC)	In FY 2016, Project 67485L, Theater Air Control Sys Imp (TACSI), includes new start effort for JTIDS LINK 16 Terminal replacement.

PROGRAM ELEMENT COMPARISON SUMMARY

PROGRAM ELEMENT (BY BUDGET ACTIVITY)

0207601F	USAF MODELING AND SIMULATION	In FY 2016, Project Number 674567, M&S Foundations includes new start efforts for simulations for systems engineering and test activities.
0208059F	CYBER COMMAND ACTIVITIES	In FY 2016, PE 0208059F, Cyber Command Activities, Project 676002, Cyber Systems Modernization, efforts were transferred to PE 0306250F, Cyber Operations Technology Development, Project 646008, US Cyber Command Technology Development, to consolidate all USCYBERCOM programs
0208088F	AF DEFENSIVE CYBERSPACE OPERATIONS	In FY 2016, this program element includes new start efforts for Cyberspace Vulnerability Assessment, Cyber Defense Analysis, and AFCERT activities.
0301017F	GLOBAL SENSOR INTEGRATED ON NETWORK (GSIN)	In FY 2016, PE 0101313F, (Strategic War Planning System), Project 675368, (Global Sensor Integrated on Network) efforts were transferred to PE 0301017F, (Global Sensor Integrated on Network), Project 675368, (Global Sensor Integrated on Network), in order to provide improved transparency.
0302015F	E-4B NAT AIRBORNE OPS CTR (NAOC)	In FY 2016, Project E-4B Recapitalization includes new start efforts for E-4B Aircraft Modernization.
0303001F	FAMILY OF ADVANCED BLOS TERMINALS (FAB-T)	In FY 2016, PE 0303001F Family of Advanced BLoS Terminals (FAB-T), Project 672490, Family of Advanced BLoS Terminals (FAB-T) efforts were transferred to PE 0303601F, MILSATCOM Terminals, Project 672490, Family of Advanced BLoS Terminals (FAB-T) in order to provide improved visibility.
0303131F	MIN ESSENT EMGNCY COMM NETWORK (MEECN)	In FY 2016, Project 676029, Global ASNT, includes a new start effort for Global ASNT Increment 2.
0303141F	GLOBAL COMBAT SUPPORT SYSTEM	In FY 2016, components of project number 675046, Systems Engineering & Integration, efforts were transferred from PE 0303141F, Global Combat Support Systems (GCSS) to PE 0303142F, Global Force Management - Data Initiative (GFM-DI) in order to provide better visibility.
0303142F	GLOBAL FORCE MGMT - DATA INITIATIVE	In FY 2016, components of project number 675046, Systems Engineering & Integration, efforts were transferred from PE 0303141F, Global Combat Support Systems (GCSS) to PE 0303142F, Global Force Management - Data Initiative (GFM-DI) in order to provide better visibility.

PROGRAM ELEMENT COMPARISON SUMMARY

PROGRAM ELEMENT (BY BUDGET ACTIVITY)

0303601F	MILSATCOM TERMINALS	In FY 2016, PE 0303601F, MILSATCOM Terminals, Project 672490, Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) was transferred to PE 0303001F, FAB-T, Project 672490 FAB-T for improved visibility of ACAT I programs.
0304260F	AIRBORNE SIGINT ENTERPRISE	In FY 2016, PE 0304260F, Airborne SIGINT Enterprise, Project 675181, High Altitude SIGINT Development - High Altitude efforts are transferred to PE 0304260F, Airborne SIGINT Enterprise, Project 675183, Common Development (Airborne SIGINT Development - Common Development) to better align efforts.
0305206F	AIRBORNE RECONNAISSANCE SYSTEMS	In FY 2016, PE 0305220F, RQ-4, Project 675148, Common Airborne Sense and Avoid (C-ABSAA), efforts transferred to PE 0305206F, Airborne Reconnaissance Systems, Project 675148, Common Airborne Sense and Avoid (C-ABSAA), in order to provide greater visibility into this capability and prepare for expanded applications. In FY 2016, PE 0305208F, Distributed Common Ground Station (DCGS), Project 676025, Data Compression, efforts transferred to PE 0305206F, Airborne Reconnaissance Systems, Project 676025, Data Compression, in order to provide greater visibility into this capability.
0305208F	DISTRIBUTED COMMON GROUND/SURFACE SYSTEMS	In FY 2016, PE 0305208F, Distributed Common Ground Station (DCGS), Project 676025, Data Compression, efforts transferred to PE 0305206F, Airborne Reconnaissance Systems, Project 676025, Data Compression, in order to provide greater visibility into this capability.
0305220F	RQ-4 UAV	In FY 2016, PE 0305220F, RQ-4, Project 675148, Common-Airborne Sense & Avoid (C-ABSAA), transferred to PE 0305206F, Airborne Reconnaissance Systems, Project 675148. This transfer will provide greater visibility into this capability and prepares for expanded applications by making the capability program and platform agnostic.
0305614F	JSPOC MISSION SYSTEM	In FY 2016, Project 65A035, (Increment 3), includes new start efforts for JMS Increment 3.
0305940F	SPACE SITUATION AWARENESS OPERATIONS	In FY 2016, Project 67A017, Sensor Service Life Extension Program, includes a new start effort for Space Situational Awareness (SSA) Ops Demo.

PROGRAM ELEMENT COMPARISON SUMMARY

PROGRAM ELEMENT (BY BUDGET ACTIVITY)

0306250F	CYBER OPERATIONS TECHNOLOGY DEVELOPMENT	In FY 2016, PE 0208059F, Cyber Command Activities, Project 676002, Cyber Systems Modernization, efforts were transferred to PE 0306250F, Cyber Operations Technology Development, Project 646008, US Cyber Command Technology Development, to consolidate all USCYBERCOM programs.
0401115F	C-130 AIRLIFT SQUADRON	C-130 CNS/ATM program has been updated and renamed C-130H VAAP Increment 1.
0401119F	C-5 AIRLIFT SQUADRONS (IF)	In FY 2016, Project 675359, C-5 Communication, Navigation, Surveillance / Air Traffic Management (CNS/ATM), is a new start effort.
0401318F	CV-22	In FY 2016, Project 676033 includes new start effort for Aircraft Electrical Power upgrade.
0401319F	PRESIDENTIAL AIRCRAFT REPLACEMENT (PAR)	In the FY 2016, PE 0401319 Presidential Aircraft Replacement, Project 655250 Presidential Aircraft Recap (PAR), was transferred to PE 0401319 Presidential Aircraft Replacement, Project 655250 Presidential Aircraft Recap (PAR), BA07 to realign budget activity for execution.

PROGRAM ELEMENT COMPARISON SUMMARY

PROGRAM ELEMENT (BY BUDGET ACTIVITY)

0604233F	SPECIALIZED UNDERGRADUATE FLIGHT TRAINING	In FY 2016 PE 0604233F Specialized Undergraduate Flight Training, Project 654102 JPATS, was transferred from BA05 as the program achieved full-rate production. In FY 2016 Project 674101 Undergraduate Remotely Piloted Aircraft Training includes a new start effort for Remotely Piloted Aircraft (RPA) Predator Reaper Integrated Mission Environment (PRIME) Desktop Training System (DTS). In FY 2016 Project 676034 Joint Primary Aircraft Training System (JPATS) was completed. In FY 2016 Project 676035 T-6 Operational System Development includes new start efforts for studies & development efforts to support future ACAT III Engineering Change Proposals(ECPs) to the T-6 Aircraft. This includes development for the FAA mandated ACAT III program for ADS-B Out and associated upgrades. In FY 2016 Project 676037 T-38 Operational Systems Development includes a new start effort for Block upgrades to incorporate software and/or hardware improvements to comply with new requirements mandated by Department of Defense, Federal Aviation Administration or National Airspace System (DoD/FAA/NAS) and to address flight safety issues. The block upgrades support the T-38C aircraft and Aircrew Training Devices (ATD).
0605278F	HC/MC-130 RECAP RDT&E	In FY 2016, PE 0605278F, HC/MC-130 Recap RDTE, Project 655249 HC-130Recap, efforts were transferred from PE 0605278F, HC/MC-130 Recap RDTE, Project 655249, HC/MC-130 Recap, BA 05 as the program achieved full rate production.
0708611F	SUPPORT SYSTEMS DEVELOPMENT	In FY 2016, PE 0708611 Support Systems Development, Project 673318, Product Data Systems Modernization efforts transferred to PE 0708610F, Logistics Information Technology (Log IT), Project 675207 to align with the Enhanced Technical Information Management System (ETIMS) modification efforts funded within the Log IT PE. In FY 2016, PE 0708611 Support Systems Development, Project Number 675042, Logistics Application Logistics Integration (LALI), the F-35 User Identification Data Exchange System (UIDES) effort was transferred to PE 0604800F, F-35 Lightning II Joint Strike Fighter, in order to align the activity under the F-35 RDT&E Program Element.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601102F / *Defense Research Sciences*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	364.195	389.979	329.721	-	329.721	337.648	341.342	346.931	355.983	Continuing	Continuing
613001: *Physics and Electronics*	-	104.602	115.599	95.932	-	95.932	96.765	98.242	99.871	102.440	Continuing	Continuing
613002: *Aerospace, Chemical and Material Sciences*	-	113.812	128.624	107.833	-	107.833	111.063	112.016	113.791	116.930	Continuing	Continuing
613003: *Mathematics, Information and Life Sciences*	-	116.996	122.915	101.914	-	101.914	104.477	105.533	107.293	110.046	Continuing	Continuing
613004: *Education and Outreach*	-	28.785	22.841	24.042	-	24.042	25.343	25.551	25.976	26.567	Continuing	Continuing

A. Mission Description and Budget Item Justification

Defense Research Sciences consists of extramural research activities in academia and industry along with in-house investigations performed in the Air Force Research Laboratory. This program funds 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)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	373.151	314.482	341.535	-	341.535
Current President's Budget	364.195	389.979	329.721	-	329.721
Total Adjustments	-8.956	75.497	-11.814	-	-11.814
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	75.497			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-8.956	-			
• Other Adjustments	-	-	-11.814	-	-11.814

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: 613001: *Physics and Electronics*		

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Congressional Add: *Program Increase*	-	23.782
Congressional Add Subtotals for Project: 613001	-	23.782
Project: 613002: *Aerospace, Chemical and Material Sciences*		
Congressional Add: *Program Increase*	-	26.424
Congressional Add Subtotals for Project: 613002	-	26.424
Project: 613003: *Mathematics, Information and Life Sciences*		
Congressional Add: *Program Increase*	-	25.291
Congressional Add Subtotals for Project: 613003	-	25.291
Congressional Add Totals for all Projects	-	75.497

Change Summary Explanation

In FY15 congressional add of $75.497 was spread across three projects in this program.
Decrease in FY16 is due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / *Defense Research Sciences*	Project (Number/Name) 613001 / *Physics and Electronics*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
613001: *Physics and Electronics*	-	104.602	115.599	95.932	-	95.932	96.765	98.242	99.871	102.440	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 thrust 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. 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 2014	FY 2015	FY 2016
Title: Complex Electronics and Fundamental Quantum Processes	48.028	42.154	44.043
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 2014 Accomplishments:*** Demonstrated 51 percent higher efficiency in a solar cell made of gallium arsenide using a unique anti-reflection coating scheme for space and terrestial power. 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 2015 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 2016 Plans:*** Continue to explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, meta-materials, cathodes, dielectric and magnetic materials, memristive systems, new classes of high-temperature superconductors, quantum dots, quantum wells and graphene. Includes generating and controlling quantum states, such as superposition and entanglement, in photons and ultracold atoms and molecules.			
Title: Plasma Physics and High Energy Density Non-Equilibrium Processes	21.060	18.492	19.321

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613001 / *Physics and Electronics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Scientific focus areas are plasma, electro-energetic physics and space sciences. ***FY 2014 Accomplishments:*** Created new research initiative to determine the internal magnetic topology of interplanetary coronal mass ejections, providing insight into inpact to space weather around Air Force assets. Explored a wide range of activities characterized by processes sufficiently energetic to require the understanding and managing of plasma phenomenology and the non-linear response of materials to high electric and magnetic fields. Included space weather, plasma control of boundary layers in turbulent flow, plasma discharges, Radio Frequency (RF) propagation, RF-plasma interaction, and high-power, beam-driven microwave devices. ***FY 2015 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 control of boundary layers in turbulent flow, plasma discharges, RF propagation, RF-plasma interaction, and high-power, beam-driven microwave devices. ***FY 2016 Plans:*** Continue to explore a wide range of activities characterized by processes sufficiently energetic to require understanding and managing plasma phenomenology and the non-linear response of materials to high electric and magnetic fields. Includes space weather, plasma discharges, RF propagation, RF-plasma interaction, and high-power, beam-driven microwave devices.			
Title: Lasers and Optics, Electromagnetics, Communication and Signal Processing ***Description:*** Scientific focus areas are physical mathematics and applied analysis, novel computational methods, dynamics sensing capability, electromagnetics, remote sensing and imaging physics, and surveillance and navigation. ***FY 2014 Accomplishments:*** Developed a nonreciprocal acoustic circulator that can transmit acoustic waves in one direction and block them in the other via acoustic metamaterials, with application to advanced sensors and communication systems. Explored all aspects of producing and receiving electromagnetic and electro-optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Investigated aspects of the phenomenology of lasers including high energy lasers, non-linear optics, and ultra-short pulse laser science. Included the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals. ***FY 2015 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. Investigate aspects of the phenomenology of lasers including high	35.514	31.171	32.568

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613001 / *Physics and Electronics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
energy lasers, non-linear optics, and ultra-short pulse laser science. Includes the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals. ***FY 2016 Plans:*** Continue to explore all aspects of producing and receiving electromagnetic and electro-optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Continue to investigate aspects of the phenomenology of lasers including high energy lasers, non-linear optics, and ultra-short pulse laser science. Includes the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals.			
Accomplishments/Planned Programs Subtotals	104.602	91.817	95.932

	FY 2014	FY 2015
Congressional Add: Program Increase	-	23.782
FY 2014 Accomplishments: NA		
FY 2015 Plans: Conduct congressionally directed effort		
Congressional Adds Subtotals	-	23.782

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / *Defense Research Sciences*	Project (Number/Name) 613002 / *Aerospace, Chemical and Material Sciences*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
613002: *Aerospace, Chemical and Material Sciences*	-	113.812	128.624	107.833	-	107.833	111.063	112.016	113.791	116.930	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 2014	FY 2015	FY 2016
Title: Aero Structure Interactions and Control	32.761	29.419	31.041
Description: Scientific focus areas are high temperature aerospace materials, hypersonics, aerothermodynamics and turbulence, and flow interactions and control.			
FY 2014 Accomplishments: Developed new algorithm for building reliable molecular models for understanding turbulent flow that is critical to next generation airframes. 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 2015 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 2016 Plans: Continue to investigate the characterization, modeling, and exploitation of interactions between the unsteady aerodynamic flow field and the dynamic air vehicle structure to enable enhanced performance in next generation Air Force systems. Explore the			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613002 / *Aerospace, Chemical and Material Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, high-performance structures, and thermodynamics.			
Title: Energy, Power, and Propulsion ***Description:*** Scientific focus areas are thermal control, theoretical chemistry, molecular dynamics, space power and propulsion, and combustion and diagnostics. ***FY 2014 Accomplishments:*** Collaborated with multiple government agencies in support of research to explore turbulent flame property, diagnostic, and modeling foundations. These turbulent flames are critical to next generation energy and combustion propulsion systems. Exploited technological innovations and developed potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hybrid simulation, structures, and materials. Investigated processes associated with the generation, storage, and utilization of energy, specifically for Air Force systems. Included developing novel energetic materials as well as understanding and optimizing combustion processes. ***FY 2015 Plans:*** Exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hybrid simulation, structures, and materials. Investigate processes associated with the generation, storage, and utilization of energy, specifically for Air Force systems. This includes developing novel energetic materials as well as understanding and optimizing combustion processes. ***FY 2016 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.	40.018	35.935	37.916
Title: Complex Materials and Structures ***Description:*** Scientific focus areas are mechanics of multifunctional materials and microsystems, multi-scale mechanics and prognosis, low density materials, and polymer chemistry. ***FY 2014 Accomplishments:*** Demonstrated that common materials, such as polymer fishing line and sewing thread, can be cheaply converted to artificial muscles for systems that enhance and augment human physical performance. Investigated multifunctional materials and structures composed of different classes of materials that may be able to change functionality or performance characteristics to enhance the mission versatility of future air and space systems, with a key goal of increasing functionality while decreasing weight	41.033	36.846	38.876

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613002 / *Aerospace, Chemical and Material Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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. ***FY 2015 Plans:*** Investigate multifunctional materials and structures composed of different classes of materials, both organic and inorganic, that may be able to change functionality or performance characteristics to enhance the mission versatility of future air and space systems, with a key goal of increasing functionality while decreasing weight and volume. Explore complex materials, microsystems, and structures that incorporate hierarchical design and functionality from the nano-scale through the meso-scale, ultimately leading to controlled, well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility. ***FY 2016 Plans:*** Continue to investigate multifunctional materials and structures composed of inorganic materials that may be able to change functionality or performance characteristics to enhance the mission versatility of future air and space systems, with a key goal of increasing functionality while decreasing weight and volume. Explore materials, microsystems, and structures that incorporate hierarchical design and functionality from the nano-scale through the meso-scale, ultimately leading to controlled, well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility.			
Accomplishments/Planned Programs Subtotals	113.812	102.200	107.833

	FY 2014	FY 2015
Congressional Add: Program Increase	-	26.424
FY 2014 Accomplishments: NA		
FY 2015 Plans: Conduct congressionally directed effort		
Congressional Adds Subtotals	-	26.424

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613002 / *Aerospace, Chemical and Material Sciences*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / *Defense Research Sciences*	Project (Number/Name) 613003 / *Mathematics, Information and Life Sciences*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
613003: *Mathematics, Information and Life Sciences*	-	116.996	122.915	101.914	-	101.914	104.477	105.533	107.293	110.046	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 thrust areas being investigated in this project are information and complex networks, decision making, dynamical systems, optimization and control, and natural materials and systems. 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 2014	FY 2015	FY 2016
Title: Information and Complex Networks	31.816	26.548	27.715

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

FY 2014 Accomplishments:
Collaborated with multiple government agencies in support of research in spectrum analytics, software verification, and future internet architectures, critical for next-generation communications and computer networks. Designed and analyzed techniques to enable reliable and secure exchange of information and predictable operation of networks and systems. This 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 2015 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 2016 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,

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613003 / *Mathematics, Information and Life Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Title: Decision Making ***Description:*** Scientific focus areas are mathematical modeling of cognition and decision making, and collective behavior and socio-cultural modeling. ***FY 2014 Accomplishments:*** Started new research initiative to analyze and develop the perceptual and social cues that drive trust perceptions and performance within human-robot interactions, which is critical to enhancing the effectiveness of warfighter and drone operations. 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. This included efforts to advance the critical knowledge base in information sciences and information fusion, and to model individual and group cognitive processing and decision making. ***FY 2015 Plans:*** Investigate new mathematical laws, scientific principles, and robust algorithms that underlie intelligent, mixed human-machine decision making to achieve accurate real-time projection of expertise and knowledge into and out of the battlespace. This includes efforts to advance the critical knowledge base in information sciences and information fusion, and to model individual and group cognitive processing and decision making. ***FY 2016 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.	22.866	19.080	19.918
Title: Dynamical Systems, Optimization, and Control ***Description:*** Scientific focus areas are computational mathematics, dynamics and control, and optimization and discrete mathematics. ***FY 2014 Accomplishments:*** Developed computer system that detects and corrects faulty airspeed readings using mathematical relationships among three data streams, there by enhancing the control and autonomy of advanced air platforms. Developed new scientific concepts supported by rigorous analysis for advancing the science of autonomy and promoting the understanding necessary to analyze and	33.224	27.722	28.941

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613003 / *Mathematics, Information and Life Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
design complex multi-scale systems as well as provide guaranteed levels of performance. Included study of novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments. ***FY 2015 Plans:*** Develop new scientific concepts supported by rigorous analysis for advancing the science of autonomy and promoting the understanding necessary to analyze and design complex multi-scale systems as well as provide guaranteed levels of performance. Develop novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments. ***FY 2016 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.			
Title: Natural Materials and Systems ***Description:*** Scientific focus areas are renewable energy, natural materials and nature inspired systems. ***FY 2014 Accomplishments:*** Initiated new basic research portfolios in human performance and biophysics, linking physical principles to biological systems. For example, understanding the safety of ultra-short pulse lasers systems around the human eye. Investigated multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems accomplish their required tasks. Studied how to adapt and mimic existing natural sensory systems and add existing capabilities to these organisms with the intent to gain more precise control over their material production. ***FY 2015 Plans:*** Investigate multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems accomplish their required tasks. Study how to adapt and mimic existing natural sensory systems and add existing capabilities to these organisms with the intent to gain more precise control over their material production. ***FY 2016 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.	29.090	24.274	25.340
Accomplishments/Planned Programs Subtotals	116.996	97.624	101.914

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613003 / *Mathematics, Information and Life Sciences*

	FY 2014	FY 2015
Congressional Add: Program Increase	-	25.291
FY 2014 Accomplishments: NA		
FY 2015 Plans: Conduct congressionally directed effort		
Congressional Adds Subtotals	-	25.291

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 1	R-1 Program Element (Number/Name) PE 0601102F / *Defense Research Sciences*	Project (Number/Name) 613004 / *Education and Outreach*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
613004: *Education and Outreach*	-	28.785	22.841	24.042	-	24.042	25.343	25.551	25.976	26.567	Continuing	Continuing

A. Mission Description and Budget Item Justification

The major thrust areas 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 2014	FY 2015	FY 2016
Title: Outreach to International S&T Community	12.501	9.919	10.440

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 2014 Accomplishments:

Organized a joint technical exchange meeting with the Embassy of Italy to explore basic research collaborations between the U.S. and Italy in the areas of material science, sensors, and applied mathematics. 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 provided primary interface to coordinate international S&T participation among DoD organizations.

FY 2015 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 2016 Plans:

Continue to leverage international expertise and support international technology liaison missions to identify and maintain awareness of foreign science and technology developments. Explore current foreign investments and influence world-class

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 1	**R-1 Program Element (Number/Name)** PE 0601102F / *Defense Research Sciences*	**Project (Number/Name)** 613004 / *Education and Outreach*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
scientific research on specific topics of Air Force interest. Pursue access to technical information on foreign research capabilities within our interests. Support international visits by scientists and high-level DoD S&T delegations.			
Title: Outreach to U.S. S&T Workforce ***Description:*** Strengthen science, mathematics, and engineering research and infrastructure in the U.S., thereby strengthening current and future Air Force S&T capabilities. ***FY 2014 Accomplishments:*** 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 including Historically Black Colleges and Universities, Hispanic serving institutions, and other minority institutions. ***FY 2015 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 2016 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.	16.284	12.922	13.602
Accomplishments/Planned Programs Subtotals	28.785	22.841	24.042

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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601103F / *University Research Initiatives*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	133.798	147.079	141.754	-	141.754	145.044	147.923	150.158	154.054	Continuing	Continuing
615094: *University Research Initiatives*	-	133.798	147.079	141.754	-	141.754	145.044	147.923	150.158	154.054	Continuing	Continuing

Note

FY16 decrease due to higher DoD priorities.

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 competition. 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103F / *University Research Initiatives*

B. Program Change Summary ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	138.333	127.079	145.695	-	145.695
Current President's Budget	133.798	147.079	141.754	-	141.754
Total Adjustments	-4.535	20.000	-3.941	-	-3.941
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	20.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-4.535	-			
• Other Adjustments	-	-	-3.941	-	-3.941

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: 615094: *University Research Initiatives*		
Congressional Add: *Program Increase*	-	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 2014	FY 2015	FY 2016
Title: Multidisciplinary University Research Initiative	74.259	70.530	78.676
Description: Promote fundamental, multi- and interdisciplinary science and engineering research projects involving multiple principle investigators.			
FY 2014 Accomplishments: Awarded 10 new grants 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. Awarded 4 new grants under the Presidential Early Career Award for Scientists and Engineers (PECASE) program to support and recognize superior academic researchers in the early stages of their careers. Continued funding of multi-disciplinary programs initially awarded in prior years.			
FY 2015 Plans: Fund competitive research grants at U.S. universities that focus on significantly expanding the basic knowledge of Air Force-relevant science and technology areas, not normally achievable in smaller funded, single investigator awards. Support and			

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103F / *University Research Initiatives*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
recognize superior academic researchers in the early stages of their careers through the PECASE program. Continue funding of multi-disciplinary programs initially awarded in prior years. ***FY 2016 Plans:*** Continue funding competitive research grants at U.S. universities that focus on significantly expanding the basic knowledge of Air Force-relevant science and technology areas, not normally achievable in smaller funded, single investigator awards. Support and recognize superior academic researchers in the early stages of their careers through the PECASE program. Continue funding of multi-disciplinary programs initially awarded in prior years.			
Title: Science and Engineering Education ***Description:*** Support post-graduate, graduate, and undergraduate education in science and engineering disciplines at U.S. universities. ***FY 2014 Accomplishments:*** Awarded 189 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. ***FY 2015 Plans:*** Award highly competitive NDSEG fellowships. Continue to support competitive awards for graduate and undergraduate research experiences, including those established under the ASSURE program. Continue funding for awards initiated under prior year DoD programs. ***FY 2016 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.	44.421	42.190	47.062
Title: Research Instrumentation ***Description:*** Enhance scientific and engineering research through advanced education infrastructure and instrumentation at U.S. universities. ***FY 2014 Accomplishments:***	15.118	14.359	16.016

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601103F / *University Research Initiatives*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Awarded 30 grants on a competitive basis under the Defense University Research Instrumentation Program (DURIP) to U.S. universities to acquire state-of-the-art, high technology instrumentation and infrastructure to enhance research and educational capabilities. ***FY 2015 Plans:*** Award grants on a competitive basis under the DURIP to U.S. universities to acquire state-of-the-art, high technology instrumentation and infrastructure to enhance research and educational capabilities. ***FY 2016 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.			
Accomplishments/Planned Programs Subtotals	133.798	127.079	141.754

	FY 2014	FY 2015
Congressional Add: Program Increase	-	20.000
FY 2014 Accomplishments: NA		
FY 2015 Plans: Conduct 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601108F / *High Energy Laser Research Initiatives*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	12.837	13.950	13.778	-	13.778	14.168	14.417	14.615	14.906	Continuing	Continuing
615097: *High Energy Laser Research Initiatves*	-	12.837	13.950	13.778	-	13.778	14.168	14.417	14.615	14.906	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 programs 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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	13.286	12.929	13.870	-	13.870
Current President's Budget	12.837	13.950	13.778	-	13.778
Total Adjustments	-0.449	1.021	-0.092	-	-0.092
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	1.021			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.449	-			
• Other Adjustments	-	-	-0.092	-	-0.092

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: 615097: *High Energy Laser Research Initiatves*		
Congressional Add: *Program Increase*	-	1.021
Congressional Add Subtotals for Project: 615097	-	1.021

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601108F / *High Energy Laser Research Initiatives*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Congressional Add Totals for all Projects	-	1.021

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: HEL Devices ***Description:*** Improve the fundamental understanding of HEL sources, to include solid state, fiber, and gas laser technologies. ***FY 2014 Accomplishments:*** Continued development of innovative laser technologies including diode-pumped alkali, short-pulse, free electron, fiber, and solid state laser technologies. Continued overseas efforts to leverage international technology advancements. ***FY 2015 Plans:*** Continue innovative laser technologies in diode-pumped alkali, short-pulse, free electron, fiber and solid state laser technologies. Continue overseas efforts to leverage international technology advancements. Conduct a proposal call to universities for advanced laser research initiatives. ***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.	7.424	7.682	8.608
Title: HEL Beam Control ***Description:*** Improve the fundamental understanding of beam control technologies, as they relate to HEL applications. Conduct research in atmospheric characterization, metrology, control systems, algorithms, and beam control component technology. ***FY 2014 Accomplishments:*** Continued research on innovative beam control architectures. Continued overseas efforts to leverage international technology advancements. ***FY 2015 Plans:*** Continue research on innovative beam control architectures. Continue overseas efforts to leverage international technology advancements. Conduct a proposal call to Universities for advanced beam control initiatives. ***FY 2016 Plans:*** Continue research on innovative beam control architectures. Continue overseas efforts to leverage international technology advancements.	4.663	4.427	4.200
Title: HEL Education	0.750	0.820	0.970

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601108F / *High Energy Laser Research Initiatives*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Fund educational grants intended to stimulate interest in HELs among students. ***FY 2014 Accomplishments:*** Provided scholarships and internships to support college students studying HEL degrees. Provided grants to Service Academies to stimulate HEL studies among military cadets. Funded publication of journals and support continuing education for professionals in the HEL field. ***FY 2015 Plans:*** Provide scholarships and internships to support college students studying HEL degrees. Provide grants to Service Academies to stimulate HEL studies among military cadets. Fund publication of journals and support continuing education for professionals in the HEL field. ***FY 2016 Plans:*** Provide scholarships and internships to support college students studying HEL degrees. Provide grants to Service Academies to stimulate HEL studies among military cadets. Fund publication of journals and support continuing education for professionals in the HEL field.			
Accomplishments/Planned Programs Subtotals	12.837	12.929	13.778

	FY 2014	FY 2015
Congressional Add: Program Increase	-	1.021
FY 2015 Plans: Conduct 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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602102F / *Materials*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	118.951	110.680	125.234	-	125.234	127.175	133.286	131.184	133.332	Continuing	Continuing
624347: *Materials for Structures, Propulsion, and Subsystems*	-	53.486	34.776	47.165	-	47.165	46.057	46.358	45.786	46.205	Continuing	Continuing
624348: *Materials for Electronics, Optics, and Survivability*	-	37.810	33.693	34.530	-	34.530	34.877	35.504	34.113	34.801	Continuing	Continuing
624349: *Materials Technology for Sustainment*	-	27.655	42.211	43.539	-	43.539	46.241	51.424	51.285	52.326	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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	120.846	105.680	126.589	-	126.589
Current President's Budget	118.951	110.680	125.234	-	125.234
Total Adjustments	-1.895	5.000	-1.355	-	-1.355
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	5.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.895	-			
• Other Adjustments	-	-	-1.355	-	-1.355

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: 624347: *Materials for Structures, Propulsion, and Subsystems*		
Congressional Add: *Nanotechnology Research*	4.000	-
Congressional Add Subtotals for Project: 624347	4.000	-
Project: 624348: *Materials for Electronics, Optics, and Survivability*		
Congressional Add: *Nanotechnology Research*	-	5.000
Congressional Add Subtotals for Project: 624348	-	5.000
Congressional Add Totals for all Projects	4.000	5.000

Change Summary Explanation

Decrease in FY16 due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / *Materials*	Project (Number/Name) 624347 / *Materials for Structures, Propulsion, and Subsystems*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
624347: *Materials for Structures, Propulsion, and Subsystems*	-	53.486	34.776	47.165	-	47.165	46.057	46.358	45.786	46.205	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 2014	FY 2015	FY 2016
Title: Ceramics and Composites	27.712	20.500	27.803
Description: Develop ceramic, ceramic matrix composite, and hybrid materials technologies for performance and supportability improvement in propulsion systems and high temperature aerospace structures.			
FY 2014 Accomplishments: Developed next generation high temperature organic and ceramic matrix composite material systems for Air Force weapon systems. Continued development of advanced processing methods and validation process models for organic matrix composites. Initiated process models for ceramic matrix composites. Conducted durability assessments of composite material behavior to gain understanding of time-dependent degradation. Developed novel hybrid approaches for optical and radio frequency communication system aperture applications. Developed advanced electromagnetic and laser protection technologies for structurally harden aerospace structures. Continued the transition of behavior and life prediction models of organic matrix composites.			
FY 2015 Plans: Demonstrate new advanced processing methods, coating technologies, and behavioral life prediction for higher temperature capable organic and ceramic matrix composites. Validate severe environment durability of advanced composite systems via mechanical testing. Continue to advance the development of new ceramic and organic matrix composite materials and processes with higher temperature capability for propulsion systems and aerospace structures. Validate hybrid materials and processes for			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624347 / *Materials for Structures, Propulsion, and Subsystems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
applications in combined optical and radio frequency communication system apertures. Validate advanced electromagnetic and laser protection technologies for aerospace structures. ***FY 2016 Plans:*** Continue to demonstrate new advanced processing methods, coating technologies, and behavioral life prediction for higher temperature capable organic and ceramic matrix composites. Demonstrate severe environment durability of advanced composite systems via mechanical testing. 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. Demonstrate hybrid materials and processes for applications in combined optical and radio frequency communication system apertures. Demonstrate advanced electromagnetic and laser protection technologies for aerospace structures.			
Title: Metals ***Description:*** Develop lightweight and high temperature metallics, life prediction, and metals processing technologies for increased affordability, durability, and reliability. ***FY 2014 Accomplishments:*** Continued to demonstrate advanced computation methods to support material development and characterization modeling. Continued to demonstrate quantitative, predictive models for performance of metallic based thermal management systems. Analyzed relationships between microstructure, processing, functional properties, and performance of metallic, hybrid, nanoscale, and gradient metallic materials. Continued development of analysis of residual stress in nickel-base superalloys. Initiated development of integrated material/manufacturing and component analysis for life management and development of structural materials innovative research. Initiated development of next generation turbine engine disk. ***FY 2015 Plans:*** Validate repeatability of advanced computation methods to support material development and characterization modeling. Demonstrate quantitative, predictive models for performance of metallic based thermal management systems. Continue to analyze relationships between microstructure, processing, functional properties, and performance of metallic, hybrid, nanoscale, and gradient metallic materials. Demonstrate 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 development of next generation turbine engine disk. ***FY 2016 Plans:*** Continue validation of 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, functional properties, and performance of metallic, hybrid, nanoscale, and gradient metallic materials. Continue demonstration of analysis techniques for understanding and	14.351	10.750	14.580

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624347 / *Materials for Structures, Propulsion, and Subsystems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Title: Thermal Protection Materials ***Description:*** Develop and evaluate lightweight, active, adaptive, multifunctional, high temperature, and durable material systems for extreme environments and hypersonic applications. ***FY 2014 Accomplishments:*** Developed advanced metallic, oxide, and ceramic materials for hypersonic weapon systems. Initiated novel materials and processing methods to fabricate structurally integrated thermal protection systems for expendable hypersonic applications such as control surfaces, leading edges, and acreage designs. Developed unique experimental techniques to assess mechanical properties and time-dependent behavior of advanced metallic and ceramic material systems. Initiated incorporation of solutions for optical and radio frequency communication system aperture applications on hypersonic systems. Continued validating performance of fabricated ultra-high temperature ceramics using field assisted sintering technology using a hypersonic experimental propulsion rig. Developed and validated computational models to assess environmental degradation of materials in a hypersonic environment. ***FY 2015 Plans:*** Refine and improve processing methods to fabricate structurally integrated thermal protection systems for expendable hypersonic applications. Develop unique experimental techniques to assess mechanical properties and time-dependent behavior. Validate material properties and performance meets design needs for control surfaces, leading edges and acreage. Develop 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. Continue to validate material properties and performance meets design needs for control surfaces, leading edges and acreage. Validate computational models to assess environmental degradation of materials in a hypersonic environment.	7.423	3.526	4.782
Accomplishments/Planned Programs Subtotals	49.486	34.776	47.165

	FY 2014	FY 2015
Congressional Add: Nanotechnology Research	4.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624347 / *Materials for Structures, Propulsion, and Subsystems*

	FY 2014	FY 2015
FY 2014 Accomplishments: Conduct Congressionally-directed effort.		
Congressional Adds Subtotals	4.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / *Materials*	Project (Number/Name) 624348 / *Materials for Electronics, Optics, and Survivability*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
624348: *Materials for Electronics, Optics, and Survivability*	-	37.810	33.693	34.530	-	34.530	34.877	35.504	34.113	34.801	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Infrared Detector Materials	11.064	9.443	11.364
Description: Develop IR detector materials and processes technologies for performance, affordability, and operational capability of surveillance, tracking, targeting, and situational awareness systems.			
FY 2014 Accomplishments: Developed materials for use in high resolution mid wave infrared (MWIR) applications. Developed materials to support and provide persistent air ISR. Continued to demonstrate models of materials optical/infrared behavior for low-observable, ISR, and other applications. Continued to develop nanoscale materials for use in producing detectors. Utilized computational materials science to improve performance prediction models. Continued to develop inorganic quantum materials for aerospace applications. Initiated development of short wave IR detector materials and hyperspectral long wave IR materials. Initiated development of radio frequency (RF)/IR photonics for compact air vehicle applications.			
FY 2015 Plans: Validate and continue to develop materials for use in high resolution MWIR applications. Demonstrate materials to support and provide persistent air ISR. Demonstrate models of materials optical/IR behavior for LO, ISR, and other applications. Validate nanoscale materials for use in producing detectors. Validate and continue to utilize computational materials science to improve performance prediction models. Demonstrate inorganic quantum materials for aerospace applications. Continue to advance the			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624348 / *Materials for Electronics, Optics, and Survivability*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
development of short wave IR detector materials and hyperspectral long wave IR materials. Continue to advance the development of RF/IR photonics for compact 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 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 inorganic quantum materials for aerospace applications. Continue development of short wave IR detector materials and hyperspectral long wave IR materials. Continue development of RF/IR photonics for compact air vehicle applications.			
Title: Directed Energy Hardened Materials ***Description:*** Develop and demonstrate technologies to enhance the safety, survivability, and mission effectiveness of aircrews, sensors, viewing systems, and related assets. ***FY 2014 Accomplishments:*** Validated and demonstrated 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. Continued to develop materials for high energy laser interactions. Utilized computational materials science to enhance multi-scale modeling. Continued to develop materials and processes for hardening and optical materials applications. Initiated development of photonic enabled RF phased arrays and tunable inductors/large area films. ***FY 2015 Plans:*** 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. Validate materials for high energy laser interactions. Utilize computational materials science to enhance multi-scale modeling. Demonstrate materials and processes for hardening and optical materials applications. Continue development of photonic enabled RF phased arrays and tunable inductors/large area films. ***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	12.175	10.817	13.017

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624348 / *Materials for Electronics, Optics, and Survivability*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
for advanced applications in airborne, space, and personnel systems. Continue to validate materials for high energy laser interactions. Continue to utilize computational materials science to enhance multi-scale modeling. Continue to demonstrate materials and processes for hardening and optical materials applications. Continue to advance development of photonic enabled RF phased arrays and tunable inductors/large area films.			
Title: Laser Source Materials ***Description:*** Develop materials to enable higher performance lasing media, new laser architectures, optical isolators, beam steering, and other high energy laser components for directed energy. ***FY 2014 Accomplishments:*** Developed and demonstrated reliable materials and processes to optimize components for compact, lightweight, directed energy applications. Continued to develop materials and processes for Polymeric Energy Conversion. Continued to demonstrate materials for improved laser source components operating in the mid-infrared range. Continued to develop materials with tailorable properties for beam steering in the newly accessible W band. Continued to demonstrate materials processes for fabricating new laser beam scanning devices that utilize electrooptic polymers to enable high-speed beam steering. Continued to develop and demonstrate materials that increase high energy laser efficiency and output. Utilized computational materials science to improve performance predictions and shorten design cycle time. ***FY 2015 Plans:*** Demonstrate materials with tailorable properties for beam steering in the newly accessible W band. Validate materials processes for fabricating new laser beam scanning devices that utilize electro-optic polymers to enable high-speed beam steering. ***FY 2016 Plans:*** Continue to demonstrate materials with tailorable properties for beam steering in the newly accessible W band. Demonstrate materials processes for fabricating new laser beam scanning devices that utilize electro-optic polymers to enable high-speed beam steering.	3.825	1.184	1.425
Title: Nanostructured and Biological Materials ***Description:*** Develop enabling and foundational biotechnologies for guidance and control, rapid tagging, tracking, and identification of targets, and bio-integrated electronics and sensing. ***FY 2014 Accomplishments:*** Continued to develop and demonstrate biological engineering methods for sensors and electro-optic devices for complex hybrid materials. Used pervasive computational materials science to model guided experiments and to enable rapid in-situ experimental data acquisition. Continued to develop and demonstrate reliable materials and processes to optimize components for compact, lightweight, multifunctional devices for use in autonomy. Continued to develop materials and processes for writing and printing	10.746	7.249	8.724

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624348 / *Materials for Electronics, Optics, and Survivability*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
robust electronics on varied flexible and stretchable substrates, and the development of structurally resilient architectures and nanostructures with embedded energy and/or comm. Focused develop of integrated sensor platform, suitable for multiple sensor components. Continued to develop and analyze nano-biomaterials for human performance sensing. Validated computation materials science techniques and models to characterize nanomaterials. Continued development and support of nano-bio manufacturing consortium. ***FY 2015 Plans:*** Validate biological engineering methods for sensors and electro-optic devices for complex hybrid materials. Continue to advance the use pervasive computational materials science to model guided experiments and to enable rapid in-situ experimental data acquisition. Validate reliable materials and processes to optimize components for compact, lightweight, multi-functional devices for use in autonomy and human performance monitoring applications. Demonstrate materials and processes for writing and printing robust electronics on varied flexible and stretchable substrates, and the development of structurally resilient architectures and nanostructures with embedded energy and/or comm. Focused develop of integrated sensor platform, suitable for multiple sensor components. Initiate materials and process or strain resilient electronics. Continue to develop and analyze nano-biomaterials for human performance sensing. Continue to validate computation materials science techniques and models to characterize nanomaterials. Continue development and support of nano-bio manufacturing consortium. ***FY 2016 Plans:*** Demonstrate biological engineering methods for sensors and electro-optic devices for complex hybrid materials. Continue to use pervasive computational materials science to model guided experiments and to enable rapid in-situ experimental data acquisition. Demonstrate reliable materials and processes to optimize components for compact, lightweight, multi-functional devices for use in autonomy and human performance monitoring applications. Continue to develop materials and processes for writing and printing robust electronics on varied flexible and stretchable substrates, and the development of structurally resilient architectures and nanostructures with embedded energy and/or comm. Focused develop of integrated sensor platform, suitable for multiple sensor components. Initiate materials and process or strain resilient electronics. Validate and continue to develop and analyze nano-biomaterials for human performance sensing. Demonstrate computation materials science techniques and models to characterize nanomaterials. Continue support of nano-bio manufacturing consortium.			
Accomplishments/Planned Programs Subtotals	37.810	28.693	34.530

	FY 2014	FY 2015
Congressional Add: Nanotechnology Research ***FY 2015 Plans:*** Conduct Congressionally-directed effort.	-	5.000
Congressional Adds Subtotals	-	5.000

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624348 / *Materials for Electronics, Optics, and Survivability*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602102F / *Materials*	Project (Number/Name) 624349 / *Materials Technology for Sustainment*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
624349: *Materials Technology for Sustainment*	-	27.655	42.211	43.539	-	43.539	46.241	51.424	51.285	52.326	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 2014	FY 2015	FY 2016
Title: Sensing Technologies	12.109	16.000	16.503
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 2014 Accomplishments: Continued to improve and validate modeling capabilities required to enable materials and damage characterization via nondestructive evaluation methods. Conducted and demonstrated enhanced sensing and characterization of damage in multi-layered structures to improve detectable limits and the probabilities of finding deeply imbedded or hidden damage in aerospace systems. Continued developing advanced sensing technologies to detect and characterize changes in material structure, material properties, damage, and other factors that detrimentally affect aerospace systems. Continued to develop innovative inspection technologies to enable rapid assessment of LO material performance. Continued research to assess metals performance in aerospace systems for more affordable life management practices and life extension for aerospace structures and turbine engines.			
FY 2015 Plans: Continue 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. Begin 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. Validate advanced sensing technologies to detect and characterize changes in material properties, damage evolution, and other factors that detrimentally affect aerospace			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624349 / *Materials Technology for Sustainment*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
systems. Initiate development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Validate repeatability and functionality of innovative LO inspection methods to enable rapid assessment of LO material performance. Demonstrate assessment of enhanced metals performance in aerospace systems. Initiate development of advanced materials and processes to monitor and evaluate LO material state awareness. ***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 changes in material properties, damage evolution, and other factors that detrimentally affect aerospace systems. Continue development and validation of damage state awareness approaches and methodologies for use on aerospace structures and engine components. Continue to validate repeatability and functionality of innovative LO inspection methods to enable rapid assessment of LO material performance. Continue to demonstrate assessment of enhanced metals performance in aerospace systems. Continue development of advanced materials and processes to monitor and evaluate LO material state awareness.			
Title: Production and Repair Technologies ***Description:*** Develop support capabilities, information, and processes to resolve problems with materials in the production and repair of systems components and structures. ***FY 2014 Accomplishments:*** Validated and demonstrated advanced materials and processes technology to repair and extend the life of Air Force legacy systems. Continued to investigate failure limits for emerging Air Force systems. Continued to validate and demonstrate test methods and techniques to understand effects of service environments, corrosion, residual stresses, and material processes on structural materials. Continued to transition advanced materials technologies and designs for improved maintainability and life cycle costs of conductive outer-moldline films, coatings, access panel treatments, and multifunctional systems. ***FY 2015 Plans:*** Continue to validate and demonstrate advanced materials and processes technology to repair and extend the life of Air Force legacy systems. Validate understanding of failure limits for emerging Air Force systems. Develop improved lifecycle prediction test methods and techniques to understand effects of service environments, corrosion, residual stresses, and material processes on structural and functional materials. Assess advanced materials, processes and designs for improved repair and maintainability and life cycle cost of outer-moldline coatings, access panel treatments, and multifunctional systems. Initiate LO affordability technologies and processes to reduce maintenance costs of LO materials. ***FY 2016 Plans:***	5.546	11.500	11.862

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624349 / *Materials Technology for Sustainment*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Validate repeatability and demonstrate advanced materials and processes technology to repair and extend the life of Air Force legacy systems. Demonstrate understanding of failure limits for emerging Air Force systems. Continue to develop improved lifecycle prediction test methods and techniques to understand effects of service environments, corrosion, residual stresses, and material processes on structural and functional materials. Continue to assess advanced materials, processes and designs for improved repair and maintainability and life cycle cost of outer-moldline coatings, access panel treatments, and multifunctional systems. Continue LO affordability technologies and processes to reduce maintenance costs of LO materials.			
Title: Failure Analysis Technologies	10.000	14.711	15.174
Description: Develop support capabilities, information, and processes to resolve materials problems and provide electronic and structural failure analysis of components. ***FY 2014 Accomplishments:*** Continued to perform quick response failure analyses and materials investigations. Initiate investigation of 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. Developed advanced functional materials and Micro-Electro-Mechanical system (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. Continued to validate and demonstrate advanced wiring materials technologies to replace aging wiring systems. Validated and demonstrated new wiring technologies for emerging weapon systems. Initiated research to provide advanced materials to improve systems sustainment in field and Air Force Program Offices. ***FY 2015 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 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. Initiate 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. ***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			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602102F / *Materials*	**Project (Number/Name)** 624349 / *Materials Technology for Sustainment*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Accomplishments/Planned Programs Subtotals	27.655	42.211	43.539

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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	117.724	105.673	123.438	-	123.438	122.766	129.556	133.505	142.228	Continuing	Continuing
622401: *Structures*	-	43.346	32.756	52.257	-	52.257	49.685	53.509	55.185	57.812	Continuing	Continuing
622403: *Flight Controls and Pilot-Vehicle Interface*	-	34.663	29.478	27.578	-	27.578	28.465	29.921	30.480	31.107	Continuing	Continuing
622404: *Aeromechanics and Integration*	-	39.715	27.287	28.674	-	28.674	28.691	29.579	29.617	29.780	Continuing	Continuing
622405: *High Speed Systems Technology*	-	-	16.152	14.929	-	14.929	15.925	16.547	18.223	23.529	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. Flight control technologies are developed and simulated for aerospace vehicles. Advanced aerodynamic vehicle configurations are developed and analyzed through simulations, experiments, and multi-disciplinary analyses. Resulting technologies improve performance of existing and future manned and remotely piloted air vehicles, sustained high speed, and space access vehicles. Improvements include, but are not limited to, reduced energy use by efficient air platform designs, use of lightweight composite structures and improved sustainment methods based on the condition of the platform and sub-systems. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force					Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*		R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*			
B. Program Change Summary ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	119.624	105.747	121.690	-	121.690
Current President's Budget	117.724	105.673	123.438	-	123.438
Total Adjustments	-1.900	-0.074	1.748	-	1.748
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-0.074			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.900	-			
• Other Adjustments	-	-	1.748	-	1.748

Change Summary Explanation

FY16 increase due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622401 / *Structures*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
622401: *Structures*	-	43.346	32.756	52.257	-	52.257	49.685	53.509	55.185	57.812	Continuing	Continuing

Note

In FY2015, Project 622401 Structures, Extreme Flight Technologies major thrust efforts, were moved to Project 622405 High Speed Systems Technology to better align efforts.

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 2014	FY 2015	FY 2016
Title: Aircraft Service Life Technologies	27.779	24.934	23.717

Description: Develop an economic service life analysis capability comprised of analysis tools, methodologies, and structural health monitoring technologies.

FY 2014 Accomplishments:

Completed development of engineered residual stress concepts, analysis, and applications. Continued the technology development concepts for risk informed decision-making. Continued technology efforts for condition-based maintenance of structural integrity. Continued the technology development of failure criteria tools for advanced aircraft composite and metallic components. Continued efforts in certification of advanced composite for aircraft structures. Developed an integrated system of data, models, and analysis tools that enable better decisions regarding fleet lifecycle management and sustainment.

FY 2015 Plans:

Complete technology development concepts for risk informed decision-making. Complete technology efforts for condition-based maintenance of structural integrity. Initiate 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.

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622401 / *Structures*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Title: Vehicle Design Technologies ***Description:*** Vehicle Design Technologies Develop methodologies to reduce the cost and time involved from design to full-scale testing of structural concepts and aircraft systems. ***FY 2014 Accomplishments:*** Continued development of multi-disciplinary methodologies that will allow for lower cost advanced structures. Continued the development of advanced high fidelity aircraft design analysis tools. Continued development of high fidelity multidisciplinary design methods to enable efficient supersonic air vehicle technologies. Completed development of a design framework for design of small Remotely Piloted Aircraft (RPA) including noise. ***FY 2015 Plans:*** Complete high fidelity multidisciplinary design methods to enable efficient supersonic air vehicle technologies. Complete development of multi-disciplinary methodologies that will allow for lower cost advanced structures. Continue the development of advanced high fidelity aircraft design analysis tools. Initiate design methods for innovative control of supersonic tailless aircraft. Initiate parametric modeling methods for integrated multidiscipline collaborative design. ***FY 2016 Plans:*** 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.	2.641	3.656	15.709
Title: Structural Concepts ***Description:*** Structural Concepts. Develop design methods, processes, and lightweight, adaptive, and multifunctional structural concepts to capitalize on new materials, multi-role considerations, and technology integration into aircraft systems. ***FY 2014 Accomplishments:*** Completed the development of low-cost technologies to increase the survivability and performance of future systems. Developed innovative energy efficient conformal load bearing antenna structural concepts. ***FY 2015 Plans:***	2.816	4.166	12.831

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622401 / *Structures*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continue innovative energy efficient conformal load bearing antenna structural concepts. Initiate development of lightweight, adaptive, and efficient structural concepts for mobility and special operations. Initiate ultra low cost airframe design and manufacturing methods. ***FY 2016 Plans:*** Continue innovative energy efficient conformal load bearing antenna structural concepts. Continue development of lightweight, adaptive, and efficient structural concepts for mobility and special operations. Continue ultra low cost airframe design and manufacturing methods. Initiate development of lightweight aircraft structural concepts for future air dominance.			
Title: Extreme Flight Environment Technologies ***Description:*** Develop technologies that will permit the structural development of platforms that can operate at an extreme altitude, while at sustained speeds greater than Mach 2. ***FY 2014 Accomplishments:*** Continued to develop structural design concepts that incorporate promising materials and components for the creation of an integrated vehicle structure that can withstand extreme flight environments. Validated extreme environment prediction methods to develop key hot structure design data. Continued development of analytical methods for predicting structural response needed for design and evaluation of hot primary structure for hypersonic vehicles. ***FY 2015 Plans:*** In FY2015, Project 622401 Structures, Extreme Flight Technologies major thrust efforts, were moved to Project 622405 High Speed Systems Technology to better align efforts. ***FY 2016 Plans:*** N/A	10.110	-	-
Accomplishments/Planned Programs Subtotals	43.346	32.756	52.257

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622401 / *Structures*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622403 / *Flight Controls and Pilot-Vehicle Interface*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
622403: *Flight Controls and Pilot-Vehicle Interface*	-	34.663	29.478	27.578	-	27.578	28.465	29.921	30.480	31.107	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops technologies that enable maximum affordable capability from manned and remotely piloted 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 2014	FY 2015	FY 2016
Title: Advanced Flight Controls Technologies	14.650	10.846	12.152
Description: Develop technologies for advanced control-enabled capabilities, including flight controls, components, and integrated vehicle monitoring systems for both manned and remotely piloted aircraft. ***FY 2014 Accomplishments:*** Continued the development, demonstration, and assessment of advanced flight control mechanization technologies for trusted and certifiable operations under adverse and contested environments. Continued development of survivable and health-adaptive control system architectures. Completed the assessment of adaptive guidance and control technologies for fault/damage tolerance in unmanned space access systems. Completed development of control configurations for small remotely piloted aerospace systems. Initiate development of adaptive guidance and control technologies for small-scale hypersonic air vehicles ***FY 2015 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. ***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. Complete the development of adaptive guidance and control technologies for small-scale hypersonic air vehicles.			
Title: Manned and Unmanned Teaming Technologies	13.792	13.297	10.101
Description: Develop technology for flight control systems that will permit safe interoperability between manned and remotely piloted aircraft.			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622403 / *Flight Controls and Pilot-Vehicle Interface*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Continued development, demonstration, and assessment of advanced control automation techniques. Continued the development of mixed initiative control techniques for multiple remotely piloted aircraft teams in dynamic mission environments, as well as for the integration of unmanned systems into controlled airspace and airbase operations. Developed and assessed manned-unmanned aircraft teams in tactical environments. Completed proof of concept demonstration of autonomous aircraft operations on an airfield. ***FY 2015 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. Complete study of airbase infrastructure options and implications, and initiate systems prototype development. ***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. Complete development of airborne control of Unmanned Air Systems (UAS) in preparation for flight test activities.			
Title: Flight Controls Technologies Modeling and Simulation	6.221	5.335	5.325
Description: Develop tools and methods for capitalizing on simulation-based research and development of future aerospace vehicles. ***FY 2014 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 in controlled airspace and airbase operations, as well as in adversarial mission environments. Continued trade studies of vehicle concepts for strike, mobility and reconnaissance. ***FY 2015 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			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622403 / *Flight Controls and Pilot-Vehicle Interface*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
environments, initiating development of testbed for emerging technologies. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Complete autonomy in mobility testbed and begin evaluations. ***FY 2016 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. Complete manned-unmanned teaming testbed and begin evaluations.			
Accomplishments/Planned Programs Subtotals	34.663	29.478	27.578

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622404 / *Aeromechanics and Integration*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
622404: *Aeromechanics and Integration*	-	39.715	27.287	28.674	-	28.674	28.691	29.579	29.617	29.780	Continuing	Continuing

Note

In FY2015, Project 622404 Aeromechanics and Integration, Concepts, Designs, and Analysis of High Speed Technologies major thrust efforts, were moved to Project 622405 High Speed Systems Technology to better align efforts.

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 2014	FY 2015	FY 2016
Title: Aerodynamic Systems Technologies	8.506	10.245	8.689
Description: Develop aerodynamic assessment prediction methods centered on expanding the design capabilities of future air vehicles. ***FY 2014 Accomplishments:*** Continued to develop and assess aeronautical technologies that enable broad use of unmanned aircraft. Completed demonstration of flow control techniques to enable unsteady load suppression for unmanned ISR platforms and future fleet mobility aircraft to increase aerodynamic efficiency. Continued development of innovative aerodynamic control methods for integrating high bypass propulsion for unmanned ISR platforms and future mobility aircraft. ***FY 2015 Plans:*** Continue to develop and assess aerodynamic technologies that enable future revolutionary manned and unmanned air vehicles. Continue to develop and assess advanced aircraft configurations for Mobility and Future Air Dominance. Complete technology assessments on Future Air Dominance vehicle concepts. Initiate technology assessments on next generation tanker systems. ***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 Dominance. Complete technology assessments on next generation tanker systems.			
Title: Concepts, Designs, and Analysis of High Speed Technologies	8.447	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622404 / *Aeromechanics and Integration*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop new and improved concepts, designs, and analysis of technologies to enable revolutionary capabilities for sustained high-speed re-useable high altitude vehicle efforts. ***FY 2014 Accomplishments:*** Continued to develop technologies to enable high-speed flight. Continued development of analysis/design techniques and tools to enable shock/boundary layer interaction flow control and enhanced stability for high-speed propulsion concepts. Continued efforts to characterize high-speed phenomena and develop and validate fundamental high-speed component technologies through experimental testing in a relevant environment. ***FY 2015 Plans:*** In FY2015, Concepts, Designs, and Analysis of High Speed Technologies major thrust efforts, were moved to Project 622405 High Speed Systems Technology to better align efforts. ***FY 2016 Plans:*** N/A			
Title: Next Generation Aerodynamic Technologies ***Description:*** To develop and assess technologies for the next generation of multi-role large aircraft. ***FY 2014 Accomplishments:*** Continued high fidelity aerodynamic analysis and method development for Mobility and Future Air Dominance. Continued development of practical laminar flow technologies for highly swept wings. Completed studies and analysis to investigate more extensive legacy fleet fuel savings opportunities for drag reduction and formation flight. ***FY 2015 Plans:*** Continue development of high fidelity aerodynamic analysis and method development for Mobility and Future Air Dominance. Continue development of practical laminar flow technologies for highly swept wings. Initiate aerodynamics technologies to enable control of supersonic tailless aircraft. ***FY 2016 Plans:*** Continue development of high fidelity aerodynamic analysis and method development for Mobility and Future Air Dominance. 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.	22.762	9.929	11.415
Title: Aircraft Integration Technologies	-	7.113	8.570

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622404 / *Aeromechanics and Integration*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop enabling technologies to allow efficient and effective integration of propulsion, weapons, and subsystems into current and future air vehicles. ***FY 2014 Accomplishments:*** N/A ***FY 2015 Plans:*** Develop aerodynamic and propulsion integration technologies that enable future mobility and fighter aircraft. Develop analyses and experiments to investigate propulsion integration flow control to enhance Mobility and Future Air Dominance vehicle performance. Develop innovative aerodynamic design methods for integrating high bypass propulsion for future mobility aircraft. Develop advanced kinetic and directed energy weapons integration technologies for Future Air Dominance. ***FY 2016 Plans:*** Continue to develop aerodynamic and propulsion integration technologies that enable future mobility and fighter aircraft. Continue to develop analyses and experiments to investigate propulsion integration flow control to enhance Mobility and Future Air Dominance vehicle performance. Continue innovative aerodynamic design methods for integrating high bypass propulsion for future mobility aircraft. Continue development of advanced kinetic and directed energy weapons integration technologies for Future Air Dominance.			
Accomplishments/Planned Programs Subtotals	39.715	27.287	28.674

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622405 / *High Speed Systems Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
622405: *High Speed Systems Technology*	-	-	16.152	14.929	-	14.929	15.925	16.547	18.223	23.529	Continuing	Continuing

Note

In FY2015, Project 622401 Structures, Extreme Flight Technologies major thrust efforts, were moved to Project 622405 High Speed Systems Technology to better align efforts.

In FY2015, Project 622404 Aeromechanics and Integration, Concepts, Designs, and Analysis of High Speed Technologies major thrust efforts, were moved to Project 622405 High Speed Systems Technology to better align efforts.

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 2014	FY 2015	FY 2016
Title: High Speed Systems Technology	-	6.231	8.425
Description: Develop high temperature structural analysis methods and technologies for extreme operating conditions in current and future air vehicles.			
FY 2014 Accomplishments: N/A			
FY 2015 Plans: Initiate development of innovative structural concepts for high speed/hypersonic air vehicles. Initiate 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. Initiate the development and integrate model uncertainty methods into multi-disciplinary simulations and quantify its impact on the structural margin. Initiate development of structural analysis methods and technology for hot structure concepts under extreme environment loading conditions. Initiate the assessment of the aerospace community to quantify the structural			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622405 / *High Speed Systems Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
margins for extreme environment hot structure through experimental validation of ground test articles. Complete fabrication and initiate 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. Complete testing of representative vehicle structures for combined aero, thermal, and acoustic loads. Validate combined loads methodology to predict structural response.			
Title: High Speed Vehicle Aeromechanics and Integration	-	9.921	6.504
Description: Develop new and improved components, concepts, and designs for sustained flight of high-speed/hypersonic expendable and re-useable vehicles. Conduct analyses of high speed/hypersonic vehicles to enable revolutionary capabilities. ***FY 2014 Accomplishments:*** N/A ***FY 2015 Plans:*** Mature critical technologies for high speed/hypersonic flight. Begin 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. Begin development of high speed system concepts that provide revolutionary capabilities. Investigate aeromechanic technologies to reduced drag and enable robust stability & control at low dynamic pressure flight conditions. Initiate efforts to characterize high-speed phenomena and develop and validate fundamental high-speed technologies through experimental testing. As part of international collaborative effort, conduct flight tests boundary layer transition experiment. Develop design of multi-functional terminal sensor integrated flight experiment. Assess mission-level effectiveness and refine definition of preferred high speed weapon alternatives. Develop campaign-level modeling and simulation of high speed weapon alternatives. Assess campaign-level benefits of preferred high speed weapon alternatives ***FY 2016 Plans:*** 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. Complete performance and operability ground testing			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622405 / *High Speed Systems Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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 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, conduct flight tests of Mach 6 adaptive guidance and control flight experiment. Assess mission-level effectiveness and refine definition of preferred high speed weapon alternatives and limited life hypersonic intelligence, surveillance, and reconnaissance vehicles. Assess campaign-level benefits of preferred high speed weapon alternatives.			
Accomplishments/Planned Programs Subtotals	-	16.152	14.929

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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	101.157	96.894	100.530	-	100.530	109.280	112.208	114.902	117.266	Continuing	Continuing
621123: *Learning and Operational Readiness*	0.000	11.971	16.592	21.275	-	21.275	22.927	23.264	21.149	21.578	Continuing	Continuing
625328: *Human Dynamics Evaluation*	0.000	25.692	17.130	23.544	-	23.544	25.559	25.566	26.026	26.574	Continuing	Continuing
625329: *Sensory Evaluation and Decision Science*	0.000	37.267	37.912	29.018	-	29.018	30.757	30.915	31.997	32.653	Continuing	Continuing
627757: *Bioeffects*	0.000	26.227	25.260	26.693	-	26.693	30.037	32.463	35.730	36.461	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 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	

B. Program Change Summary ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	104.427	81.957	97.212	-	97.212
Current President's Budget	101.157	96.894	100.530	-	100.530
Total Adjustments	-3.270	14.937	3.318	-	3.318
• Congressional General Reductions	-	-0.063			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	15.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-2.000	-			
• SBIR/STTR Transfer	-1.270	-			
• Other Adjustments	-	-	3.318	-	3.318

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: 625329: *Sensory Evaluation and Decision Science*		
Congressional Add: *Program Increase*	10.000	10.000
Congressional Add Subtotals for Project: 625329	10.000	10.000
Project: 627757: *Bioeffects*		
Congressional Add: *Program Increase*	5.000	5.000
Congressional Add Subtotals for Project: 627757	5.000	5.000
Congressional Add Totals for all Projects	15.000	15.000

Change Summary Explanation

In FY 2014, funds were reprogrammed for a higher priority effort.

In FY 2016, increase for higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 621123 / *Learning and Operational Readiness*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
621123: *Learning and Operational Readiness*	-	11.971	16.592	21.275	-	21.275	22.927	23.264	21.149	21.578	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 2014	FY 2015	FY 2016
Title: Continuous Learning	10.305	16.592	21.275

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 2014 Accomplishments:

Extended methodologies for managing learning and performance to apply across combat operations, tactical C2 and ISR teams in LVC environments. Initiated evaluations of technologies required for a complementary family of trainers. Evaluated rule-sets for training across multiple security levels in LVC environments. Evaluated scenarios for integrated C2/ISR/cyber team training in a Red Flag exercise environment.

FY 2015 Plans:

Complete development of an analyst readiness research testbed for ISR and cyber operators. Extend learning assessment and management tools to support undergraduate pilot training. Evaluate different methods for secure, credible LVC training and rehearsal for fourth and fifth generation fighters. Create and document standards for tactical LVC training and readiness. Validate methods to quickly generate rule sets for security applications in C2 and ISR domains. Develop methods to generate realistic representations of adversary tactics for LVC training. Evaluate methods to rapidly reconfigure training environments for different scenarios and mission sets. Initiate work to develop agents to manage training activities in LVC. Begin 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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 621123 / *Learning and Operational Readiness*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Title: Cognitive Modeling ***Description:*** Research explores application of cognitive science for performance improvement by enhancing training in mission-relevant environments (e.g., flight simulators). ***FY 2014 Accomplishments:*** Completed predictive performance optimization for cognitively valid readiness tracking in Air Force training. Initiated research in mechanisms of human knowledge learning and seeking and their interaction. Validated the ability of a first-generation synthetic teammate to perform effectively in a team environment. ***FY 2015 Plans:*** Effort is moved to Continuous Learning thrust to be consistent with future integration into LVC contexts. N/A	1.666	-	-
Accomplishments/Planned Programs Subtotals	11.971	16.592	21.275

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 625328 / *Human Dynamics Evaluation*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
625328: *Human Dynamics Evaluation*	-	25.692	17.130	23.544	-	23.544	25.559	25.566	26.026	26.574	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 2014	FY 2015	FY 2016
Title: Human Analyst Augmentation	6.255	7.742	5.172
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 2014 Accomplishments:*** Expanded multi-intelligence analysis prototypes to include autonomous systems and human performance augmentation technologies. Provided robust situation awareness to enhance decision-makers' understanding and knowledge by improving ISR capabilities and data processing, exploitation, and dissemination. ***FY 2015 Plans:*** Research and develop 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.			
Title: Human Trust and Interaction	10.259	4.774	9.139

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625328 / *Human Dynamics Evaluation*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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 be trusted. ***FY 2014 Accomplishments:*** Matured speech recognition and machine translation capabilities for new languages and domains. Assessed emerging speech recognition and machine translation technologies against data sets representative of general ISR applications. Investigated how to adapt these algorithms to evolving contexts such as changing topics. Investigated strategies and methodologies for combining multiple algorithms simultaneously to optimize system performance. ***FY 2015 Plans:*** Develop guidelines for calibrated trust for symbiotic human-machine teaming. Develop 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. ***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.			
Title: Human Signatures ***Description:*** Develop databases of human motion and features collected from air/space platforms. Identify human threat signatures across diverse populations for ISR and force protection applications. Develop nano, bio, and molecular signatures of airman performance. ***FY 2014 Accomplishments:*** Developed algorithms to detect and characterize adversary human signatures in radar, video, infrared, and hyperspectral modalities for human threat situational awareness. Developed applications to integrate airman performance sensors into mobile devices. ***FY 2015 Plans:***	9.178	4.614	9.233

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625328 / *Human Dynamics Evaluation*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Develop algorithms capable of reliably detecting and characterizing human signatures by leveraging multiple sensing modalities, from multiple platforms, for human threat situation awareness. Develop sensors for novel molecular signatures for increased threat detection in an operational environment and human performance assessment. ***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.			
Accomplishments/Planned Programs Subtotals	25.692	17.130	23.544

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 625329 / *Sensory Evaluation and Decision Science*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
625329: *Sensory Evaluation and Decision Science*	-	37.267	37.912	29.018	-	29.018	30.757	30.915	31.997	32.653	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 2014	FY 2015	FY 2016
Title: Applied Neuroscience	9.572	12.000	12.515
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.			
FY 2014 Accomplishments: Examined new sense, assess, and augmentation technologies to provide adaptive aiding based on warfighter performance. Validated team workload and trust measures to enhance effective human-human and human-machine system performance. Defined team synchronicity and cognitive functional state metrics that aid team performance. Researched stress-driven processes and their effects on human performance. Explored psychological and neurophysiological mechanisms and processes for developing unique operational strategies that enhance cognitive resiliency and performance. Developed physiology models to predict the effects of high-stress/extreme environments on the human. Investigated interface technologies and exposure design criteria to protect operators and mitigate injury and performance risks. Developed on-board oxygen generating technologies to mitigate hypoxia vulnerability risks.			
FY 2015 Plans: Investigate individual and team state sensing and assessment algorithms and methods to examine augmentation mitigation strategies leading to improved warfighter performance. Develop team workload and trust models for autonomy, increased human			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
performance monitoring, and performance improvement. Identify stress-driven metrics and processes that influence human performance. Define neurophysiological, psychological, and genetic mechanisms and processes for developing guidelines to enhance warfighter cognitive resiliency and performance. Apply physiology computational modeling methods to predict high-stress/extreme environmental effects on the human. Develop augmentation techniques for improving performance in operational environments that include human-machine teaming. Investigate interface technologies and exposure design criteria to protect operators and mitigate injury and performance risks in current and future weapon systems. Develop contamination sensor technology for on-board oxygen generation systems for hypoxia vulnerability risk mitigation. Investigate new technologies for aircraft next generation on-board oxygen generation system. ***FY 2016 Plans:*** 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.			
Title: Human Role in Semiautonomous Systems ***Description:*** Research new control/display concepts and technologies (e.g., information portrayal, control devices, decision-aiding algorithms). Identify best design to direct operator attention. ***FY 2014 Accomplishments:*** Investigated various automation technologies for the command and control of multiple RPAs. Examined the interplay between automation technologies and various tools to enable choices between courses of action. Evaluated advanced visualizations concepts and interaction methods for managing information from on-board and off-board sources to support RPA operator decision-making. Developed adjustable, adaptive levels of automation to support flexible control of unmanned systems depending on mission and environmental context. ***FY 2015 Plans:*** Demonstrate and quantify the use of selected automation technologies and various tools to enable choices between courses of action for the command and control of multiple RPAs. Integrate advanced visualization concepts and interaction methods	5.923	5.580	6.062

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
for managing information from on- and off-board sources to support RPA operator decision-making into high-fidelity simulations for test and evaluation. Perform advanced simulation of adjustable, adaptive levels of automation to support flexible control of unmanned systems depending on mission and environmental context. ***FY 2016 Plans:*** 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.			
Title: Battlespace Visualization ***Description:*** Advances science and technology associated with collecting, optimizing, displaying, and assimilating sensory information to enhance warfighter decision-making. ***FY 2014 Accomplishments:*** Developed a suite of image enhancement and fusion tools based on human perception and performance. Designed and evaluated visualizations based on visual analytics to represent and visualize relevant information from large, disparate data sets. Assessed application of visual analytics to various warfighting domains. Evaluated the effectiveness of using three-dimensional (3-D) displays to augment human decision-making and situational awareness. Evaluated the use of various devices that can be used to interact with visualizations to determine their effectiveness in aiding human performance. ***FY 2015 Plans:*** Evaluate image enhancement and fusion techniques for improving human perception and performance. Assess visual analytics techniques for visualizing large, disparate data sets. Investigate cyber operations visualization techniques for transforming numerical data into actionable information. Explore decision aids for multisource fusion methods. ***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.	7.706	6.660	6.972
Title: Battlespace Acoustics ***Description:*** Conducts research on advanced auditory and communication technologies that mitigate effects of noise and enhance performance in operational environments.	4.066	3.672	3.469

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Developed auditory interfaces to enable the human operator to respond to cyber attacks. Developed interface concepts for using multimodal displays and visualizations to support combat search and rescue teams. Examined the effectiveness of audio displays combined with multimodal interaction techniques to support human operator decision-making. ***FY 2015 Plans:*** Validate auditory interfaces that enable the human operator to respond to cyber attacks through persistent auditory displays. Optimize the use of multimodal displays and visualizations to communicate time critical information to distributed teams. Validate 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.			
Accomplishments/Planned Programs Subtotals	27.267	27.912	29.018

	FY 2014	FY 2015
Congressional Add: Program Increase	10.000	10.000
FY 2014 Accomplishments: Conducted Congressionally-directed effort.		
FY 2015 Plans: Conduct Congressionally-directed effort.		
Congressional Adds Subtotals	10.000	10.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 625329 / *Sensory Evaluation and Decision Science*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602202F / *Human Effectiveness Applied Research*	Project (Number/Name) 627757 / *Bioeffects*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
627757: *Bioeffects*	-	26.227	25.260	26.693	-	26.693	30.037	32.463	35.730	36.461	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project conducts applied research on the effects of human exposure to 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 and to monitor and enhance cognitive and physiological performance.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Optical Radiation Bioeffects	5.968	4.990	8.181
Description: Conduct laboratory experiments and field research on laser bioeffects, enabling military exploitation of laser technology while providing countermeasures for optical hazards/threats.			
FY 2014 Accomplishments: Integrated operational tasks into laser vision effects models to identify impacts to human operators. Explored daytime dazzling effects via multiple wavelength stimulation in human subjects. Enhanced dose-response models to support risk-based hazard analysis for low-power probabilistic laser safety tools. Expanded models and methods for application to unique approaches for using optical radiation for future weapon systems with scalable, disruptive, and ultra-precise effects.			
FY 2015 Plans: Integrate 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. Initiate studies to evaluate bioeffects, protection needs, and collateral effects of emerging directed energy systems concepts. Complete 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 evaluation 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			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 627757 / *Bioeffects*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Title: Radio Frequency Bioeffects ***Description:*** Conduct laboratory experiments and field research to enable safe exploitation of directed energy technologies for communication, target identification, and weapons development. ***FY 2014 Accomplishments:*** Conducted empirical laboratory tests on the human behavioral response to combined effects of directed energy sources. Initiated validation of high-peak power exposure models. Incorporated THz exposure test results into THz exposure standards and whole-body exposure models. ***FY 2015 Plans:*** Conduct empirical laboratory tests on the human behavioral response to combined effects of directed energy sources. Investigate high peak power human performance effects. Explore whole-body biological effects of directly applied ultra-short pulses. Determine effects of RF overexposure on neurological tissue. ***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.	7.712	4.945	9.301
Title: Molecular Bioeffects ***Description:*** Conduct studies to assess human responses to non-lethal weapons and effects/risks of these weapons. Conduct bio/nanotechnology research to advance warfighter performance. Leverage toxicological/biological data to improve airman performance and decision-making abilities. ***FY 2014 Accomplishments:*** Evaluate the quantitative framework for relating novel-effects technologies to operationally relevant mission outcomes. Conduct research to define toxicity issues in current and future aircraft environments. Begin development of models incorporating toxicity data and mechanisms of action to inform sensor development and development of hazard protection. Conduct research to elucidate novel mechanisms of fundamental interaction of nanomaterials in a biological system. Begin development of a new prototype of non-traditional effects of nanomaterials under the influence of incidental EM fields. ***FY 2015 Plans:***	7.547	10.325	9.211

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602202F / *Human Effectiveness Applied Research*	**Project (Number/Name)** 627757 / *Bioeffects*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Advance toxicity and nanotoxicity research; investigate/establish toxicity impacts to selected organ systems in the body of advanced fuels, materials, and chemicals used to support existing and future weapon systems. Define and pursue modulation of major cell pathways affecting human performance using in vitro and in vivo models and modeling and support human studies of the same. Conduct research to define toxicity issues in current and future aircraft environments. Begin 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. Conduct research to understand novel mechanisms of fundamental interaction of nanomaterials in a biological system. ***FY 2016 Plans:*** Advance knowledge and capability to complete analysis of aerospace fluid(s) toxicity characterization and impacts on high performance aircraft operators. Pursue development and application capabilities of biomarkers for short- and long-term exposure modeling for existing and emerging militarily-relevant chemicals and materials. Examine novel mechanisms of fundamental interaction of nanomaterials in a biological system. Conduct and develop novel research studies to elucidate mechanisms of fundamental interaction of nanomaterials in biological systems. Examine molecular cognition applications used in biomarker development for airman.			
Accomplishments/Planned Programs Subtotals	21.227	20.260	26.693

	FY 2014	FY 2015
Congressional Add: Program Increase	5.000	5.000
FY 2014 Accomplishments: Conduct Congressionally-directed Effort.		
FY 2015 Plans: Conduct Congressionally-directed effort.		
Congressional Adds Subtotals	5.000	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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	193.204	172.550	182.326	-	182.326	174.471	182.673	185.275	188.001	Continuing	Continuing
623012: *Advanced Propulsion Technology*	-	21.814	17.646	19.670	-	19.670	22.471	23.223	23.847	24.298	Continuing	Continuing
623048: *Combustion and Mechanical Systems*	-	12.944	12.008	11.652	-	11.652	11.873	12.192	12.415	12.664	Continuing	Continuing
623066: *Turbine Engine Technology*	-	75.742	57.245	63.712	-	63.712	51.687	54.771	55.249	55.341	Continuing	Continuing
623145: *Aerospace Power Technology*	-	26.003	29.393	28.213	-	28.213	29.752	30.120	30.730	31.359	Continuing	Continuing
624847: *Rocket Propulsion Technology*	-	51.494	51.287	54.232	-	54.232	53.696	57.231	57.818	59.020	Continuing	Continuing
625330: *Aerospace Fuel Technology*	-	5.207	4.971	4.847	-	4.847	4.992	5.136	5.216	5.319	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 evaluates lubricants and combustion concepts and technologies for new and existing 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 are part of energy optimized aircraft development. 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force					Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*		R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*			
B. Program Change Summary ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	197.546	172.550	185.363	-	185.363
Current President's Budget	193.204	172.550	182.326	-	182.326
Total Adjustments	-4.342	-	-3.037	-	-3.037
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-4.341	-			
• Other Adjustments	-0.001	-	-3.037	-	-3.037

Change Summary Explanation

Decrease in FY16 is due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
623012: *Advanced Propulsion Technology*	-	21.814	17.646	19.670	-	19.670	22.471	23.223	23.847	24.298	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops combined/advanced cycle air breathing high-speed (up to Mach 4) 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 2014	FY 2015	FY 2016
Title: Hypersonic Scramjet Technologies	21.814	17.646	19.670

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

FY 2014 Accomplishments:
Developed advanced engine components to improve scramjet operating margin and to refine scramjet scaling laws for reusable applications. Developed techniques to decrease the minimum scramjet ignition from Mach 4.5 to Mach 3.5 to provide robust options for Combined Cycle Engines (CCEs). Developed low drag flame stabilization devices and flight test components. Initiated fabrication of common test hardware for direct testing of medium scale (ten times) scramjet engines operating at Mach 3.5 to Mach 7 conditions. Initiated test facility characterization for direct connect testing with new test facility primary flow nozzles and test facility primary flow distortion generator to simulate inlet flow conditions.

FY 2015 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. Assess distortion impact on isolator operability. Continue to develop low internal drag flame stabilization devices and flight test engine components. Fabricate heavyweight direct connect scramjet combustors in medium scale (ten times). Initiate direct connect testing of first performing contractor medium scale (ten times) scramjet combustors from Mach 3.5 to Mach 7.

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. Fabricate heavyweight direct connect scramjet combustors in medium

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623012 / *Advanced Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Accomplishments/Planned Programs Subtotals	21.814	17.646	19.670

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 623048 / *Combustion and Mechanical Systems*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
623048: *Combustion and Mechanical Systems*	-	12.944	12.008	11.652	-	11.652	11.873	12.192	12.415	12.664	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 2014	FY 2015	FY 2016
Title: Combustion Technologies	5.004	4.658	4.520
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 2014 Accomplishments: Designed and tested full-annular ultra compact combustors. Evaluated augmentor technologies for screech reduction. Fabricated and tested reference combustors for alternative fuels. Implemented new technologies to operate small-scale propulsion systems with reduced octane fuels. Developed new rotational detonation engine (RDE) concepts.			
FY 2015 Plans: Begin to develop combustor, augmentor and constant volume combustion or pressure gain combustion technologies such as pulse detonation engines (PDEs) or rotational detonation engines (RDEs) to enable the next generation of gas turbine engines, new engine cycles, and combined-cycles. Explore the 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.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623048 / *Combustion and Mechanical Systems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continue development of combustor, augmentor and constant volume combustion or pressure gain combustion technologies such as pulse detonation engines (PDEs) or rotational detonation engines (RDEs) to enable the next generation of gas turbine engines.			
Title: Diagnostic Technologies ***Description:*** Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary propulsion technologies. ***FY 2014 Accomplishments:*** Developed high-speed laser systems to measure combustion species, temperature, and velocity. Applied new diagnostics to combustion systems at relevant engine conditions. Refined fiber optic methods for high-power laser diagnostics use. ***FY 2015 Plans:*** Develop and demonstrate 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. Apply 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.	0.969	0.884	0.900
Title: Lubricant Technologies ***Description:*** Develop, test, and qualify advanced turbine engine lubricants. Generate and maintain military specifications for aviation engine lubricants. ***FY 2014 Accomplishments:*** Finalized transition plans of enhanced ester oil to current and future engines. Qualified additional enhanced ester oil candidates for field use. Demonstrated advanced mechanical system health monitoring algorithms on full-scale demonstrator engine. Continued investigating advanced lube system thermal management technologies for fuel efficient engines. Incorporated new traction models into bearing heat generation models. ***FY 2015 Plans:*** Execute plan for transitioning Enhanced Ester (EE) oils into the fleet. Develop transition plans for mechanical system health monitoring system technologies. Continue investigating advanced lube system thermal management technologies for fuel efficient and hi-mach engine applications. ***FY 2016 Plans:***	3.413	3.123	3.030

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623048 / *Combustion and Mechanical Systems*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Demonstrate Enhanced Ester (EE) oils on Adaptive Engine Technology Demonstrator (AETD) engine cores. Demonstrate mechanical system health monitoring system technologies on fielded systems. Continue investigating advanced lube system thermal management technologies for fuel efficient and hi-mach engine applications.			
Title: Bearing Technologies ***Description:*** Develop and test advanced bearing material technology and bearing concepts for small, intermediate, and large-scale turbine engine applications. ***FY 2014 Accomplishments:*** Conducted full-scale bearing tests in support of adaptive turbine engines. Conducted foil bearing rig tests in support of expendable supersonic turbine engine follow-on development. Developed improved bearing material life model. Matured autonomous active thrust bearing system. Finalized transition plans of hybrid ceramic/metallic bearings into upgrades of current aircraft. ***FY 2015 Plans:*** Continue full-scale bearing rig testing in support of adaptive, fuel efficient engines. Continue oil-free, foil bearing R&D in support of supersonic expendable engines and remotely piloted aircraft. Continue developing improved bearing material life model. Continue maturing active bearing thrust control system and fuse with engine prognostics health monitoring system for future fuel efficient engines. ***FY 2016 Plans:*** Complete full-scale bearing rig testing in support of adaptive, fuel efficient engines. Complete oil-free, foil bearing research and development 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 engine prognostics health monitoring system for future efficient engines.	3.558	3.343	3.202
Accomplishments/Planned Programs Subtotals	12.944	12.008	11.652

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623048 / *Combustion and Mechanical Systems*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 623066 / *Turbine Engine Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
623066: *Turbine Engine Technology*	-	75.742	57.245	63.712	-	63.712	51.687	54.771	55.249	55.341	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops technology to increase turbine engine operational reliability, durability, mission flexibility, and performance, while reducing weight, fuel consumption, and cost of ownership. Analytical and experimental areas of emphasis are fans and compressors, high temperature combustors, turbines, internal flow systems, controls, augmentor and exhaust systems, integrated power and thermal management systems, engine inlet integration, mechanical systems, adaptive cycle technologies, and structural design. This project develops component technology for an adaptive cycle engine architecture that provides both optimized performance and fuel efficiency for widely varying mission needs. This project supports joint Department of Defense, agency, and industry efforts to focus turbine propulsion technology on national needs. The 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 2014	FY 2015	FY 2016
Title: Turbofan/Turbojet Engine Core Technologies	34.292	27.905	31.057

Description: Develop core turbofan/turbojet engine components (i.e., compressors, combustors, and turbines) for fighters, bombers, sustained supersonic/hypersonic cruise vehicles, and transports.

FY 2014 Accomplishments:
Developed 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 increasae efficiency. Initiated conceptual design of efficient, very high pressure ratio core component technologies. Completed Adaptive Versatile Engine Technology (ADVENT) effort.

FY 2015 Plans:
Continue developing 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 combustor and turbine components operating in a realistic engine environment. Continue to develop improved compressor aerodynamic design tools to extend engine operability and efficiency. Complete conceptual design, and initiate 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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
design tools to extend engine operability and efficiency. Complete detailed design of efficient, very high pressure ratio core component technologies.			
Title: Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies ***Description:*** Develop turbofan/turbojet engine components (i.e., fans, nozzles, etc.) used in engines for fighters, bombers, sustained supersonic strike and hypersonic cruise vehicles, and transports. ***FY 2014 Accomplishments:*** Developed modeling and simulation tools, including methods to predict behavior of serpentine inlets and nozzles. Developed modeling and simulation tools to predict fan/inlet interaction for both podded and embedded propulsion systems. Developed a probabilistic ignition prediction tool for advanced augmentor design. Developed models to validate function and durability of high temperature electronics for engine control. ***FY 2015 Plans:*** Initiate 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. Continue to develop modeling and simulation tools, including methods to predict behavior of serpentine inlets and nozzles. Conduct bench and rig tests to validate modeling and simulation tools to predict fan/inlet interaction for both podded and embedded propulsion systems. Conduct bench and rig tests to validate probabilistic ignition prediction tool for advanced augmentor design system. Develop models to validate function and durability of high temperature electronics for engine control. ***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. Complete 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.	7.997	23.738	26.283
Title: Missile and Remotely Piloted Aircraft Engine Technologies ***Description:*** Develop limited life engine components for missile and remotely piloted aircraft (RPA) applications, including long-range supersonic and hypersonic vehicles. ***FY 2014 Accomplishments:***	3.814	4.541	5.054

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Developed and applied advanced modeling and simulation tools for variable cycle component design, advanced cooling concepts, compact augmentors, and composite structures. Demonstrated advanced designs in rig testing. Developed and validated a test protocol for small engine augmentor designs. ***FY 2015 Plans:*** Continue to develop and apply advanced modeling and simulation tools for variable cycle component design, advanced cooling concepts, compact augmentors, and composite structures. Continue to demonstrate advanced designs in rig testing. Utilize validation data to develop improved test protocol for small engine augmentor designs. ***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.			
Title: Turboshaft/Turboprop and Small Turbofan Engine Technologies ***Description:*** Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. ***FY 2014 Accomplishments:*** Developed and applied advanced modeling and simulation tools for advanced cooling concepts, high efficiency gearboxes, and high performance airfoils. Developed advanced vibration and temperature sensors for use in demonstration of engine durability requirements. ***FY 2015 Plans:*** Continue to refine and develop and apply advanced modeling and simulation tools for advanced cooling concepts, high efficiency gearboxes, and high performance airfoils. Continue to develop advanced vibration and temperature sensors for use in demonstration of engine durability requirements. ***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.	1.590	1.061	1.318
Title: Adaptive Turbine Engine Technologies ***Description:*** Develop high performance, durable components which enable adaptive turbine engine technologies. ***FY 2014 Accomplishments:***	28.049	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Completed detailed design of at least two unique adaptive fan concepts and initiated fabrication of components for ground engine testing. Conducted ground rig tests to validate preliminary design technologies and reduce risk for several parts of adaptive engines. Transitioned effort from development to demonstration of parts of adaptive engines. This effort has been completed. ***FY 2015 Plans:*** N/A ***FY 2016 Plans:*** N/A			
Accomplishments/Planned Programs Subtotals	75.742	57.245	63.712

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.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 623145 / *Aerospace Power Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
623145: *Aerospace Power Technology*	-	26.003	29.393	28.213	-	28.213	29.752	30.120	30.730	31.359	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 component 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 2014	FY 2015	FY 2016
Title: High Power System Technologies	26.003	29.393	28.213
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 2014 Accomplishments:*** Initiated testing of adaptive power and thermal management subsystems hardware for next generation air platforms in conjunction with continued platform level tip-to-tail modeling and simulation energy optimization. Initiated architecture study, to include propulsion integration, for future air dominance platforms. ***FY 2015 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. Initiate integrated ground demonstration of adaptive power and thermal management system for next generation air platforms. Initiate 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. 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, initiate component development.			
Accomplishments/Planned Programs Subtotals	26.003	29.393	28.213

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 623145 / *Aerospace Power Technology*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 624847 / *Rocket Propulsion Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
624847: *Rocket Propulsion Technology*	-	51.494	51.287	54.232	-	54.232	53.696	57.231	57.818	59.020	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. Technologies are developed 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 developed under this program enable capabilities of interest to both DoD and 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 achievement of RP21 Goals.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Fuel Technologies	5.951	6.927	7.372
Description: Develop, characterize, and test advanced hydrocarbons, energetics, solid propellants, and monopropellants to increase space launch payload capability and refine new synthesis methods.			
FY 2014 Accomplishments: Evaluated 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. Continued development and characterization of next generation ionic liquid propellants for use in spacecraft and missile defense applications. Completed scale-up capability for advanced solid propellant ingredients. Evaluated and modified polymeric systems for use in rocket applications.			
FY 2015 Plans: Scale up methods for removing components from fuels that adversely affect fuel coking in rocket engine environments. Evaluate scaled-up propellants in advanced combustion devices to determine materials compatibility and performance to include supporting large-scale motor tests. Develop advanced binder systems to enable use of advance solid propellant ingredients with significant improvements over state of the art. Complete scale-up capability of to sixty liters for advanced solid propellant ingredients and begin testing these ingredients in large scale motors. Continue development and characterization of next generation ionic liquid propellants for use in spacecraft and missile defense applications.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Complete scale up methods for removing components from fuels that adversely affect fuel coking in rocket engine environments. Evaluate scaled-up propellants in advanced combustion devices to determine materials compatibility and performance to include supporting large-scale motor tests. Develop advanced binder systems to enable use of advance solid propellant ingredients with significant improvements over state of the art. Continue using 60 liter reactor for advanced solid propellant ingredients and continue testing these ingredients in large scale motors to determine propellant feasibility and payoffs. Continue development and characterization of next generation ionic liquid propellants for use in spacecraft and missile defense applications.			
Title: Liquid Engine Combustion Technologies	6.043	5.780	5.958
Description: Develop advanced liquid engine combustion technology for improved performance, while preserving chamber lifetime and reliability needs for engine uses in heavy lift space vehicles.			
FY 2014 Accomplishments: Began 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 feed data to HCB to influence supporting design efforts. Incorporated data from HCB sub-scale preburner testing into combustion models. Developed and demonstrated in-house, moderate scale liquid rocket component testing capability; completed hot fire capability to support risk reduction in hydrocarbon boost technology. Continued to develop high performance compact liquid rocket engine technologies. Continued characterization of novel cooling channels and transferred info to HCB to influence rocket engine thrust chamber design. 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 can fuels be engineered with a purpose. Continued to evaluate and develop advanced material solutions for high temperature components in rocket engines.			
FY 2015 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 Hydrocarbon Boost (HCB), a rocket engine 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 Hydrocarbon Boost Demonstration and all future hydrocarbon fueled liquid rocket engines. Release beta version of analysis/design code to rocket community. Complete characterization of novel cooling channels and transfer info to HCB to influence rocket engine thrust chamber design. 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, how can fuels be engineered with a purpose. Design 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. 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; begin testing a sub-scale preburner in the facility			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
to provide additional risk reduction for future engine designs. Continue to develop high performance compact liquid rocket engine technologies. ***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 Hydrocarbon Boost (HCB), a rocket engine 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 Hydrocarbon Boost Demonstration and all future hydrocarbon fueled liquid rocket engines. Release beta version of analysis/design code to rocket community. Complete characterization of novel cooling channels and transfer info to HCB to influence rocket engine thrust chamber design. 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, how can fuels be engineered with a purpose. Design 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. 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; begin 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.			
Title: Advanced Liquid Engine Technologies ***Description:*** Develop advanced liquid engine technologies for improved performance, while increasing life and reliability needs for engine uses in expendable and reusable launch vehicles. ***FY 2014 Accomplishments:*** Continued to develop enabling hydrocarbon boost technology for future spacelift concepts and continued risk reduction activities for the development of hydrocarbon boost technologies such as subscale turbopump assembly and thrust chamber assembly. ***FY 2015 Plans:*** Continue to develop enabling hydrocarbon boost technology for future spacelift concepts and continue risk reduction activities for the development of hydrocarbon boost technologies such as subscale turbopump assembly and thrust chamber assembly. ***FY 2016 Plans:*** Continue to develop enabling hydrocarbon boost technology for future spacelift concepts and continue risk reduction activities for the development of hydrocarbon boost technologies (subscale turbopump assembly, thrust chamber assembly). 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.	16.224	16.900	17.255
Title: On-Orbit Propulsion Technologies	12.045	12.290	12.790

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for station-keeping, repositioning, and orbit transfer for satellites and satellite constellations. ***FY 2014 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 multi-scale/multi-physics. Conducted experiments to understand the physics behind the wide range of spacecraft propulsion concepts/technologies and accurately model the physics. Began transition of new thruster modeling framework to spacecraft industry for use in future designs. Explored and developed new generation of chemical spacecraft thruster technologies. Began initial support for future NASA flight of the Air Force Research Laboratory's AF-M315E non-toxic monopropellant (replaces toxic Hydrazine currently used in spacecraft). ***FY 2015 Plans:*** Conduct scale-up of advanced monopropellants and evaluate advanced ignition schemes and chamber concepts. Continue development of next generation high power electric spacecraft propulsion. 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 modeling framework to spacecraft industry for use in future designs. Explore and develop new generation of chemical spacecraft thruster technologies. Continue support of future NASA flight of AFRL's AF-M315E non-toxic monopropellant. ***FY 2016 Plans:*** Conduct scale-up of advanced monopropellants and evaluate advanced ignition schemes and chamber concepts. Continue development of next generation high power electric spacecraft propulsion. 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 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. Continue support of NASA flight of AFRL's AF-M315E non-toxic monopropellant (replaces toxic Hydrazine currently used in spacecraft).			
Title: Space Access and Strike Applications ***Description:*** Develop missile propulsion and boost technologies for space access and strike applications. ***FY 2014 Accomplishments:*** Continued to develop advanced tactical propulsion. Continued development and evaluation of next generation of updated, physics- based modeling, simulation, and analysis tools for missile propulsion components and applications. Continued to develop	6.607	5.380	6.707

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
advanced component technologies for missile propulsion applications for strategic and strike systems helping to ensure their long-term sustainment. Completed propellant combustion and hazards characterization efforts. ***FY 2015 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. ***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.			
Title: Ballistic Missile Technologies ***Description:*** Develop missile propulsion technologies and aging and surveillance technologies for ballistic missiles. ***FY 2014 Accomplishments:*** Completed sub-scale testing of existing and advanced sensors to be attached to solid rocket motors and tools that can integrate sensor data into existing aging and surveillance tool suite. Completed integration of advanced aging and surveillance technologies into full-scale demonstrations to validate and verify efforts to reduce uncertainties and accurately model motor behavior. Applied next generation of chemical and aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, and non-destructive analysis tools. Completed data management system used to track and correlate aging and surveillance data for individual missiles. Began advanced sensor development efforts to further improve data acquisition and reduce uncertainty in ballistic missile life predictions. ***FY 2015 Plans:*** 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. ***FY 2016 Plans:*** 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. Improve the fidelity and precision of non-destructive evaluation tools, improving capability to determine flaw size, orientation, and location. Support transition of previous tools, models, data management system	4.624	4.010	4.150

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
to user. Begin long-term validation of tools through long-term aging of sub-scale motors. Sub-scale motors will be periodically dissected over the next seven years to validate the sensor and analytical analysis of each motor.			
Accomplishments/Planned Programs Subtotals	51.494	51.287	54.232

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602203F / *Aerospace Propulsion*	Project (Number/Name) 625330 / *Aerospace Fuel Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
625330: *Aerospace Fuel Technology*	-	5.207	4.971	4.847	-	4.847	4.992	5.136	5.216	5.319	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 2014	FY 2015	FY 2016
Title: Alternative Fuels	2.312	0.200	0.194
Description: Conduct evaluations and perform technical assessments of alternative hydrocarbon fuels derived from coal, natural gas, and biomass for use in legacy and advanced aerospace systems. ***FY 2014 Accomplishments:*** Continued evaluation of cellulosic aviation biofuels, focusing on potential fuels capable of being used at a 100% pure state rather than blends. ***FY 2015 Plans:*** Evaluate alternative fuels being considered for addition to Jet A specification (ASTM D7566), which AF will use due to conversion to Jet A/F-24. ***FY 2016 Plans:*** Continue to evaluate advanced cellulosic alternative fuels being considered for addition to Jet A specification (ASTM D7566), which AF will use due to conversion to Jet A/F-24.			
Title: Integrated Thermal and Energy Management	1.021	1.500	1.463
Description: Develop and demonstrate advanced components and conduct performance assessments of advanced aircraft integrated thermal and energy management systems for engines and aircraft. ***FY 2014 Accomplishments:***			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 625330 / *Aerospace Fuel Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Developed advanced producible endothermic fuel composition with enhanced heat sink and life to support medium-scale scramjet engine demonstrations. ***FY 2015 Plans:*** Develop and evaluate nano-catalysts/nano-additives for enhancing heat sink and reducing coking. ***FY 2016 Plans:*** 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.			
Title: Fuel Logistics ***Description:*** Study and evaluate low-cost approaches to reduce fuel logistics footprint to reduce cost. Study fuel logistics vulnerabilities and develop detection and mitigation technologies. ***FY 2014 Accomplishments:*** Developed composition-to-performance link and models for Jet A fuels for physical properties. ***FY 2015 Plans:*** Evaluate anti-microbial peptides and biological active control for mitigating biological growth an aviation fuels. ***FY 2016 Plans:*** Evaluate AF capability to reduce/eliminate additives from F-24 (commercial Jet A + additives).	0.937	1.500	1.463
Title: Combustion Emissions and Performance ***Description:*** Develop and test advanced emissions diagnostic techniques for airbreathing propulsion systems. Conduct evaluations of the combustion and emissions characteristics of aviation fuels. ***FY 2014 Accomplishments:*** Evaluated combustor operability of narrow-boiling and high/low cetane alternative fuels as well as fully-synthetic fuels. ***FY 2015 Plans:*** Evaluate advanced in-situ diagnostics to assess in-combustor engine emissions and combustion characteristics. ***FY 2016 Plans:*** Initiate combustor/hot section materials durability study as a function of fuel composition.	0.937	1.771	1.727
Accomplishments/Planned Programs Subtotals	5.207	4.971	4.847

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602203F / *Aerospace Propulsion*	**Project (Number/Name)** 625330 / *Aerospace Fuel Technology*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	125.989	118.321	147.291	-	147.291	173.838	176.303	181.739	185.455	Continuing	Continuing
622002: *Electronic Component Technology*	-	35.246	27.169	38.261	-	38.261	42.539	43.193	43.339	44.186	Continuing	Continuing
622003: *EO Sensors & Countermeasures Tech*	-	22.795	27.958	26.832	-	26.832	28.246	30.225	33.272	34.006	Continuing	Continuing
626095: *Sensor Fusion Technology*	-	25.688	23.486	27.382	-	27.382	31.822	34.671	32.600	33.290	Continuing	Continuing
627622: *RF Sensors and Countermeasures Tech*	-	42.260	39.708	54.816	-	54.816	71.231	68.214	72.528	73.973	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.

This program is in Budget Activity 2, Applied Research because this budget activity includes scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force					Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*		R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*			
B. Program Change Summary ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	127.419	118.343	145.655	-	145.655
Current President's Budget	125.989	118.321	147.291	-	147.291
Total Adjustments	-1.430	-0.022	1.636	-	1.636
• Congressional General Reductions	-	-0.022			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.010	-			
• SBIR/STTR Transfer	-1.420	-			
• Other Adjustments	-	-	1.636	-	1.636

Change Summary Explanation

Increase in FY 2016 to prioritize Automatic Target Recognition Technologies.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*	Project (Number/Name) 622002 / *Electronic Component Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
622002: *Electronic Component Technology*	-	35.246	27.169	38.261	-	38.261	42.539	43.193	43.339	44.186	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 2014	FY 2015	FY 2016
Title: Multifunction Sensor Subsystems	11.681	8.120	9.222
Description: Develop, analyze, demonstrate, and perform engineering trade studies for technologies for compact, affordable, multi-function subsystems for aerospace sensors. ***FY 2014 Accomplishments:*** Developed and demonstrated a capability to predict performance versus lifetime in military relevant environments for a large variety of emerging electronic devices. Initiated engineering trade analysis, and developed optimized sensor system technology. Developed initial trade space models for advanced sensing, and electronic warfare front-ends. ***FY 2015 Plans:*** Continue to develop, refine and demonstrate advanced trade space and prediction tools for emerging devices. Complete engineering trade analysis for baseline sensing system technologies. Continue 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.			
Title: Microelectronic/Optoelectronic Technologies	12.680	9.036	10.172

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622002 / *Electronic Component Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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. ***FY 2014 Accomplishments:*** Developed optimized device concepts for multi-use cyber, sensing, warfare and communication applications. Identified and evaluated concepts for compact, high-performance electro-optic and electronic devices and components. Synthesized test articles, characterized behavior, and optimized fabrication methods for enhanced devices and components. Developed tools and methods for analysis and efficient design of game-changing components. ***FY 2015 Plans:*** Complete device concept baseline for multi-use (sense environments and counter threat) applications. Continue to identify and evaluate concepts for compact, high-performance devices and components. Demonstrate projected gains through characterization of test articles in relevant environments. Continue to develop tools and methods to design and analyze game-changing components. ***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.			
Title: Antennas ***Description:*** Design and develop antennas for airborne and space-based surveillance. Develop novel and advanced antennas for lightweight, conformal arrays. ***FY 2014 Accomplishments:*** Initiated development of optimized antenna concepts for multi-use sensing, electronic warfare and communication applications. Fabricated and characterized innovative electronic device concepts for wideband, reconfigurable and tunable, and trusted applications. Demonstrated prototype hardware for agile/affordable advanced detector arrays with emphasis on combined spectro-polarimetric filtering. Designed and fabricated high-brightness and agile waveform sources for integration into components and subsystems. ***FY 2015 Plans:*** Continue to fabricate and characterize innovative devices to extend bandwidth, reconfigurability, tunability and trustworthiness. Continue demonstrations of multi-wavelength, agile and affordable advanced detectors and arrays with emphasis on integrated	6.305	4.763	5.417

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622002 / *Electronic Component Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
filtering. Continue the design and fabrication of high-brightness and agile waveform sources to integrate into microsystems and subsystems. ***FY 2016 Plans:*** Complete characterization and evaluation of novel high-brightness and agile waveform source. Continue to explore and evaluate innovative devices for increase bandwidth and tunability. Continue demonstrations of multi-wavelength, agile and affordable advanced detectors and arrays.			
Title: Trusted Systems for ISR and Avionics Systems ***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, metamaterials, data compression, high-frequency power modules, EO/IR sources, EO/IR detectors, beam control and waveguides, and trusted and reliable electronics. ***FY 2014 Accomplishments:*** Initiated development of optimized device concepts for multi-use cyber, sensing, warfare and communication applications. Fabricated and characterized innovative electronic device concepts for wideband, reconfigurable and tunable, and trusted applications. Demonstrated prototype hardware for agile/affordable advanced detector arrays with emphasis on combined spectropolarimetric filtering. Designed and fabricated high-brightness and agile waveform sources for integration into components and subsystems. ***FY 2015 Plans:*** Continue to identify COTS and GOTS technologies nearly ready or ready for integration into microsystem and subsystem demonstration. Develop, mature and demonstrate solutions utilizing COTs/GOTs technology that enable cyber-hardness, rad-hardness and resistance to tampering. ***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.	4.580	5.250	6.190
Title: Advanced Components for Electronic Warfare ***Description:*** Develop, mature, and demonstrate critical electronic technologies to enable revolutionary electronic warfare substems. ***FY 2014 Accomplishments:***	-	-	7.260

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622002 / *Electronic Component Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
N/A ***FY 2015 Plans:*** N/A ***FY 2016 Plans:*** In FY16 research in this effort has been transferred from efforts in project 622003, "EO Sensors and Countermeasures Tech," in this program to better coordinate and align research. 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.			
Accomplishments/Planned Programs Subtotals	35.246	27.169	38.261

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*	Project (Number/Name) 622003 / *EO Sensors & Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
622003: *EO Sensors & Countermeasures Tech*	-	22.795	27.958	26.832	-	26.832	28.246	30.225	33.272	34.006	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 2014	FY 2015	FY 2016
Title: Non-cooperative Detection and Identification Technologies	11.076	12.435	-
Description: Develop innovative optical sensing technology for non-cooperative detection and identification of airborne and ground-based targets. ***FY 2014 Accomplishments:*** Developed innovative sensor concepts to increase long range image quality for passive electro-optical and infrared reconnaissance sensors for high altitude platforms. Assessed fundamental geometrical environmental and atmospheric limitations to system performance. Developed approaches for image restoration. Conducted long wave infrared hyperspectral phenomenology and change detection research. ***FY 2015 Plans:*** Evaluate, 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. Mature longwave infrared hyperspectral imaging to achieve operationally useful radiometric sensitivity and area coverage rate with a sensor system that is practical and affordable. ***FY 2016 Plans:*** In FY 2016 this effort moves to "Passive EO/IR Sensing in Contested Environments" in this project to better align efforts.			
Title: EO/IR Sensors and Threat Countermeasure Technologies	5.958	7.791	-
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.			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622003 / *EO Sensors & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Refined modeling and simulations for multiple ladar modes. Conducted laboratory testing of initial foundry runs of focal planes optimized for three dimensional and holographic imaging. Developed optical materials and devices for improved reliability and performance of mid-infrared lasers operating in harsh environments. Began test of prototype Silicon Gallium (SiGa) detectors. Started design and fabrication of SiGa focal plane array. ***FY 2015 Plans:*** Initiate 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. Research the problem of improving system capabilities to provide high confidence target identification at standoff ranges for both reconnaissance and targeting platforms. Continue evaluation of prototype Silicon Gallium (SiGa) detectors. Continue design and fabrication of SiGa focal plane array. ***FY 2016 Plans:*** In FY 2016 this effort moves to "Laser Radar Sensing in Contested Environments" in this project to better align efforts.			
Title: Optical Technologies ***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. ***FY 2014 Accomplishments:*** Refined and demonstrated candidate component technologies for image stabilization and restoration. Determined the utility of non-traditional sensor architectures in improving image quality, and the operational range of passive imagers. Initiated prototyping of a flexible, next generation long wave infrared hyperspectral imaging spectrometer. ***FY 2015 Plans:*** Initiate 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. Research will also supports phenomenology understanding, signature collection, sensor product visualization, and automatic target recognition in collaboration with other AFRL directorates. Continue prototyping of a flexible, next generation long wave infrared hyperspectral imaging spectrometer. ***FY 2016 Plans:*** In FY 2016 this effort moves to "Passive EO/IR Sensing in Contested Environments" in this project to better align efforts.	5.761	7.732	-
Title: Passive EO/IR Sensing in Contested Environments	-	-	8.944

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622003 / *EO Sensors & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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. ***FY 2014 Accomplishments:*** N/A ***FY 2015 Plans:*** N/A ***FY 2016 Plans:*** This effort continues the work realigned from "Optical Technologies," "Non-cooperative Detection and Identification Technologies" efforts in this project. 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 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.			
Title: Laser Radar Sensing in Contested Environments ***Description:*** This effort continues the work done in "EO/IR Sensors and Threat Countermeasure Technologies" effort in this project. 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.	-	-	17.888

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 622003 / *EO Sensors & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: N/A ***FY 2015 Plans:*** N/A ***FY 2016 Plans:*** Develop synthetic aperture ladar (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 ladar 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 ladar updating modeling and simulation, phenomenology measurement capabilities and to support utility analysis and system design and evaluations.			
Accomplishments/Planned Programs Subtotals	22.795	27.958	26.832

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*	Project (Number/Name) 626095 / *Sensor Fusion Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
626095: *Sensor Fusion Technology*	-	25.688	23.486	27.382	-	27.382	31.822	34.671	32.600	33.290	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 persistent intelligence, surveillance, and reconnaissance (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 2014	FY 2015	FY 2016
Title: Automatic Target Recognition Technologies	9.599	9.500	-
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 2014 Accomplishments: Assessed and enhanced 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 & Direction, Collection, Processing & Exploitation, Analysis & Production, and Dissemination - eXperimental (PCPAD-X) in contested and uncontested environments. Assessed and developed capabilities to represent and utilize sensor parameters and errors to improved fused geo-location accuracy. Conducted research of bio-inspired automatic target recognition technologies.			
FY 2015 Plans: Develop advanced object recognition methods which correlate data from multiple sensors from air, space and cyber domains. Continue 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			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 626095 / *Sensor Fusion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
identification applications, and PCPAD-X in contested and uncontested environments. Continue 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 this effort moves to "Distributed Sensing for ATR" in this project to better align efforts.			
Title: Target Signature Modeling ***Description:*** Develop, evaluate, and demonstrate target signature models to support sensor exploitation algorithm development and testing for reconnaissance and strike mission applications. ***FY 2014 Accomplishments:*** Matured target signature models for signature exploitation of multi-spectral systems and signals intelligence sensors emphasizing one target model for application to all parts of the spectrum. Developed signatures, algorithms, target modeling, and phenomenological modeling of features not previously exploited. Developed automatic target recognition algorithm-driven radio-frequency sensor design. ***FY 2015 Plans:*** Continue development of all-source target models for emerging threat systems in contested environments. Create and assess methods for validating all-source signature models. Continue to mature target signature models for signature exploitation of multi-spectral systems and signals intelligence sensors. Mature promising approaches to develop a single target model for application to all parts of the spectrum. ***FY 2016 Plans:*** 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. Continue maturing promising approaches to develop a single target model for application to all parts of the spectrum. Continue development of all-source target models for emerging threat systems in contested environments. Demonstrate maturing methods for validating all-source signature models.	4.180	4.080	3.814
Title: Sensor Exploitation Technologies ***Description:*** Develop technical methods required for algorithm performance models, performance driven sensing, layered sensing and other sensing and exploitation technologies impacted by automated exploitation capabilities. ***FY 2014 Accomplishments:***	7.034	6.500	5.817

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 626095 / *Sensor Fusion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Developed performance models for sensor exploitation technologies, and associated databases and tools. Conducted validation of algorithm performance models to be used in the PCPAD-X integrative and virtual environments. Enhanced development of an integrated, unified automatic target recognition (ATR) methodology. ***FY 2015 Plans:*** Develop novel techniques for analysis of large sensor data sets to discover, characterize, and identify threatening activities in contested environments. Continue development of sensor resource optimization enablers for autonomous sensor employment. Continue 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. Continue to enhance development of an integrated, unified ATR methodology through industry and university outreach. ***FY 2016 Plans:*** 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.			
Title: Trusted Sensing Technologies	4.875	3.406	-
Description: Develop, evaluate, and demonstrate methodologies, techniques, and strategies to instill trust in distributed, heterogeneous sensing systems within air, space, and cyber domains. ***FY 2014 Accomplishments:*** Developed advanced trusted sensing services, middleware, and frameworks for multilayered sensing and spectrum warfare. Developed methods, tools, and processes to determine and assess vulnerability and mission assurance for complex system-of-systems for spectrum warfare. Developed autonomic trusted sensor technologies to address self-aware, self-healing, and self-organizing sensor systems. Developed detect and response mechanisms to remedy software and hardware supply chain vulnerabilities. ***FY 2015 Plans:*** Initiate research in trusted exploitation algorithms and tools for PC-PAD, defining and quantifying metrics. Build 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. ***FY 2016 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 626095 / *Sensor Fusion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
In FY 2016 this effort moves to "Sensor Management for ATR" in this project to better align efforts.			
Title: Sensor Management for ATR ***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 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 automatic target recognition (ATR), sensor management, and sensor fusion technologies by application of multi-sensor data and distributed data processing. ***FY 2014 Accomplishments:*** N/A ***FY 2015 Plans:*** N/A ***FY 2016 Plans:*** This effort continues work from "Trusted Sensing Technologies" effort. 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.	-	-	13.884
Title: Distributed Sensing for ATR ***Description:*** Develop techniques and metrics for adaptive, penetrating, distributed RF exploitation in contested environments. ***FY 2014 Accomplishments:*** N/A ***FY 2015 Plans:*** N/A ***FY 2016 Plans:*** This effort continues work accomplished in effort "Automatic Target Recognition Technologies."	-	-	3.867

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 626095 / *Sensor Fusion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Accomplishments/Planned Programs Subtotals	25.688	23.486	27.382

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602204F / *Aerospace Sensors*	Project (Number/Name) 627622 / *RF Sensors and Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
627622: *RF Sensors and Countermeasures Tech*	-	42.260	39.708	54.816	-	54.816	71.231	68.214	72.528	73.973	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and assesses affordable, reliable all weather radio frequency (RF) sensing and countermeasure concepts for aerospace applications covering the range of RF sensors including communications, navigation, intelligence, surveillance, reconnaissance (ISR), and radar, both active and passive, across the air, land, sea, space and cyber domains. This project also develops and evaluates technology for ISR sensors, fire control radars, electronic warfare, integrated radar and electronic warfare systems, and offensive information operations systems. It emphasizes the detection and tracking of surface and airborne targets with 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 2014	FY 2015	FY 2016
Title: Hybrid Sensor Technologies	7.372	7.939	12.082
Description: Develop hybrid sensor solutions to be responsive to needs and detect difficult targets. Develop jam-resistant time, position, and velocity sensors.			
FY 2014 Accomplishments: Developed strategies to optimize reference technologies for distributed sensing mission. Expanded research of alternatives when GPS is degraded or denied in contested environments. Reduced size, weight, and power of inertial components, while pursuing near navigation grade performance.			
FY 2015 Plans: Mature 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. Develop technologies that expand the ability to incorporate GNSS signals into 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			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 627622 / *RF Sensors and Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
sensing, such as vision or magnetic sensors, to improve inertial measurement unit aided navigation accuracy in GPS sparse or denied environments.			
Title: RF Sensor Technologies ***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. ***FY 2014 Accomplishments:*** Conducted research and development in dismount classification, waveform diversity, multiple inputs-multiple outputs (MIMO) for electronic protection and ATI for GMTI radar. Conducted model development for MIMO and waveform diverse distributed sensing networks, and for airborne multi-static radar, illumination management and bi-static airborne early warning systems. ***FY 2015 Plans:*** Continue 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. Continue 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. ***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.	13.798	11.614	16.055
Title: Optimize RF Sensing Technology ***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. ***FY 2014 Accomplishments:*** Initiated development of distributed and layered EW effects to maintain spectrum dominance for assured operations, and position, navigation, and timing (PNT) in contested environments. Explored and analyzed next generation RF-based threats for potential	5.905	5.195	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 627622 / *RF Sensors and Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
counters and perform vulnerability assessments. Researched advanced electronic support (ES) concepts. Completed research and exploration of an adaptable ES/electronic attack (EA) capability. ***FY 2015 Plans:*** Conduct 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. Identify, develop and integrate improved electronics that reduce cost, size, weight and power of current EW systems to facilitate development of distributed EW jammers/sensor systems. Develop new approaches to protection of aircraft avionics systems and on-board data networks. ***FY 2016 Plans:*** Efforts moves to "Sensor Resource Management" thrust in this Project.			
Title: Multi-Band/Multi-Beam Technologies ***Description:*** Develop multi-band and multi-beam forming technologies. Address technologies for antenna array operations in dynamic sensor networks. ***FY 2014 Accomplishments:*** Developed RF/EO subsystem concept prototype and began its development to validate trade space tools. Initiated trade space analysis for RF/EO subsystem and device concepts. Developed MIMO and waveform-diverse system models for multi-sensor networks operating in contested environments containing complex clutter and multi-path. Developed cognitive and phenomenology-based algorithms. Developed GPS and non-GPS navigation schemes for hypersonic vehicles. ***FY 2015 Plans:*** Identify advanced RF/EO subsystem concepts to refine and update trade space capability. Complete the MIMO and waveform-diverse models for system and system of systems analysis. Initiate highly integrated, mostly digital microsystems for reconfigurable and tunable capabilities. ***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.	5.901	5.616	10.928
Title: Counter RF Threat Technologies ***Description:*** Develop aerospace platform jamming technologies and techniques to counter advanced radio-frequency (RF) threats associated with current and future aerospace weapons systems.	9.284	9.344	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 627622 / *RF Sensors and Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Developed technologies that ensure unfettered access to the electromagnetic spectrum while denying the same to adversaries. Conducted long-term research on integrating bio-inspired decision-making and cognitive capabilities into EW and EW battle management systems to improve responses in ambiguous EM environments. ***FY 2015 Plans:*** Develop multi-faceted approaches to countering RF threats. Efforts include development of machine learning, autonomous systems to identify frequency agile and changing waveforms. Develop counter-countermeasures to digital radio frequency memory (DRFM) based jammers. Develop Electromagnetic/Electronic Warfare Battle Management (EM/EWBM) tools, and distributed EW techniques to counter state-of-the-art integrated air defense systems. Develop novel disruptive technologies that leverage cyber, directed energy, and machine learning to counter RF, EO/IR threats. ***FY 2016 Plans:*** In FY 2016 this effort moves to "Sensor Resource Management" in this project.			
Title: Sensor Resource Management ***Description:*** Develop technology to enable optimization of sensor resources in contested environments on own-ship and multi-ship in manned, unmanned and manned/unmanned teaming concepts. ***FY 2014 Accomplishments:*** N/A ***FY 2015 Plans:*** N/A ***FY 2016 Plans:*** This effort continues research from efforts "Optimize RF Sensing Technology" and "Counter RF Threat Technologies". 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.	-	-	15.751
Accomplishments/Planned Programs Subtotals	42.260	39.708	54.816

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602204F / *Aerospace Sensors*	**Project (Number/Name)** 627622 / *RF Sensors and Countermeasures Tech*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	100.066	98.229	116.122	-	116.122	108.936	117.514	120.336	122.811	Continuing	Continuing
621010: *Space Survivability & Surveillance*	-	36.620	35.159	42.970	-	42.970	32.954	38.922	35.447	35.165	Continuing	Continuing
624846: *Spacecraft Payload Technologies*	-	15.812	15.203	14.478	-	14.478	14.655	14.917	15.175	15.138	Continuing	Continuing
625018: *Spacecraft Protection Technology*	-	7.568	8.498	15.049	-	15.049	19.800	21.964	23.646	25.239	Continuing	Continuing
628809: *Spacecraft Vehicle Technologies*	-	40.066	39.369	43.625	-	43.625	41.527	41.711	46.068	47.269	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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	103.955	98.229	108.821	-	108.821
Current President's Budget	100.066	98.229	116.122	-	116.122
Total Adjustments	-3.889	-	7.301	-	7.301
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-2.062	-			
• SBIR/STTR Transfer	-1.827	-			
• Other Adjustments	-	-	7.301	-	7.301

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*

Change Summary Explanation

Funding realigned in FY14 to support high priority science and technology effort.

Increase in FY16 is due in part to realignment of research efforts.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*	Project (Number/Name) 621010 / *Space Survivability & Surveillance*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
621010: *Space Survivability & Surveillance*	-	36.620	35.159	42.970	-	42.970	32.954	38.922	35.447	35.165	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 2014	FY 2015	FY 2016
Title: Space Environment Research	5.473	5.309	14.795

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 2014 Accomplishments:

Continued research on energetic space particle dynamics due to distorted magnetic fields and exploited multiple recent data sets to improve quality of spacecraft environmental hazard predictions. Continued spacecraft material temperature, dose, and aging effects research. Developed next-generation miniaturized space environment sensor concepts. Exploited developing solar ultraviolet emission and solar wind models to enable a time-dependent solar wind model capable of handling transients. Investigated potential alternatives to traditional solar flare specification and prediction to achieve more accurate predictions. Developed improved solar radio frequency monitoring concepts.

FY 2015 Plans:

Take delivery of unique pulsed electroacoustic sensor to measure charging inside materials and begin testing capability to research material susceptibility to internal charging while exploiting continued material aging research. Exploit new on-orbit data sources to enhance energetic space environment models. Initiate research on methods for remote measurement of spacecraft material properties. Begin researching novel techniques for solar energetic particle forecast.

FY 2016 Plans:

Initiate research program to quantify/predict internal charging for new and aged materials. Begin analyzing and exploiting data from the on-orbit radiation remediation proof-of-concept experiment, as well as existing on-orbit spacecraft. 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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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. Deliver an improved, validated ionospheric scintillation model for the Global Positioning System (GPS) Interference and Navigation Tool (GIANT) software program, the standard for estimating real world operational GPS performance. 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 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.			
Title: Surveillance Technologies ***Description:*** Develop advanced target detection techniques, spectral signature libraries, and decision aids for space-based sensors and surveillance systems. ***FY 2014 Accomplishments:*** Continued space-based hypertemporal (HT) sensor performance trade studies. Evaluated HT detection methods for concealed activity monitoring. Discontinued hyperspectral imaging work due to increased emphasis in HT sensor technologies. ***FY 2015 Plans:*** Evaluate HT data processing methods and target detection algorithms for space-based, early missile warning. Deliver space-based HT sensor performance trade studies for optimal early missile detection. Explore and evaluate new innovative HT detection methods for concealed activity monitoring. ***FY 2016 Plans:*** Expand evaluation of HT 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 HT detection methods for concealed activity, including identification of technology gaps needing additional investigation for use in monitoring difficult threats. Initiate development of HT space-based data collection events and ground truth field campaigns for new HT flight experiment investigating advanced concept for early missile warning and dim target detection.	10.379	9.534	8.358
Title: Ionospheric Research	7.274	6.689	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop techniques, forecasting tools, and sensors for ionospheric specification and forecasting, space-based geolocation demonstrations, and determination of potential radar degradation. ***FY 2014 Accomplishments:*** Continued investigations for physics-based improvements of space weather specification and forecast models related to impacts on DoD systems. Developed improved modeling capability for scintillation impacts on communication, GPS, and remote sensing, and for environmentally-induced satellite anomalies, by assimilating space, ground, and unexploited data sources. Began implementing plan for increasing measurements in under-sampled regions for more accurate prediction of radio link degradation. Validated preliminary baseline ionospheric simulation and radio frequency illumination capability for high frequency (HF) geolocation and radar systems; initiated model and data utility trade studies; began development of advanced simulation techniques. ***FY 2015 Plans:*** Continue investigations for physics-based space weather specification and forecast models related to impacts on DoD systems. Validate improved modeling capabilities for scintillation impacts on communications, GPS and remote sensing, and for environmentally-induced satellite anomalies. Begin development of next model increments. Integrate and quantitatively assess 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. Incorporate advanced ionospheric sounding techniques and traveling ionospheric disturbance effects into simulation model for next generation radar systems. Conduct application-specific trade studies for model components and data types. Demonstrate high frequency radio geolocation coordinate registration capability. ***FY 2016 Plans:*** This effort has been combined with the Space Environment Research effort in the same project.			
Title: Radiation Remediation Research ***Description:*** Conduct Radiation Belt Remediation (RBR) research through developing and validating analytical performance models for remediation of Earth radiation belts following high altitude nuclear detonation. ***FY 2014 Accomplishments:*** Continued ground-based very low frequency (VLF) propagation experiments using national and international assets. Validated revised VLF ionospheric propagation models for RBR modeling to include natural and man-made VLF sources. Incorporated results from planned VLF and particle mapping flight experiment to support ground-based and space-based VLF transmitter experiments. ***FY 2015 Plans:***	4.366	3.529	4.756

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Validate RBR end-to-end model version 2.0 using ground and space-based measurements with the very low frequency particle mapper and satellite experiments. Conduct fielded RBR capability assessments to determine rough order fielded system requirements. ***FY 2016 Plans:*** Validate RBR end-to-end model version 3.0 using ground and space-based measurements with the very low frequency particle mapper and satellite and terrestrial experiments. Conduct fielded RBR capability assessments to determine rough order fielded system requirements.			
Title: Seismic Technologies ***Description:*** Develop seismic technologies to support national requirements for monitoring nuclear explosions with special focus on regional distances less than 2,000 kilometers from the sensors. ***FY 2014 Accomplishments:*** Improved resolution of three-dimensional physics-based seismic wave propagation models through scientific and computational advances. Investigated use of these three-dimensional models to match all details of seismic signals. Continued extending coverage of unified model. ***FY 2015 Plans:*** Assess relative utility of different scientific and computational advances for improving the accuracy of three-dimensional seismic wave propagation models. Explore use of details of seismic signals in three-dimensional models for discrimination of explosions from earthquakes. Extend coverage and increase resolution of unified model. ***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.	4.824	5.292	7.532
Title: Alternative Navigation Technologies ***Description:*** Develop new technologies based on cold atom physics that provide autonomous jam-proof precision inertial navigation to augment Global Positioning System (GPS) in case of GPS-denial. Develop atomic clocks based on new technologies to replace legacy GPS atomic clocks. ***FY 2014 Accomplishments:*** Designed a compact atomic clock that would provide both the accuracy and robustness necessary to replace legacy atomic clocks for GPS with modern sustainable technology. Began construction of a free space cold atom gyroscope/accelerometer	4.304	4.806	7.529

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 621010 / *Space Survivability & Surveillance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
that would enable GPS-free precision navigation. Evaluated design of a confined cold atom gyroscope to reduce size and weight requirements to expand GPS-free navigation to a larger number of Air Force platforms. ***FY 2015 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. Test a completed free space, cold atom single-axis gyroscope/accelerometer to learn about its strengths and limitations. Continue 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 AF platforms. ***FY 2016 Plans:*** Continue to advance the development of compact atomic clocks with improved accuracy and stability to replace legacy atomic clocks. Receive clock deliverable from the National Institute of Standards and Technology for testing. 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.			
Accomplishments/Planned Programs Subtotals	36.620	35.159	42.970

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*	Project (Number/Name) 624846 / *Spacecraft Payload Technologies*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
624846: *Spacecraft Payload Technologies*	-	15.812	15.203	14.478	-	14.478	14.655	14.917	15.175	15.138	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 2014	FY 2015	FY 2016
Title: Space-Based Detector Technologies	2.098	0.982	2.656
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 2014 Accomplishments:*** Continued to develop innovative alternative materials/components and technologies to enable new capabilities or enhance existing performance of space sensors. Pursued revolutionary breakthroughs to improve target detection and identification, enable mission configurability, and provide all-weather, all-terrain, dim/distant target detection and identification while reducing the volume, weight and cost. ***FY 2015 Plans:*** Continue to develop and mature an alternative sensor material system to include: increased operating temperature, reduced non- uniformity, and reduced cost. Explore 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.			
Title: Space Situational Awareness Sensing (SSA) Research	3.091	3.102	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 624846 / *Spacecraft Payload Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop innovative means for measuring, modeling, and predicting phenomena for SSA and protection applications. Develop new methods to evaluate how well specific data contributes to identifying particular physical and functional information about a space-based object, and ultimately enable decision-makers to pursue courses of action. ***FY 2014 Accomplishments:*** Verified and validated predictive modeling capabilities against laboratory and field measurements. Initiated next-generation analysis of sensing methods and phenomena to exploit for space protection. ***FY 2015 Plans:*** Begin execution of experiment campaign to measure satellite components to verify and validate predictive modeling capabilities against these laboratory and field measurements. Begin systems analysis to establish performance requirements under validated threat scenarios. Initiate next-generation analysis of sensing methods and phenomena to exploit for space protection. ***FY 2016 Plans:*** Note: In FY16, this effort will be combined with the Threat Warning Research effort in project 625018, "Spacecraft Protection Technology," to better align technical efforts.			
Title: Space Electronics Research ***Description:*** Develop technologies for space-based payload components such as radiation-hardened electronic devices, micro-electro-mechanical system devices, and advanced electronics packaging. ***FY 2014 Accomplishments:*** Completed investigation of hardening techniques to protect satellites from high power microwaves. Completed integration model of basic technologies for proof-of-concept system-on-chip integration. Continued research and development of advanced system-on- chip integration for improved performance of space sensor systems. Completed three-dimensional evaluation test devices to prove feasibility of the process within the foundry. Continued development of integrated modules using three-dimensional techniques to reduce size, weight, and power and increase performance. Began investigating multicore processor architectures for integration with three-dimensional and system-on-chip techniques. ***FY 2015 Plans:*** Complete development of integrated modules using three-dimensional techniques to increase throughput while reducing size, weight, and, especially, power. Explore new transistor designs that are compatible with current manufacturing techniques but more efficient and radiation tolerant at ultra-small feature sizes (e.g., 7nm). Expand 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. Continue exploration of successful integration techniques for system-on-chip integrated circuits. ***FY 2016 Plans:***	3.634	3.684	2.580

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 624846 / *Spacecraft Payload Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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 Memristor 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.			
Title: Modeling and Simulation Tools for Space Applications ***Description:*** Develop modeling and simulation tools for space-based ground surveillance systems, rendezvous and proximity operations, imaging of space systems, disaggregated satellite architecture, and space control payloads. ***FY 2014 Accomplishments:*** Continued to develop spacecraft and mission simulations in close conjunction with customers across DoD. Integrated state-of-the-art system performance and mission planning algorithms into modeling and simulation software tools. Transitioned validated tools to the data center in preparation for upcoming flight programs. ***FY 2015 Plans:*** Continue to develop spacecraft and mission simulations in close conjunction with customers across the DoD. Continue to integrate state-of-the-art system performance and mission planning algorithms into modeling and simulation software tools. Revise flight tools based on recent flight program experience. Support technology development and maturation through capability and mission utility studies and size, weight, and power-cost trade studies. ***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.	4.683	4.451	4.791
Title: Alternative Positioning, Navigation, and Timing Technology ***Description:*** Identify and develop technologies that enable new, or enhance existing, U.S. positioning, navigation, and timing (PNT) satellite capabilities by increasing resiliency and availability of accuracy, and/or increasing the affordability of providing current capabilities. Develop technologies to meet identified Air Force Space Command/Space and Missile Systems Center PNT space payload technology needs. ***FY 2014 Accomplishments:***	2.306	2.984	4.451

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 624846 / *Spacecraft Payload Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Began program development activities required to design, fabricate, integrate, test and deliver an advanced technology, high power, high efficiency and reliable L-band Radio Frequency (RF) amplifier that is compatible with Global Positioning Systems L-band navigation signal transmission. ***FY 2015 Plans:*** Conduct 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. Conduct studies to identify alternative and innovative technology options for PNT payloads. ***FY 2016 Plans:*** 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.			
Accomplishments/Planned Programs Subtotals	15.812	15.203	14.478

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*	Project (Number/Name) 625018 / *Spacecraft Protection Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
625018: *Spacecraft Protection Technology*	-	7.568	8.498	15.049	-	15.049	19.800	21.964	23.646	25.239	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 2014	FY 2015	FY 2016
Title: Threat Warning Research	7.568	8.498	15.049

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.

FY 2014 Accomplishments:

Enhanced satellite-as-a-sensor technology development. Demonstrated improved ability to determine satellite orbital conjunctions and develop proof-of-concept for closed loop situational awareness system. Developed integrated sensor and response system for threat detection, characterization, and warning. Advanced detection sensor technology to improve data-to-information-to-decision capabilities. Developed improved sensor algorithms and data fusion techniques. Continued to reduce size, weight, and power requirements for next generation proximity detection sensors.

FY 2015 Plans:

Down select and mature next generation proximity detection sensor technologies and sensor suite integration. Provide technology support for the next Joint Space Operations Center (JSpOC) Mission Systems upgrade. Complete instantiation of JSpOC Mission Systems (JMS) space situational awareness testbed. Develop SSA closed loop simulation showing automated threat detection and response actions. Evaluate 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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 625018 / *Spacecraft Protection Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Accomplishments/Planned Programs Subtotals	7.568	8.498	15.049

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602601F / *Space Technology*	Project (Number/Name) 628809 / *Spacecraft Vehicle Technologies*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
628809: *Spacecraft Vehicle Technologies*	-	40.066	39.369	43.625	-	43.625	41.527	41.711	46.068	47.269	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 2014	FY 2015	FY 2016
Title: Space Power/Thermal Research	4.486	4.491	5.078
Description: Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts. ***FY 2014 Accomplishments:*** Completed preliminary cryocooler modeling, energy analysis of single and multi-stage coolers, and cross gimbal/distributed cooling to improve cryocooler efficiency and demonstrate some strategies. Continued to research and advance effective low and zero vibration cryocooler technologies, including solid state coolers. Began moving forward with maturation of most promising technical approaches for greater than 40% efficient solar cells. Continued development of novel flexible array technologies to enable greater launch volume stowage efficiency and higher specific power. ***FY 2015 Plans:*** Continue to examine new solid state, zero vibration cryocooler methods. Perform studies on how new solid state technologies may be integrated directly to a focal plane array to show representative thermal loading. Continue development of greater than 40% efficient solar cell approaches. Investigate advanced photon management approaches. Continue optimizing flexible solar array for mass and volume efficiency. ***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 60kW/m3 performance. Initiate follow-on development for achieving 70-80 kW/m3 array performance.			
Title: Space Structures and Controls Research	10.440	7.884	10.037
Description: Develop revolutionary and enabling technologies, including lighter weight, lower cost, high performance structures for space platforms; guidance, navigation, and controls hardware and software for next generation of space superiority systems.			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 628809 / *Spacecraft Vehicle Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Performed multi-physics characterization of relevant and non-linear structural materials (mechanical, thermal, electromagnetic). Produced flight hardware for experimental de-orbit mechanism for satellites and rocket stages. Completed advanced dynamics analysis methods efforts and demonstrate in relevant environment(s); continued space debris mitigation efforts; continued collaborative autonomous spacecraft guidance, navigation, and control efforts supporting distributed spacecraft missions; initiated efforts to integrate guidance, navigation, and control methods with advanced spacecraft autonomy decision architectures. Demonstrated on the ground space-to-space surveillance system with autonomous sensor control. ***FY 2015 Plans:*** Improve and refine collaborative autonomous spacecraft guidance, navigation, and control efforts supporting distributed spacecraft missions. Continue efforts to integrate guidance, navigation, and control methods with advanced spacecraft autonomy decision architectures. Integrate multi-spacecraft and autonomous spacecraft efforts to establish multiple autonomous spacecraft technology capability. Develop improved constitutive models for composite materials. Continue research to improve the fabrication and manufacture of precision and high tolerance composite structures. Perform research in thermal management technologies for heat dissipation of high power and high energy density electronics. Deliver and transition analytic and numerical tools and demonstrate multi-physics optimization of satellite structures. ***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 Global Positioning System (GPS) spacecraft. Explore new meta-material technologies to improve the electromagnetic interaction characteristics of Air Force spacecraft structures.			
Title: Space Experiments ***Description:*** Develop flight experiments to improve the capabilities of existing operational space systems and to enable new transformational space capabilities. ***FY 2014 Accomplishments:*** Continued pre-launch preparations and pre-launch-vehicle integration for on-orbit radiation remediation proof-of-concept experiment. Developed innovative technologies for planned on-orbit experiment using the Evolved Expendable Launch Vehicle	19.537	20.947	19.435

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 628809 / *Spacecraft Vehicle Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Secondary Payload Adaptor to support both platform and payloads, as well as developing advanced interfaces to accommodate partner payloads and technologies. Completed manufacturing and delivery of very low frequency particle mapper (VPM) payload suite, and begin satellite bus integration. Began VPM mission launch readiness actions. ***FY 2015 Plans:*** Continue pre-launch preparations, launch the on-orbit radiation remediation proof-of-concept experiment. Perform launch and early orbit activities and then on-orbit satellite experiments operations. Complete science payload designs and long lead procurement for maneuverable geosynchronous space vehicle experiment. Verify system design for science data collections. Verify payload subsystem hardware and software after component/subsystem delivery. Prepare for component/subsystem tests, complete experiment planning for maneuverable geosynchronous experimental platform design payload configurations, and begin to prepare for final spacecraft integration and test. Complete VPM space vehicle assembly integration and test. ***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 HyperTemporal (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. Identify candidate technologies and payloads for next-generation space experiment. Determine technical objectives for multiple space experiment payloads and technology maturation necessary in a space experiment planned for the FY19-21 timeframe.			
Title: Space Communication Technologies ***Description:*** Develop technologies for next-generation space communications terminals and equipment and methods/techniques to enable future space system operational command and control concepts. ***FY 2014 Accomplishments:*** Continued applied research and development efforts (modeling, simulation, and laboratory testing) to reduce component technical risks (e.g., functionality and performance) and to meet technology and capability needs for optical (i.e., laser communication), millimeter-wave (i.e., Ka-band, V-band, W-band), and protected satellite communication technology. ***FY 2015 Plans:***	5.603	6.047	9.075

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602601F / *Space Technology*	**Project (Number/Name)** 628809 / *Spacecraft Vehicle Technologies*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continue applied research and development efforts (modeling, simulation, and laboratory testing) to reduce component technical risks and to meet technology needs. Specifically, work to develop a propagation flight experiment to characterize the W and V frequency bands for future military satellite communications. Begin evaluation of optical communication links with small spacecraft. ***FY 2016 Plans:*** Complete design phase of W and V frequency band flight experiment. Establish Continental US 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.			
Accomplishments/Planned Programs Subtotals	40.066	39.369	43.625

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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602602F / *Conventional Munitions*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	80.804	87.387	99.851	-	99.851	101.043	103.921	104.261	106.387	Continuing	Continuing
622068: *Advanced Guidance Technology*	-	32.513	40.757	46.822	-	46.822	47.549	47.713	47.046	47.998	Continuing	Continuing
622502: *Ordnance Technology*	-	48.291	46.630	53.029	-	53.029	53.494	56.208	57.215	58.389	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)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	81.521	87.387	97.399	-	97.399
Current President's Budget	80.804	87.387	99.851	-	99.851
Total Adjustments	-0.717	-	2.452	-	2.452
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.717	-			
• Other Adjustments	-	-	2.452	-	2.452

Change Summary Explanation

Increase in FY 2016 due to a higher priority for seeker, guidance and control, and ordnance technologies for air superiority.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / *Conventional Munitions*	Project (Number/Name) 622068 / *Advanced Guidance Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
622068: *Advanced Guidance Technology*	-	32.513	40.757	46.822	-	46.822	47.549	47.713	47.046	47.998	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, 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 2014	FY 2015	FY 2016
Title: Seeker Technologies	6.780	9.000	11.500

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

FY 2014 Accomplishments:
Developed technologies that simplify, increase the flexibility, and reduce the cost of passive and active electro-optical, infrared, and radar munition seekers, with focus on combat operations in adverse weather and in high-speed engagements. Continued developing seeker technologies that provide enhanced mission capability for fifth generation aircraft, specifically as it applies to success in denied or anti-access environments. Developed algorithms and processing technologies to acquire and track targets with and without an operator in the loop. Increased emphasis on revolutionary bio-inspired seeker technologies to increase immunity to countermeasures, to exploit multi-discriminant signatures, and to reduce the size and cost of detectors; and also increased emphasis on high-resolution wide field of view (WFOV) sensors, particularly with bio-inspired and high-rate processing characteristics.

FY 2015 Plans:
Develop technologies that simplify, increase the flexibility, and reduce the cost of passive and active electro-optical, infrared, and radar munition seekers, with focus on combat operations in adverse weather and in high-speed engagements. Continue to emphasize high-resolution WFOV sensors, particularly with bio-inspired and high rate processing characteristics to allow precise munition terminal guidance in degraded, contested environments.

FY 2016 Plans:
Continue to develop technologies that simplify, increase the flexibility, and reduce the cost of passive and active electro-optical, infrared, and radar munition seekers, with focus on combat operations in adverse weather and in high-speed engagements. Continue to emphasize technology development for high-resolution WFOV sensors, particularly with bio-inspired and high rate

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622068 / *Advanced Guidance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
processing characteristics to allow precise munition terminal guidance in degraded, contested environments. Explore terminal seeker technologies that enable innovative air-to-air engagements.			
Title: Aerodynamics, Navigation and Control Technologies ***Description:*** Develop weapon aerodynamic, control, navigation, and networking technologies for air-delivered munitions to provide precise, agile flight, networked effects, and immunity to countermeasures. ***FY 2014 Accomplishments:*** Developed technologies for precision navigation under GPS-degraded and GPS-denied conditions. Developed 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, especially for munitions during high-speed engagements. Investigated multi-functional, multi-strategy weapon swarms to defeat enemy defenses. ***FY 2015 Plans:*** Increase emphasis in developing technologies that achieve precision navigation under GPS-degraded and GPS-denied conditions. 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. Continue to investigate multi-functional, multi-strategy weapon swarms to defeat enemy defenses. Develop technologies for weapon-platform interfaces that enable flexible, reprogrammable load-outs and achieve hardware and software modularity. ***FY 2016 Plans:*** Continue developing technologies that achieve precision navigation 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. Continue to investigate multi-functional, multi-strategy weapon swarms to defeat enemy defenses. Continue developing technologies for weapon-platform interfaces that enable flexible, reprogrammable load-outs and achieve hardware and software modularity. Develop airframe and control technologies that enable innovative air-to-air engagements.	18.800	24.000	26.212
Title: Guidance Technologies ***Description:*** Develop guidance subsystem integration and evaluation technologies to provide open and closed loop ground testing, flight test risk reduction, and digital simulation of novel concepts. ***FY 2014 Accomplishments:*** Developed precision guided munition integration technology and functionality. Focused on capabilities to simulate, test, and refine seeker concepts and navigation and control approaches in a realistic operational environment. Continued to emphasize guidance	6.933	7.757	9.110

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622068 / *Advanced Guidance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
integration and evaluation technologies that provide enhanced mission capability for fifth-generation aircraft. Developed modeling techniques and tools to evaluate integrated, multi-weapon, and swarming search and attack. Improved test technologies for evaluating higher speed weapon guidance subsystems. ***FY 2015 Plans:*** Continue to develop a modular radio-frequency hardware-in-the-loop capability to support munitions concepts with high speed target engagement. Continue developing new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems. 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. ***FY 2016 Plans:*** Continue to develop a modular radio-frequency hardware-in-the-loop capability to support munitions concepts with high speed target engagement. Continue developing new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems. 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 improved simulation technologies that evaluate innovative air-to-air engagements.			
Accomplishments/Planned Programs Subtotals	32.513	40.757	46.822

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602602F / *Conventional Munitions*	Project (Number/Name) 622502 / *Ordnance Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
622502: *Ordnance Technology*	-	48.291	46.630	53.029	-	53.029	53.494	56.208	57.215	58.389	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 2014	FY 2015	FY 2016
Title: Energetic Materials Technology	10.000	10.000	10.300
Description: Investigate and develop energetic materials technology that can maximize weapon lethality, while applying appropriate safety and security features. ***FY 2014 Accomplishments:*** Developed, modeled, and tested explosive fills that reduce pre-detonation during warhead penetration. Further developed low density energetic materials for small munition applications. Exploited new nanoenergetic materials to enhance and tailor explosive effects. Emphasized development of energetic materials that improve performance and reduce bomb and missile size to increase loadout. ***FY 2015 Plans:*** Continue to emphasize development of energetic materials, including reactive cases, that improve performance and reduce bomb and missile size so as to increase loadout and increase safety. Continue to investigate energetic formulations that increase thermal and vibration tolerance required for very long range, high speed munitions. Continue to develop a virtual design tool for use in material design activities. ***FY 2016 Plans:*** Continue to emphasize development of energetic materials, including reactive cases, that improve performance and reduce bomb and missile size so as to increase loadout and increase safety. Continue to investigate energetic formulations that increase thermal and vibration tolerance required for very long range, high speed munitions. Continue to develop a virtual design tool for use in material design activities			
Title: Fuze Technologies	13.580	13.000	14.729
Description: Investigate and develop fuzes for air-delivered weapon applications to develop novel energetic initiation concepts, penetration fuzing, point burst fuzes, and develop predictive models.			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622502 / *Ordnance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Improved modeling and testing techniques to investigate novel methods to initiate explosives, to include distributed and embedded fuzing concepts. Emphasized development of fuze technologies that enable increased capacity and capability of fifth-generation aircraft, specifically as it facilitates success in denied or anti-access environments. Continued to investigate and characterize the mechanical environment that a fuze must survive during hard target penetration, and explore ground profiling imaging fuze technology. ***FY 2015 Plans:*** Continue developing a fuzing system employing ground profiling radar for miniature ordnance packages to enable more lethal forward-firing as well as low collateral damage. Investigate the capability to predict and measure fuze performance during munition penetration at high impact speeds. ***FY 2016 Plans:*** Continue developing fuzing system technologies to employ ground profiling radar for miniature ordnance packages 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 fuzing technologies that facilitate tailored lethal effects.			
Title: Warhead Technologies ***Description:*** Investigate and develop innovative warhead kill mechanisms, such as adaptable warheads, directional-control fragmenting warheads, and reactive metals. ***FY 2014 Accomplishments:*** Increased emphasis in developing warhead technologies, especially those that enable munition agility, variable effects, and improved energy coupling. Continued investigating directional warhead concepts to improve standoff kills for non-direct hit encounters by employing reactive fragments or by utilizing a forward focusing fragment capability. Developed tools to better predict material-to-material interface dynamics, loading, and vibration during high-speed penetration. ***FY 2015 Plans:*** Develop 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. Continue to develop small, multi-output warhead technologies primarily for soft surface targets, but with limited penetration capability for hardened, shallow structures. ***FY 2016 Plans:*** Develop 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. Continue to develop small, multi-output warhead	13.700	13.000	15.000

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622502 / *Ordnance Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
technologies primarily for soft surface targets, but with limited penetration capability for hardened, shallow structures. Explore novel warhead technologies that increase lethality in innovative air-to-air engagements.			
Title: Ordnance Technologies	11.011	10.630	13.000
Description: Using a system approach, investigate and develop ordnance concepts by making technology trades between fuzes, warheads, and explosives and by improving weapon carriage, release, and dispensing. ***FY 2014 Accomplishments:*** Continued to investigate precision guided munition integration issues and functionality in various flight environments, and continue building and using interoperable simulations to evaluate emerging technologies. Continued developing technologies to improve models for small munitions, penetrators, and counter chemical, biological, radiological, and nuclear effects. Developed ordnance concepts that increase the capacity and capability of fifth-generation aircraft. ***FY 2015 Plans:*** Continue to develop mission-level simulation architecture capability to enable weapon system and weapon technology assessments. Continue development of 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 aircraft. ***FY 2016 Plans:*** Continue to develop mission-level simulation architecture capability to enable weapon system and weapon technology assessments. Continue development of 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 aircraft. 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.			
Accomplishments/Planned Programs Subtotals	48.291	46.630	53.029

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602602F / *Conventional Munitions*	**Project (Number/Name)** 622502 / *Ordnance Technology*

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602605F / *Directed Energy Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	110.725	125.866	115.604	-	115.604	118.401	118.193	119.622	122.077	Continuing	Continuing
624866: *Lasers & Imaging Technology*	-	78.304	76.270	76.290	-	76.290	84.230	83.872	84.670	86.410	Continuing	Continuing
624867: *Advanced Weapons & Survivability Technology*	-	32.421	49.596	39.314	-	39.314	34.171	34.321	34.952	35.667	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; ground-based optical space situational awareness (SSA); and high power electromagnetics (HPEM). Laser research includes moderate to high power laser devices that are applicable to a wide range of applications, optical technologies to propagate lasers beams from a device, and integration of these technologies. 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. 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. 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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	112.783	125.955	117.559	-	117.559
Current President's Budget	110.725	125.866	115.604	-	115.604
Total Adjustments	-2.058	-0.089	-1.955	-	-1.955
• Congressional General Reductions	-	-0.089			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.058	-			
• Other Adjustments	-	-	-1.955	-	-1.955

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602605F / *Directed Energy Technology*

Change Summary Explanation

In FY16 decrease due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / *Directed Energy Technology*	Project (Number/Name) 624866 / *Lasers & Imaging Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
624866: *Lasers & Imaging Technology*	-	78.304	76.270	76.290	-	76.290	84.230	83.872	84.670	86.410	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. 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 2014	FY 2015	FY 2016
Title: High Energy Laser Technologies and Directed Energy Assessments	52.244	51.192	51.890

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 2014 Accomplishments:

Continued to conduct research supporting a joint Air Force/Defense Advanced Research Projects Agency (DARPA) ground demonstration of a high power solid state laser with a beam control system. Prepared for future flight tests of beam control technologies. Continued integration and began testing of horizontal propagation compensation concepts. Began developing analysis tools including platform, optics, controls, and atmospheric effects as well as target predictions supporting future weapons analysis for an Integrated Weapons Environment for Analysis (IWEA) to analyze directed and kinetic energy weapons in a common environment to help plan weapons investments. Conducted effects testing to establish system requirements and validate modeling efforts. Designed a narrow line width (sub-gigahertz) monolithic fiber amplifier with good beam quality. Began design of laser system for aircraft self-protection.

FY 2015 Plans:

Continue to conduct research supporting a joint Air Force/DARPA ground demonstration of a high power solid state laser with a beam control system. Use effects testing to establish system requirements and validate modeling efforts. Evaluate subscale turret beam control technologies. Update and use IWEA to analyze directed and kinetic energy weapons in a common environment to help plan weapons investments. Use intelligence information to evaluate foreign HEL threats and provide

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624866 / *Lasers & Imaging Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
weapon system and technology developers with tools and criteria to help protect US systems. Begin integration of beam control technologies and monolithic fiber amplifier for ground to air field tests. Continue 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 subscale 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 and SSA systems to help users plan weapons investments. Model and characterize foreign HEL threats to blue systems and provide assessments to developers for hardening materials and designs.			
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. Operated the Starfire Optical Range in support of internal and customer requirements. ***FY 2014 Accomplishments:*** Demonstrated capability to determine orientation of geosynchronous satellites. Demonstrated use of laser guidestar to enable detection of objects the size of a basketball in close proximity to geosynchronous satellites. Developed data analysis techniques to understand and keep track of potential threat objects in space. Developed initial capabilities for extending existing techniques into 24-hour operations. Developed technologies to quantify the vulnerability and protection needs of certain blue satellite components. ***FY 2015 Plans:*** Develop dynamic telescope control to keep track of potential threat objects in space. Demonstrate data analysis techniques to understand characteristics of potential space threats and satellite anomalies. Demonstrate capabilities for extending existing techniques into 24-hour operations. Evaluate concepts for persistent monitoring of space events and capability to image and search the local space around our high-value satellite assets, including low power testing for 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 advise Air Force Space Command programs on technology options. 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.	26.060	25.078	24.400
Accomplishments/Planned Programs Subtotals	78.304	76.270	76.290

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624866 / *Lasers & Imaging Technology*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / *Directed Energy Technology*	Project (Number/Name) 624867 / *Advanced Weapons & Survivability Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
624867: *Advanced Weapons & Survivability Technology*	-	32.421	49.596	39.314	-	39.314	34.171	34.321	34.952	35.667	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. 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 2014	FY 2015	FY 2016
Title: HPEM and Unconventional Weapon Technologies	19.933	30.268	19.810
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 2014 Accomplishments:*** Developed state-of-the-art components to further shrink antennas, microwave sources, and energy storage/prime power systems. Investigated technologies to provide frequency agile, broadband sources. Conducted assessments on the feasibility of particle beam weapons for counter-electronics. ***FY 2015 Plans:*** Begin ultra-short pulsed laser atmospheric propagation studies. Conduct effects studies on electronics based on the assessments from FY14. Develop compact 50 kilovolt solid state switch. Develop designs for 100 megavolt test facility accelerator. Increase 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 demonstration.			
Title: HPEM Effects and Mitigation Research	12.488	19.328	19.504

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624867 / *Advanced Weapons & Survivability Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Assess the effects/lethality of HPEM technologies. Develop and apply sophisticated models to enhance the development of HPEM and related technology. Develop tools and perform assessments which allow comparisons among DE concepts and tradeoffs between DE and non-DE solutions. Investigate technologies to counter the effects of HPEM. ***FY 2014 Accomplishments:*** Began incorporating effects of high bandwidth and smart waveform technologies and techniques into numerical simulations. Began funding the Air Force portion of the High Power Microwave Software Applications Institute. This is an Air Force/DoD High Performance Computing Modernization Program for the development of advanced, user friendly, modeling and simulation capability for entire HPEM systems. ***FY 2015 Plans:*** Develop source for effects testing that operates in three microwave bands. Complete integration of software into DE High Performance Computing Software Applications Institute, 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. Use intelligence information to evaluate foreign HPEM threats and provide weapon system and technology developers with tools and criteria to help protect US systems. ***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.			
Accomplishments/Planned Programs Subtotals	32.421	49.596	39.314

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624867 / *Advanced Weapons & Survivability Technology*

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	136.885	147.749	164.909	-	164.909	163.132	159.658	164.707	168.102	Continuing	Continuing
625315: *Connectivity and Protection Tech*	-	56.969	65.675	72.746	-	72.746	72.130	68.943	74.675	76.224	Continuing	Continuing
625316: *Info Mgt and Computational Tech*	-	25.626	27.511	31.187	-	31.187	34.020	32.747	31.809	32.466	Continuing	Continuing
625317: *Information Decision Making Tech*	-	15.631	13.191	20.485	-	20.485	14.932	14.855	14.193	14.486	Continuing	Continuing
625318: *Operational Awareness Tech*	-	20.378	20.650	19.235	-	19.235	20.342	22.049	22.553	23.012	Continuing	Continuing
62OMMS: *Research Site Support*	-	18.281	20.722	21.256	-	21.256	21.708	21.064	21.477	21.914	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. 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 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force					Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*		R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*			
B. Program Change Summary ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	138.145	147.789	167.051	-	167.051
Current President's Budget	136.885	147.749	164.909	-	164.909
Total Adjustments	-1.260	-0.040	-2.142	-	-2.142
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.260	-			
• Other Adjustments	-	-0.040	-2.142	-	-2.142

Change Summary Explanation

Decrease in FY16 Other Adjustments is due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 625315 / *Connectivity and Protection Tech*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
625315: *Connectivity and Protection Tech*	-	56.969	65.675	72.746	-	72.746	72.130	68.943	74.675	76.224	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Advanced Connectivity Technologies	25.154	23.806	28.239
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 2014 Accomplishments: Completed development of techniques to fuse disparate IP-based airborne radio networks into a single, Joint Aerial Layer Network (JALN)-responsive airborne mesh. Developed techniques to reduce information bandwidth requirements by 3 orders of magnitude allowing for real-time operations using existing communication links. Developed key technologies to address issues in dealing with the extremely dynamic nature of the tactical edge/airborne network environment. Continued effort in V/W SATCOM technology by developing an attenuation prediction model for V and W band frequencies. Demonstrated quantum key communications in quantum noise (KCQ) over a free space link to test key distribution protocols in a real environment. Performed synthetic aperture radar (SAR) data optical relay flight test, transmitting data through a 2.5 Gb/s radio frequency (RF) link over 30 Km. Developed capability to measure V/W band attenuation with over 30 dB of dynamic range using the sun as a beacon. Measured attenuation statistics for V and W band (72.5 and 82.5 GHz) - the first attenuation statistics measured for frequencies greater than 50 GHz. Used field tests to verify the benefits in channel capacity of multiple input, multiple output (MIMO) systems.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625315 / *Connectivity and Protection Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Complete an accelerated waveform development process and associated tools. Demonstrate the digital portion of a 32 X 32 MIMO system. Continue ongoing 81 to 86 GHz Traveling Wave Tube Amplifier (TWTA) development. Complete bench-top demonstration of quantum key distribution (QKD) in concert with a multi-access lasercom system. Initiate research to investigate the use of autonomy on small unmanned aircraft system platforms to support (semi-)autonomous distributed cooperative airborne tactics using airborne networks. Initiate 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. Develop a waveform starter kit for multi-mission communications and radar. Perform dual site diversity radiometric testing for mitigating weather limitations. Continue development of automated process to port communication models to real-time hardware in the loop. Continue 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. 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 command, control, intelligence, surveillance, and reconnaissance (C2ISR) dissemination. ***FY 2016 Plans:*** Complete development of automated process to port communication models to real-time hardware in the loop. Continue 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. 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 command, control, intelligence, surveillance, and reconnaissance (C2ISR) dissemination. Continue research to advance autonomy in unmanned air vehicles to support distributed cooperative airborne tactics using advanced communications techniques. Continue the development and integration waveform components, tools, and hardware into an innovative ecosystem for affordable rapid waveform development over a continuum of COTS/GOTS software defined radio frequency architectures. Initiate development of advanced hardware for multi-mission agile RF capability. Perform analysis of radiometric site diversity data for rain cell sizes and distribution of rain cells.			
Title: Cyber Defense Technologies ***Description:*** Develop cyber defense and supporting technologies to detect, defend, and respond to attacks on computer systems as well as provide forensic analysis concerning the attacks. ***FY 2014 Accomplishments:*** Developed a solution for technology-enforced policy and non-cloud detonation chamber solution. Extended IP hopping technology from IPv4 to IPv6, and enhanced the technology with situational awareness sensor feed and interface with cyber C2 system. Extended configuration-based agility/moving target capability from centralized to decentralized architecture, and added support for IPv6, additional device families, IP hopping control, limited quality of service, firewall verification, and improved resiliency.	14.463	17.860	20.906

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625315 / *Connectivity and Protection Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Extended polymorphic enclave technology from hypervisor-based host installation to external in-line device, added management console and improved policy flexibility, and gateway capability for access outside of the polymorphic network. Developed a capability for self-regenerative code. Continued development in the areas of Survive and Recover, Trusted and Resilient Systems and Secure End-to-End Publish and Subscribe, under the University Center of Excellence (UCoE) in Assured Cloud Computing (ACC). Completed early stage design and development of a framework to support trusted execution of cloud applications using diagnostics to test trustworthiness. Developed prototype survivability architecture for continuous mission-oriented assessment and management that is planned to be validated at Eglin Air Force Base's simulated Air Operations Center environment. ***FY 2015 Plans:*** Initiate research in Cyber Intelligence, Surveillance, and Reconnaissance (ISR) technologies to support integrated Signals Intelligence (SIGINT)-Cyber operations. Initiate 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. Continue interaction with the University Center of Excellence (UCoE) in Assured Cloud Computing (ACC) and collect performance results for a framework to assess cloud trustworthiness. Initiate research for enhanced cyber situational awareness through the automated assessment of mission execution through the analysis of network traffic flows. ***FY 2016 Plans:*** Initiate development of a desktop and mobile variant of a cyber detonation chamber; a critical component for mission assurance. Continue enhancement, maturation, testing, and demonstration of Cyber Agility technologies through exercises and other user-focused venues toward the objective of transition. Expand Cyber ISR research to further focus on location and processing of data of interest. Continue interaction with the UCoE ACC. Continue research for enhanced cyber situational awareness through the automated assessment of mission execution through the analysis of network traffic flows.			
Title: Cyber Offense Technologies ***Description:*** Develop offensive cyber operations technologies to access, maintain presence on, and deliver effects to adversary systems. ***FY 2014 Accomplishments:*** Developed and tested blind signal classification and interference mitigation techniques for software-defined signal processing in unlicensed spectrum and anti-access area-denial (A2/AD) scenarios of dense spectrum conflict. Developed and tested algorithms, hardware, software and techniques for prosecuting low-frequency signals of interest (SOI). Initiated design of a highly configurable cyber simulation environment which produces high fidelity cyber telemetry for analysis. Initiated development of distributive and disruptive cyber technologies capable of achieving non-kinetic military objectives. Transitioned software to provide new capabilities to Big Safari program office (details classified). Developed SOA components for the Cyber Mission Framework to	16.930	18.380	18.291

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625315 / *Connectivity and Protection Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
enable cross-service tool operation, mission reporting, and cyber use control constructs. Initiated red-teaming analysis of this framework. Continued developing techniques for the exploitation of signals of interest. ***FY 2015 Plans:*** Developed and tested blind signal classification and interference mitigation techniques for software-defined signal processing in unlicensed spectrum and anti-access area-denial (A2/AD) scenarios of dense spectrum conflict. Developed and tested algorithms, hardware, software and techniques for prosecuting low-frequency signals of interest (SOI). Initiated design of a highly configurable cyber simulation environment which produces high fidelity cyber telemetry for analysis. Initiated development of distributive and disruptive cyber technologies capable of achieving non-kinetic military objectives. Transitioned software to provide new capabilities to Big Safari program office (details classified). Developed SOA components for the Cyber Mission Framework to enable cross-service tool operation, mission reporting, and cyber use control constructs. Initiated red-teaming analysis of this framework. Continued developing techniques for the exploitation of signals of interest. ***FY 2016 Plans:*** Initiate research on automation of cyber defense in order to survive in a contested cyber environment. Design, develop, and demonstrate tools and techniques to withstand cyber-attacks and to sustain (survive) or recover critical functions. Perform independent verification and validation (IV&V) as well as offensive-defensive red teaming of general-purpose electronic support (ES) and electronic attack (EA) software subsystems to enable offensive cyber operations via radio frequency (RF)-based methods. Continue to develop technologies to remain current with new waveforms and signals. Continue service oriented architecture component development for use in the Air Force Lifecycle Management Center (AFLCMC) Cyber Mission Platform (CMP). Continue red-teaming new components to improve security. Continue to increase automation and develop a software only processing capability for the exploitation of special signals of interest.			
Title: Survivability Technologies ***Description:*** Develop methods and technologies for controlled operation of information systems during attacks and fault conditions, minimizing vulnerabilities of cyber attacks, and guaranteeing the accuracy and correctness of data and codes. ***FY 2014 Accomplishments:*** Completed development of defensive cyber technologies to increase system survivability while under a cyber-attack. Demonstrated successful integration of four cyber S&T technologies into a singular system-of-systems providing cyber C2, SA, and defensive capabilities. ***FY 2015 Plans:***	0.422	0.235	0.803

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625315 / *Connectivity and Protection Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Initiate 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. ***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 on hiding mission essential functions (MEFs) in the cloud and rapidly recovering MEFs using the vast computing cloud resources.			
Title: Cyber Technologies for Spectrum Warfare ***Description:*** Develop technologies combining electronic warfare, signals intelligence (SIGINT), communications, and cyber technologies that provide synergistic access, exploitation, and effects across air and cyber domains in congested and contested environments. ***FY 2014 Accomplishments:*** N/A ***FY 2015 Plans:*** Initiate development of active and passive methods to locate, acquire, and process data and signals of interest. ***FY 2016 Plans:*** Continue development of active and passive methods to locate, acquire, and process data and signals of interest.	-	5.394	4.507
Accomplishments/Planned Programs Subtotals	56.969	65.675	72.746

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 625316 / *Info Mgt and Computational Tech*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
625316: *Info Mgt and Computational Tech*	-	25.626	27.511	31.187	-	31.187	34.020	32.747	31.809	32.466	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Dissemination Technologies	4.690	9.152	9.455
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 2014 Accomplishments:*** Completed research to develop and demonstrate resource-aware information management services that are responsive to the information needs of active missions by ensuring delivery of the most relevant, high priority information to the warfighter. Initiated development of embedded information management software services and adaptable user interfaces that will automate sensor tasking based on sensor availability and multiple consumer information needs. Continued 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. ***FY 2015 Plans:*** Complete development of information management services embedded with the sensor that will boost the effective communication bandwidth available to tactical users and link pilots, RPA, and ground assets in the field. Continue development			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625316 / *Info Mgt and Computational Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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. Initiate 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. Initiate 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. ***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 situational awareness (SA) across the theater of war for targeting and force protection operations.			
Title: Processing Technologies ***Description:*** Develop automatic and dynamically reconfigurable, affordable, scalable, distributed petaflop processing technologies for real-time global information systems. ***FY 2014 Accomplishments:*** Developed a general processing unit (GPU) implementation of a neural simulator based on Synchronous Matching Adaptive Resonance Theory (SMART), and the initial capability of multi-INT association of heterogeneous data via a SMART framework. Demonstrated the Air Force Research Laboratory Secure Processor chip on its test board with morphing opcodes, hardware AES encryption with key storage, and other security features. Continued research into computational models or approaches for increased system processing efficiency. Developed new approaches to coupling/processing quantum qubits. ***FY 2015 Plans:*** Continue development of advanced computing techniques, enabling superior information processing for Air Force warfighters through in-house research. Improve on-board processing to include real-time dissemination of 3D situational awareness of the battlespace. Investigate 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. Investigate the use of neuromorphic neural network techniques for real-time learning about unanticipated	10.867	7.156	6.720

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625316 / *Info Mgt and Computational Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
events (hypothesis discovery and testing). Initiate 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 A2/AD environments. ***FY 2016 Plans:*** 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 A2/AD 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 AFRL Secure Processor.			
Title: Cross Domain Technologies ***Description:*** Develop secure cross domain discovery services for access to services outside of existing domain. Develop the tools to allow collaboration of workflows required by the Air Force net-centric information management environment. ***FY 2014 Accomplishments:*** Delivered a suite of new collaboration capabilities for US and Coalition Multiple Levels of Security (MLS) environments producing four new cross-domain collaboration tools in: Voice over IP (VoIP) / Video Teleconferencing; Secure Full Motion Video (FMV) streaming; Automated & resilient data content inspection; Global trusted remote monitoring & management. Developed analytics to provide network and user behavioral information that relate to risk management decisions for cross domain solutions (CDS). ***FY 2015 Plans:*** Develop an innovative approach to malicious code detection by running suspect files within a virtual environment and comparing the execution with normal application behaviors. Develop a secure foundation for mobile devices that will act as a foundation for a multiple levels of security (MLS) mobile device. Develop a cross-domain video teleconference (VTC) capability that allows VTC participants to be on networks of differing classification. Develop automated techniques to correlate network events to CDS policy configurations allowing for automated remediation of attacks. ***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.	5.428	3.421	5.772
Title: Advanced Architectural Technologies ***Description:*** Develop the architectural mechanisms that form the basis for predictable software and high assurance systems.	4.641	7.782	9.240

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625316 / *Info Mgt and Computational Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: Emulated 40,000 neurons on neuromorphic processors with 200X more efficiency than state of the art conventional processing. Demonstrated model-based auto-code generation (analyze concurrent implementability and generates multi-threaded code) for polysynchronous system. Demonstrated multi-core worst-case analysis, scheduling methodology and deployment optimization for real-time systems, showing a 50% performance increase for real-time multi-core system with 24% increase in processor capacity. ***FY 2015 Plans:*** Complete creation of a trade space analysis tool used to determine feasibility and scale of autonomy on mobile systems. Complete demonstration of 3D stacking of logic chips on other logic chips while using standard processor fabrication lines. Initiate development of theory and techniques to continuously validate / reestablish trust utilizing mission objectives & warfighter perspectives (environment). Develop a continuous calculus of trust (verification & validation) as the system executes the mission. Initiate research of trusted and resilient systems using evolutionary and formal approaches. Develop automated repairs that are trusted, understandable and maintainable by humans. Initiate research for embedded processor to address the middle range computing requirements and having significant cyber hardening features. Initiate research to develop new, unconventional processing technologies with greater than10 X conventional processing energy efficiencies to allow efficient co-processing on-board. ***FY 2016 Plans:*** Develop new approaches to building trusted and resilient systems. Develop theory and techniques for trust of inherently resilient systems. Develop a strategic root of trust. Develop resiliency techniques such as artificial diversity. Develop containment areas for execution of untrusted software. Develop new hardware architectures that support trusted and resilient systems. Continue research for embedded processor to address the middle range computing requirements and having significant cyber hardening features. Develop and mature technologies for neuromorphic co-processing. Develop and mature memristive technologies for use in reducing the size weight and power of conventional processing while providing intrinsic, hardware based cyber security features for encryption, anti-tamper and unique identification. Develop an algorithm and system operation control for continuous, dynamic autonomous operations. Develop a processor to achieve universal quantum computation.			
Accomplishments/Planned Programs Subtotals	25.626	27.511	31.187

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625316 / *Info Mgt and Computational Tech*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 625317 / *Information Decision Making Tech*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
625317: *Information Decision Making Tech*	-	15.631	13.191	20.485	-	20.485	14.932	14.855	14.193	14.486	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 2014	FY 2015	FY 2016
Title: Campaign Planning Technologies	7.596	6.517	5.918
Description: Develop advanced monitoring, planning, and assessment technologies enabling aerospace commanders to develop effects-based campaigns. ***FY 2014 Accomplishments:*** Continued development of decision theory and continued the development of a capability for autonomous adaptive re-planning in a real-time simulation environment using a case-based planning system. Initiated development of evaluation services to determine operational planning feasibility. Completed investigation of full-spectrum, quantitative analysis techniques that aid operational assessor's ability to link actions to effects to desired objectives. Continued development of robust autonomous control algorithms for heterogeneous and distributed assets capable of learning in dynamic environments. Initiated research and development in cooperative agency and group transfer learning. ***FY 2015 Plans:*** Continue development of robust autonomous control algorithms for heterogeneous and distributed assets capable of learning in dynamic environments. Complete research in cooperative agency and group transfer learning. Initiate 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:*** Continue research for trust and verification and validation (V&V) for autonomous systems; develop a validation and verification methodology such that an agent acting autonomously will never act outside of a prescribed policy. 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. Initiate development of the living plan concept; decision theory and autonomous adaptive re-planning in a real-time.			
Title: Command and Control System Technologies	8.035	6.674	14.567

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625317 / *Information Decision Making Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Investigate, analyze, and develop technologies for planning, execution, and automatic rapid reconfiguration of distributed intelligent and integrated command and control (C2) information systems to achieve the commander's intent throughout varying crisis levels. ***FY 2014 Accomplishments:*** Continued in-house and university development of planning, decision making, and course of action (COA) tools supporting the commander's ability to exercise a wide range of command and execution options for Air Force assets. Developed technology to assist in the creation of COAs based on past experiences through the retrieval and matching of prior actions against current needs, then modifying these actions to adapt to new situations and world states. Initiated C2 capability that orchestrates the dynamic employment of multiple Moving Target Defense (MTD) components, configurations, and services across the enterprise to assure mission success. Continue development of fundamental visualization components that address 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. Automated space and intelligence processes to deliver web-based tools to space operations centers; research Bayesian techniques utilizing causal and physics-based modeling and simulation, as well as integer programming for enhanced course of action analysis. ***FY 2015 Plans:*** Characterize MTD attributes and de-conflict network and system resources across competing defenses. Complete development of fundamental visualization components that address 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. Initiate research on new concepts for space operations, such as the applicability of crowdsourcing methods in the space C2 domain; design and implement an Electromagnetic Spectrum Common Operational Picture (EMS-COP). ***FY 2016 Plans:*** Demonstrate planning, decision making, and COA tools supporting the commander's ability to exercise a wide range of command and execution options for Air Force assets. Demonstrate automated COA generation from an automated intelligence indicator. Continue research and development of automated decision aids for obtaining timely assessments of executing operations within and across the air, space and cyber domains. Continue research for the orchestration of the dynamic employment of multiple moving target defense components, configurations and services across the information enterprise to ensure the mission.			
Accomplishments/Planned Programs Subtotals	15.631	13.191	20.485

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625317 / *Information Decision Making Tech*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 625318 / *Operational Awareness Tech*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
625318: *Operational Awareness Tech*	-	20.378	20.650	19.235	-	19.235	20.342	22.049	22.553	23.012	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 2014	FY 2015	FY 2016
Title: Multi-Source Fusion Technologies	13.425	11.038	10.736
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 2014 Accomplishments: Developed scalable pattern mining analytics for multi-intelligence data (static and streaming). Initiated development of advanced reasoning tools for use in determining space object characteristics and behavior. Applied pattern learning algorithms against ground threats to space. Developed on-board ("the edge") technologies that track ground targets in real / near real time. The volume of information collected on-board and the necessity of operating in a contested environment requires the development of on-board techniques which in turn enables tactical support of the operators. Developed video-text fusion for Distributed Common Ground Station (DCGS)processing, exploitation, and dissemination (PED) cell operations. Developed a web service (client and web-based applications) that supports the mission and PED management of all AF RPA missions, improving processing time for analysts 60 fold for their most frequently requested product related to patterns of life. Utilizing distributed computing with only 7 nodes, improved search and retrieval performance by a factor of 5 and processing time by a factor of 300 compared to a single desktop. Developed automatic optimization of a tracker against multiple sensor sources. Developed time-based social network analysis metrics, plug and play algorithms for dynamic SNA, pattern discovery and social media analysis.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625318 / *Operational Awareness Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continue in-house and university research dealing with the information fusion using multi-source intelligence and sensor feeds to advance the Air Force capability to anticipate the variety of threats from the ground, air, and cyber domains. Apply advanced reasoning techniques to Multi-INT data including SIGINT and space surveillance network (SSN) data to assess space objects and determine significance of activity. Continue the development of on-board technologies that integrate and fuse data from disparate sensors and sources. Integrate on-board passive 3D processing to enhance algorithm performance and provide operators with greatly improved situational awareness. Continue to develop multi-INT fusion for contested environments to aid NASIC/ DCGS analysts. Develop automatic optimization of tracking algorithms across sensors, modes, and regions. Migrate tools and data to distributed (cloud) computing to extract additional performance gains. Provide baseline Activity-Based Intelligence (ABI) capabilities and metrics. Develop distributed cross-document co-reference for automated consolidation of information across documents; a flexible and adaptive platform for layered Network analysis. ***FY 2016 Plans:*** Continue in-house and university research dealing with the information fusion using multi-source intelligence 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 to apply 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.			
Title: Exploitation Technologies ***Description:*** Develop digital information exploitation technologies for electronic communications and special signals intelligence, imagery, and measurement signatures to increase accuracy, correlation, and timeliness of the information. ***FY 2014 Accomplishments:*** Continued development of a wide variety of exploitation methods to enhance signals exploitation of modern emerging signals expected from contested environments and increase situational awareness. Developed Level Zero Fusion algorithms that operate on disparate data types for the purpose of detection of a given hypothesized event. Developed detection performance analysis, under various signal strengths, that demonstrated Level Zero Fusion outperforms decision level fusion. Derived computational and bandwidth requirements for several implementation use cases of said fusion algorithms. Continued development of tools and techniques for the exploitation of audio signals and identifying contextual gist. Demonstrated accuracy improvements methods using iVector and MHEC for SID/LID, improvements to speech activity detection, classifier evaluations. Initiated development of an automated capability to search and retrieve objects of interest (OOIs) in full motion video (FMV) sources and correlate with	5.188	6.720	6.085

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625318 / *Operational Awareness Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
information from Multi-INT sources. Refined automated analysis & correlation algorithm and tested using data from the 11th Intelligence Squadron. ***FY 2015 Plans:*** Investigate novel algorithms for collection, identification, detection and geo-location of modern emitter signals. Experiment with digital hardware solutions for capturing modern emitter signals Improve 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. Apply previously developed Level Zero fusion algorithms to recorded data for performance analysis. Derive distributed fusion approach that operates across a network of distributed, multi-modality, sensors. Incorporate machine learning approaches into event discovery. Continue development of an automated capability to search and retrieve objects of interest (OOIs) in full motion video (FMV) sources and correlate with information from Multi-INT sources. ***FY 2016 Plans:*** Develop and experiment with prototype hardware and software solutions for modern emitter signals can improve upon the signal characterization, detection and mitigation of coding and channel condition effects, and advance information extraction capabilities. Research and develop novel measurement and signatures intelligence (MASINT) algorithms and hardware to detect and locate targets of interest in a contested environment. Investigate the combined use of motion detection/tracking and content based imagery retrieval for detecting objects of interest.			
Title: Next Generation Command Technologies ***Description:*** Develop modeling and simulation technologies for the next generation of planning, assessment, and execution environments. ***FY 2014 Accomplishments:*** Developed links and tools to effectively employ cyber, directed energy and electronic warfare weaponry within a target folder environment; designed/developed import utility allowing auto ingestion of DIA Fishnet data (for any country). Formalized the design and development of civilian and military critical infrastructure models and their interconnectivity for modeling cascading effects. ***FY 2015 Plans:*** Develop a CATALiST (Common Automated Targeting Architecture Linking integrated Solution Threads) framework which includes data & user management; security, and role-based access; integrated, re-configurable workflows linking targeting materials production tasks, tools, and dashboards; dashboards enabling real-time management of targeting material production resources;	1.765	2.892	2.414

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 625318 / *Operational Awareness Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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. ***FY 2016 Plans:*** Continue to develop a working prototype of the CATALiST framework and associated capabilities, including a framework for data & user management, security, and role-based access; integrated, re-configurable workflows linking targeting materials production tasks, tools, and dashboards; dashboards enabling 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.			
Accomplishments/Planned Programs Subtotals	20.378	20.650	19.235

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602788F / *Dominant Information Sciences and Methods*	Project (Number/Name) 62OMMS / *Research Site Support*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
62OMMS: *Research Site Support*	-	18.281	20.722	21.256	-	21.256	21.708	21.064	21.477	21.914	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Air Force Research Laboratory Information Directorate leads the discovery, development and implementation of information science and technology to drive transformation within the Air Force and across the 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 2014	FY 2015	FY 2016
Title: Rome Research Infrastructure	18.281	20.722	21.256
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 (NETWORX (CONUS)), trunk connectivity and wireless communications.			
FY 2014 Accomplishments: Provided civilian payroll and non-pay costs for installation operations in support of the Rome Research Site property and all onsite personnel. Provided facilities, facility operations, facility sustainment, support equipment, contracts and associated costs to plan, manage and execute the following functions: fire prevention, disaster preparedness, plant operation and purchase of commodity, refuse collection, pavement clearance of snow and ice, grounds maintenance including landscaping, real property special inspections, pest control and custodial services. Provided Real Property Management & Engineering Services, including: (1) Facility Management and Administration and (2) Installation Engineering Services. Facility Management includes public works management costs, contract management, material procurement, facility data management, furnishings management costs, and real estate management. Installation Engineering Services includes annual inspection of facilities, master planning, overhead of planning and design, overhead of construction management, and non-Sustainment and Restoration Modernization (SRM) service			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 62OMMS / *Research Site Support*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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. ***FY 2015 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-Sustainment and Restoration Modernization (SRM) service calls. Provide basic installation communication services, including long haul trunk and telecommunications services. Provide site vehicle lease under GSA for logistics, security, and mission support. ***FY 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-Sustainment and Restoration Modernization (SRM) service calls. Provide basic installation communication services, including long haul trunk and telecommunications services. Provide site vehicle lease under GSA for logistics, security, and mission support.			
Accomplishments/Planned Programs Subtotals	18.281	20.722	21.256

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602788F / *Dominant Information Sciences and Methods*	**Project (Number/Name)** 62OMMS / *Research Site Support*

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602890F / *High Energy Laser Research*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	38.853	37.441	42.037	-	42.037	42.300	43.049	43.685	44.553	Continuing	Continuing
625096: *High Energy Laser Research*	-	38.853	37.441	42.037	-	42.037	42.300	43.049	43.685	44.553	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 complimenting 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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	40.155	37.496	42.316	-	42.316
Current President's Budget	38.853	37.441	42.037	-	42.037
Total Adjustments	-1.302	-0.055	-0.279	-	-0.279
• Congressional General Reductions	-	-0.055			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.302	-			
• Other Adjustments	-	-	-0.279	-	-0.279

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Robust Electric Laser Initiative	9.030	5.870	6.436

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602890F / *High Energy Laser Research*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Advance solid-state laser development. ***FY 2014 Accomplishments:*** Continued a joint high power electric laser product improvement program, as part of the Robust Electric Laser Initiative (RELI) effort. Monitored technical progress toward 60kW and 30kW laser source development for integration onto relevant military platforms. Analyzed trade space to understand performance and integration issues for other platforms. Continued investigation into other laser architectures for further development and scaling and initiate additional effort(s). Finalized preparations and equipment for government-sponsored measurements to validate performance. ***FY 2015 Plans:*** Continue the joint high power electric laser product improvement program, as part of the RELI effort. Initiate two additional major efforts for risk reduction and to explore other architectures for scalability. Monitor technical progress of the 60kW and the 30kW lasers and other sources. Monitor preparation for integration onto specific relevant military platforms. Continue analysis of trade space to understand performance and integration issues for other platforms. Perform government-sponsored measurements to validate performance. ***FY 2016 Plans:*** Continue 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 relevant military platforms. Continue analysis of trade space to understand performance, fielding, robustness and integration issues for future platforms. Complete government-sponsored measurements to validate performance.			
Title: Solid State Laser Technologies ***Description:*** Mature technologies that will provide system level performance commensurate with fieldable laser devices. ***FY 2014 Accomplishments:*** Developed highly efficient, compact, modular electric laser system component technologies that are scalable and robust. Develop high reliability/cost efficient diode pump sources. Scaled alternate laser wavelengths to militarily relevant power levels. Developed high power delivery fiber technologies. Conducted an industry proposal call for FY 2014 and awarded five new projects. ***FY 2015 Plans:***	6.103	5.281	6.090

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602890F / *High Energy Laser Research*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Develop high reliability, lower cost, efficient and high temperature diode pump sources. Scale alternate laser wavelengths to militarily relevant power levels. Develop high power delivery fiber technologies. Focus efforts on risk reduction for fielding of laser systems. Conduct a reduced Service and Agency call for FY15. ***FY 2016 Plans:*** Develop high reliability, lower cost, efficient and high temperature diode pump sources. Scale alternate laser wavelengths to militarily relevant power levels. Develop high power delivery fiber technologies. Focus efforts on risk reduction for fielding of laser systems. Conduct a industry proposal call for FY16.			
Title: Free Electron Laser Technologies ***Description:*** Conduct system-level technology development to facilitate scaling of free electron lasers (FELs) to weapons-class power levels. ***FY 2014 Accomplishments:*** Demonstrated technologies that can support 100kW future FEL performance. Performed an orderly completion of all FEL efforts. ***FY 2015 Plans:*** Effort transitioned to Navy program 0602114N, Power Projection Applied Research, to be incorporated in ongoing Navy program. ***FY 2016 Plans:*** N/A	0.500	-	-
Title: Advanced High Energy Laser (HEL) Technologies ***Description:*** Investigate new technologies that have revolutionary potential HEL applications. ***FY 2014 Accomplishments:*** Explored novel laser technologies to improve efficiency and decrease mass/volume. Evaluated new materials for HEL applications, to include optics in a high-gain vacuum. Furthered understanding of short pulse laser technology to include material interaction and propagation. Establishd and began a Predictive Avoidance and Air Space Deconfliction (PAAD) program to develop a prototype standalone capability that will interface with aviation, surface and space situational awareness systems and an HEL weapons systems to demonstrate an initial capability. Conducted an industry proposal call for FY 2014 and awarded five new projects. ***FY 2015 Plans:*** Explore novel laser technologies to improve efficiency and decrease mass/volume. Evaluate new materials for HEL 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. Begin efforts to further characterize and understand the physics	8.540	7.490	8.181

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602890F / *High Energy Laser Research*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
of HEL propagation in adverse weather conditions such as fog, rain, smoke and dust. Continue development of the PAAD system and begin initial testing on HEL test range(s). Conduct a reduced Service and Agency call for FY15. ***FY 2016 Plans:*** Explore novel laser technologies to improve efficiency and decrease mass/volume. Evaluate new 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 PAAD system and begin initial testing on HEL test range(s). Conduct an industry proposal call for FY16.			
Title: Laser Beam Control Technologies ***Description:*** Develop technology to support high performance beam control systems and integrated demonstrations. ***FY 2014 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. Developed and began execution of a program for kill assessment technologies. Initiated a program plan for a joint beam control effort to develop hardware and technologies to improve throughput efficiency through the beam director, decrease component weight, and improve tracking and compensation through the atmosphere. Conducted an industry proposal call for FY14 and awarded nine new projects. ***FY 2015 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. Enhance execution of a program for kill assessment technologies. Continue execution of the program plan for joint beam control to develop hardware and technologies to improve throughput efficiency through the beam director, decrease component weight, and improve tracking and compensation through the atmosphere. Conduct 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 execution of the program plan for joint beam control to develop hardware and technologies to improve throughput efficiency through the beam director,	8.030	12.250	15.670

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602890F / *High Energy Laser Research*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
decrease component weight, and improve tracking and compensation through the atmosphere. Select programs for service specific applications. Conduct an industry proposal call for FY16.			
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 2014 Accomplishments:*** In close coordination with existing HEL models, integrated 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. ***FY 2015 Plans:*** In close coordination with existing HEL models, integrate new lethality data into campaign-level HEL system models. Conduct laser vulnerability experiments on materials, components, and targets. Continue development of an unmanned air vehicle vulnerability module for integration into the modeling and simulation toolkit. Support 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:*** In close coordination with existing HEL models, integrate new lethality data into campaign-level HEL system models. Conduct laser vulnerability experiments on materials, components, and targets. Complete development of a 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.	3.450	3.630	3.230
Title: High Energy Laser (HEL) Modeling ***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 2014 Accomplishments:*** Provided maintenance, verification, validation, and accreditation for updated system level HEL models. Conducted mission-level HEL engagement scenarios and wargame HEL concepts. Incorporated additional predictive avoidance modeling into existing HEL toolkit. Continued development of a risk assessment for illumination of objects in space by tactical laser weapons. ***FY 2015 Plans:***	3.200	2.920	2.430

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602890F / *High Energy Laser Research*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Provide maintenance, verification, validation, and accreditation for updated system level HEL models. Continue validation and verification of HEL models. Conduct mission-level HEL engagement scenarios and wargame HEL concepts. 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. Continue 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 maintenance, verification, validation, and accreditation for updated system level HEL models. Conduct 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 of scenario conditions to understand relative gains in hardware developments.			
Accomplishments/Planned Programs Subtotals	38.853	37.441	42.037

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603112F / *Advanced Materials for Weapon Systems*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	53.593	40.177	37.665	-	37.665	36.284	37.012	38.251	39.545	Continuing	Continuing
632100: *Laser Hardened Materials*	-	22.330	17.285	15.629	-	15.629	17.145	16.986	17.349	17.693	Continuing	Continuing
633153: *Non-Destructive Inspection Development*	-	5.450	5.275	5.029	-	5.029	6.350	6.331	6.423	6.550	Continuing	Continuing
633946: *Materials Transition*	-	25.813	17.617	17.007	-	17.007	12.789	13.695	14.479	15.302	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 four projects which develop: hardened materials technologies for the protection of aircrews and sensors; non-destructive inspection and evaluation technologies; transition data on structural and non-structural materials for aerospace applications; and airbase operations technologies including deployable base infrastructure, force protection, and fire fighting capabilities. 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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	54.572	32.177	39.975	-	39.975
Current President's Budget	53.593	40.177	37.665	-	37.665
Total Adjustments	-0.979	8.000	-2.310	-	-2.310
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	8.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.897	-			
• Other Adjustments	-0.082	-	-2.310	-	-2.310

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: 633946: *Materials Transition*		

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Congressional Add: *Materials Research and Technology*	10.000	-
Congressional Add: *Metals Affordability Research*	5.000	8.000
Congressional Add Subtotals for Project: 633946	15.000	8.000
Congressional Add Totals for all Projects	15.000	8.000

Change Summary Explanation

Decrease in FY16 due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / *Advanced Materials for Weapon Systems*	Project (Number/Name) 632100 / *Laser Hardened Materials*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
632100: *Laser Hardened Materials*	-	22.330	17.285	15.629	-	15.629	17.145	16.986	17.349	17.693	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 2014	FY 2015	FY 2016
Title: Aerospace Systems Protection	10.800	8.161	7.379

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

FY 2014 Accomplishments:
Demonstrated strategies to mitigate directed energy damage for visual/near-infrared (NIR), short wave infrared (SWIR), and mid wave infrared (MWIR) detectors critical to Intelligence, Surveillance, and Reconnaissance (ISR) sensors. Demonstrated damage-limiting semiconductor materials in a test bed configuration representing protection of both visual/NIR and SWIR sensors. Employed computation materials science to model material characteristics to increase accuracy and shorten design cycle time of coatings and dyes for use in sensor hardening. Conducted an air systems airframe and anti-access munitions hardening assessment.

FY 2015 Plans:
Continue to advance development of protection materials for visual/NIR ISR Sensors. Validate and 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 evaluating the performance impact of damage-limiting semiconductor materials designed to harden electro-optic imaging sensors. Continue to develop laser countermeasures for survivability of dynamic electro-optional and infrared (EO/IR) imagers. Validate and continue to employ computation materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings for use in sensor hardening. Initiate 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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 632100 / *Laser Hardened Materials*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
performance impact of damage-limiting semiconductor materials designed to harden electro-optic imaging sensors. Develop laser countermeasures for survivability of dynamic electro-optional and infrared (EO/IR) imagers. Continue to employ computation materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings for use in sensor hardening. Initiate air systems airframe and anti-access munitions hardening assessment.			
Title: Aircrew Protection ***Description:*** Develop and demonstrate materials technologies that enhance protection for Air Force aircrews to ensure safety and to enable aircrews to perform required missions in a threat environment. ***FY 2014 Accomplishments:*** Developed and demonstrated personnel protection technologies for night-time operation across the visible/NIR and SWIR spectral bands. Fabricated and demonstrated performance of agile optical coatings and dyes for use in night-time applications. Characterized eye protection technologies using computational materials science tools. Insured process repeatability and performed demonstrations of personnel protection technologies in realistic operation environments. ***FY 2015 Plans:*** Develop and demonstrate laser protection materials and technologies for personnel protection. Continue development of helmet mounted sensor hardening materials. Continue development of visor based aircrew protection materials. Characterize eye protection technologies using computational materials science tools. Continue 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.	11.530	9.124	8.250
Accomplishments/Planned Programs Subtotals	22.330	17.285	15.629

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 632100 / *Laser Hardened Materials*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / *Advanced Materials for Weapon Systems*	Project (Number/Name) 633153 / *Non-Destructive Inspection Development*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
633153: *Non-Destructive Inspection Development*	-	5.450	5.275	5.029	-	5.029	6.350	6.331	6.423	6.550	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Advanced Engine Inspection Technologies	1.036	1.298	1.237
Description: Develop and demonstrate advanced technologies to improve capabilities to inspect for cracks and other damage to extend the total safe life of turbine engines.			
FY 2014 Accomplishments: Continued development of novel, whole-field nondestructive inspection/evaluation 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 to critical gas turbine engine components.			
FY 2015 Plans: Continue development of nondestructive inspection/evaluation 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.			
FY 2016 Plans: Demonstrate nondestructive inspection/evaluation 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.			
Title: Low-Observable Inspection Technologies	0.927	0.985	0.939
Description: Develop and demonstrate advanced inspection technologies supporting low-observable (LO) systems to enhance affordability and ensure full performance and survivability.			
FY 2014 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 633153 / *Non-Destructive Inspection Development*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Validated handheld inspection method and sensor system for signature and material integrity assessment of existing and next generation LO material systems. Validated that the handheld nondestructive inspection tool can identify damage and register position relative to an aircraft, enabling more affordable signature assessment. ***FY 2015 Plans:*** Initiate development of improved methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of LO materials that enables/ensures more affordable signature assessment. ***FY 2016 Plans:*** 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.			
Title: Advanced System Monitoring Technologies ***Description:*** Develop and demonstrate advanced systems status monitoring technologies to provide on-board and embedded sensing to gain continuous awareness of the state of key subsystems. ***FY 2014 Accomplishments:*** Transitioned augmented field and depot-level inspection technologies for assessing the structural integrity of airframes. Integrated computational materials science tools with life prediction methods to increase accuracy of life prediction. Continued to demonstrate and transition advanced turbine engine process/status monitoring technologies to enable adaptive functions. ***FY 2015 Plans:*** Validate improved field and depot-level nondestructive inspection/evaluation technologies and methodologies for assessing the structural integrity of airframes. Validate improved nondestructive inspection/evaluation methods to minimize maintenance burden to access critical, hard to reach locations on aircraft structures. Initiate enhanced methods for collecting and analyzing digital nondestructive inspection/evaluation data necessary for improved damage detection and characterization. Validate the integration of computational materials science tools with life prediction methods to enable risk-based life management. Validate technologies to analyze materials state awareness and prevent corrosion. Initiate development of digitally enhanced nondestructive inspection/evaluation techniques. ***FY 2016 Plans:*** Transition improved field and depot-level nondestructive inspection/evaluation technologies and methodologies for assessing the structural integrity of airframes. Transition improved nondestructive inspection/evaluation methods to minimize maintenance burden to access critical, hard to reach locations on aircraft structures. Continue enhanced methods for collecting and analyzing digital nondestructive inspection/evaluation data necessary for improved damage detection and characterization. Demonstrate the integration of computational materials science tools with life prediction methods to enable risk-based life management.	3.487	2.992	2.853

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 633153 / *Non-Destructive Inspection Development*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Demonstrate technologies to analyze materials state awareness and prevent corrosion. Continue development of digitally enhanced nondestructive inspection/evaluation techniques.			
Accomplishments/Planned Programs Subtotals	5.450	5.275	5.029

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / *Advanced Materials for Weapon Systems*	Project (Number/Name) 633946 / *Materials Transition*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
633946: *Materials Transition*	-	25.813	17.617	17.007	-	17.007	12.789	13.695	14.479	15.302	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 2014	FY 2015	FY 2016
Title: Air Vehicle Materials Technologies	7.178	8.213	14.524
Description: Develop and demonstrate materials and processes technologies for air vehicle and subsystems to enhance lift, propulsion, LO performance, power generation management, and affordability of air vehicles. ***FY 2014 Accomplishments:*** Continued to advance validation of processing methods and lifing tools for ceramic matrix composites and graded microstructure turbine engine disk concepts. Continued validation and initiated transition of next generation nondestructive inspection/evaluation sensor systems for advanced LO material systems. Continued to advance development of magnetoresistive sensing technologies. Initiated integration of damage characterization with risk-based life management strategies for turbine engines. Initiated development of materials and processes to increase LO materials affordability. ***FY 2015 Plans:*** Validate processing methods and lifing tools for ceramic matrix composites and graded microstructure turbine engine disk concepts. Demonstrate repeatability of magnetoresistive sensing technologies. Continue integration of damage with risk-based life management strategies for turbine engines. Continue development of materials and processes to increase LO materials affordability. ***FY 2016 Plans:*** Demonstrate processing methods and lifing tools for ceramic matrix composites and graded microstructure turbine engine disk concepts. Continue demonstration of repeatability of magnetoresistive sensing technologies. Integrate damage with risk-based life management strategies for turbine engines. Continue development of materials and processes to increase LO materials affordability.			
Title: High Temperature Material Technologies	1.635	1.404	2.483

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 633946 / *Materials Transition*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop and demonstrate affordable, novel high temperature materials/structures and thermal management concepts to enable future defense capabilities for prompt global strike concepts. ***FY 2014 Accomplishments:*** Developed and demonstrated 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 development of 2700F ceramic matrix composites for turbine hot section components. ***FY 2015 Plans:*** Initiate 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. Validate 2700F ceramic matrix composites for turbine hot section components. ***FY 2016 Plans:*** 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.			
Title: Adapative Turbine Engine Technologies ***Description:*** Develop and demonstrate material and process technologies to increase power and efficiency for adaptive turbine engine propulsion and subsystem integration. ***FY 2014 Accomplishments:*** Completed materials and production process assessments for an adaptive turbine engine prototype. ***FY 2015 Plans:*** Work completed in FY14. ***FY 2016 Plans:*** Work completed in FY14.	2.000	-	-
Accomplishments/Planned Programs Subtotals	10.813	9.617	17.007

	FY 2014	FY 2015
Congressional Add: Materials Research and Technology	10.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603112F / *Advanced Materials for Weapon Systems*	**Project (Number/Name)** 633946 / *Materials Transition*

	FY 2014	FY 2015
FY 2014 Accomplishments: Conduct Congressionally-directed effort.		
Congressional Add: Metals Affordability Research	5.000	8.000
FY 2014 Accomplishments: Conduct Congressionally-directed effort.		
FY 2015 Plans: Conduct Congressionally directed effort.		
Congressional Adds Subtotals	15.000	8.000

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-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603199F / *Sustainment Science and Technology (S&T)*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	12.380	15.800	18.378	-	18.378	20.636	22.811	23.217	23.680	Continuing	Continuing
635351: *Technology Sustainment*	-	12.380	15.800	18.378	-	18.378	20.636	22.811	23.217	23.680	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, composite certification 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. 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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	12.800	15.800	18.500	-	18.500
Current President's Budget	12.380	15.800	18.378	-	18.378
Total Adjustments	-0.420	-	-0.122	-	-0.122
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.420	-			
• Other Adjustments	-	-	-0.122	-	-0.122

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: System Health Management/Assessment Technologies	4.261	4.868	5.010

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603199F / *Sustainment Science and Technology (S&T)*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop, demonstrate, and transition state awareness/system health management technologies. Conduct studies and analyses to design sustainability into future applications. ***FY 2014 Accomplishments:*** Continued efforts to demonstrate and validate algorithms and techniques for system assessment and health management. Continue health assessment capability development for fielded systems and components. Continued development and demonstration of diagnostic technology to monitor/assess health of airframe/engine and components. Initiated active fuel bladder leak detection capability. Completed efforts to detect cracks beneath flush head fasteners and life prediction of wiring insulation. ***FY 2015 Plans:*** Continue development and demonstration of diagnostic technology to monitor/assess health of airframe/engine and components. Complete development of active fuel bladder leak detection capability. Continue health assessment capability development for fielded systems and components. Initiate arc mitigation for 270VDC systems. Initiate streamlined inspection data for improved health assessment. ***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.			
Title: Prevention/Enhanced Maintainability Technologies ***Description:*** Develop, demonstrate, and transition technologies to improve component design, maintenance, replacement, and concepts for performance improvement and reduced maintenance burden. ***FY 2014 Accomplishments:*** Continued efforts to demonstrate high reliability repair and maintenance technologies to increase service time between maintenance actions. Continued maturation of airframe/engine/subsystem technologies including replacement for honeycomb structures, and validation of erosion coating test protocol for improved component durability, reliability, and safety to increase time between maintenance actions and reduce maintenance cost drivers. Initiated development of friction plug welding for a B-1B panel repair; repair technologies for B-1 airfoils; and of a solid state amplifier replacement for unsupportable vacuum tubes used on the B-1 aircraft's ALQ-161 defensive avionics system. Completed specialty materials inspection system demo. ***FY 2015 Plans:*** Continue efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions, including a solid state amplifier replacement for unsupportable vacuum tubes used on the B-1 aircraft's	5.067	4.224	4.241

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603199F / *Sustainment Science and Technology (S&T)*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
ALQ-161, defensive avionics system. Continue airframe/engine/subsystem technology efforts including replacement for honeycomb structures. Complete validation of erosion coating test protocol and flush head fastener inspection technologies for improved component durability, reliability, and safety to increase time between maintenance actions and reduce maintenance cost drivers. Continue integrally bladed rotor repair improvements. Initiate dust containment and on-aircraft mold mitigation improvements. Initiate demo for enhanced ester oil for turbine engines. ***FY 2016 Plans:*** Continue efforts to demonstrate high reliability of repair and maintenance technologies to increase service time between maintenance actions. Complete friction plug welding for B-1B panel. Complete thermal spray coating process. Continue solid state amplifier replacement for B-1B.			
Title: Management/Improved Reliability Technologies ***Description:*** Develop, demonstrate, and transition technologies to improve existing and new components, fleet management/ decision-making tools, and supply chain/sustainment infrastructure to decrease downtime and costs, and increase reliability. ***FY 2014 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. Initiated injection molded canopy demo. Initiated canopy coating improvements. Initiated updated spacecraft propulsion model. Initiated cold work holes analysis to reduce inspections. ***FY 2015 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 F-22 canopy efforts. Initiate structural/NDI tool verification. Continue updated spacecraft propulsion model. Continue quantification of life extension prediction of A-10 and T-38 aircraft cold worked holes. ***FY 2016 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.	3.052	4.208	4.749
Title: Composite Certification ***Description:*** Develop, demonstrate and transition reliability-based design of advanced composites for aircraft structures. ***FY 2014 Accomplishments:*** N/A ***FY 2015 Plans:***	-	2.500	4.378

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603199F / *Sustainment Science and Technology (S&T)*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Demonstrate accurate prediction of the probability of failure and life of bonded and unitized composite structures. Demonstrate manufacturing processes and manufacturing process control of composite primary structures. Demonstrate feasibility of implementing a damage tolerant design approach for composite structures. Demonstrate feasibility and benefits of a robust process for predicting and addressing the risk elements for safe and affordable certification of composite structures. Demonstrate life extension of a composite primary structure beyond that of the original certified service life. ***FY 2016 Plans:*** 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.			
Accomplishments/Planned Programs Subtotals	12.380	15.800	18.378

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

Not Applicable.

F. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603203F / *Advanced Aerospace Sensors*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	31.968	34.334	42.183	-	42.183	40.945	40.516	38.793	39.565	Continuing	Continuing
63665A: *Advanced Aerospace Sensors Technology*	-	19.822	14.745	17.521	-	17.521	16.547	15.650	15.575	15.884	Continuing	Continuing
6369DF: *Target Attack and Recognition Technology*	-	12.146	19.589	24.662	-	24.662	24.398	24.866	23.218	23.681	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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	30.546	34.420	39.901	-	39.901
Current President's Budget	31.968	34.334	42.183	-	42.183
Total Adjustments	1.422	-0.086	2.282	-	2.282
• Congressional General Reductions	-	-0.086			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	2.000	-			
• SBIR/STTR Transfer	-0.578	-			
• Other Adjustments	-	-	2.282	-	2.282

Change Summary Explanation

Increase in FY14 to support Live Virtual Constructive technology effort.

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	

Increase in FY16 due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / *Advanced Aerospace Sensors*	Project (Number/Name) 63665A / *Advanced Aerospace Sensors Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
63665A: *Advanced Aerospace Sensors Technology*	-	19.822	14.745	17.521	-	17.521	16.547	15.650	15.575	15.884	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 2014	FY 2015	FY 2016
Title: Integrated Navigation Technologies	4.483	4.910	4.484

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 2014 Accomplishments:
Developed technologies to preserve position, navigation, and timing (PNT) availability, including augmentation technologies for GPS in the event of outage, and advanced technologies that do not rely on GPS. Explored integration of GPS with precise inertial measurement units (IMUs) and augmentation using geo-referenced imagery. Collaborated with the Air Force Research Laboratory's Space Vehicles Directorate to develop advanced, low-drift IMUs involving novel measurement techniques.

FY 2015 Plans:
Mature 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. Develop technologies that expand the ability to incorporate GNSS signals into GPS user equipment as a means to improve 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 PNT. Continue to develop and mature technologies to incorporate GNSS capability in user

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 63665A / *Advanced Aerospace Sensors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Title: Persistent Sensing in Contested Environment Technologies ***Description:*** Develop active radio frequency (RF) sensor solutions to use against difficult-to-detect targets in challenging environments, and advanced RF architectures for open and reconfigurable systems. Enable persistent intelligence, surveillance, and reconnaissance (ISR) over wide areas, and detect advanced air and ground targets. ***FY 2014 Accomplishments:*** Completed modular RF backend demonstration for combined radar and signal intelligence (SIGINT). Researched and developed a wide area staring radar, and began development of a staring radar RF testbed. Initiated research and development in next generation active RF sensing for contested spectrum environments, including investigation of the limits of active RF sensing with an emphasis on contested and denied environments. ***FY 2015 Plans:*** Continue 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. 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. ***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, Multiple-Input Multiple-Output (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.	5.200	3.000	3.419
Title: Passive Radio Frequency (RF) Sensing Technologies ***Description:*** Develop advanced techniques and prototype passive RF sensors to intercept, collect, locate and track enemy RF sensor systems for intelligence, reconnaissance and surveillance (ISR) of air and ground targets. ***FY 2014 Accomplishments:*** Initiated research for creating passive RF sensing testbed for use in indoor and outdoor range laboratories. Initiated advanced exploration and investigation of the limits of passive RF sensing with an emphasis on innovative passive techniques for operations in contested and denied environments. Developed advanced techniques for the exploitation of active RF emitters utilizing passive	4.149	3.884	6.411

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 63665A / *Advanced Aerospace Sensors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
RF sensing techniques. Conducted research and development of passive RF sensors including phenomenology, modeling and simulation, algorithm development and experimentation. ***FY 2015 Plans:*** Continue 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 develop 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. Continue development of algorithms and hardware for passive RF sensing applications, with emphasis on both high endurance at long stand-off range, and survivable, covert stand-in RF sensing within contested airspace. ***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.			
Title: Long Range Sensing Technologies ***Description:*** Develop radio frequency (RF) and electro-optical (EO) sensor technology to detect, locate, and identify air and ground targets at long ranges, including those that are low-observable, or use deception or camouflage. ***FY 2014 Accomplishments:*** Initiated development of advanced active and passive electro-optical (EO) sensing technologies for surveillance and reconnaissance at standoff ranges in contested environments. Developed long range temporal synthetic aperture radar system. Demonstrated high power, high coherence transmitter and receiver array. Initiated ground and flight test plans for aircraft integration. Developed transceiver hardware for ground based imaging of satellite in geosyncronous orbit. Initiated test and characterization of mercury-cadmium-teluride on silicone focal plane. Initiated design and prototyping of passive infrared imaging system for enhanced range infrared target recognition and full motion video. ***FY 2015 Plans:*** Extend ground moving target indicator (GMTI) and synthetic aperture radar (SAR) techniques developed for detection and tracking of dismounts and high value mobile ground targets from high angle, close-in radio frequency (RF) sensing scenarios to low angle, long stand-off RF sensing geometric scenarios with anti-access/area denial (A2/AD). 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. ***FY 2016 Plans:***	5.990	2.951	3.207

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 63665A / *Advanced Aerospace Sensors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Accomplishments/Planned Programs Subtotals	19.822	14.745	17.521

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603203F / *Advanced Aerospace Sensors*	Project (Number/Name) 6369DF / *Target Attack and Recognition Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
6369DF: *Target Attack and Recognition Technology*	-	12.146	19.589	24.662	-	24.662	24.398	24.866	23.218	23.681	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 2014	FY 2015	FY 2016
Title: Integrated Sensor Targeting Technologies	2.700	3.570	4.564
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 2014 Accomplishments: Identified new candidate technologies to improve electro-optical automatic target recognition, synthetic aperture radar automatic target recognition, and the multi-sensor fusion algorithms for both Planning, Collection, Processing, Analysis, and Dissemination (PCPAD) and combat identification applications in contested and denied environments. Enhanced phenomenological modeling, target and scenario databases and exploitation tools necessary to address contested and denied environments. Developed PCPAD capabilities for non-contested environments.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 6369DF / *Target Attack and Recognition Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continue assessing integrated sensor targeting technologies for permissive environments which could serve as candidate solutions for PCPAD in contested environments. Create 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 databases from electro-optical, synthetic aperture radar, and multi-source 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 2014 Accomplishments:*** Assessed technology supporting intelligence, surveillance and reconnaissance systems in contested anti-access/area denial environments. Developed new automatic target recognition fusion research to address technology gaps. Initiated research in development and assessment of multi-sensor automatic target recognition specifically for strike. Initiated spiral development of sensor exploitation algorithms of multi-sensor automatic target recognition systems supporting PCPAD. ***FY 2015 Plans:*** Continue development of target signature formation techniques from single and multiple cooperating sensors, and sensors and signals of opportunity. Create 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.	4.716	8.169	10.142
Title: Wide-Angle, Continuously-Staring Technologies	4.730	7.850	9.956

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603203F / *Advanced Aerospace Sensors*	**Project (Number/Name)** 6369DF / *Target Attack and Recognition Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop wide angle, continuous staring, multi-sensor/wavelength sensing and automated exploitation technology to detect, track, and identify targets over large areas at low sensor update rates. ***FY 2014 Accomplishments:*** Conducted an assessment of technology supporting intelligence, surveillance and reconnaissance systems in contested anti-access/area denial environments. Developed new automatic target recognition fusion to address technology gaps. Initiated research in development and assessment of multi-sensor automatic target recognition specifically for strike. Initiated spiral development of sensor exploitation algorithms of multi-sensor automatic target recognition systems supporting PCPAD. ***FY 2015 Plans:*** Continue development of stand-off (air and space) and episodic stand-in sensing capabilities for contested and denied environments. Continue development of exploitation algorithms, phenomenological modeling, image formation, and target and scenario databases necessary to support transition of staring sensing capabilities to the warfighter. Continue to integrate, demonstrate and evaluate enhanced wide angle and wide area sensing and exploitation technologies in conditions representative of contested and denied environments. ***FY 2016 Plans:*** 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 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.			
Accomplishments/Planned Programs Subtotals	12.146	19.589	24.662

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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603211F / *Aerospace Technology Dev/Demo*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	75.029	91.037	100.733	-	100.733	63.866	76.800	83.557	77.271	Continuing	Continuing
634920: *Flight Vehicle Tech Integration*	-	75.029	5.663	25.779	-	25.779	17.289	21.234	26.118	29.658	Continuing	Continuing
634926: *High Speed/Hypersonic Intgr and Demo*	-	-	66.999	50.700	-	50.700	32.301	38.782	37.884	21.328	Continuing	Continuing
634927: *Flight Systems Control*	-	-	18.375	24.254	-	24.254	14.276	16.784	19.555	26.285	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. In FY 2015, this program has two new projects, High Speed/Hypersonic Integration and Demonstration and Flight Systems Control. 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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	77.329	91.062	99.103	-	99.103
Current President's Budget	75.029	91.037	100.733	-	100.733
Total Adjustments	-2.300	-0.025	1.630	-	1.630
• Congressional General Reductions	-	-0.025			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-2.300	-			
• Other Adjustments	-	-	1.630	-	1.630

Change Summary Explanation

Increase in FY 2016 due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / *Aerospace Technology Dev/ Demo*	Project (Number/Name) 634920 / *Flight Vehicle Tech Integration*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
634920: *Flight Vehicle Tech Integration*	-	75.029	5.663	25.779	-	25.779	17.289	21.234	26.118	29.658	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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Title: Flight Systems Controls	3.556	-	-	-	-
Description: Integrates and demonstrates advanced control technologies that improve the performance, reliability, safety, and survivability of 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. ***FY 2014 Accomplishments:*** Continued to develop and demonstrate technologies for situational awareness, autonomous control, and survivability for unmanned systems and manned platforms. Demonstrated airborne control of small unmanned platforms in complex, low altitude environments. Continued demonstration of autonomous and safe airspace interoperability for manned and remotely piloted aircraft systems. ***FY 2015 Plans:*** Starting in FY 2015, efforts and funding in this area will be transferred to new project 634927, Flight Systems Control to better align efforts. ***FY 2016 Base Plans:*** N/A					
Title: Aerospace Vehicle Technology Integration	20.952	1.607	11.245	-	11.245
Description: Develop, simulate, and demonstrate integrated technologies to improve the performance of aerospace platform capabilities.					

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603211F / *Aerospace Technology Dev/ Demo*	**Project (Number/Name)** 634920 / *Flight Vehicle Tech Integration*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
FY 2014 Accomplishments: Furthered efforts for precision air delivery capability for legacy mobility aircraft by reducing tracking errors and better integration of airdrop technologies. Furthered 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. Completed demonstration of large cargo aircraft in formation flight for fuel burn reduction to support transition decision. Completed flight safety validation and operational compatibility of C-130 aircraft with aft body drag reduction devices. ***FY 2015 Plans:*** Initiate C-17 formation flight Advanced Technology Demonstration. Initiate feasibility flight test of C-17 aircraft with aft body drag reduction devices. Continue 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 Base Plans:*** Further development of the C-17 formation flight Advanced Technology Demonstration. 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.					
Title: Advanced Aerospace Structure Technologies ***Description:*** This title 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. ***FY 2014 Accomplishments:*** Continued flight test of directional finding communication antenna integration technology demonstration into load-bearing structures for small remotely piloted aircraft (RPA). Continued flight technology demonstrations of key high altitude persistent ISR for active flutter suppression, gust load alleviation, and adaptive, multi-purpose wing surfaces. ***FY 2015 Plans:***	8.615	4.056	14.534	-	14.534

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603211F / *Aerospace Technology Dev/ Demo*	**Project (Number/Name)** 634920 / *Flight Vehicle Tech Integration*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Complete flight test of directional finding communication antenna integration technology demonstration into load-bearing structures for small RPA. Complete flight technology demonstrations of key high altitude persistent ISR for active flutter suppression, gust load alleviation, and adaptive, multi-purpose wing surfaces. ***FY 2016 Base Plans:*** Initiate an electronic warfare and passive radar flight demonstration of an integrated antenna into load-bearing structures for small remotely piloted aircraft. Initiate an ultra-low cost airframe design and manufacturing demonstration.					
Title: High Speed/Hypersonic Vehicle Technologies ***Description:*** 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 along 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. This major thrust will move to Project 634926, High Speed/Hypersonic Integration and Demostration, in FY 2015. ***FY 2014 Accomplishments:*** Began 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. Effort builds upon successful scramjet engine demonstration under the X-51A program. Increase in FY14 also supported high speed/hypersonics testing support and advancement of high temperature materials and structures for hypersonic vehicles. ***FY 2015 Plans:*** Efforts and funding in this area will be transferred to new Project 634926, High Speed/Hypersonic Integration and Demonstration, in FY 2015 to consoidate efforts. ***FY 2016 Base Plans:*** N/A	41.906	-	-	-	-
Accomplishments/Planned Programs Subtotals	75.029	5.663	25.779	-	25.779

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603211F / *Aerospace Technology Dev/ Demo*	**Project (Number/Name)** 634920 / *Flight Vehicle Tech Integration*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / *Aerospace Technology Dev/ Demo*	Project (Number/Name) 634926 / *High Speed/Hypersonic Intgr and Demo*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
634926: *High Speed/Hypersonic Intgr and Demo*	-	-	66.999	50.700	-	50.700	32.301	38.782	37.884	21.328	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 along 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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Title: High Speed/Hypersonic Vehicle Technologies	-	66.999	50.700	-	50.700
Description: Develop, simulate, and demonstrate integrated vehicle technologies to enable and improve the performance of future high-speed and hypersonic systems. ***FY 2014 Accomplishments:*** N/A ***FY 2015 Plans:*** Complete preliminary design review of air-breathing weapon concept vehicle. Continue accelerated development and demonstration of tactically-relevant long-range high-speed strike technologies including ground and flight demonstrations needed for potential follow-on acquisition program. Continue advancement of high temperature materials and structures for hypersonic vehicles. ***FY 2016 Base 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.					
Accomplishments/Planned Programs Subtotals	-	66.999	50.700	-	50.700

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
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)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603211F / *Aerospace Technology Dev/ Demo*	Project (Number/Name) 634927 / *Flight Systems Control*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
634927: *Flight Systems Control*	-	-	18.375	24.254	-	24.254	14.276	16.784	19.555	26.285	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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Title: Autonomous Systems Control	-	18.375	24.254	-	24.254
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 2014 Accomplishments:*** N/A ***FY 2015 Plans:*** Further 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 safety of flight of analog flight control system hosting of digital flight control algorithms. Initiate demonstration of integrated ground & air collision avoidance. Initiate development and demonstration of robust, adaptive guidance, and control of hypersonic aircraft. ***FY 2016 Base Plans:*** Further 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					

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603211F / *Aerospace Technology Dev/ Demo*	**Project (Number/Name)** 634927 / *Flight Systems Control*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
demonstration of airborne control of teams of unmanned aircraft. Complete development and demonstration of improved accuracy, situational awareness, and safety for air drop operations. ***FY 2016 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	-	18.375	24.254	-	24.254

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	160.765	132.681	168.821	-	168.821	94.717	98.118	107.344	112.610	Continuing	Continuing
632480: *Aerospace Fuels*	-	2.380	2.274	2.270	-	2.270	2.262	2.302	2.343	2.389	Continuing	Continuing
633035: *Aerospace Power Technology*	-	17.301	13.915	9.306	-	9.306	8.010	9.934	10.135	10.337	Continuing	Continuing
634921: *Aircraft Propulsion Subsystems Int*	-	67.879	53.651	77.889	-	77.889	19.757	17.902	23.284	25.647	Continuing	Continuing
634922: *Space & Missile Rocket Propulsion*	-	23.362	26.540	31.280	-	31.280	24.288	28.778	29.421	30.007	Continuing	Continuing
635098: *Advanced Aerospace Propulsion*	-	18.194	27.240	23.720	-	23.720	25.013	22.797	20.346	20.751	Continuing	Continuing
63681B: *Advanced Turbine Engine Gas Generator*	-	31.649	9.061	24.356	-	24.356	15.387	16.405	21.815	23.479	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 weapons and aircraft as part of energy-optimized aircraft development. The Aircraft Propulsion Subsystems Integration project integrates the engine cores demonstrated in the Advanced Turbine Engine Gas Generator project with low-pressure components into demonstrator engines. The Space and Missile Rocket Propulsion project develops and demonstrates innovative rocket propulsion technologies, propellants, and manufacturing techniques. The Advanced Aerospace Propulsion project develops the scramjet propulsion cycle to a technology readiness level appropriate for in-flight demonstration and for full integration with other engine cycles (including turbine and rocket based). The Advanced Turbine Engine Gas Generator project develops and demonstrates core turbine engine technologies for current and future aircraft propulsion systems. Portions of the Aerospace Fuels, Advanced Turbine Engine Gas Generator, and Aerospace Propulsion Subsystems Integration projects support adaptive cycle technology demonstrations, which develop component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, and durability for widely varying mission needs. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	

B. Program Change Summary ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	159.291	124.236	164.953	-	164.953
Current President's Budget	160.765	132.681	168.821	-	168.821
Total Adjustments	1.474	8.445	3.868	-	3.868
• Congressional General Reductions	-	-0.055			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	8.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	5.813	-			
• SBIR/STTR Transfer	-4.339	-			
• Other Adjustments	-	-	3.868	-	3.868

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: 633035: *Aerospace Power Technology*		
Congressional Add: *Silicon Carbide Research*	10.000	8.500
Congressional Add Subtotals for Project: 633035	10.000	8.500
Congressional Add Totals for all Projects	10.000	8.500

Change Summary Explanation

FY2016 increase due to higher DoD priorities to include Adaptive Engine Technology Development(AETD)Program risk reduction efforts.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 632480 / *Aerospace Fuels*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
632480: *Aerospace Fuels*	-	2.380	2.274	2.270	-	2.270	2.262	2.302	2.343	2.389	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 2014	FY 2015	FY 2016
Title: Fuel-Related Thermal Management	0.331	0.630	0.628
Description: Demonstrate thermally stable fuels and fuel system hardware concepts to enhance cooling capacity (performance), minimize fuel coking, and reduce fuel system maintenance.			
FY 2014 Accomplishments: Demonstrated fuel-cooled thermal management approaches for variable-cycle engines.			
FY 2015 Plans: Demonstrate heat sink and coking performance of advanced producible endothermic fuel.			
FY 2016 Plans: Demonstrate nano-catalysts/nano-additives for enhancing heat sink and reducing coking.			
Title: Gas Turbine Combustion, Emissions, and Performance	0.331	0.630	0.629
Description: Develop and demonstrate efficacy of low-cost, environmentally friendly fuel approaches to assess and reduce soot/ particulate emissions from gas turbine engines.			
FY 2014 Accomplishments: Demonstrated international standard methodology for measuring soot (particulates) on a variety of gas turbine engines. This measurement methodology will be transitioned through publication as a recommended international aerospace practice.			
FY 2015 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 632480 / *Aerospace Fuels*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Demonstrate advanced particulate characterization enabling the identification and quantification of particulates absorbed in volatile and non-volatile hydrocarbon fuels. ***FY 2016 Plans:*** Assess operability in referee combustor of reference jet fuels representing range of conventional jet fuels being used by Air Force.			
Title: Fuel System Technologies ***Description:*** Develop and demonstrate enhancements to fuel system technology. ***FY 2014 Accomplishments:*** Demonstrated effectiveness of enhanced endothermic fuel under higher heat sink conditions in reduced scale cooling simulations. This effort completed in FY14. ***FY 2015 Plans:*** N/A ***FY 2016 Plans:*** N/A	0.331	-	-
Title: Fuel Logistics ***Description:*** Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Air Force. ***FY 2014 Accomplishments:*** Evaluated impact of commercial aviation jet fuel conversion (including alternative fuels) on Air Force fuel infrastructure. ***FY 2015 Plans:*** Continue to demonstrate and evaluate commercical conversion impacts and fuel filtration devices with nano-size meshes to mitigate biological growth in aviation fuels. ***FY 2016 Plans:*** Demonstrate anti-microbial peptides and biological active control for mitigating biological growth an aviation fuels.	0.529	0.814	0.813
Title: Alternative Jet Fuels ***Description:*** Characterize and demonstrate the use of alternative hydrocarbon jet fuel to comply with Air Force certifications and standards for jet fuels. ***FY 2014 Accomplishments:***	0.858	0.200	0.200

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 632480 / *Aerospace Fuels*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Evaluated storage, distribution, ignition, combustion, and other properties of cellulosic-based alternative aviation fuels produced through fermentation processes. Supported interagency combustor operability testing. Published research reports for industry review to faciliate development of consistent and common military and commercial fuel specifications. Supported interagency combustor operability testing. ***FY 2015 Plans:*** Complete combustor operability study with low-temperature fuel-air ignition and re-light investigation for reference fuels and fuels that are 100% synthetic. Continue to evaluate cellulosic-based alternative aviation fuels produced through fermentation processes. ***FY 2016 Plans:*** Demonstrate combustion performance/operability of advanced cellulosic alternative fuels being considered for addition to Jet A specification (ASTM D7566), which Air Force will use due for conversion to Jet A/F-24.			
Accomplishments/Planned Programs Subtotals	2.380	2.274	2.270

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 633035 / *Aerospace Power Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
633035: *Aerospace Power Technology*	-	17.301	13.915	9.306	-	9.306	8.010	9.934	10.135	10.337	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 technologies 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 developed are projected to provide a two- fold to five-fold improvement in aircraft reliability and maintainability, and a reduction in power system weight. This project is integrated into energy optimized aircraft efforts and power and thermal programs.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: High Power Aircraft Subsystem Technologies	7.301	5.415	9.306
Description: Develop and demonstrate integrated architecture and components for power generation, conditioning, and distribution; energy storage components; and thermal management and subsystem technologies for integration into high power aircraft.			
FY 2014 Accomplishments: Completed demonstration of adapative power and thermal management components for next generation air platforms and initiated integration of power and thermal management subsystems for platform-level hardware-in-the-loop energy optimization demonstration. Facilitated technology and hardware integration for demonstration. Completed design work and initiated component subsystem testing.			
FY 2015 Plans: Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Continue demonstration of platform-level hardware-in-the-loop integrated power and thermal management subsystems. Initiate development of actuation technology for applications with power, volume, and thermal limitations. Initiate development of hybrid-cycle power and thermal management system.			
FY 2016 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 development of hybrid-cycle power and thermal management system. Complete demonstration			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 633035 / *Aerospace Power Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
of platform-level hardware-in-the-loop integrated power and thermal management. Initiate development of advanced power generation and distribution system.			
Accomplishments/Planned Programs Subtotals	7.301	5.415	9.306

	FY 2014	FY 2015
Congressional Add: Silicon Carbide Research	10.000	8.500
FY 2014 Accomplishments: Conducted Congressionally directed efforts		
FY 2015 Plans: Conduct Congressionally directed efforts		
Congressional Adds Subtotals	10.000	8.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 634921 / *Aircraft Propulsion Subsystems Int*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
634921: *Aircraft Propulsion Subsystems Int*	-	67.879	53.651	77.889	-	77.889	19.757	17.902	23.284	25.647	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 subsystemstechnologies. 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 2014	FY 2015	FY 2016
Title: Turbofan/Turbojet Durability	0.200	-	-
Description: Design, fabricate, and demonstrate durability and integration technologies for turbofan engines and for turbojet engines to improve durability, supportability, and affordability of Air Force aircraft. ***FY 2014 Accomplishments:*** Completed inlet and exhaust interaction study and demonstrated health monitor technologies. This effort completed in FY14. ***FY 2015 Plans:*** N/A ***FY 2016 Plans:*** N/A			
Title: Missile/Remotely Piloted Aircraft Engine Performance	18.428	14.250	20.713

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634921 / *Aircraft Propulsion Subsystems Int*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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 2014 Accomplishments:*** Accelerated engine activity to meet follow on need date. Continued rig testing of advanced components for engine technology applicable to subsonic missiles or unmanned vehicles. Continued detailed design of subsonic small turbine engine technology. Began preliminary design of subsonic mid-sized turbine engine technology for remotely piloted aircraft. ***FY 2015 Plans:*** Complete ground testing of demonstration supersonic, long endurance turbine engines at simulated altitude conditions. Complete testing of advanced components for engine technology applicable to missiles and unmanned vehicles. Complete detailed design and begin fabrication and instrumentation of a subsonic small turbine engine technology experimental test. ***FY 2016 Plans:*** 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.			
Title: Adaptive Turbine Engine Technologies ***Description:*** Design, fabricate, and demonstrate performance, durability, and operability technologies to mature adaptive turbine engine technologies. ***FY 2014 Accomplishments:*** Completed preliminary designs for an adaptive turbine engine with reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. Initiated manufacturing of advanced adaptive fan, augmentor, and exhaust rig test hardware. Continued engine technology development activity to support component instrumentation and integration into core engine. ***FY 2015 Plans:*** Complete preliminary design reviews and initiate detailed design of an adaptive turbine engine with reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. Continue engine technology development activity to support core engine assembly and initial ground testing. ***FY 2016 Plans:*** Instrument, assemble, and complete core experimental ground testing of an adaptive turbine engine with reduced specific fuel consumption, improved thrust-to-weight, and reduced cost.	49.251	39.401	57.176
Accomplishments/Planned Programs Subtotals	67.879	53.651	77.889

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634921 / *Aircraft Propulsion Subsystems Int*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 634922 / *Space & Missile Rocket Propulsion*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
634922: *Space & Missile Rocket Propulsion*	-	23.362	26.540	31.280	-	31.280	24.288	28.778	29.421	30.007	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 developed 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 Department of Defense and 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 2014	FY 2015	FY 2016
Title: Liquid Rocket Propulsion Technologies	17.746	20.034	23.601
Description: Develop liquid rocket propulsion technology for current and future space launch vehicles.			
FY 2014 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. Continued sub-scale preburner and continued sub-scale turbine component testing to demonstrate hydrocarbon boost technologies. Continued thrust chamber sub-scale development. Continued full-scale pre-burner component development.			
FY 2015 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 sub-scale preburner and complete sub-scale turbine component testing to demonstrate hydrocarbon boost technologies. Complete thrust chamber sub-scale development and test device. Continue full-scale pre-burner component development, conduct Preliminary Design Review, Critical Design Review,			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634922 / *Space & Missile Rocket Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
and begin fabrication of test article. Conduct Preliminary Design Review on the full-scale turbopump design. Continue design of thrust chamber assembly and conduct Preliminary Design Review and Critical Design Review of the full-scale design. ***FY 2016 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. Continue fabrication of full-scale preburner and begin testing the component. Conduct Critical Design Review on the full-scale turbopump design and begin fabrication. Begin fabrication of thrust chamber assembly.			
Title: Ballistic Missile Technologies ***Description:*** Develop and demonstrate missile propulsion and post-boost control systems technologies for ballistic missiles. ***FY 2014 Accomplishments:*** Continued development and prototyping of advanced missile case, insulation, and nozzle technologies. Continued validation of modeling and simulation tools. ***FY 2015 Plans:*** Continue to develop advanced missile case, insulation, and nozzle technologies. Continue validation of modeling and simulation tools. ***FY 2016 Plans:*** Continue to develop advanced missile case, insulation, and nozzle technologies. Continue validation of modeling and simulation tools.	3.320	4.456	5.264
Title: Strategic System Motor Surveillance ***Description:*** Develop and demonstrate aging and surveillance technologies for strategic systems to reduce lifetime prediction uncertainty for individual motors, enabling motor replacement for cause. ***FY 2014 Accomplishments:*** Completed integration and full-scale demonstration of advanced aging and surveillance tools into solid rocket motors to validate and verify modeling and simulation tools and component technologies. Began development of next generation of sensors used for aging and surveillance. ***FY 2015 Plans:***	2.296	2.050	2.415

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634922 / *Space & Missile Rocket Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continue development of next generation of sensors used for aging and surveillance. Support transition of previous tools, models, and data management system to user. ***FY 2016 Plans:*** 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. Improve the fidelity and precision of non-destructive evaluation tools, improving 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. Sub-scale motors will be periodically dissected over the next seven years to validate the sensor and analytical analysis of each motor.			
Accomplishments/Planned Programs Subtotals	23.362	26.540	31.280

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 635098 / *Advanced Aerospace Propulsion*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635098: *Advanced Aerospace Propulsion*	-	18.194	27.240	23.720	-	23.720	25.013	22.797	20.346	20.751	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 2014	FY 2015	FY 2016
Title: Scramjet Technologies	18.194	27.240	23.720
Description: Develop and demonstrate technologies for a hydrocarbon-fueled scramjet with robust operation up to Mach 7.			
FY 2014 Accomplishments: Continued development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and engine controls. Initiated additional component development and testing for insensitive munition compliant scramjet cold start system after difficulty attaining reliable scramjet ignition within strict time requirements. Designed and initiated fabrication of ground test flight weight engine components for High Speed Strike Weapon demonstration.			
FY 2015 Plans: Continue development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and engine controls. Initiate testing of flight weight ground test engine to demonstrate tactically compliant cold start system. Continue 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-dimenstional, scramjet flow lines. Conduct ground test of flight weight engine components for High Speed Strike Weapon demonstration and support preliminary design review.			
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 and initiate free-jet test hardware. Continue accelerated development and demonstration of			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 635098 / *Advanced Aerospace Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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.			
Accomplishments/Planned Programs Subtotals	18.194	27.240	23.720

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 63681B / *Advanced Turbine Engine Gas Generator*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
63681B: *Advanced Turbine Engine Gas Generator*	-	31.649	9.061	24.356	-	24.356	15.387	16.405	21.815	23.479	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 the continued 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 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 2014	FY 2015	FY 2016
Title: Core Engine Technologies	11.030	3.091	8.316
Description: Design, fabricate, and demonstrate performance predictions in core engines, using innovative engine cycles and advanced materials for turbofan and for turbojet engines.			
FY 2014 Accomplishments: Continued testing of an engine core with engine durability technology for demonstration. Based on test data, refined development and fabrication of component technologies for increased reliability, maintainability, and affordability for potential transition to fielded systems. Initiated durability testing of component technologies.			
FY 2015 Plans: Complete fabrication of hardware components enabling increased reliability, maintainability, and affordability for potential follow-on ground engine demonstration or potential acquisition program for transition to fielded systems.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 63681B / *Advanced Turbine Engine Gas Generator*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Instrument and assemble hardware for core demonstration and validation of increased reliability, maintainability, and affordability for potential follow-on ground engine demonstration or potential acquisition program for transition to fielded systems.			
Title: High Pressure Ratio Core Engine Technologies ***Description:*** Design, fabricate, and demonstrate high overall pressure ratio engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines. ***FY 2014 Accomplishments:*** Continued detailed design 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. ***FY 2015 Plans:*** Initiate 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. ***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.	1.200	0.337	0.905
Title: Adaptive Turbine Engine Core Technologies ***Description:*** Design, fabricate, and demonstrate high overall pressure ratio cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines. ***FY 2014 Accomplishments:*** Completed preliminary design of engine core technologies for application to adaptive turbine engine with reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. Initiated long lead hardware procurement and manufacturing of components for experimental engine core demonstration. ***FY 2015 Plans:*** Complete detailed design of engine core technologies for application to adaptive turbine engine with reduced specific fuel consumption, improved thrust-to-weight, and reduced cost. Initiate hardware procurement and manufacturing of components	19.419	5.633	15.135

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 63681B / *Advanced Turbine Engine Gas Generator*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
for transition to experimental engine core demonstration. Initiate instrumentation and assembly of hardware for transition to experimental engine core demonstration. ***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.			
Accomplishments/Planned Programs Subtotals	31.649	9.061	24.356

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	42.516	47.508	47.032	-	47.032	54.250	55.851	56.580	57.704	Continuing	Continuing
633720: *EW Quick Reaction Capabilities*	-	17.194	28.668	27.171	-	27.171	33.547	35.641	36.486	37.212	Continuing	Continuing
63431G: *RF Warning & Countermeasures Tech*	-	20.692	14.484	15.800	-	15.800	15.671	15.284	15.237	15.539	Continuing	Continuing
63691X: *EO/IR Warning & Countermeasures Tech*	-	4.630	4.356	4.061	-	4.061	5.032	4.926	4.857	4.953	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. The first project develops and demonstrates technologies for integrating electronic combat sensors and systems into a fused and seamless whole. The second project integrates and focuses research efforts in electronic warfare (EW), directed energy weapons (DEW), and cyber warfare to rapidly demonstrate a capability for rapid fielding. The third project develops and demonstrates advanced technologies for radio-frequency electronic combat suites. The fourth project develops and demonstrates 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.

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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	43.381	47.602	49.502	-	49.502
Current President's Budget	42.516	47.508	47.032	-	47.032
Total Adjustments	-0.865	-0.094	-2.470	-	-2.470
• Congressional General Reductions	-	-0.094			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.865	-			
• Other Adjustments	-	-	-2.470	-	-2.470

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*

Change Summary Explanation

Decrease in FY16 is due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 633720 / *EW Quick Reaction Capabilities*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
633720: *EW Quick Reaction Capabilities*	-	17.194	28.668	27.171	-	27.171	33.547	35.641	36.486	37.212	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 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 2014	FY 2015	FY 2016
Title: Disruptive Electronic Warfare (EW) and Countermeasure Technologies	3.794	13.493	12.121
Description: Develop disruptive EW and countermeasure concepts specifically selected for rapidly fieldable, high-impact effects and demonstrate them in an operational environment. ***FY 2014 Accomplishments:*** Developed disruptive EW and countermeasures concepts and technologies specifically selected for high impact effects and demonstrated them in simulated or operational environments. Expanded these SoS developments to include GPS-denied techniques and technology solutions, networked-systems electronic protection (EP), and effects experimentation between/across EMS, cyber and directed energy (DE) domains. ***FY 2015 Plans:*** Focus research on investigating the use of directed energy and cyber effects for EW use against Radio Frequency (RF) threats. Determine trade space and conduct experiments of these disruptive technologies against integrated air defense systems and other RF threats. Explore multi-spectral approaches to defense 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.			
Title: Threat-to-Countermeasure System of Systems (SoS) Methods	5.800	7.020	7.032

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 633720 / *EW Quick Reaction Capabilities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Establish and maintain an all-source, physics-based, design-level, red-blue, comparative, threat-to-countermeasure SoS techniques methodology. This systems engineering-based electronic warfare (EW) approach will inform programmatic planning, quantify desirable research areas with realistic SoS metrics, and foster improved understanding of future concept contributions to EW warfighting capabilities. ***FY 2014 Accomplishments:*** Developed an all source, physics based, design level, red-blue, comparative, threat-to countermeasure SoS techniques methodology for use in concept development and simulation based testing. Initiated integration of SoS engineering methods across virtual/modeling, hardware-in-the-loop (HWIL) and systems integration lab (SIL) options to optimize end-to-end (threat-to-countermeasure) systemic effects. ***FY 2015 Plans:*** Improve in-house system of systems analysis capabilities in order to develop new techniques to address multi-spectral EW threats. Conduct initial systems engineering research on new technology initiatives in order to provide physics based, metric-driven projects that will address threats to countermeasure systems. ***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.			
Title: Evaluation of Advanced Countermeasure Concepts	7.600	8.155	8.018
Description: Develop a core analytic function, supported by simulation-based wargaming and engineering modeling capabilities for evaluation, development, and demonstration of advanced electronic warfare (EW), cyber, directed energy (DE) and integrated/ systemic, non-kinetic concepts to include special capability programs. ***FY 2014 Accomplishments:*** Developed a core analytical function, supported by simulation based war gaming and engineering modeling capabilities for evaluation, development, and demonstration of advanced countermeasure concepts to include special capability programs. Expanded evaluation capabilities to incorporate full systemic electromagnetic spectrum (EMS) effects and netted/distributed EW capabilities in anti-access/area denial (A2/AD) scenarios. ***FY 2015 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 633720 / *EW Quick Reaction Capabilities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Enhance in-house analysis and assessment capability to include current threat arrays and allow the analysis of distributed EW techniques against these systems. These include 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). ***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 threats with highly agile and adaptable waveform structures. Demonstrate in-house analysis and assessment technologies for countering A2/AD scenarios.			
Accomplishments/Planned Programs Subtotals	17.194	28.668	27.171

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 63431G / *RF Warning & Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
63431G: *RF Warning & Countermeasures Tech*	-	20.692	14.484	15.800	-	15.800	15.671	15.284	15.237	15.539	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced technologies for radio-frequency electronic combat suites to enhance the survivability of aerospace vehicles and to provide crew situational awareness. One major area 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. Another major technology area 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 2014	FY 2015	FY 2016
Title: Electronic Attack	20.692	14.484	15.800
Description: Develop aerospace platform jamming technologies and techniques to counter advanced radio-frequency (RF) threats associated with current and future aerospace weapon systems. ***FY 2014 Accomplishments:*** Developed and demonstrated adaptable electronic attack (EA) technique concepts, cognitive jammer system concepts, and advanced EP concepts to defeat next generation RF threats with a major emphasis on penetrating contested, anti-access/area denial environments. ***FY 2015 Plans:*** Develop and conduct laboratory simulation experiments of adaptable EA technique concepts. Develop software prototype algorithms for cognitive jammer system concepts as well as protection of avionics systems to cyber-attacks. Continue to develop and demonstrate in laboratory environment advanced 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.			
Accomplishments/Planned Programs Subtotals	20.692	14.484	15.800

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 63431G / *RF Warning & Countermeasures Tech*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 63691X / *EO/IR Warning & Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
63691X: *EO/IR Warning & Countermeasures Tech*	-	4.630	4.356	4.061	-	4.061	5.032	4.926	4.857	4.953	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 (EO) / infrared (IR), and laser threats to aerospace platforms. Off-board (decoys and expendables) and on-board countermeasure technologies developed for aircraft self-protection will 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 2014	FY 2015	FY 2016
Title: Advanced Electro-Optical (EO)/Infrared (IR) Warning and Countermeasure Technologies	4.630	4.356	4.061

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

FY 2014 Accomplishments:

Developed, tested, and refined infrared countermeasures concepts with emphasis on penetrating contested, anti-access/area denial environments. Developed surrogate imaging sensors, processors, and track algorithms and performed advance proactive infrared countermeasure (PIRCM) search, detect, and countermeasure research. Developed concepts for protection of postulated future threats to 6th generation aircraft, including definition of component and subsystem requirements.

FY 2015 Plans:

Develop advanced EO/IR concepts for protection from postulated future threats, including definition of component and subsystem requirements. Concepts will address contested, anti-access/area denial threats. Conduct laboratory experiments of surrogate multi-mode EO/IR sensors, processors, and track algorithms and continue 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. Development of 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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 63691X / *EO/IR Warning & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
effects against advanced IR and multispectral threats. Conduct tests with advanced, next generation missile warning, hostile fire indication (HFI) and laser warning technologies.			
Accomplishments/Planned Programs Subtotals	4.630	4.356	4.061

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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	57.787	68.907	54.897	-	54.897	61.693	60.343	59.210	60.346	Continuing	Continuing
632181: *Spacecraft Payloads*	-	14.683	12.664	15.573	-	15.573	15.989	15.908	16.672	16.853	Continuing	Continuing
633834: *Integrated Space Technology Demonstrations*	-	9.565	18.346	17.766	-	17.766	22.416	23.454	15.994	15.692	Continuing	Continuing
634400: *Space Systems Protection*	-	9.691	3.874	6.197	-	6.197	8.091	7.607	8.644	9.057	Continuing	Continuing
634950: *Space Demonstration*	-	10.114	11.737	-	-	-	-	-	-	-	-	21.851
635021: *Space Systems Survivability*	-	2.313	3.076	2.207	-	2.207	1.949	1.946	2.042	2.040	Continuing	Continuing
635083: *Ballistic Missiles Technology*	-	3.280	7.733	3.924	-	3.924	1.687	1.339	0.993	-	Continuing	Continuing
63682J: *Spacecraft Vehicles*	-	8.141	11.477	9.230	-	9.230	11.561	10.089	14.865	16.704	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops, integrates, and demonstrates space technologies in the areas of spacecraft payloads, spacecraft protection, spacecraft vehicles, ballistic missiles, and space systems survivability. The integrated space technologies are demonstrated by component or system level tests on the ground or in flight. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force					Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*			R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*		
B. Program Change Summary ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	67.894	69.026	60.110	-	60.110
Current President's Budget	57.787	68.907	54.897	-	54.897
Total Adjustments	-10.107	-0.119	-5.213	-	-5.213
• Congressional General Reductions	-	-0.119			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-8.271	-			
• SBIR/STTR Transfer	-1.836	-			
• Other Adjustments	-	-	-5.213	-	-5.213

Change Summary Explanation

FY2014 funding of $8.271 million reprogrammed to support high priority science and technology effort.

FY2016 decrease due to realignment of research efforts.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 632181 / *Spacecraft Payloads*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
632181: *Spacecraft Payloads*	-	14.683	12.664	15.573	-	15.573	15.989	15.908	16.672	16.853	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 2014	FY 2015	FY 2016
Title: Advanced Space Electronics	4.933	4.344	4.116
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 2014 Accomplishments:*** Focused development of multiprocessor components to reduce power required for on-orbit processing capability. Developed volatile memory for satellite high-density data storage capability. Began to develop analog structured application specific integrated circuits for affordable space electronic support logic. ***FY 2015 Plans:*** Continue development of multi-processor components to provide extremely-high-performance, low-power on-orbit processing capability. Continue to develop high-density volatile memory devices. Continue 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. Continue development of E-Beam lithography tool. Investigate development of on-shore advanced field programmable gate array (FPGA). ***FY 2016 Plans:*** Begin development of Memristor 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.			
Title: Spacecraft Design Tools	0.190	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 632181 / *Spacecraft Payloads*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop satellite system technologies for spacecraft operations and for satellite control, precision navigation, formation flying, and proximity operations technologies. ***FY 2014 Accomplishments:*** Completed development, refinement and use of modular space component ground testbed. Matured plug-and-play standards and structure. Finished supporting Air Force development of a plug-and-play based space vehicle. ***FY 2015 Plans:*** Effort completed in FY 2014. ***FY 2016 Plans:*** N/A			
Title: Advanced Space Modeling and Simulation Tools ***Description:*** Develop modeling, simulation, and analysis tools for space-based surveillance systems, space capability protection technologies, access/mobility technologies, and flight experiments. ***FY 2014 Accomplishments:*** Validated system to mission-level modeling and simulation tools for flight program mission planning. Finalized data requirements fro upcoming flight programs to gather critical validation data on orbit to enhance previously developed modeling and simulations tools. Evaluated the military and technical utility of emerging space vehicle technologies and associated software algorithms. ***FY 2015 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. ***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.	1.977	0.897	1.263
Title: Advanced Space Sensors ***Description:*** Develop space infrared technology and hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of hot targets, as well as "cold body" objects. ***FY 2014 Accomplishments:***	2.190	2.592	1.806

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 632181 / *Spacecraft Payloads*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continued developing wide field of view large focal plane array for theater missile warning, missile detection, and battlespace awareness. Initiated radiation hardened visible scanning effort to improve sensor capabilities for comprehensive Space Situational Awareness (SSA). ***FY 2015 Plans:*** Investigate 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. Continue to mature radiation hardened visible starrers and/or scanners as well as long wavelength infrared detection in support of SSA missions. ***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.			
Title: Positioning, Navigation, and Timing (PNT) Space Payload Technologies ***Description:*** Develop, validate, and transition technologies that: enable new, or enhance existing, U.S. PNT satellite capabilities by increasing resiliency and availability of accuracy; and/or increase the affordability of providing current capabilities. Develop validate, and transition technologies to meet identified Air Force Space Command/Space and Missile Systems Center PNT space payload technology needs. ***FY 2014 Accomplishments:*** Initiated acquisition of advanced on-orbit reprogrammable digital waveform generator technology for application to future satellites in the Global Positioning System (GPS) system to enable after-launch modification of the GPS signals or the implementation of new signals and signal combining/synthesis techniques over the on-orbit life of the satellite. Enabled increased flexibility and resiliency of the GPS system. Conduct system engineering and initiate designs of advanced technology space qualifiable L-band radio frequency (RF) amplifier(s) for PNT/GPS. ***FY 2015 Plans:*** Finalize design and begin performance evaluation of advanced technology space qualifiable L-band RF amplifier(s) for PNT/GPS. ***FY 2016 Plans:*** Finalize design and begin performance evaluation of on-orbit reprogrammable digital waveform generator for PNT/GPS. Take delivery of advanced technology space qualifiable L-band radio frequency amplifier(s) for PNT/GPS.	5.393	4.831	8.388
Accomplishments/Planned Programs Subtotals	14.683	12.664	15.573

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 632181 / *Spacecraft Payloads*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 633834 / *Integrated Space Technology Demonstrations*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
633834: *Integrated Space Technology Demonstrations*	-	9.565	18.346	17.766	-	17.766	22.416	23.454	15.994	15.692	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 2014	FY 2015	FY 2016
Title: Integrated Satellite Demonstrations	9.565	18.346	17.766

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

FY 2014 Accomplishments:
Began space flight operations of geosynchronous orbit satellite demonstrating advanced autonomy technologies. Continued maintenance and debugging of geosynchronous orbit experimental satellite flight software and orbit analysis tools. Procured long-lead components, the platform, and Air Force payloads for planned demonstration of an augmented Evolved Expendable Launch Vehicle Secondary Payload Adaptor (ESPA) geosynchronous orbit experiment.

FY 2015 Plans:
Continue one year of experimental flight operations. Begin analyzing science and health and status data. Verify maneuverable geosynchronous experimental platform design. Verify 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 FY17. Demonstration payloads include HyperTemporal 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 concept for next-generation integrated demonstration. Determine military utility and define specific goals, scope,

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 633834 / *Integrated Space Technology Demonstrations*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
technical objectives, and concepts of operation. Begin design engineering trade studies for space flight demonstration with a target launch of FY18-19.			
Accomplishments/Planned Programs Subtotals	9.565	18.346	17.766

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 634400 / *Space Systems Protection*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
634400: *Space Systems Protection*	-	9.691	3.874	6.197	-	6.197	8.091	7.607	8.644	9.057	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 2014	FY 2015	FY 2016
Title: Space Situational Awareness Capability Development	6.481	2.685	1.371
Description: Develop tools and technologies that advance space-based proximity awareness capabilities and enable protection and countermeasure courses of action. Efforts will assess a variety of phenomenologies and concepts in response to multiple threat classes and scenarios. ***FY 2014 Accomplishments:*** Used experimental test results from deep-space imaging experiments, conduct an engineering trade study for a space-based concept. ***FY 2015 Plans:*** Initiate hardware development on space-based imaging concepts that show viability under the feasibility study. Complete data analysis from the joint threat scenario study to quantify technology return-on-investment metrics. Initiate concept development, modeling, and simulations. ***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.			
Title: Space Indicators and Warning Research	3.017	0.295	1.699
Description: Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites. ***FY 2014 Accomplishments:***			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 634400 / *Space Systems Protection*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continued local area sensor for indication and warning engineering unit development. Continued design concept for integrated sensor suite and response system for automated response options. ***FY 2015 Plans:*** Continue 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.			
Title: Spacecraft Threat Detection ***Description:*** Develop active satellite local space awareness technologies and exploitation tools for satellite systems. ***FY 2014 Accomplishments:*** Expanded satellite autonomy architecture and demonstrate threat/anomaly detection and response with real-time sensor processing and control. ***FY 2015 Plans:*** Develop components to enable on-board detection, assessment, and resolution of spacecraft anomalies to include co-orbital and directed energy threats. Apply efforts towards geosynchronous spaceflight demonstration as well as extensions to demonstrate multi-asset, space and ground, coordination. Employ 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. Down-select cross queuing concepts and identify specific candidate technologies to integrate and increase cross coordination between space and ground sensor assets.	0.193	0.894	3.127
Accomplishments/Planned Programs Subtotals	9.691	3.874	6.197

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 634400 / *Space Systems Protection*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 634950 / *Space Demonstration*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
634950: *Space Demonstration*	-	10.114	11.737	-	-	-	-	-	-	-	-	21.851

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 2014	FY 2015	FY 2016
Title: S&T Space Launch Integration and Test	10.114	11.737	-
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 2014 Accomplishments:*** Provided mission definition, design, development, and operations planning. Refined satellite and payload manifest. Continued planning and integration of satellites and payloads onto launch vehicle. ***FY 2015 Plans:*** Finalize satellite and payload manifest. Complete payload/satellite/launch vehicle integration. ***FY 2016 Plans:*** Effort completes in FY 2015.			
Accomplishments/Planned Programs Subtotals	10.114	11.737	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 635021 / *Space Systems Survivability*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635021: *Space Systems Survivability*	-	2.313	3.076	2.207	-	2.207	1.949	1.946	2.042	2.040	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 2014	FY 2015	FY 2016
Title: Spacecraft Survivability/Reliability	2.313	3.076	2.207

Description: Develop technologies to provide improved space radiation and ionospheric hazard specification and forecasting.

FY 2014 Accomplishments:

Completed preliminary design review of compact environmental sensor and began assembly of engineering unit. Accepted delivery and began integrating high-energy particle telescopes into compact space environment sensor. Utilized newly available space environment data sets to improve the accuracy of standard radiation belt model for satellite design. Delivered microdosimeter space environment sensor for integration into customer spacecraft. Demonstrated ability to generate tailored space environment hazards for spacecraft.

FY 2015 Plans:

Continue utilizing on-orbit data to generate tailored space environment hazards for operational systems. Expand space environment anomaly attribution tool to new orbital domains. Complete assembly and initiate calibration and test of compact space environment sensor. Update standard radiation belt model with additional new on-orbit data. Begin 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 space environment 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.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 635021 / *Space Systems Survivability*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Begin transition of solar radio emission monitoring specification and forecasting of radio-frequency into updated model, which will enable understanding and assessment of impacts on Air Force assets.			
Accomplishments/Planned Programs Subtotals	2.313	3.076	2.207

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 635083 / *Ballistic Missiles Technology*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635083: *Ballistic Missiles Technology*	-	3.280	7.733	3.924	-	3.924	1.687	1.339	0.993	-	Continuing	Continuing

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 2014	FY 2015	FY 2016
Title: Advanced Navigation Instruments	3.280	7.733	3.924
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 2014 Accomplishments:*** Continued design and build of fully weapons hardened Advanced Inertial Measurement Unit (AIMU) design to meet Minuteman III requirements. Continued ground testing to include component testing and sled test of prototype AIMU to validate performance. ***FY 2015 Plans:*** Continue weapons hardening of critical technology elements of AIMU system. Build two ground test units with improved design updates for additional testing and integration planning. Investigate and implement multipath mitigation improvements. Incorporate in militarily relevant hardware and conduct 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.			
Accomplishments/Planned Programs Subtotals	3.280	7.733	3.924

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 635083 / *Ballistic Missiles Technology*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / *Advanced Spacecraft Technology*	Project (Number/Name) 63682J / *Spacecraft Vehicles*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
63682J: *Spacecraft Vehicles*	-	8.141	11.477	9.230	-	9.230	11.561	10.089	14.865	16.704	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 2014	FY 2015	FY 2016
Title: Space Power Technologies	2.192	1.705	1.161
Description: Develop power generation space technologies such as multi-junction solar cells, thin-film solar cells, lightweight solar cell arrays, and radiation resistant solar cell modules. ***FY 2014 Accomplishments:*** Completed development of efficient 35% inverted metamorphic (IMM) solar cell. Continued development of 36-37% IMM and quantum dot enhanced IMM solar cells. Completed IMM solar cell interconnection and continue maturation of module technologies. ***FY 2015 Plans:*** Continue development of approaches for greater than 35% efficient solar cells. Mature module/blanket technologies for increased reliability and resiliency. Mature flexible array technologies. ***FY 2016 Plans:*** Down-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.			
Title: Spacecraft Thermal Technologies	0.784	1.080	0.255
Description: Develop technologies for long-life, efficient, low-vibration, lightweight mechanical cryocoolers and integration components for space applications. ***FY 2014 Accomplishments:*** Using correlated computer modeling results, continued to reduce size, weight, and power requirements, ease integration, and increased reliability of cryocoolers and supporting payload thermal management systems for very large format focal plane arrays for missile warning capability and for industry to significantly improve overall cryocooler design. Further expanded computer			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 63682J / *Spacecraft Vehicles*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
modeling to additional cryocooler components, to include flow straightening effects and other refrigeration cycles (reverse Brayton), and provided correlated results to industry. ***FY 2015 Plans:*** Continue 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. Increase manufacturability of space-borne cryocoolers through the implementation of commercial, terrestrial cryocooler technologies, combined with space-like designs. ***FY 2016 Plans:*** Complete validation of high-order models to low order models to reduce optimization time through quick parametric analysis			
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 2014 Accomplishments:*** Performed data analysis on variable heat transfer modulation experiment aboard the International Space Station. Produced flight-representative deployable baffle and folded optics for compact star-trackers and wide-field-of-view imagers. ***FY 2015 Plans:*** Develop new thermal technologies for heat dissipation of high energy density spacecraft electronics slated for use on Air Force communications and Global Positioning System (GPS) spacecraft. Initiate in-house testing of these technologies and begin working the technology transition process to Air Force spacecraft prime contractors. Mature technologies for composite spacecraft deployable structures, solar arrays, electro-optical and radio-frequency apertures, and de-orbit mechanisms. Test 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 by six times. 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.	1.765	2.141	1.161
Title: On-Orbit Satellite Controls	1.106	0.523	0.453

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 63682J / *Spacecraft Vehicles*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop technologies for spacecraft controls and mechanisms for on-orbit applications. ***FY 2014 Accomplishments:*** Continued advanced spacecraft guidance, navigation, and control subsystem hardware development efforts. ***FY 2015 Plans:*** Initiate development of advanced low size/weight/power high-precision navigation hardware for geosynchronous SSA missions. ***FY 2016 Plans:*** Continue development of advanced low size/weight/power inertial measurement units and high-precision maneuvering technology for geosynchronous SSA missions.			
Title: Space Communication and Control Technologies ***Description:*** Develop technologies for next-generation space communications terminals and equipment, along with methods/ techniques to enable future space system operational command and control concepts. ***FY 2014 Accomplishments:*** Developed 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. ***FY 2015 Plans:*** Continue 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. Support Space and Missile Systems Center Low-Cost User Terminal initiatives. ***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 applied research and development projects that address technology gaps identified by Air Force Space Command for future military satellite communication systems.	2.294	4.441	3.297
Title: Advanced Alternative Navigation Technologies ***Description:*** Develop new atomic clock technologies and transition these technologies to industry for potential application to future positioning, navigation, and timing space considerations.	-	1.587	2.903

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 63682J / *Spacecraft Vehicles*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
FY 2014 Accomplishments: N/A ***FY 2015 Plans:*** Initiate efforts to transition newly-developed atomic clock technology from laboratory experiments to industry for potential space systems application. Design and begin fabricating engineering models of these clocks to meet DoD positioning and timing requirements. ***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.			
Accomplishments/Planned Programs Subtotals	8.141	11.477	9.230

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603444F / *Maui Space Surveillance System (MSSS)*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	25.535	14.031	12.853	-	12.853	11.681	11.681	11.912	12.147	Continuing	Continuing
634868: *Maui Space Surveillance System*	-	25.535	14.031	12.853	-	12.853	11.681	11.681	11.912	12.147	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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	26.299	14.031	12.938	-	12.938
Current President's Budget	25.535	14.031	12.853	-	12.853
Total Adjustments	-0.764	-	-0.085	-	-0.085
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.764	-			
• Other Adjustments	-	-	-0.085	-	-0.085

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Operate and Upgrade Maui Space Surveillance System (MSSS)	20.166	11.002	10.853
Description: Operate and upgrade the MSSS to support development, demonstration, and integration of ground-based optical SSA technologies.			
FY 2014 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 including completing			

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603444F / *Maui Space Surveillance System (MSSS)*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
refurbishment of 1.6 meter dome. Completed delivery and began installation of the upgraded Laser Guidestar system at MSSS. Implemented procedures and operated MSSS facility for development and demonstration of ground based optical SSA capabilities in conjunction with customer programs and an operational SSA mission. ***FY 2015 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 installation and testing of equipment for upgraded Laser Guidestar system at MSSS. ***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. Demonstrate operation of Laser Guidestar system at MSSS.			
Title: Geosynchronous Object Sensor ***Description:*** Develop and demonstrate dual-use integrated sensor technology for imaging of geosynchronous objects as well as other long-range applications. ***FY 2014 Accomplishments:*** Continued to develop laser detection and ranging transceiver for initial low-power technology demonstration to image objects in geosynchronous orbit. ***FY 2015 Plans:*** Integrate low power transceiver hardware prior to low power testing to image objects in geosynchronous orbit. ***FY 2016 Plans:*** Conduct low power demonstration of augmented objects for refinement of high power system. Begin build-out of high-power transceiver hardware and initiate telescope modifications for future demonstration of laser imaging of objects in geosynchronous orbit.	5.369	3.029	2.000
Accomplishments/Planned Programs Subtotals	25.535	14.031	12.853

D. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603444F / *Maui Space Surveillance System (MSSS)*

D. Other Program Funding Summary ($ in Millions)

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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	24.508	21.788	25.448	-	25.448	26.314	22.811	23.470	25.114	Continuing	Continuing
635323: *Directed Energy Bioeffects Parameters*	-	3.615	3.092	2.439	-	2.439	4.731	4.888	5.115	6.393	Continuing	Continuing
635324: *Human Dynamics and Terrain Demonstration*	-	8.459	8.839	7.149	-	7.149	6.759	6.935	7.068	7.209	Continuing	Continuing
635325: *Mission Effective Performance*	-	6.279	4.461	10.724	-	10.724	10.141	6.626	6.846	6.982	Continuing	Continuing
635327: *Warfighter Interfaces*	-	6.155	5.396	5.136	-	5.136	4.683	4.362	4.441	4.530	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates technologies to enhance airman performance and effectiveness in the aerospace force. State-of-the-science advances are made in warfighter training, warfighter system interfaces, directed energy bioeffects, deployment and sustainment of warfighters in extreme environments, and understanding and shaping adversarial behavior. The Directed Energy Bioeffects Parameters project develops, demonstrates, and transitions technologies to predict, evaluate, and mitigate the effects of directed energy on personnel and mission performance, and exploits the offensive capabilities of directed energy systems. The Human Dynamics and Terrain Demonstration project develops, demonstrates, and transitions human-centric technologies to address processing, exploitation, and dissemination of intelligence, surveillance, and reconnaissance (ISR) capability needs. The Mission Effective Performance project develops, demonstrates, and transitions advanced training, simulation, mission rehearsal, and other performance-aiding methods and technologies to enhance warfighter readiness. The Warfighter Interfaces project develops, demonstrates, and transitions technologies to revolutionize the way airmen synergistically use Air Force systems, including autonomous machines and adaptive teams of airmen and machines. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force					Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*			R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*		
B. Program Change Summary ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	20.902	21.788	19.817	-	19.817
Current President's Budget	24.508	21.788	25.448	-	25.448
Total Adjustments	3.606	-	5.631	-	5.631
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	4.001	-			
• SBIR/STTR Transfer	-0.395	-			
• Other Adjustments	-	-	5.631	-	5.631

Change Summary Explanation

In FY 2014, funds were reprogrammed to support a high-priority live, virtual and constructive demonstration effort.

FY 2016 increase to support high-priority live, virtual and constructive demonstration effort.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635323 / *Directed Energy Bioeffects Parameters*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635323: *Directed Energy Bioeffects Parameters*	-	3.615	3.092	2.439	-	2.439	4.731	4.888	5.115	6.393	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 2014	FY 2015	FY 2016
Title: Optical Radiation Bioeffects	2.177	1.500	1.622
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 2014 Accomplishments: Merged a frame and format design capability with a visual performance metrics and modeling capability to create a single, integrated package allowing complete human systems integration of laser eye protection (LEP). Used three-dimensional (3-D) optical modeling tools to quantify and visually render the effects of LEP filters on human vision. Participated in demonstration of mission planning analysis tool for optimization of directed energy/kinetic energy weapons use. Validated bioeffects models. Integrated probabilistic tools into high energy laser collateral damage models.			
FY 2015 Plans: Begin integration of physiological/behavioral response models into engagement-level simulation capabilities for directed energy weapon threats and concepts. 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. Apply these models in the battlespace simulation at tactical levels with contribution of bioeffect human vulnerability models in a DoD standardized format. Continue 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:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635323 / *Directed Energy Bioeffects Parameters*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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 LEP evaluations to perform night visor aircrew acceptance testing, including laboratory testing, and ground and flight assessments.			
Title: Radio Frequency Bioeffects ***Description:*** Develop and demonstrate technologies to assess RF bioeffects and collateral hazards from high power RF directed energy systems. ***FY 2014 Accomplishments:*** Identified candidate directed energy weapons system and began to incorporate real-time collateral effects and hazard calculations into weapon systems. Participated in demonstration of mission planning analysis tool for optimization of directed energy/kinetic energy weapons use. Validated bioeffects models. Began 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 2015 Plans:*** Validate predictive capability of models against high average power scenarios and begin integration of high peak power models and high average power models into one software suite. Continue 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.	1.438	1.592	0.817
Accomplishments/Planned Programs Subtotals	3.615	3.092	2.439

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635323 / *Directed Energy Bioeffects Parameters*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635324 / *Human Dynamics and Terrain Demonstration*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635324: *Human Dynamics and Terrain Demonstration*	-	8.459	8.839	7.149	-	7.149	6.759	6.935	7.068	7.209	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 2014	FY 2015	FY 2016
Title: Human Analyst Augmentation	2.977	3.419	5.194
Description: Develop and demonstrate human-centered design processes and operational tools that optimize ISR information exploitation and analysis.			
FY 2014 Accomplishments: Demonstrated and delivered work aids for intelligence analysts and tools for collaborative synthesis and social cognitive analysis. Demonstrated and delivered human-centric analytic work environment for intelligence analysis by processing, exploitation, and dissemination teams. Assessed effectiveness of analyst aids in the processing, exploitation, and dissemination process.			
FY 2015 Plans: Develop 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.			
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.			
Title: Human Trust and Interaction	2.349	2.150	1.206
Description: Develop and demonstrate machine translation and speech-to-text tools to support the span of Air Force mission areas including ISR and cyber operations.			
FY 2014 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635324 / *Human Dynamics and Terrain Demonstration*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Matured human language technologies to develop tools that improve the effectiveness of ISR operators and intelligence analysts. Developed, assessed, and tested capabilities against specific customer data sets, especially those characterized by scientific and technical terminology. Evaluated and integrated algorithms into frameworks supporting ISR collection and exploitation. ***FY 2015 Plans:*** Develop advanced multimedia machine translation and automatic speech recognition tools. Develop 'soft' and 'hard' fusion methodology experiments. ***FY 2016 Plans:*** Demonstrate and test advanced multimedia machine translation and automatic speech recognition tools.			
Title: Human Signatures ***Description:*** Develop automated and assisted methods to exploit human threat biosignatures to defeat terrorist activities and hidden person-borne threats. Provide improved models of virtual humans to deliver mission-ready training for ISR analysts and create more immersive, realistic experiences in joint and coalition exercises. ***FY 2014 Accomplishments:*** Initiated multimodal exploitation of signatures through fusion of radar, electro-optical, and infrared sensing. Collected outdoor signatures for hyperspectral and polarized light with realistic background. Initiated development of multimodal avatar with radar output and morphology governing size, shape, and motion definition and an on-the-job training platform for ISR analysts. ***FY 2015 Plans:*** Demonstrate utility of integrated normative anthropometric-based human signatures data sets. Demonstrate wearable wireless monitors for human performance real-time assessment for multiple operational settings. ***FY 2016 Plans:*** Investigate integration of normative anthropometric-based human signatures algorithms into sensor system processors.	3.133	3.270	0.749
Accomplishments/Planned Programs Subtotals	8.459	8.839	7.149

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635324 / *Human Dynamics and Terrain Demonstration*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*	Project (Number/Name) 635325 / *Mission Effective Performance*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635325: *Mission Effective Performance*	-	6.279	4.461	10.724	-	10.724	10.141	6.626	6.846	6.982	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 incorporating performance assessment and feedback tools. These methods and technologies facilitate the development of mission-essential competencies.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Continuous Learning	6.279	4.461	10.724
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 2014 Accomplishments: Completed development, demonstration, and initial transition of learning management system for distributed mission operations (DMO) and LVC operations. Initiated development of standards for shareable scenario content, data, and metrics. Began development of operational LVC requirements and secure enterprise architecture to support LVC operational training.			
FY 2015 Plans: Complete performance-based LVC environment fidelity assessment system. Complete development of automated tools to analyze training utility for alternative ways to accomplish mixes of live and virtual training in and across mission sets. Begin development of common scenario, learner performance, and after action review content tagging for training. Develop learning management technologies for undergraduate pilot training. Develop adaptive training and performance measurement system for ISR analysts. Develop low-cost, multiple-platform remotely piloted aircraft (RPA) training system. Initiate adaptive training for Red Flag preparation. Develop 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 DMO and LVC environments. Demonstrate deployable LVC training in integrated manned and			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635325 / *Mission Effective Performance*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
unmanned aircraft and ground operations exercise. Begin development of scenario and metrics specifications and standards for deployable LVC operations.			
Accomplishments/Planned Programs Subtotals	6.279	4.461	10.724

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603456F / *Human Effectiveness Advanced Technology Development*	Project (Number/Name) 635327 / *Warfighter Interfaces*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635327: *Warfighter Interfaces*	-	6.155	5.396	5.136	-	5.136	4.683	4.362	4.441	4.530	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 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 2014	FY 2015	FY 2016
Title: Applied Neuroscience	0.785	0.729	0.437
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 2014 Accomplishments:*** Completed analysis of human operator team composition and requisite skill sets based upon cyber tool set composition, operational information flow, and concept of operations. Began initial design of an integrated offensive and defensive cyber operator tool set. ***FY 2015 Plans:*** Finalize design recommendations for an integrated offensive and defensive cyber operator tool set. Integrate neurophysiological sensors and validated biofluid sensors capable of real-time assessment of human cognition, human-machine teaming status, and calibrated trust. Conduct 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. Integrate 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.			
Title: Battlespace Acoustics	3.398	2.901	3.119

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635327 / *Warfighter Interfaces*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Demonstrate ability to forecast acoustic profiles for any atmospheric/terrain condition. Demonstrate technologies to enhance the battlefield airman's situational awareness through wearable interfaces. ***FY 2014 Accomplishments:*** Refined high-fidelity 3-D acoustic models for integration into mission planning tools. Validated acoustic models against real-world data obtained from airborne platform measurements. Incorporated weather effects, landscape sounds, and geography into acoustic models. Developed prototype user interfaces based on pararescue jumper requirements and use-case scenarios. Refined wearable interface designs based on battlefield airmen feedback. ***FY 2015 Plans:*** Integrate real-time 3-D acoustic models into mission planning tools. Validate high-fidelity 3-D acoustic models against real-world data obtained from airborne platform measurements in different weather and terrain environments. Validate weather effects, landscape sounds, and geography used in developed acoustic models. Apply human factors and usability engineering methodologies to prototype and test wearable interfaces for seamless integration of data for battlefield airmen. ***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.			
Title: Human Role in Semiautonomous Systems ***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. ***FY 2014 Accomplishments:*** Integrated, tested, and evaluated operator interface designs to support decision-making and situation awareness while controlling multiple advanced and legacy RPAs in a dynamic mission environment. Developed multi-transit control station interface technology to enable a single pilot to simultaneously control multiple RPAs transiting through airspace. Began developing and evaluating interface controls for a networked RPA collaborative environment allowing teams of pilots along with sensor and payload operators to work together during stringent mission phases. ***FY 2015 Plans:***	1.972	1.766	1.580

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603456F / *Human Effectiveness Advanced Technology Development*	**Project (Number/Name)** 635327 / *Warfighter Interfaces*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Demonstrate and evaluate operator interface designs to support decision-making and situation awareness while controlling multiple advanced and legacy RPAs in a dynamic mission environment. Perform initial evaluations of multi-transit control station interface technology to enable a single pilot to simultaneously control multiple RPAs transiting through airspace by using high-fidelity simulations. Using high-fidelity simulations and flight tests, evaluate interfaces for a networked RPA collaborative environment to allow teams of pilot, sensor, and payload operators to work together during various RPA mission phases. ***FY 2016 Plans:*** 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.			
Accomplishments/Planned Programs Subtotals	6.155	5.396	5.136

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 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603601F / *Conventional Weapons Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	33.410	42.046	48.536	-	48.536	45.401	52.969	56.529	58.566	Continuing	Continuing
63670A: *Conventional Weapons Development*	-	33.410	42.046	48.536	-	48.536	45.401	52.969	56.529	58.566	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops, demonstrates, and integrates 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 address blast, fragmentation, penetration, low-collateral damage, variable depth/location fuzing, precise guidance, and high performance and insensitive explosives. Efforts in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

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

B. Program Change Summary ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	33.996	42.046	50.047	-	50.047
Current President's Budget	33.410	42.046	48.536	-	48.536
Total Adjustments	-0.586	-	-1.511	-	-1.511
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.586	-			
• Other Adjustments	-	-	-1.511	-	-1.511

Change Summary Explanation

Decrease in FY 2016 due to higher DoD priorities.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Ordnance Technologies	6.400	8.000	4.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603601F / *Conventional Weapons Technology*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Develop and demonstrate ordnance technologies to improve conventional, air-delivered munitions. Specific technical areas of focus include fuzes, energetic materials, and warheads. ***FY 2014 Accomplishments:*** Completed demonstrations of a conventional ordnance package capable of penetrating high performance concrete at increased impact velocities. Demonstrated survivability and performance of a new hard target warhead explosive fill, which subsequently was certified as a DoD-approved energetic. Completed demonstration of technologies that enable velocity augmentation for penetrating weapons. Continued developing an ordnance package capable of tailoring the effect of the weapon for the target and its surrounding environment. Continued development of alternate fuze technologies to increase the reliability of penetrating weapons. ***FY 2015 Plans:*** Demonstrate alternate fuzing technologies to increase the reliability of penetrating weapons. Develop and assess ordnance technologies that enable high-speed strike weapon concepts through use of reactive composite cases, dual use of propulsion fuels, and focused fragmentation. Complete the development of an ordnance package that enables the warfighter to tailor the weapon effects for the target and its surrounding environment. ***FY 2016 Plans:*** Continue to demonstrate 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.			
Title: Guidance Technologies	11.500	7.000	5.500
Description: Develop and demonstrate guidance technologies to improve the precision, controlled lethality, and flexibility of conventional, air-delivered munitions. Specific technical areas include precision navigation and terminal seekers. ***FY 2014 Accomplishments:*** Completed simulations of weapon navigation and control necessary for penetration into hard targets at high velocities. Demonstrated technologies for precision weapon navigation in GPS-degraded environments. Developed technologies capable of guiding a high-speed strike weapon characterized by very high terminal speed and high end-game maneuverability. ***FY 2015 Plans:***			

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603601F / *Conventional Weapons Technology*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
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. ***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.			
Title: Advanced Munition Concept Technologies ***Description:*** Demonstrate advanced conventional munition concepts. These innovative concepts integrate ordnance, guidance, and carriage and release technologies to demonstrate warfighter capability. ***FY 2014 Accomplishments:*** Completed full scale, sled track demonstrations of a high-speed penetrating weapon concept. Investigated concepts for cooperative control of small weapons to produce scalable effects to increase the capacity and capability of fifth-generation aircraft. Developed ordnance and guidance technologies for tactically relevant long range strike weapons and reduce risk for a potential follow-on acquisition program. ***FY 2015 Plans:*** 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. 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 the joint weapons effectiveness analyses. Demonstrate weapon integration concept for air target engagement. ***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 the joint weapons effectiveness analyses. Demonstrate weapon integration concept for air target engagement.	15.510	27.046	38.536
Accomplishments/Planned Programs Subtotals	33.410	42.046	48.536

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603601F / *Conventional Weapons Technology*

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603605F / *Advanced Weapons Technology*

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
Total Program Element	-	18.519	33.542	30.195	-	30.195	31.064	38.677	30.238	30.840	Continuing	Continuing
633151: *Lasers and Imaging Development and Integration*	-	9.277	16.011	13.385	-	13.385	12.824	11.987	12.237	12.480	Continuing	Continuing
633152: *High Power Microwave Development and Integration*	-	9.242	17.531	16.810	-	16.810	18.240	26.690	18.001	18.360	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 including 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. 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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	19.000	23.542	32.295	-	32.295
Current President's Budget	18.519	33.542	30.195	-	30.195
Total Adjustments	-0.481	10.000	-2.100	-	-2.100
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	10.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.481	-			
• Other Adjustments	-	-	-2.100	-	-2.100

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: 633152: *High Power Microwave Development and Integration*		
Congressional Add: *Counter-electronics high power microwave advanced missile*	-	10.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603605F / *Advanced Weapons Technology*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Congressional Add Subtotals for Project: 633152	-	10.000
Congressional Add Totals for all Projects	-	10.000

Change Summary Explanation

Decrease in FY16 is due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603605F / *Advanced Weapons Technology*	Project (Number/Name) 633151 / *Lasers and Imaging Development and Integration*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
633151: *Lasers and Imaging Development and Integration*	-	9.277	16.011	13.385	-	13.385	12.824	11.987	12.237	12.480	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project provides for the development, integration, demonstration, and detailed assessment of HEL device 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 2014	FY 2015	FY 2016
Title: High Energy Laser/Beam Control	9.277	16.011	13.385
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 military utility. ***FY 2014 Accomplishments:*** With DARPA, continued to prepare for the integration of their high energy electric laser device and the Air Force beam control system on level ground and prepared to conduct high energy laser tests against various targets including rockets, artillery, and mortars (RAM). Continued to investigate concepts and technology requirements for future HEL applications such as aircraft self-protection ***FY 2015 Plans:*** With DARPA, integrate their electric high energy laser with the Air Force beam control system and begin to conduct high power testing against counter-RAM targets using the integrated high energy electric laser system on level ground and prepare to conduct high energy laser tests from a 3000 foot peak 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 design of a full scale turret with aero-effects mitigation. ***FY 2016 Plans:*** Continue experiments with the joint DARPA and Air Force high energy laser system from a 3000 foot peak against various targets including ground targets and surface-to-air missiles. Begin preperation for integration of a moderate power laser system into a pod for aircraft self-protection ground demo. Start developing lethality data, modeling and simulation tools for the ground demo. Complete the design of a full scale turret with aero-effects mitigation and plan for testing.			
Accomplishments/Planned Programs Subtotals	9.277	16.011	13.385

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603605F / *Advanced Weapons Technology*	**Project (Number/Name)** 633151 / *Lasers and Imaging Development and Integration*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603605F / *Advanced Weapons Technology*	Project (Number/Name) 633152 / *High Power Microwave Development and Integration*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
633152: *High Power Microwave Development and Integration*	-	9.242	17.531	16.810	-	16.810	18.240	26.690	18.001	18.360	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 2014	FY 2015	FY 2016
Title: HPEM Technologies	9.242	7.531	16.810
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 2014 Accomplishments:*** Evaluated four candidate source technologies for potential use in a multi-target, reusable HPM counter-electronics munition demonstrator. Developed and evaluated technologies to reduce size, weight, and power consumption for a compact multi-pulse system in an integrated platform with anti-tamper and battle damage assessment capabilities. ***FY 2015 Plans:*** Begin 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. ***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 demonstration.			
Accomplishments/Planned Programs Subtotals	9.242	7.531	16.810

	FY 2014	FY 2015
Congressional Add: Counter-electronics high power microwave advanced missile	-	10.000
FY 2015 Plans: Conduct Congressionally directed effort.		
Congressional Adds Subtotals	-	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603605F / *Advanced Weapons Technology*	**Project (Number/Name)** 633152 / *High Power Microwave Development and Integration*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603680F / *Manufacturing Technology Program*

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
Total Program Element	-	40.221	52.772	42.630	-	42.630	46.344	45.386	40.700	41.510	Continuing	Continuing
635280: *Manufacturing Technologies*	-	40.221	52.772	42.630	-	42.630	46.344	45.386	40.700	41.510	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. Manufacturing Technologies is in Budget Activity 3, Advanced Technology Development, since it develops and demonstrates manufacturing technologies for existing upgrades and/or new system developments that have military utility and address warfighter needs.

B. Program Change Summary ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	41.353	42.772	43.164	-	43.164
Current President's Budget	40.221	52.772	42.630	-	42.630
Total Adjustments	-1.132	10.000	-0.534	-	-0.534
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	10.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-1.132	-			
• Other Adjustments	-	-	-0.534	-	-0.534

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: 635280: *Manufacturing Technologies*		
Congressional Add: *Additive Manufacturing*	-	10.000
Congressional Add Subtotals for Project: 635280	-	10.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603680F / *Manufacturing Technology Program*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Congressional Add Totals for all Projects	-	10.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Sustainment Manufacturing Technologies	12.158	11.880	11.841
Description: Develop and implement cost-effective maintenance, repair, and manufacturing technologies for sustainment of Air Force weapon systems. ***FY 2014 Accomplishments:*** Developed cost effective conventional and low-observable production and repair technologies enabling affordable sustainment of aircraft systems. Conducted assessments and developed manufacturing technology to reduce logistics support costs, lead times, and cycle times for depot repair. ***FY 2015 Plans:*** Continue development of cost effective conventional and low-observable production and repair technologies to enable affordable sustainment of aircraft systems. Continue manufacturing technology development for depot maintenance. ***FY 2016 Plans:*** Continue development of cost effective conventional and low-observable production and repair technologies to enable affordable sustainment of aircraft systems. Continue manufacturing technology development for depot maintenance.			
Title: Advanced Manufacturing Technologies	28.063	30.892	30.789
Description: Develop and transition pervasive affordability and producibility technologies for weapon systems and processes. ***FY 2014 Accomplishments:*** Developed and demonstrated next generation agile manufacturing methods, commercial/military integration, quality processing and supply chain improvements. Developed and demonstrated manufacturing capabilities for more affordable and hot structures, advanced propulsion technologies, Air Force munitions, and electronics manufacturing technologies for communications, space solar cells, advanced Active Electronically Scanned Array (AESA) sensor applications, and Mid Wave Infrared optics. Conducted agile manufacturing risk reduction assessments on intelligence, surveillance, and reconnaissance components. ***FY 2015 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.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force	Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603680F / *Manufacturing Technology Program*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continue 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. Continue development of agile manufacturing applications and hot structures affordability and continue to mature advanced material development.			
Accomplishments/Planned Programs Subtotals	40.221	42.772	42.630

	FY 2014	FY 2015
Congressional Add: Additive Manufacturing ***FY 2015 Plans:*** Conduct Congressionally-directed effort.	-	10.000
Congressional Adds Subtotals	-	10.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A.

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force											Date: February 2015	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*							
COST ($ in Millions)	**Prior Years**	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	48.101	35.289	46.414	-	46.414	52.042	55.362	57.291	59.357	Continuing	Continuing
635319: *Anticipatory OPS Intent and Response*	-	5.997	4.229	3.661	-	3.661	7.128	4.710	6.144	6.267	Continuing	Continuing
635320: *Assured Worldwide Connectivity*	-	21.296	19.397	25.310	-	25.310	27.738	34.024	31.226	32.773	Continuing	Continuing
635321: *Global Battlespace Awareness*	-	13.669	7.953	12.214	-	12.214	8.425	12.739	14.638	14.929	Continuing	Continuing
635322: *Knowledge Management and Computing*	-	7.139	3.710	5.229	-	5.229	8.751	3.889	5.283	5.388	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.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Air Force					Date: February 2015
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*			R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*		
B. Program Change Summary ($ in Millions)	**FY 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**
Previous President's Budget	49.079	35.315	44.531	-	44.531
Current President's Budget	48.101	35.289	46.414	-	46.414
Total Adjustments	-0.978	-0.026	1.883	-	1.883
• Congressional General Reductions	-	-0.026			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.449	-			
• SBIR/STTR Transfer	-1.427	-			
• Other Adjustments	-	-	1.883	-	1.883

Change Summary Explanation

Increase in FY16 is due to higher DoD priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*	Project (Number/Name) 635319 / *Anticipatory OPS Intent and Response*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635319: *Anticipatory OPS Intent and Response*	-	5.997	4.229	3.661	-	3.661	7.128	4.710	6.144	6.267	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 2014	FY 2015	FY 2016
Title: Adaptive Planning and Decision Tools	2.082	3.548	3.257

Description: Develop and demonstrate the integration of planning tools and information-based intelligent agents for adaptive replanning and decision support tools.

FY 2014 Accomplishments:
Developed integrated battle planning services across warfighting and security domains allowing geographically distributed decision makers to leverage the full spectrum of AF assets. Developed air, space, and cyber constraint services enabling integration of federated and collaborative domains.

FY 2015 Plans:
Design and develop a set of planning tools and services that proactively build and shape the portion of cyberspace employed in support of mission assurance objectives. Develop a moving target defense (MTD) specification for integration into a Command and Control (C2) mission assurance framework. Continue 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. Generate optimized means of synchronizing cross-domain effects while respecting hard and soft constraints within and across domains.

FY 2016 Plans:
Prototype 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,

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635319 / *Anticipatory OPS Intent and Response*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
space and cyber missions in support of combined, global operations. Validate ability to synchronize efforts across warfighting domains (air, space, cyber, land and maritime) to create desired effects.			
Title: Next Generation Planning and Assessment Tools ***Description:*** Develop and demonstrate an effects-based approach for the next generation of planning and assessment techniques that enable decision makers to determine operational effects. ***FY 2014 Accomplishments:*** Continued development of tools in machine learning to autonomously generate patterns of life in support of mission planning operations. Continued development of 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 2015 Plans:*** Complete development of tools in machine learning for patterns of life generation. Demonstrate 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; providing a set of models that will give targeteers greater comprehension of the second and third order effects of targeting actions.	3.915	0.681	0.404
Accomplishments/Planned Programs Subtotals	5.997	4.229	3.661

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*	Project (Number/Name) 635320 / *Assured Worldwide Connectivity*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635320: *Assured Worldwide Connectivity*	-	21.296	19.397	25.310	-	25.310	27.738	34.024	31.226	32.773	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.)

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Cyber Offense	5.019	5.300	5.543
Description: Develop and demonstrate offensive cyber operations capabilities in a series of experimental technology demonstrations.			
FY 2014 Accomplishments: Initiated research to characterize emerging cyber environments to enable more proficient cyber operations. Continued enhancement of the Cyber Experimentation Environment (including extending its reach to the Stockbridge remote test range) to enable early trials of emerging technologies in realistic, large scale, contested environments. Initiated work on next generation of distributive and disruptive cyber technologies capable of achieving non-kinetic military objectives. Transitioned software to provide new capabilities to Big Safari program office (details classified). Developed Service oriented architecture (SOA) components for the Cyber Mission Framework to enable cross-service tool operation, mission reporting, and cyber use control constructs. Initiated red-teaming analysis of this framework. Developed advanced space situational awareness signal processor which captured new targets that had never before been. Researched, developed and tested Cyber Filter tool for high value target data.			
FY 2015 Plans: Continue development and delivery of a capability which processes available cyber observables to deliver operational preparation of the environment information vital to the warfighter. Develop highly configurable cyber simulation environment which produces			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635320 / *Assured Worldwide Connectivity*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
high fidelity cyber telemetry for analysis. Continue to assess military objectives for places were non-kinetic solutions can aid kinetic missions and enhance technologies for military relevant environments. Develop technologies to remain current with new waveforms and signals (details classified). ***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 (details classified). Continue SOA component development for use in the Air Force Lifecycle Management Center (AFLCMC) Cyber Mission Platform (CMP).			
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 2014 Accomplishments:*** Completed initial development of a network level encryptor/Traffic Aware router to allow enclaves at different security levels to share common network. Performed a technology assessment for Software Defined Networking and its applicability to the Aerial Layer. Developed a capability to effectively implement cross-layer protocol including efficient and robust routing capabilities. Conducted Triple Target Terminator (T3) Test with a live flight of the T3 system on live missiles. Conducted dynamic proxy radio test between Rome NY and Stockbridge NY. ***FY 2015 Plans:*** Continue development of a network level encryptor/Traffic Aware router to allow enclaves at different security levels to share common network. Demonstrate interference-tolerant waveform design, dissemination and utility on portable radio platform. Develop decentralized control algorithms and protocols for radio networks that optimally allocate resources from the bottom to higher layers of the protocol stack. Continue development of key technologies to be demonstrated in laboratory on software definable radio testbed. ***FY 2016 Plans:*** Continue development of a network level encryptor/Traffic Aware router to allow enclaves at different security levels to share common network. Continue research to push limits of technologies that improve the AF's Aerial Layer Networks. 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.	5.635	6.742	11.415
Title: Resiliency	2.524	3.011	3.247

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635320 / *Assured Worldwide Connectivity*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: Integrate and demonstrate a resilient and self-regenerating information enterprise that dynamically recognizes, characterizes, and understands novel cyber attacks and reconfigures and self-optimizes to resist new attacks. ***FY 2014 Accomplishments:*** Extended IP hopping technology from IPv4 to IPv6, and enhanced with situational awareness sensor feed and interface with cyber C2 system. Extended configuration-based agility/moving target capability extended from centralized to decentralized architecture, and added support for IPv6, Juniper devices in addition to Cisco, IP hopping control, limited quality of service (QoS), firewall verification, and improved resiliency. Extended polymorphic enclave technology from hypervisor-based host installation to external in-line device and added management console and improved policy flexibility, and gateway capability for access outside of the polymorphic network. Updated laboratory environment for demonstration and evaluation of Mission-Aware Cyber Command and Control(MACC2) integration, to include upgrading hardware and virtual machines. ***FY 2015 Plans:*** Continue the enhancement, maturation, testing, and demonstration of cyber agility technologies through exercises and other user-focused venues. ***FY 2016 Plans:*** Prototype demonstration deception capability to provide confusion to attacker. Complete high-speed IP hopping gateway. Continue automated tool for generation, verification, and deployment of secure system/network configurations.			
Title: Effects-based Cyber Defense ***Description:*** Integrate technology to demonstrate an effects-based strategic approach to cyber defense that focuses on avoiding, deterring, and minimizing the threat, and rendering the adversary ineffective. ***FY 2014 Accomplishments:*** Developed SecureServe Beta software to securely consolidate multiple information domains on a single server using virtualization. Developed capability for self-regenerative code and demonstrated for PACOM with the result being a request to integrate this capability into GLobal Command and Control System (GCCS). Prototyped survivability architecture for continuous mission oriented assessment and management that is planned to be validated at Eglin Air Force Base's simulated Air Operations Center (AOC) environment. Initiated a new research direction focused on survivability in cyberspace using diverse replicas and game theory. Demonstrated active steganalysis functionality leading to insertion into software system that has passed acceptance testing and is now fielded and operational. ***FY 2015 Plans:***	7.179	4.344	5.105

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635320 / *Assured Worldwide Connectivity*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continue development and performance analysis of new enhancement for insertion into active steganalysis product. ***FY 2016 Plans:*** Complete development and demonstrate new enhancements into the active steganalysis product. Initiate research into novel resiliency technologies as a packaged adaptive systems solution.			
Title: Airborne Communication Technologies ***Description:*** Develop and demonstrate flight ready systems consisting of high capacity RF and optical components and architectures for next generation communications. ***FY 2014 Accomplishments:*** Developed quantum key distribution sources and accurately measured the quantum states; conducted analysis and plans for performing site diversity radiometric testing for two sites with varying distances between the sites; continued effort in V/W-band SATCOM technology includes the modeling effort for propagation characterization and the development of the W-band Traveling Wave Tube amplifier. ***FY 2015 Plans:*** Effort terminated due to higher Department of Defense priorities. ***FY 2016 Plans:*** N/A	0.939	-	-
Accomplishments/Planned Programs Subtotals	21.296	19.397	25.310

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*	Project (Number/Name) 635321 / *Global Battlespace Awareness*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635321: *Global Battlespace Awareness*	-	13.669	7.953	12.214	-	12.214	8.425	12.739	14.638	14.929	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)	FY 2014	FY 2015	FY 2016
Title: Advanced Signal and Data Exploitation Technologies	5.082	2.284	5.503
Description: Demonstrate advanced signal and data exploitation technologies for detection, tracking, identification, and targeting of time-critical targets, and information extraction.			
FY 2014 Accomplishments: Developed imagery intelligence (IMINT) exploitation and text-data extraction fusion techniques. Continued development of applications to augment existing manual, human intensive and error-prone processing, exploitation, and dissemination (PED) processes. Demonstrated active steganalysis functionality leading to insertion into software system that has passed acceptance testing and is now fielded and operational. Continued development of techniques for the collection and analysis of non-communication emitters, primarily radar and radar jammer signals, to parameterize, classify, and geolocate the system. Continued development of technology that will work on short segment lengths, multiple languages, hostile/noisy signal environment enabling a time-critical response. Continued development of technologies to provide access, exploitation, and effects to communications and networks.			
FY 2015 Plans: Develop technologies to enhance ELINT detection and processing capabilities against emerging emitter weapon systems. Explore SIGINT, COMINT and other INTs signal exploitation for contested environments. Continue to develop speech processing algorithms will be investigated to improve feature extraction techniques, speed and efficiency of training/testing algorithms, and classifiers that aid in improvements to component technologies. Develop and perform an analysis of new enhancement for insertion into active steganalysis product. Develop technologies to remain current with new waveforms and signals. Research and			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635321 / *Global Battlespace Awareness*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
development of full motion video object of interest signature detection and exploitation algorithms. Continue development of Multi-INT correlation approaches. Investigate and develop techniques to improve the motion imagery capabilities. Continue to develop automated capabilities to exploit 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 insertion into active steganalysis product. Develop technologies to remain current with new waveforms and signals. Integrate full motion video object of interest detection and exploitation algorithms with multi-INT correlation algorithms and demonstrate capability. Integrate enhanced motion imagery capabilities with existing imagery exploitation tools. Continue to develop automated capabilities to exploit signals of interest.			
Title: Advanced Data Handling, Visualization and Distributed Data Fusion	4.134	1.354	3.092
Description: Develop and demonstrate advanced data handling, event visualization technologies, and distributed data fusion to enable a more effective utilization of data available. ***FY 2014 Accomplishments:*** Developed scalable pattern mining analytics for Multi-INT data (static and streaming). Architected and developed prototype enhancements to the Web Enabled Temporal Analysis System Enterprise with scalable storage for Activity Based Intelligence. Completed enhancements to the existing Pattern Learning software to increase the utility of the current software baseline for multi-INT analysts across multiple Air Force applications. Transitioned STARGate multi-mission sensor metadata management system and Knowledge Association SIGINT Toolkit to BIG SAFARI and 55th Wing. Analyzed performance of Level Zero fusion algorithms with both simulated and recorded data. Performance indicates the benefit of Level Zero Fusion. Developed computational and bandwidth requirements for developed algorithms. Provided a web service that supports the mission and PED management of all AF RPA missions. Provided automatic optimization of a tracker against multiple sensor sources. Completed secure MLS video streaming effort for transition to ISSE Guard PMO. ***FY 2015 Plans:*** Continue analysis of recorded multi-intelligence test data with developed algorithms. Apply object based processing and activity based intelligence tradecraft to selected domains and intelligence problems. Develop approaches of filtering multi-intelligence data for ingestion into machine learning approaches for the purpose of event discovery. Mature capabilities to provide graph-based approaches for handling large and complex relationships observed across various sources. Deliver automatic optimization of tracking algorithms across sensors, modes, and regions. Migrate tools and data to distributed (cloud) computing to extract			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635321 / *Global Battlespace Awareness*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
additional performance gains. Complete an improved cross domain solution independent file filtering capability within Cross Domain Solution (CDS) systems. ***FY 2016 Plans:*** Continue to apply object based processing and activity based intelligence tradecraft to selected domains and intelligence problems. Provide advanced activity-based intelligence (ABI) tools with built-in optimization tailored against operator objectives transitioning to National Air and Space Intelligence Center (NASIC) and National Geospatial-Intelligence Agency (NGA). Continue to develop, demonstrate, and transition technology solutions for automated recognition of indicators to associate potential and emerging threats against Blue assets. Continue to develop computational capabilities that automate the decision-making process that encompasses sensing, data mining and analysis, information extraction and understanding, and activity recognition. Continue to develop technologies to create activity based intelligence from motion data.			
Title: Autonomous Text Exploitation ***Description:*** Develop and demonstrate capabilities for reasoning and learning, text understanding, link and group discovery, and advanced analysis for situational awareness and understanding. ***FY 2014 Accomplishments:*** Delivered techniques to analyze evolving social networks. Developed plug and play framework for dynamic social network analysis, pattern discovery and social media analysis. Continue to developed Text Exploitation transition platform. ***FY 2015 Plans:*** Continue to develop cross-document co-reference capability integrated into document processing pipeline. Continue to develop web-based Text Exploitation and Analysis framework. ***FY 2016 Plans:*** Continue to develop cross-document co-reference capability integrated into document processing pipeline. Continue to develop 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.	1.588	1.178	0.724
Title: Adversary Courses of Action ***Description:*** Develop models to provide detailed understanding of the adversary's probable intent and future strategy to identify adversary COAs, the most likely COA, and the COA most dangerous to friendly forces and mission accomplishment. ***FY 2014 Accomplishments:***	2.865	3.137	2.895

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635321 / *Global Battlespace Awareness*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Continued to develop links and tools to effectively employ cyber, directed energy and electronic warfare weaponry within a target folder environment; developing a set of models that will give targeteers greater comprehension of the second and third order effects of targeting actions. Continued development of a functional graphical user environment to support output analysis and complete investigations in developing screening techniques that give the analyst/decision-maker insight into the contribution or sensitivity of various factors on a given observable/response Initiated development of technologies that identify causal linkages of executing mission results to achievement of effects. ***FY 2015 Plans:*** Continue development of a demonstration of advanced analytical capabilities that integrate kinetic and non-kinetic options for full spectrum targeting. Initiate 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. Continue to add targeting capabilities to increase the full range of options available. ***FY 2016 Plans:*** Continue to develop links and tools to effectively employ cyber, directed energy and electronic warfare weaponry within a target folder environment; developing a set of models that will give targeteers greater comprehension of the second and third order effects of targeting actions. Continue development of a demonstration of advanced analytical capabilities that integrate kinetic and non-kinetic options for full spectrum targeting. Continue the development of 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 to add targeting capabilities to increase the full range of options available.			
Accomplishments/Planned Programs Subtotals	13.669	7.953	12.214

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force			Date: February 2015
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603788F / *Battlespace Knowledge Development and Demonstration*	Project (Number/Name) 635322 / *Knowledge Management and Computing*	

COST ($ in Millions)	Prior Years	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
635322: *Knowledge Management and Computing*	-	7.139	3.710	5.229	-	5.229	8.751	3.889	5.283	5.388	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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Game Changing Computing Power	1.124	0.924	2.695
Description: Develop and demonstrate computer architectures with greater capacity and sophistication to enable game changing computing power to the warfighter, anywhere, anytime.			
FY 2014 Accomplishments: Demonstrated the stacking of logic chips on other logic chips while using standard processor fabrication lines. Developed computational models/approaches for increased system processing efficiency and increased on-board, improved photon sources and new approaches to coupling/processing qubits. Demonstrated a secure processor that provides a foundation for a trusted computing system by using hardware techniques and features, such as remappable opcodes, encryption and authentication to drastically reduce major vulnerabilities. Demonstrated increased levels of mission assurance in critical network centric operations by using advanced information management concepts with a hardware root of trust designed to support communication by means of managed information objects (MIO) and a minimal set of standard protocols to maintain interoperability.			
FY 2015 Plans: Continue the design, development and demonstration of 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 and anti-access/area denial (A2/AD) environments. Initiate development of trusted resilient legacy systems that can continuously			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Air Force		Date: February 2015
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603788F / *Battlespace Knowledge Development and Demonstration*	**Project (Number/Name)** 635322 / *Knowledge Management and Computing*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
and simultaneously assess and reestablish warfighter trust as the resilient system dynamically responds to fight through failures and attacks. ***FY 2016 Plans:*** Continue the design, development and demonstration of 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 and A2/AD environments. Continue development of capabilities to simultaneously assess, maintain or reestablish trust as resiliency actions respond to failures and/or attacks. Continue development of 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 while providing intrinsic, hardware based cyber security features for encryption, anti-tamper and unique identification, algorithm and system operation control for continuous, dynamic autonomous operations and the development of a processor to achieve universal quantum computation.			
Title: Advanced Information Management ***Description:*** Demonstrate how a publish, subscribe, and query information management (IM) paradigm can enable vertical and horizontal integration of Air Force information systems. ***FY 2014 Accomplishments:*** Successfully demonstrated a point-to-point multiple levels of security (MLS) secure VTC capability at 2014 joint exercise experiment. Completed the multi-point VTC capability and is transitioning full cross-domain video teleconferencing (CD-VTC) capability to certification and accreditation and fielding to EUCOM and CENTCOM. ***FY 2015 Plans:*** Develop and deliver a suite of new collaboration capabilities for US and Coalition Multiple Levels of Security (MLS) environments producing four new cross-domain collaboration tools in: Voice over IP (VoIP) / Video Teleconferencing; Secure Full Motion Video (FMV) streaming; Automated & resilient data content inspection; Global trusted remote monitoring & management. Initiate 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. ***FY 2016 Plans:*** Continue 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 and force protection operations. Continue the development of information management capabilities that securely bridge the gaps between	1.695	0.980	2.534

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
enterprise and tactical domains for increased shared situational awareness (SA) across the theater of war for targeting and force protection operations.			
Title: Agile Information Management Services ***Description:*** Demonstrate how agile information management services enable effective information sharing in a tactical environment. ***FY 2014 Accomplishments:*** Continued 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. Completed research to develop and demonstrate resource-aware information management services that are responsive to the information needs of active missions by ensuring delivery of the most relevant, high priority information to the warfighter. ***FY 2015 Plans:*** Complete 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 Department of Defense priorities.	4.320	1.806	-
Accomplishments/Planned Programs Subtotals	7.139	3.710	5.229

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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