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

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

A. Mission Description and Budget Item Justification

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

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

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Appropriation/Budget Activity	R-1 Program Element (Number/Name)
3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>	PE 0603401F / <i>Advanced Spacecraft Technology</i>

B. Program Change Summary (\$ in Millions)	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total
Previous President's Budget	68.907	54.897	61.693	0.000	61.693
Current President's Budget	65.207	61.813	61.593	0.000	61.593
Total Adjustments	-3.700	6.916	-0.100	0.000	-0.100
• Congressional General Reductions	0.000	-0.084			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	7.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-1.594	0.000			
• SBIR/STTR Transfer	-2.106	0.000			
• Other Adjustments	0.000	0.000	-0.100	0.000	-0.100

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

Project: 633834: *Integrated Space Technology Demonstrations*

Congressional Add: *Program Increase*

Congressional Add Subtotals for Project: 633834

Congressional Add Totals for all Projects

	FY 2015	FY 2016
	-	7.000
	-	7.000
	-	7.000

Change Summary Explanation

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

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force										Date: February 2016		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 632181 / <i>Spacecraft Payloads</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
632181: <i>Spacecraft Payloads</i>	-	11.946	15.555	15.936	0.000	15.936	15.873	16.672	16.853	17.191	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds the development, demonstration, and evaluation of radiation-hardened space electronic hardware, satellite control hardware, and software for advanced satellite surveillance operations. Future improved space-qualifiable electronics and software for data and signal processing will be more interchangeable, interoperable, and standardized. In the near-term, this project's work concentrates on converting (i.e., radiation-hardening) commercial data and signal processor technologies for use in Air Force space systems. For mid-term applications, this project merges advanced, radiation-hardened space processor, memory, and interconnect technologies with commercially-derived, open system architectures to develop and demonstrate robust, on-board processing capabilities for 21st century Department of Defense (DoD) satellites. In the long-term, this project area focuses on developing low-cost, easily modifiable software and hardware architectures for fully autonomous constellations of intelligent satellites capable of performing all mission related functions without operator intervention.

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

	FY 2015	FY 2016	FY 2017
Title: Advanced Space Electronics	4.098	4.111	4.834
Description: Develop microelectronic devices, including radiation-hardened data processors and high-density hardened memories, advanced packaging technologies, and micro-electro-mechanical system components and applications.			
FY 2015 Accomplishments: Continued development of multi-processor components to provide extremely-high-performance, low-power on-orbit processing capability. Continued to develop high-density volatile memory devices. Continued structured application specific circuits development to include development of reconfigurable or structured analog array integrated circuits to meet growing need for mixed-signal space electronics. Continued development of electron-beam (E-Beam) lithography tool. Investigated development of on-shore advanced field programmable gate array (FPGA).			
FY 2016 Plans: Begin development of advanced electronic circuit components to achieve increased memory density with greater resiliency to the space environment. Continue development of mission-enabling advanced processors, memory, analog to digital/digital to analog converters, FPGAs, and E-Beam lithography tool.			
FY 2017 Plans: Continue development of advanced electronic circuit components producing first pass component. Complete first pass of split-fabrication and begin verification. Complete commercialization development of Programmable Analog Array. Continue technical lead for E-Beam transition and trusted FPGA development. Complete development of high density non-volatile memory technologies. Continue development of high-efficiency power conversion devices.			
Title: Advanced Space Modeling and Simulation Tools	0.846	1.262	1.149

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

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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 632181 / <i>Spacecraft Payloads</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
observed. Investigate potential detector materials for long wavelength infrared detection. Deliver a scanning focal planning array for missile warning capability demonstration during laser impingement.				
Title: Positioning, Navigation, and Timing (PNT) Space Payload Technologies		4.557	8.378	7.586
Description: Develop, validate, and transition technologies that: enable new, or enhance existing, U.S. PNT satellite capabilities by increasing resiliency and availability of accuracy; and/or increase the affordability of providing current capabilities. Develop validate, and transition technologies to meet identified Air Force Space Command/Space and Missile Systems Center PNT space payload technology needs.				
FY 2015 Accomplishments: Finalized design and began performance evaluation of advanced technology space qualifiable L-band radio frequency (RF) amplifier(s) for PNT/Global Positioning System (GPS).				
FY 2016 Plans: Develop initial designs and fabricate breadboards of on-orbit reprogrammable digital waveform generator for PNT/GPS. Complete advanced technology space qualifiable L-band RF amplifier(s) for PNT/GPS.				
FY 2017 Plans: Finalize design and begin brass-board performance evaluation of on-orbit reprogrammable digital waveform generator for PNT/GPS.				
Accomplishments/Planned Programs Subtotals		11.946	15.555	15.936
C. Other Program Funding Summary (\$ in Millions) N/A				
Remarks				
D. Acquisition Strategy N/A				
E. Performance Metrics Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.				

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Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 633834 / <i>Integrated Space Technology Demonstrations</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
633834: <i>Integrated Space Technology Demonstrations</i>	-	17.512	24.739	22.416	0.000	22.416	23.454	15.994	15.692	16.006	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project is a series of advanced technology demonstrations designed to address mission needs by applying emerging technologies from the Air Force Research Laboratory, other U.S. government laboratories, and industry. These technologies are integrated into system-level demonstrations that are used to test, evaluate, and validate the technologies in a relevant environment.

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

	FY 2015	FY 2016	FY 2017
Title: Integrated Satellite Demonstrations	17.512	17.739	22.416
Description: Develop satellite technologies for integrated, robust, flexible, satellite demonstrations building on previous work and leveraging investments by other organizations.			
FY 2015 Accomplishments: Continued one year of experimental flight operations. Began analyzing science and health and status data. Verified maneuverable geosynchronous experimental platform design. Verified spacecraft subsystem and payload hardware and software post component/ subsystem delivery in preparation for component/subsystem tests and system integration and test.			
FY 2016 Plans: Continue and complete payload integration for geosynchronous spaceflight demonstration and begin launch vehicle integration targeted for launch in FY2017. Demonstration payloads include hyper temporal imaging (HTI) sensor to detect missile launches under sun-lit clouds which could enable all weather early missile detection; integrated on-board sensing, assessment, and autonomy technology payload which could enable Air Force space asset resiliency to a specific set of threats; and an experiment to demonstrate increased autonomy and safety in advanced proximity operations which could enable Air Force inspector satellites for high value Air Force assets. The spacecraft will demonstrate a multi-orbit, multi-mission-capable, propulsive secondary payload adapter which could enable increased flexibility and affordability for the Evolved Expendable Launch Vehicle (EELV). Develop space and ground segment concepts for integrated demonstration of an advanced GPS payload for contested environments. Determine military utility and define specific goals, scope, technical objectives and concepts of operation. Begin design engineering trade studies for space flight demonstration with target launch of FY2021-2023.			
FY 2017 Plans: Launch and perform initial operations for geosynchronous spaceflight demonstration; conduct experimental flight operations. Demonstration payloads include HTI sensor to detect missile launches under sun-lit clouds which could enable all weather early missile detection; integrated on-board sensing, assessment, and autonomy technology payload which could enable Air Force			

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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 633834 / <i>Integrated Space Technology Demonstrations</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
space asset resiliency to a specific set of threats; and an experiment to demonstrate increased autonomy and safety in advanced proximity operations which could enable Air Force inspector satellites for high value Air Force assets. The spacecraft will demonstrate a multi-orbit, multi-mission-capable, propulsive secondary payload adapter which could enable increased flexibility and affordability for the EELV. Design and build space segment of space based integrated demonstration of an advanced GPS payload for contested environments with a target launch of FY2021-2023. Refine experiment plans and ground segment concept for experimental operations.			

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

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air 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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Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>				Project (Number/Name) 634400 / <i>Space Systems Protection</i>			
COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
634400: <i>Space Systems Protection</i>	-	3.654	6.191	8.091	0.000	8.091	7.607	8.644	9.057	9.237	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates tools, instruments, and mitigation techniques required to assure operation of U.S. space assets in hostile warfighting environments. The project performs assessments of critical components and subsystems, and evaluates susceptibility and vulnerability to radio frequency (RF) and laser threats. This project also develops technologies that mitigate identified vulnerabilities. Technologies are developed and demonstrated to support balanced satellite protection strategies for detecting and avoiding threats and operating in a hostile space environment.

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

	FY 2015	FY 2016	FY 2017
<p>Title: SSA Capability Development</p> <p>Description: Develop tools and technologies that advance space-based proximity awareness capabilities and enable protection and countermeasure courses of action. Efforts will assess a variety of phenomenologies and concepts in response to multiple threat classes and scenarios.</p> <p>FY 2015 Accomplishments: Initiated hardware development on space-based imaging concepts that show viability under the feasibility study. Completed data analysis from the joint threat scenario study to quantify technology return-on-investment metrics. Initiated concept development, modeling, and simulations.</p> <p>FY 2016 Plans: Transition space-based imaging concepts to system development community for further maturation. Begin development of integrated tracking filter incorporating physics-based neutral density drag models for improved SSA.</p> <p>FY 2017 Plans: Continue development of integrated tracking filter incorporating physics-based neutral density drag models for improved SSA. Initiate testing of sensors with reduced solar exclusion angle constraints to provide improved coverage for SSA sensors.</p>	2.533	1.370	1.778
<p>Title: Space Indicators and Warning Research</p> <p>Description: Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites.</p> <p>FY 2015 Accomplishments:</p>	0.278	1.697	2.268

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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 634400 / <i>Space Systems Protection</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Continued updating sensor specifications and evaluating additional sensors to compare attributes (size, weight, power, performance, maturity, etc.) of sensor technologies against case uses/scenarios/missions. FY 2016 Plans: Review improvements in local environment sensing technologies in support of rapid space-based threat identification and attribution capabilities to enable/improve spacecraft resilient course-of-action options in a threat environment. Identify and review holistic, resilient spacecraft concept technologies. Identify and develop integration paths for key resilient spacecraft technology discoveries. FY 2017 Plans: Identify enabling rapid space-based threat identification and attribution capabilities. Assess, refine, and begin developing best candidate resilient spacecraft concept technologies. Continue to identify and develop integration paths for resiliency enabling technology discoveries.				
Title: Spacecraft Threat Detection Description: Develop active satellite local space awareness technologies and exploitation tools for satellite systems. FY 2015 Accomplishments: Developed components to enable on-board detection, assessment, and resolution of spacecraft anomalies to include co-orbital and directed energy threats. Applied efforts towards geosynchronous spaceflight demonstration as well as extensions to demonstrate multi-asset, space and ground, coordination. Employed system levels concepts to enable cross queuing of assets both on-orbit and on the ground. FY 2016 Plans: Refine capabilities to perform on-board course of action mission planning which will involve tasking of satellite subsystems as well as other space system entities; mature technology through ground and flight demonstration opportunities. Select cross queuing concepts and identify specific candidate technologies to integrate and increase cross coordination between space and ground sensor assets. FY 2017 Plans: Continue and demonstrate on-board threat detection and course-of-action generation and response using live satellite data. Complete demonstration of closed loop tasking and sensor cross queuing utilizing on-orbit and ground assets. Initiate development of enterprise-level situation monitoring and command and control.		0.843	3.124	4.045
Accomplishments/Planned Programs Subtotals		3.654	6.191	8.091

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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 634400 / <i>Space Systems Protection</i>
C. Other Program Funding Summary (\$ in Millions) N/A		
Remarks		
D. Acquisition Strategy N/A		
E. Performance Metrics Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.		

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

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

A. Mission Description and Budget Item Justification

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

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

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

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 635021 / <i>Space Systems Survivability</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
635021: <i>Space Systems Survivability</i>	-	2.901	2.202	1.849	0.000	1.849	1.846	1.942	1.940	1.979	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates technologies to improve space system survivability and reliability of current and future Department of Defense space systems that must continue operation despite natural space hazards. It develops and demonstrates cost-effective solutions to mitigate hazardous space environmental interactions including electrical charge buildup and electronics failures due to both single radiation events and long-term radiation doses.

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

	FY 2015	FY 2016	FY 2017
Title: Spacecraft Survivability/Reliability	2.901	2.202	1.849
Description: Develop technologies to provide improved space radiation and ionospheric hazard specification and forecasting.			
FY 2015 Accomplishments: Continued utilizing on-orbit data to generate tailored space environment hazards for operational systems. Expanded space environment anomaly attribution tool to new orbital domains. Completed assembly and initiated calibration and test of compact space environment sensor. Updated standard radiation belt model with additional new on-orbit data. Began integrating next-generation solar and interplanetary models with anomaly resolution tool to provide predictions of space environment hazards.			
FY 2016 Plans: Enhance computational performance of standard radiation belt model for satellite design while continuing to add new on-orbit data. Transition spiral one of anomaly attribution tool to operational demonstration. Begin optimizing design of compact energetic particle sensor. Evaluate performance of solar and interplanetary models to provide anomaly hazard predictions. Continue exploitation of on-orbit data from wider array of sources to improve understating of system specific space environment effects. Complete specification and forecasting of solar radio-frequency interference affecting Air Force communications and satellite systems.			
FY 2017 Plans: Support spiral one anomaly attribution tool demonstration and transition to operational use. Initiate spiral two development for anomaly attribution tool to include additional information for operators and incorporate limited space environment forecast demonstrations. Begin development, assembly, and calibration of energetic particle sensor. Continue evaluating performance of space environment forecast models for incorporation into anomaly attribution tool. Begin exploiting data from on-orbit radiation			

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2015	FY 2016	FY 2017
remediation mission for inclusion in standard radiation belt model for satellite design. Investigate and improve forecasting of solar radio events that impact Air Force operational systems.			
Accomplishments/Planned Programs Subtotals	2.901	2.202	1.849

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

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

A. Mission Description and Budget Item Justification

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

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

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

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

N/A

Remarks

D. Acquisition Strategy

N/A

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E. Performance Metrics

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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>
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COST (\$ in Millions)	Prior Years	FY 2015	FY 2016	FY 2017 Base	FY 2017 OCO	FY 2017 Total	FY 2018	FY 2019	FY 2020	FY 2021	Cost To Complete	Total Cost
63682J: <i>Spacecraft Vehicles</i>	-	10.827	9.213	13.301	0.000	13.301	11.463	15.858	16.704	17.039	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates compact, low-cost, spacecraft power generation, storage, distribution, and thermal management technologies, including cryogenic cooling technologies. This project also develops composites for spacecraft structures and technologies for spacecraft control and mechanisms.

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

	FY 2015	FY 2016	FY 2017
<p>Title: Space Power Technologies</p> <p>Description: Develop power generation space technologies such as multi-junction solar cells, thin-film solar cells, lightweight solar cell arrays, and radiation resistant solar cell modules.</p> <p>FY 2015 Accomplishments: Continued development of approaches for greater than 35% efficient solar cells. Matured module/blanket technologies for increased reliability and resiliency. Matured flexible array technologies.</p> <p>FY 2016 Plans: Select candidate approaches for achieving greater than 35% efficient solar cells and initiate cell performance and radiation optimization for selected method. Continue development of resilient technologies for module/array survivability. Initiate demonstrations of flexible array technology through ground demo and/or flight experiments.</p> <p>FY 2017 Plans: Continue to optimize 35% efficient solar cell architectures for end-of-life performance. Initiate mitigation approaches for thermal excursion events for resilient array technologies. Complete on-orbit flight experiment demonstration of flexible array technology.</p>	1.608	1.159	0.990
<p>Title: Spacecraft Thermal Technologies</p> <p>Description: Develop technologies for long-life, efficient, low-vibration, lightweight mechanical cryocoolers and integration components for space applications.</p> <p>FY 2015 Accomplishments: Continued computer simulations to optimize performance of different cryogenic coolers in support of payload thermal management systems for very large format focal plane arrays for missile warning capability and for industry. Increased manufacturability of space-borne cryocoolers through the implementation of commercial, terrestrial cryocooler technologies, combined with space-like designs.</p> <p>FY 2016 Plans:</p>	1.019	0.254	0.000

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Exhibit R-2A, RDT&E Project Justification: PB 2017 Air Force		Date: February 2016		
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603401F / <i>Advanced Spacecraft Technology</i>	Project (Number/Name) 63682J / <i>Spacecraft Vehicles</i>		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
Complete validation of high-order models to low order models to reduce optimization time through quick parametric analysis. In FY2016, Project 63682J, Spacecraft Thermal Technologies completes. FY 2017 Plans: N/A				
Title: Spacecraft Structures Technologies Description: Develop, integrate, and demonstrate composite spacecraft structures and thermal technologies for deployable structures, antennas, electronics cooling, and structural sensing. FY 2015 Accomplishments: Developed new thermal technologies for heat dissipation of high energy density spacecraft electronics slated for use on Air Force communications and GPS spacecraft. Initiated in-house testing of these technologies and began working the technology transition process to Air Force spacecraft prime contractors. Matured technologies for composite spacecraft deployable structures, solar arrays, electro-optical and radio-frequency apertures, and de-orbit mechanisms. Tested structurally-integrated sensing technologies on satellite structures to provide an improved option for monitoring spacecraft health and potential threats. FY 2016 Plans: Complete contracted efforts and in-house government testing, deliver high-performance heat spreader, compliant thermal interface material, and electronics cooling technologies for spaceflight experiment. Using the International Space Station, test the micro-gravity deployment of a new passive-strain-energy-deployed, flexible composites solar array expected to improve capability on Air Force spacecraft six fold. Develop and test deployment of a lightweight baffle and an affordable deployable radio-frequency aperture for communication and high-gain GPS signals. Initiate spaceflight experiment planning to test structurally-integrated sensing technologies for on-orbit impact detection and situational awareness of potential threats. FY 2017 Plans: Complete high-performance heat spreader, compliant thermal interface material, electronics cooling technologies, roll-out solar array, and deployable baffle development for potential applications by DoD programs and prime contractors. Continue spaceflight experiment to test structurally-integrated sensing technologies for on-orbit impact detection and situational awareness of potential threats. Initiate flight experiment to test an affordable deployable aperture for denied area communication and high-gain, anti-jam GPS applications.		2.020	1.159	0.992
Title: On-Orbit Satellite Controls Description: Develop technologies for spacecraft controls and mechanisms for on-orbit applications. FY 2015 Accomplishments:		0.493	0.452	0.423

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Initiated development of advanced low size/weight/power high-precision navigation hardware for geosynchronous SSA missions.</p> <p>FY 2016 Plans: Continue development of advanced low size/weight/power inertial measurement units and high-precision maneuvering technology for geosynchronous SSA missions.</p> <p>FY 2017 Plans: Complete development of advanced low size/weight/power inertial measurement units and high-precision maneuvering technology for geosynchronous SSA missions. Initiate development and testing of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions.</p>				
<p>Title: Space Communication and Control Technologies</p> <p>Description: Develop technologies for next-generation space communications terminals and equipment, along with methods/techniques to enable future space system operational command and control concepts.</p> <p>FY 2015 Accomplishments: Continued incremental development of satellite communication flight experiments to support future Air Force satellite systems, particularly reconfigurable/reprogrammable satellite transceivers, space laser communication terminals, and millimeter wave atmospheric propagation experiments. Supported Space and Missile Systems Center Low-Cost User Terminal initiatives.</p> <p>FY 2016 Plans: Complete evaluation of small space-based laser communication terminal and verify technology readiness for transition to the satellite development community. Complete risk reduction activities and initiate assembly, integration and testing work for a satellite communication flight experiment to support next-generation Air Force communications needs. Continue to invest in advanced development projects that address technology gaps identified by Air Force Space Command for future military satellite communication systems.</p> <p>FY 2017 Plans: Complete testing and qualification of the payload for the W and V frequency band satellite communications flight experiment. Initiate testing and evaluation of a software defined radio for a low Earth orbiting cube-satellite experiment operating in S and L frequency bands providing wide-band, high-data-rate satellite telemetry, command, and control.</p>		4.190	3.291	2.812
<p>Title: Advanced Alternative Navigation Technologies</p> <p>Description: Develop new atomic clock technologies and transition these technologies to industry for potential application to future positioning, navigation, and timing space considerations.</p> <p>FY 2015 Accomplishments:</p>		1.497	2.898	8.084

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2015	FY 2016	FY 2017
<p>Initiated efforts to transition newly-developed atomic clock technology from laboratory experiments to industry for potential space systems application. Designed and began fabricating engineering models of these clocks to meet DoD positioning and timing requirements.</p> <p>FY 2016 Plans: Continue efforts to develop atomic clock technology from laboratory experiments into prototypes to transition to industry. Continue fabrication and development of engineering models of the clocks for testing and integration.</p> <p>FY 2017 Plans: Finalize efforts to develop atomic clock technology from laboratory experiments into prototypes to transition to industry. Begin integration and testing of clock engineering models. Begin development of radiation-hardened, ultra-stable laser needed for cold-atom atomic clocks, accelerometers and gyroscopes operating in space or nuclear environments. Begin development of technology to leverage communications links to provide positioning and time knowledge, and continue second spiral demonstration of performance on hand held military radios to inform technology development activity.</p> <p>In FY 2015 and FY 2016, the advanced navigation instrumentation work was previously performed in Project 635083, Ballistic Missiles Technology, under the Advanced Navigation Instruments effort.</p>				
Accomplishments/Planned Programs Subtotals		10.827	9.213	13.301
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
D. Acquisition Strategy				
N/A				
E. Performance Metrics				
Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.				

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