Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Air Force											Date: February 2019	
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 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
Total Program Element	-	94.946	70.734	70.525	0.000	70.525	80.358	75.234	72.413	69.600	Continuing	Continuing
632181: *Spacecraft Payloads*	-	17.198	21.093	13.176	0.000	13.176	13.356	16.823	17.159	17.490	Continuing	Continuing
633834: *Integrated Space Technology Demonstrations*	-	27.896	16.362	18.856	0.000	18.856	22.486	13.981	17.538	22.870	Continuing	Continuing
634400: *Space Systems Protection*	-	35.688	8.419	7.708	0.000	7.708	7.471	7.885	8.042	8.204	Continuing	Continuing
635021: *Space Systems Survivability*	-	2.748	1.571	1.581	0.000	1.581	1.611	1.643	1.675	1.709	Continuing	Continuing
63682J: *Spacecraft Vehicles*	-	11.416	23.289	29.204	0.000	29.204	35.434	34.902	27.999	19.327	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601F, and 0602298F.

As directed in the FY 2018 NDAA, Sec 825, amendment to PL 114-92 FY 2016 NDAA, Sec 828 Penalty for Cost Overruns, the FY 2018 Air Force penalty total is $14.373M. The calculated percentage reduction to each research, development, test and evaluation and procurement account will be allocated proportionally from all programs, projects, or activities under such account.

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 2020 Air Force	Date: February 2019
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 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	58.910	54.895	53.979	0.000	53.979
Current President's Budget	94.946	70.734	70.525	0.000	70.525
Total Adjustments	36.036	15.839	16.546	0.000	16.546
• Congressional General Reductions	-0.101	-0.161			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	31.000	16.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	8.000	0.000			
• SBIR/STTR Transfer	-2.863	0.000			
• Other Adjustments	0.000	0.000	16.546	0.000	16.546

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 632181: *Spacecraft Payloads*		
Congressional Add: *Program Increase - radiation hardened microelectronics*	5.809	0.000
Congressional Add: *Program increase - radiation hardened microelectronic processors*	0.000	6.000
Congressional Add Subtotals for Project: 632181	5.809	6.000
Project: 634400: *Space Systems Protection*		
Congressional Add: *Program increase*	9.682	0.000
Congressional Add: *Program increase - commercial SSA consortia/testbed*	14.522	0.000
Congressional Add Subtotals for Project: 634400	24.204	0.000
Project: 63682J: *Spacecraft Vehicles*		
Congressional Add: *Program increase - space laser communications systems*	0.000	10.000
Congressional Add Subtotals for Project: 63682J	0.000	10.000
Congressional Add Totals for all Projects	30.013	16.000

Change Summary Explanation

Increase in FY 2018 due to $8.000 million reprogramming for Battle Management Command and Control Joint Emergent Operational Need.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Air Force	Date: February 2019
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*

Increase in FY 2020 due to greater emphasis on enhancing research and development in small satellite technologies.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force			Date: February 2019
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 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
632181: *Spacecraft Payloads*	-	17.198	21.093	13.176	0.000	13.176	13.356	16.823	17.159	17.490	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Advanced Space Electronics	2.946	3.669	3.197
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 2019 Plans: Complete verification of split-fabrication as trusted method. Continue the productization stage of electron-beam manufacturing capability. Continue to lead trusted Field-Programmable Gate Array development. Continue development of next generation memory technologies for space. Oversee qualification of processing and memory technology developments. Continue assessments of tolerance of advanced electronic circuit components to space radiation environmental conditions. Continue development of novel payload processor technologies and necessary memory to support it.			
FY 2020 Plans: Complete the productization stage of electron-beam lithography manufacturing capability. Continue leading trusted Field-Programmable Gate Array development and begin space qualification planning. Continue development of next generation memory technologies for space. Oversee qualification of next generation space processor development and planning memory technology development qualification planning. Continue assessments of tolerance of advanced electronic circuit components to space radiation environmental conditions. Continue development of novel payload processor technologies and architectures, and the electronic memory necessary to support them. Begin development of heterogeneous processing payload architecture for future on-orbit experiment.			
FY 2019 to FY 2020 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
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 2018	FY 2019	FY 2020
FY 2020 decreased compared to FY 2019 by $0.472 million. Justification for the decrease is described in the plans above.			
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 2019 Plans:*** Apply and analyze models for cross-platform modeling, simulation, and analysis support of multi-mission geosynchronous space flight demonstration. Continue trade studies and utility analysis for concept development of emerging space technologies, future space flight experiments (with associated software algorithms), and commercial space applications. ***FY 2020 Plans:*** Begin leveraging multiple domain analyses across space and terrestrial missions with model-test-model in support of multi-mission geosynchronous space flight demonstrations. Initiate simultaneous trade studies using utility analyses for concept maturation of emergent space technologies for space flight experiments and applications in commercial space. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 decreased compared to FY 2019 by $0.102 million. Justification for the increase is described in the plans above.	0.864	0.851	0.749
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 2019 Plans:*** Continue to develop III-V alternative infrared detector materials for space environments. Deliver a scanning Focal Plane Array for missile warning capability demonstration during laser impingement. Characterize performance of scanning Focal Plane Array in representative space environment to include natural and man-made radiation including focused photons will take place to identify any shortfalls that may be present and resolve if necessary. ***FY 2020 Plans:*** Continue to develop III-V alternative infrared detector materials for space environments. Continue development of scanning and staring focal plane arrays for missile warning capability demonstrations during laser impingement. Continue performance characterization of visible through infrared focal plane arrays in representative space environments, including natural and man-made radiation, i.e. focused photons, to identify and resolve any shortfalls impeding the technology transition. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	1.686	2.522	2.070

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
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 2018	FY 2019	FY 2020
FY 2020 decreased compared to FY 2019 by $0.452 million. Justification for the increase is described in the plans above.			
Title: Positioning, Navigation, and Timing Space Payload Technologies	5.893	8.051	7.160
Description: Develop, validate, and transition technologies that: enable new, or enhance existing, United States positioning, navigation, and timing satellite capabilities by increasing resiliency and availability of accuracy; and/or increase the affordability of providing current capabilities. Develop, validate, and transition technologies to meet identified Air Force Space Command/Space and Missile Systems Center positioning, navigation, and timing space payload technology needs. ***FY 2019 Plans:*** Conduct preliminary and critical design activities for multiple modular/hostable positioning, navigation, and timing payloads/ payload technologies for future Global Positioning System and Global Positioning System augmentation satellites. ***FY 2020 Plans:*** Mature developing advanced positioning, navigation, and timing signals for experimentation on the Navigation Technology Satellite - 3 flight experiment. Conduct preliminary assessments of broadband components for use in satellite payloads for Precision Navigation and Timing. Test reprogrammability aspects of on-orbit reprogrammable digital waveform generator and explore use cases for enterprise reprogrammability. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 decreased compared to FY 2019 by $0.891 million. Justification for the increase is described in the plans above			
Accomplishments/Planned Programs Subtotals	11.389	15.093	13.176

	FY 2018	FY 2019
Congressional Add: Program Increase - radiation hardened microelectronics ***FY 2018 Accomplishments:*** Conducted Congressionally directed effort ***FY 2019 Plans:*** Not applicable	5.809	0.000
Congressional Add: Program increase - radiation hardened microelectronic processors ***FY 2018 Accomplishments:*** Not applicable ***FY 2019 Plans:*** Conducted Congressionally directed effort	0.000	6.000
Congressional Adds Subtotals	5.809	6.000

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
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)

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 2020 Air Force			Date: February 2019
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 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
633834: *Integrated Space Technology Demonstrations*	-	27.896	16.362	18.856	0.000	18.856	22.486	13.981	17.538	22.870	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Integrated Satellite Demonstrations	27.896	16.362	18.856

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

FY 2019 Plans:

Conclude on-orbit operations; complete experimental flight operations of hypertemporal imaging sensor, integrated on-board sensing, threat assessment and autonomy payload, and increase autonomy and safety of advanced proximity operations. Begin transition of spacecraft operations to Air Force Space Command. Continue refining space and ground segments architecture and initial prototype hardware/software for an advanced Global Positioning System space-based integrated demonstration for contested environments with a projected launch in FY 2023.

FY 2020 Plans:

Conclude on-orbit operations; complete and close-out experimental flight operations of spacecraft, hypertemporal imaging sensor, integrated on-board sensing, threat assessment and autonomy payload, and advanced proximity operations. Complete final reports for spacecraft, payloads and experiments. Complete transition of spacecraft operations to Air Force Space Command. Continue space segment components and sub-systems development with a focus on breadboard test and verification results for next generation navigation test satellites. Continue payload and user equipment development and complete user equipment and system software compatibility review to support a projected FY 2023 launch. Conduct on-orbit demonstration of a Geosynchronous orbit small satellite extending the maturity of multiple communication technologies and operational concepts for future small satellites. Continue on-orbit demonstrations of multiple formation flying satellites for near autonomous formation control. Leverage opportunities to fly demonstrations and prototypes, where successes can identify quick transition to next generation technology needs. Coordinate a manifest timeline for critical space projects prioritizing Air Force Space Command technical, security, and operational development requirements. Utilize the Long Duration Propulsive Evolved Expendable Launch Vehicle Secondary Payload Adaptor launch schedule and other prospects to quickly fly demonstrations and prototypes. Mature

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
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 2018	FY 2019	FY 2020
payloads from concept proposal to leverage commercial Low Earth orbit constellations. Milestones for these efforts are a Systems Requirements Review and a Preliminary Design Review. Deliverables will be a preliminary system design package and a system interface document. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $2.494 million. Funding increased due to additional small satellite technology demonstration activities.			
Accomplishments/Planned Programs Subtotals	27.896	16.362	18.856

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 2020 Air Force			Date: February 2019
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 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
634400: *Space Systems Protection*	-	35.688	8.419	7.708	0.000	7.708	7.471	7.885	8.042	8.204	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Space Situational Awareness Capability Development	3.619	2.194	1.409
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 2019 Plans:*** Develop and integrate processing techniques into evolved operations centers to autonomously detect, track, identify and characterize satellites to meet timelines needed for implementation of courses of actions mitigating potential gaps for evolving threats. Initiate development of prototypes utilizing multi-phenomenology based on the observables indicating a potential threat. Begin conducting an integrated ground and space experiment for space situational awareness with available sensors. ***FY 2020 Plans:*** Continue to develop and integrate processing techniques into evolved operations centers to autonomously detect, track, identify and characterize satellites to meet timelines needed for implementation of courses of actions mitigating potential gaps for evolving threats. Continue to further develop prototypes utilizing multi-phenomenology based on the observables indicating a potential threat to mitigate knowledge gaps. Continue to conduct an integrated ground and space experiment for space situational awareness with available sensors. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 decreased compared to FY 2019 by $0.785 million. Justification for the decrease is described in the plans above.			
Title: Space Indicators and Warning Research	4.152	2.651	2.182
Description: Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
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 2018	FY 2019	FY 2020
FY 2019 Plans: Conduct RED-vs-BLUE space cyber indications and warning experimentation utilizing the on-orbit research satellite. Evaluate the efficacy of multi-spectrum indications and warning technology within the space resiliency testbed. ***FY 2020 Plans:*** Conduct RED-vs-BLUE space-cyber experiment campaign with 50th Space Wing and other government agency partners, utilizing an on-orbit space platform. Evaluate technology solutions, and develop concepts of operation and tactics, techniques, and procedures for satellite operations in a cyber-contested space environment. Utilize space resiliency testbed to integrate and assess technology solutions for a projected FY 2021 on-orbit experiment campaign. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 decreased compared to FY 2019 by $0.469 million. Justification for the decrease is described in the plans above.			
Title: Spacecraft Threat Detection ***Description:*** Develop active satellite local space awareness technologies and exploitation tools for satellite systems. ***FY 2019 Plans:*** Complete advanced technology in on-board threat detection and course-of-action generation and response using live satellite data. Continue advanced technology development for enterprise-level situation monitoring and demonstrate concepts of space battle management command and control through experimentation with ground stations and flight experiments. Initiate advanced autonomy demonstrations to prove advanced concepts in multidomain real-time command and control. Expand our threat warning and response portfolio, including further maturation of both on board and off board threat sensor suites and supporting computing / comm systems. Demonstrate and experiment with prototype threat warning and response systems within the space resiliency lab. Integrate response options into the Air Force Research Laboratory's space resiliency lab in order to conduct end-to-end multi-spectral threat and response scenarios. ***FY 2020 Plans:*** Continue to develop advanced software related technology for on-board threat detection and course-of-action generation and response using live satellite data. Continue advanced technology development for enterprise-level situation monitoring and demonstrate concepts of space battle management command and control through experimentation with ground stations and flight experiments. Perform ground based demonstration of multi-domain command and control using space based assets Initiate advanced autonomy demonstrations to prove advanced concepts in multi-domain real-time command and control. Plan for flight demonstration of satellite autonomy technologies with an emphasis on on-board planning systems. Demonstrate and experiment with prototype threat warning and response systems within an integrated multi-domain testbed. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	3.713	3.574	4.117

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
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 2018	FY 2019	FY 2020
FY 2020 increased compared to FY 2019 by $0.543 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	11.484	8.419	7.708

	FY 2018	FY 2019
Congressional Add: Program increase ***FY 2018 Accomplishments:*** Conducted Congressionally directed effort ***FY 2019 Plans:*** Not applicable	9.682	0.000
Congressional Add: Program increase - commercial SSA consortia/testbed ***FY 2018 Accomplishments:*** Conducted Congressionally directed effort ***FY 2019 Plans:*** Not applicable	14.522	0.000
Congressional Adds Subtotals	24.204	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force			Date: February 2019
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 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
635021: *Space Systems Survivability*	-	2.748	1.571	1.581	0.000	1.581	1.611	1.643	1.675	1.709	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 2018	FY 2019	FY 2020
Title: Spacecraft Survivability/Reliability	2.748	1.571	1.581
Description: Develop technologies to provide improved space radiation and ionospheric hazard specification and forecasting. ***FY 2019 Plans:*** Continue exploitation of data from on-orbit radiation remediation mission for inclusion in standard radiation belt model for satellite design. Transition updated radiation model to industry with modular architecture, additional data sources, and improved usability. Select concept to proceed to detailed design phase for next-generation highly-miniaturized energetic particle sensor for use in contested space. Begin anomaly attribution tool spiral two demonstration and transition to operational use with common ground system. Continue investigation and improvement of the forecasting of solar radio events that impact Air Force operational systems. ***FY 2020 Plans:*** Continue updating standard radiation belt model for satellite design and complete transition. Mature next-generation highly-miniaturized energetic charged particle sensor for use in contested space. Continue spiral two demonstration of anomaly attribution tool and incorporate next-generation models for enhanced exploitation of sensor data. Initiate development and demonstration of tools to specify impacts of the ionosphere and near-earth space environment dynamics on Department of Defense systems to support strategic, operational, and tactical users. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $0.010 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	2.748	1.571	1.581

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 635021 / *Space Systems Survivability*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force			Date: February 2019
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 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
63682J: *Spacecraft Vehicles*	-	11.416	23.289	29.204	0.000	29.204	35.434	34.902	27.999	19.327	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 2018	FY 2019	FY 2020
Title: Space Power Technologies	1.062	1.063	1.065
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 2019 Plans:*** Continue development of mitigation approaches for thermal excursion in resilient arrays. Continue on-orbit flight experiment development for resilient array technologies. ***FY 2020 Plans:*** Continue on-orbit flight experiment development for advanced solar cells, solar arrays, and batteries. Target integration with small, experimental satellites to leverage system-level developments. Further development of on-orbit directed energy sensing approaches. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $0.002 million. Justification for the increase is described in the plans above.			
Title: Spacecraft Structures Technologies	1.061	1.061	1.415
Description: Develop, integrate, and demonstrate composite spacecraft structures and thermal technologies for deployable structures, antennas, electronics cooling, and structural sensing. ***FY 2019 Plans:*** Complete ground experimentation to test affordable deployable antennas for denied area communication and high-gain, anti-jam Global Positioning System applications. Continue integrated experiment concepts testing structures and thermal technologies for high energy density, full spectrum radio frequency reconfigurabilty, adaptability, and protection. Initiate integrated ground experiment or flight experiment for extremely thin, multi-mission, radio frequency antennas for ensured capability in highly contested environments. ***FY 2020 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
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 2018	FY 2019	FY 2020
Complete integrated experiments testing structures and thermal technologies for high energy density, full spectrum radio frequency reconfigurability, adaptability, and protection. Complete integrated ground experiment or flight experiment for extremely thin, multi-mission, radio frequency antennas for ensured capability in highly contested environments. Initiate integrated ground experiment or flight experiment for high-power small satellites technologies. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $0.354 million. Justification for the increase is described in the plans above.			
Title: On-Orbit Satellite Controls ***Description:*** Develop technologies for spacecraft controls and mechanisms for on-orbit applications. ***FY 2019 Plans:*** Continue testing of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions. ***FY 2020 Plans:*** Complete testing of advanced computer-vision based navigation algorithms and software for precision spacecraft relative motion control missions. Initiate experiments with algorithms using on-orbit data collected from past missions. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $0.001 million. Justification for the increase is described in the plans above.	0.414	0.415	0.416
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 2019 Plans:*** Support launch of W and V frequency band flight instrument. Support execution of a W and V band propagation experiment. Conduct development and technology demonstrations to address future military satellite communications capability and technology needs, for example, high-gain antenna, high-power amplifiers, low-noise amplifiers, cognitive / resilient networks, reconfigurable satellite radios / transponders, and anti-jam signal processing technologies. Support development and demonstration of novel laser communications technology. ***FY 2020 Plans:*** Continue support of planned five-year W/V-band propagation experiment. Support ground terminal operations, maintenance, and re-deployments. Collect and analyze data to statistically characterize atmospheric propagation effects and correlate to meteorological parameters. Conduct research and development to address future military satellite communications	1.822	3.629	12.001

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
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 2018	FY 2019	FY 2020
capability and technology needs, for example, high-gain antenna, cognitive/resilient/ambient networks, reconfigurable satellite radios / transponders, and anti-jam signal processing technologies. Support development and demonstration of novel laser communications technologies such as low size, weight, power and cooling free space optical communication terminals. Continue development of space-qualified V-band high power amplifier technology. Initiate development of W/V-band satellite transponder for on-orbit experiment and demonstration. Initiate systems engineering and technology risk-reduction for W/V-band ground terminals. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $8.372 million. Funding increased due to additional development of on-orbit experimental W/V-band satellite communications system.			
Title: Advanced Alternative Navigation Technologies ***Description:*** Develop new atomic clock technologies and transition these technologies to industry for potential application to future positioning, navigation, and timing space considerations. ***FY 2019 Plans:*** Test industry-transitioned clock technology being built into flight experiment payload units for flight testing. Finalize integration and testing of clock engineering models. Start packaging of radiation-hardened, ultra-stable laser needed for cold-atom atomic clocks, accelerometers and gyroscopes operating in space or nuclear environments. Start testing of technology that leverages communications links to provide positioning and time knowledge, and continue second spiral demonstration of performance on hand held military radios to inform technology development activity. ***FY 2020 Plans:*** Finish packaging of radiation-hardened, ultra-stable laser. Complete integration of advanced clock technology onto flight experiment payload for space demo. Begin preliminary designs of gravity gradiometer test bed with cold atom system. Initiate development and design of novel inertial sensor technologies. Conduct trade studies. Begin design and validation of radiation-hardened electronics for inertial sensors in strategic environments. Establish modelling and simulation capability for design validation ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $7.186 million. Funding increase due to renewed emphasis on advanced clock technology development.	7.057	7.121	14.307
Accomplishments/Planned Programs Subtotals	11.416	13.289	29.204

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force		Date: February 2019
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603401F / *Advanced Spacecraft Technology*	**Project (Number/Name)** 63682J / *Spacecraft Vehicles*

	FY 2018	FY 2019
Congressional Add: Program increase - space laser communications systems	0.000	10.000
FY 2018 Accomplishments: Not applicable		
FY 2019 Plans: Conducted Congressionally directed effort		
Congressional Adds Subtotals	0.000	10.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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