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 0603216F / *Aerospace Propulsion and Power 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	-	122.217	148.418	113.973	0.000	113.973	115.142	114.123	117.106	120.013	Continuing	Continuing
632480: *Aerospace Fuels*	-	2.436	2.340	2.386	0.000	2.386	2.434	2.483	2.532	2.583	Continuing	Continuing
633035: *Aerospace Power Technology*	-	19.204	38.954	24.670	0.000	24.670	22.375	18.492	18.866	19.243	Continuing	Continuing
634921: *Aircraft Propulsion Subsystems Int*	-	16.341	18.058	18.016	0.000	18.016	18.295	18.853	19.362	19.851	Continuing	Continuing
634922: *Space & Missile Rocket Propulsion*	-	28.177	40.220	28.256	0.000	28.256	29.686	30.584	31.403	32.199	Continuing	Continuing
635098: *Advanced Aerospace Propulsion*	-	41.256	20.194	18.814	0.000	18.814	20.169	20.889	21.532	22.158	Continuing	Continuing
63681B: *Advanced Turbine Engine Gas Generator*	-	14.803	28.652	21.831	0.000	21.831	22.183	22.822	23.411	23.979	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 weapon systems. The Aerospace Fuels project develops and demonstrates improved hydrocarbon fuels and advanced propulsion systems, including those for air-breathing, high-speed/hypersonic flight. The Aerospace Power Technology project develops and demonstrates adaptive power and thermal management components, controls, and systems for high-power payloads and aircraft as part of energy-optimized aircraft development. The Aircraft Propulsion Subsystems Integration project develops demonstrator engines by integrating the engine cores demonstrated in the Advanced Turbine Engine Gas Generator project with low-pressure components. 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, Aircraft Propulsion Subsystems Integration, and Advanced Turbine Gas Generator 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.

Projects in this program have been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

Exhibit R-2, RDT&E Budget Item Justification: 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 0603216F / *Aerospace Propulsion and Power Technology*

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

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	104.499	115.462	115.610	0.000	115.610
Current President's Budget	122.217	148.418	113.973	0.000	113.973
Total Adjustments	17.718	32.956	-1.637	0.000	-1.637
• Congressional General Reductions	-0.028	-0.044			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	18.500	33.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	3.342	0.000			
• SBIR/STTR Transfer	-4.096	0.000			
• Other Adjustments	0.000	0.000	-1.637	0.000	-1.637

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 633035: *Aerospace Power Technology*		
Congressional Add: *Program increase - silicon carbide research*	10.634	15.000
Congressional Add Subtotals for Project: 633035	10.634	15.000
Project: 634922: *Space & Missile Rocket Propulsion*		
Congressional Add: *Program increase*	7.250	0.000
Congressional Add: *Program increase - chemical apogee engines*	0.000	2.500
Congressional Add: *Program increase - upper stage engine maturation*	0.000	8.500

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 0603216F / *Aerospace Propulsion and Power Technology*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Congressional Add Subtotals for Project: 634922	7.250	11.000
Project: 63681B: *Advanced Turbine Engine Gas Generator*		
Congressional Add: *Program increase - advanced turbine engine gas generator*	0.000	7.000
Congressional Add Subtotals for Project: 63681B	0.000	7.000
Congressional Add Totals for all Projects	17.884	33.000

Change Summary Explanation

Increase in FY 2018 of $3.342 million is due to a reprogramming action for High Speed Strike Weapon Technology Maturation efforts.

Decrease in FY 2020 of $1.637 million is due to the realignment of funds for Air Force Science and Technology demonstrations.

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 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 632480 / *Aerospace Fuels*	

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
632480: *Aerospace Fuels*	-	2.436	2.340	2.386	0.000	2.386	2.434	2.483	2.532	2.583	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 2018	FY 2019	FY 2020
Title: Fuel-Related Thermal Management	0.713	0.685	0.731
Description: Demonstrate thermally stable fuels and fuel system hardware concepts to enhance cooling capacity (performance), minimize fuel coking, and reduce fuel system maintenance. ***FY 2019 Plans:*** Continue investigation of fuel heat sink approaches for thermal management of adaptive engines, including on-board fuel deoxygenation. ***FY 2020 Plans:*** Continue investigation of fuel heat sink approaches for thermal management of adaptive engines, such as on-board fuel deoxygenation. Initiate investigation of heat exchangers including additive manufactured units. Initiate the development of integrated test rigs to tests these approaches and assess efficiency of these approaches. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 funds increased by $0.046 million compared to FY 2019. Justification for the increase is described in the plans above.			
Title: Gas Turbine Combustion, Emissions, and Performance	0.647	0.621	0.621
Description: Develop and demonstrate efficacy of low-cost, environmentally friendly fuel approaches to assess and reduce soot/ particulate emissions from gas turbine engines. ***FY 2019 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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 632480 / *Aerospace Fuels*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Continue development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions. ***FY 2020 Plans:*** Continue development of augmentor combustor/simulator to determine fuel effects on augmentor operability under realistic conditions. Initiate study of fuel temperature limitations and use data to validate models. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Not Applicable			
Title: Fuel Logistics ***Description:*** Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Air Force. ***FY 2019 Plans:*** Initiate development of fuel composition in-situ sensors to ensure thermal stability throughout platform mission. Initiate development of fuel sensors and mitigation products to detect and mitigate fuel bio-contamination. ***FY 2020 Plans:*** Continue development of fuel composition in-situ sensors to ensure thermal stability throughout platform mission. Continue development of fuel sensors and mitigation products to detect and mitigate fuel bio-contamination. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Not Applicable	0.860	0.827	0.827
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 2019 Plans:*** Continue development of generic alternative fuel specification annexes for commercial jet fuels used by Air Force. ***FY 2020 Plans:*** Complete development of generic alternative fuel specification annexes for commercial jet fuels used by Air Force. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Not Applicable	0.216	0.207	0.207
Accomplishments/Planned Programs Subtotals	2.436	2.340	2.386

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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 632480 / *Aerospace Fuels*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force			Date: February 2019
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 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
633035: *Aerospace Power Technology*	-	19.204	38.954	24.670	0.000	24.670	22.375	18.492	18.866	19.243	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates system and subsystem integration to include adaptive architectures, actuation, electrical power, thermal management, and distribution for aerospace applications. This project develops and demonstrates the components, controls and systems required to satisfy the operational needs of current and future aircraft and enables 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 2018	FY 2019	FY 2020
Title: High Power Aircraft Subsystem Technologies	8.570	23.954	24.670
Description: Develop and demonstrate integrated architecture, controls and components for power generation, conditioning, and distribution; energy storage components; and thermal management and subsystem technologies for integration into high power aircraft. ***FY 2019 Plans:*** Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Continue development of actuation technology for applications with power, volume, and thermal limitations. Continue the development of hybrid-cycle power and thermal management system. Continue development of advanced power generation and distribution system. Continue development and demonstration of integrated, adaptive megawatt-class tactical aircraft power and thermal capability. Continue development and demonstration of megawatt class architecture, controls and integration. Continue development and demonstration of robust electrical power systems for megawatt applications. Continue development and demonstration of thermal management systems for megawatt applications. Continue development and demonstration of solid state electrical distribution technology for megawatt applications. ***FY 2020 Plans:*** Continue development and demonstration of system and component electrical power, electro-mechanical, and thermal technologies for high-power aircraft. Complete development of actuation technology for applications with power, volume, and thermal limitations. Continue the development of hybrid-cycle power and thermal management system. Continue development of advanced power generation and distribution system. Continue development and demonstration of integrated, adaptive megawatt-class tactical aircraft power and thermal capability. Continue development and demonstration of megawatt class architecture, controls and integration. Continue development and demonstration of robust electrical power systems for megawatt applications.			

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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 633035 / *Aerospace Power Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Continue development and demonstration of thermal management systems for megawatt applications. Continue development and demonstration of solid state electrical distribution technology for megawatt applications. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $0.716 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	8.570	23.954	24.670

	FY 2018	FY 2019
Congressional Add: Program increase - silicon carbide research	10.634	15.000
FY 2018 Accomplishments: Conducted Congressionally directed efforts		
FY 2019 Plans: Conduct Congressionally directed efforts		
Congressional Adds Subtotals	10.634	15.000

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 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 634921 / *Aircraft Propulsion Subsystems Int*	

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
634921: *Aircraft Propulsion Subsystems Int*	-	16.341	18.058	18.016	0.000	18.016	18.295	18.853	19.362	19.851	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 Aircraft Propulsion Subsystems Integration (APSI) project includes demonstrator engines for manned systems and efficient small-scale propulsion for remotely piloted aircraft and cruise missile applications. The demonstrator engines integrate the core (high- pressure spool) technology developed under the Versatile Affordable Advanced Turbine Engines (VAATE) project with the engine (low-pressure spool) technology such as fans, turbines, engine controls, mechanical systems, exhaust nozzles, and augmentors. Additionally, this project includes activities to improve propulsion safety and readiness. This project also focuses on integration of inlets, nozzles, engine-to-airframe compatibility, and power and thermal management subsystems technologies. The APSI project provides aircraft with potential for longer range and higher cruise speeds with lower specific fuel consumption, surge power for successful engagements, high sortie rates with reduced maintenance, reduced life cycle cost, and improved survivability, resulting in increased mission effectiveness. Technologies developed are applicable to sustained high-speed vehicles and responsive space launch. The Aircraft Propulsion Subsystems Integration project is focused on improving propulsion capabilities while at the same time reducing the cost of ownership. Anticipated technology advances include turbine engine improvements providing approximately twice the range for a sustained supersonic combat aircraft, doubling the time on station with ten times the power output for surveillance aircraft and propulsion for a high speed supersonic missile with double the range for time sensitive targets. A portion of this project supports the demonstration of adaptive cycle technologies, which develop component technology for an adaptive cycle engine architecture that provides optimized performance, fuel efficiency, high power extraction, integrated thermal management, and durability for widely varying mission needs.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Missile/Remotely Piloted Aircraft Engine Performance	9.724	10.746	10.674
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 2019 Plans:*** Complete detailed design of and Critical Design Review (CDR) of a medium-scale efficient core demonstrator. Initiate risk reduction component testing of a medium-scale efficient core demonstrator. Continue risk reduction testing of components for 200lb thrust and 650lb thrust engines. Complete CDR of 200lb thrust engine. Complete testing of 650lb engine. Complete CDR of durability test utilizing small scale cruise missile engine to validate advanced design and life prediction tools for medium and large engine applications. Continue the development of derivative supersonic turbojet engines for missile and high speed			

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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634921 / *Aircraft Propulsion Subsystems Int*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
accelerators. Continue design of advanced turbine based accelerator with reusable hypersonics applications. Continue vehicle and propulsion system integration analysis. ***FY 2020 Plans:*** Continue risk reduction component testing of a medium-scale efficient core demonstrator. Continue risk reduction testing of components for small expendable turbojet/turbofans (100-900 lbs class). Initiate and complete conceptual and detailed design of a medium-scale high power, high efficiency turboprop. Initiate risk reduction component rig testing and initiate fabrication of components in preparation for engine testing for this turboprop. Initiate and complete conceptual design of a high efficiency medium-scale embedded propulsion concept. Continue development of derivative supersonic turbojet engines for missile and high speed accelerators. Complete design and review of advanced turbine based accelerator with reusable high speed applications. Complete vehicle and propulsion system integration analysis. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 decreased compared to FY 2019 by $0.072 million. Justification for the decrease is described in the plans above.			
Title: Adaptive Turbine Engine Technologies ***Description:*** Design, fabricate, and demonstrate performance, durability, and operability technologies to mature adaptive turbine engine technologies. ***FY 2019 Plans:*** Continue to provide subject matter expert support to Adaptive Engine Transition Program. Complete fabrication of components for integrated power and thermal management engine demonstrator. Continue hardware fabrication for an adaptive engine for utilization as an integrated power and thermal management engine demonstrator. ***FY 2020 Plans:*** Continue to provide subject matter expert support to Adaptive Engine Transition Program. Complete hardware fabrication for an adaptive engine for utilization as an integrated power and thermal management engine demonstrator. Initiate and complete conceptual design review of adaptive engine core technologies and initiate technology rig tests to decrease risk in core technology testing. Initiate detailed design, fabrication and testing of component technology rig for an adaptive core demonstrator. Initiate conceptual design of fully adaptive architectures and mature critical technologies for future weapon systems. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $0.030 million. Justification for the increase is described in the plans above.	6.617	7.312	7.342
Accomplishments/Planned Programs Subtotals	16.341	18.058	18.016

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 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 2020 Air Force			Date: February 2019
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 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
634922: *Space & Missile Rocket Propulsion*	-	28.177	40.220	28.256	0.000	28.256	29.686	30.584	31.403	32.199	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced and innovative low-cost rocket turbo-machinery and components, and low-cost space launch propulsion technologies. Additionally, this project develops technologies for the sustainment of strategic systems (including solid rocket motor boosters and missile propulsion, post boost control, and aging and surveillance efforts) and tactical rockets. Characteristics such as environmental acceptability, affordability, reliability, responsiveness, reduced weight, and reduced operation and launch costs are emphasized. Increased life and performance of propulsion systems are key goals. Technology areas investigated include ground demonstrations of compact, lightweight, advanced propulsion technologies, higher efficiency energy conversion systems (derived from an improved understanding of combustion fundamentals), and high-energy propellants. Technological advances in this project 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 thrusts 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 (DoD) and National Aeronautics and Space Administration (NASA). The efforts in this project are part of the Rocket Propulsion 21 (RP21) program. The efforts in this project 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 2018	FY 2019	FY 2020
Title: Liquid Rocket Propulsion Technologies	15.204	19.285	15.258
Description: Develop liquid rocket propulsion technology for current and future space launch vehicles. ***FY 2019 Plans:*** Continue study for next generation liquid propulsion technology demonstration effort focused on modularity and cost reduction. Initiate testing of hydrocarbon engines component. ***FY 2020 Plans:*** Complete study for next generation liquid propulsion technology demonstration effort focused on modularity and cost reduction. Complete testing of hydrocarbon engine components. Initiate modular engine feasibility demonstration. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 decreased compared to FY 2019 by $4.027 million. Funding decreased due to completion of hydrocarbon boost technology demonstration effort.			
Title: On-Orbit Propulsion Technologies	1.198	1.753	3.391

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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634922 / *Space & Missile Rocket Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: Develop solar electric, electric, and monopropellant propulsion technologies for existing and future satellites, upper stages, orbit transfer vehicles, and satellite maneuvering. ***FY 2019 Plans:*** Continue to develop and transition experimental, modeling and simulation, and theoretical efforts geared towards advanced thruster development with additional emphasis on understanding thrust scale-up. Continue to extend capability to study next generation of hypergolic fuels, including propellant characterization, drop-in testing, and lab-scale thruster demonstration. Continue analysis and development of multi mode propulsion opportunities to combine high efficiency and high thrust capabilities on a common propellant. Initiate thrust scale-up effort for advanced non-toxic mono-propellant thrusters. ***FY 2020 Plans:*** Continue to develop and transition experimental, modeling and simulation, and theoretical efforts geared towards advanced thruster development with additional emphasis on understanding thrust scale-up. Continue to extend capability to study next generation of hypergolic fuels, including propellant characterization, drop-in testing, and lab-scale thruster demonstration. Continue analysis and development of multi-mode propulsion opportunities to combine high efficiency and high thrust capabilities on a common propellant. Continue thrust scale-up effort for advanced non-toxic mono-propellant thrusters. Initiate electric propulsion thruster effort utilizing advanced non-toxic mono-propellant. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $1.638 million. Funding increased due to initiation of electric propulsion thruster effort utilizing advanced non-toxic mono-propellant.			
Title: Ballistic Missile Technologies ***Description:*** Develop and demonstrate missile propulsion and post-boost control systems technologies for ballistic missiles. ***FY 2019 Plans:*** Complete technology demonstration effort on advanced missile case, insulation, and nozzle technologies and validation of physics-based modeling, simulation, and analysis tools for ballistic and tactical missile solid rocket motors. Continue technology maturation and demonstration efforts for post-boost technologies and tactical missile technologies. ***FY 2020 Plans:*** Continue technology maturation and demonstration efforts for post-boost technologies and tactical missile technologies. Initiate motor component modeling & simulation tool development efforts geared towards reducing cost and schedule of new developments. ***FY 2019 to FY 2020 Increase/Decrease Statement:***	1.936	4.676	5.934

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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634922 / *Space & Missile Rocket Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2020 increased compared to FY 2019 by $1.258 million. Funding increased due to initiation of modeling & simulation tool development efforts.			
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 2019 Plans:*** Continue to apply next generation of chemical and aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, and non-destructive analysis tools. Continue advanced sensor analysis development efforts to further improve data acquisition and reduce uncertainty in ballistic missile life predictions. Continue to improve the fidelity and precision of non-destructive evaluation tools to increase the capability to determine flaw size, orientation, and location. Continue to support the transition of previous tools, models, data management system to user. Continue long-term validation of tools through long-term aging of sub-scale motors. Continue sub-scale motors dissection to validate the sensor and analytical analysis of each motor. Continue maturation and demonstration of advanced sensor, non-destructive evaluation, modeling and supporting technology development efforts to detect and explain phenomena to further improve data acquisition and reduce uncertainty in ballistic and tactical missile solid rocket motor life predictions. ***FY 2020 Plans:*** Continue to apply next generation of chemical and aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, and non-destructive analysis tools. Continue advanced sensor analysis development efforts to further improve data acquisition and reduce uncertainty in ballistic missile life predictions. Continue to improve the fidelity and precision of non-destructive evaluation tools to increase the capability to determine flaw size, orientation, and location. Continue to support the transition of previous tools, models, data management system to user. Continue long-term validation of tools through long-term aging of sub-scale motors. Continue sub-scale motors dissection to validate the sensor and analytical analysis of each motor. Continue maturation and demonstration of advanced sensor, non-destructive evaluation, modeling and supporting technology development efforts to detect and explain phenomena to further improve data acquisition and reduce uncertainty in ballistic and tactical missile solid rocket motor life predictions. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $0.167 million. Justification for the increase is described in the plans above.	2.589	3.506	3.673
Accomplishments/Planned Programs Subtotals	20.927	29.220	28.256

	FY 2018	FY 2019
Congressional Add: Program increase	7.250	0.000

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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 634922 / *Space & Missile Rocket Propulsion*

	FY 2018	FY 2019
FY 2018 Accomplishments: Conducted Congressionally directed efforts ***FY 2019 Plans:*** Not Applicable		
Congressional Add: Program increase - chemical apogee engines ***FY 2018 Accomplishments:*** Not Applicable ***FY 2019 Plans:*** Conduct Congressionally directed efforts.	0.000	2.500
Congressional Add: Program increase - upper stage engine maturation ***FY 2018 Accomplishments:*** Not Applicable ***FY 2019 Plans:*** Conduct Congressionally directed efforts.	0.000	8.500
Congressional Adds Subtotals	7.250	11.000

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 2020 Air Force			Date: February 2019
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 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
635098: *Advanced Aerospace Propulsion*	-	41.256	20.194	18.814	0.000	18.814	20.169	20.889	21.532	22.158	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 2018	FY 2019	FY 2020
Title: Scramjet Technologies	41.256	20.194	18.814
Description: Develop and demonstrate technologies for a hydrocarbon-fueled scramjet with robust operation up to Mach 7.			
FY 2019 Plans: Initiate scramjet combustor maturation efforts for flight-compliant designs based on results from direct connect testing of medium scale engine components at Aerodynamic and Propulsion Test Unit (APTU). Continue development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and engine controls. Continue development of scramjet technologies to enhance operability including robust operation during maneuvers. Continue accelerated development and demonstration of tactically-relevant long range high speed strike scramjet engine technologies including ground and flight demonstrations needed for potential follow-on acquisition program.			
FY 2020 Plans: Complete scramjet combustor maturation efforts for flight-compliant designs based on results from direct connect testing of medium scale engine components at APTU. Continue development and demonstration of tactically compliant subsystems, including scramjet engine start system, fuel system, and active engine controls. Continue development of scramjet technologies to enhance operability including robust operation during maneuvers. Continue accelerated development and demonstration of tactically- relevant long range high speed strike scramjet engine technologies including ground and flight demonstrations needed for potential follow-on acquisition program.			
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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 635098 / *Advanced Aerospace Propulsion*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2020 decreased compared to FY 2019 by $1.380 million. Justification for the decrease is due to higher Air Force Science and Technology priorities.			
Accomplishments/Planned Programs Subtotals	41.256	20.194	18.814

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 0603216F / *Aerospace Propulsion and Power Technology*	Project (Number/Name) 63681B / *Advanced Turbine Engine Gas Generator*	

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
63681B: *Advanced Turbine Engine Gas Generator*	-	14.803	28.652	21.831	0.000	21.831	22.183	22.822	23.411	23.979	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. The objective is to provide continuous evolution of technologies into an advanced gas generator in which the performance, cost, durability, repairability, and maintainability can be assessed in a realistic engine environment. The gas generator, or core, is the basic building block of the engine and nominally consists of a compressor, a combustor, a high-pressure turbine, mechanical systems, and core subsystems. Experimental core engine demonstration validates engineering design tools and enhances rapid, low-risk transition of key engine technologies into engineering development, where they can be applied to derivative and/or new systems. These technologies are applicable to a wide range of military and commercial systems including aircraft, missiles, land combat vehicles, ships, and responsive space launch. Component technologies are demonstrated in a core (sub-engine). This project also assesses the impact of low spool components such as; inlet systems, fans, low pressure turbines, exhaust systems, and system level technologies such as; integrated power generators and thermal management systems on core engine performance, and durability in ground demonstrations of engine cores. The core performances of this project are validated on demonstrator engines in the Aircraft Propulsion Subsystem 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 2018	FY 2019	FY 2020
Title: Core Engine Technologies	6.336	9.268	9.188
Description: Design, fabricate, and demonstrate performance predictions in core engines, using innovative engine cycles and advanced materials for turbofan and for turbojet engines.			
FY 2019 Plans: Continue design of medium-scale efficient core demonstrator. Initiate risk reduction component tests for medium-scale engine advanced fan and core. Initiate build of medium-scale engine. Continue design of large-scale adaptive core concepts. Continue design of bladed disks and bearing systems components for small cruise missile size engine. Continue development of small cruise missile engine demonstrator test plans to improve life prediction capability for bladed disks and bearing systems.			
FY 2020 Plans: Complete detailed design of medium-scale efficient core demonstrator. Continue risk reduction component tests for medium-scale engine advanced fan and core. Continue build of medium-scale engine. Complete conceptual design of large-scale adaptive core concepts. Complete design of bladed disks and bearing systems components for small cruise missile size engine. Complete			

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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 63681B / *Advanced Turbine Engine Gas Generator*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
development of small cruise missile engine demonstrator test plans to improve life prediction capability for bladed disks and bearing systems. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 decreased compared to FY 2019 by $0.080 million. Justification for the decrease is described in the plans above.			
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 2019 Plans:*** Complete risk reduction testing of components for 200lb thrust and 650lb thrust engines. Complete critical design review of 200lb thrust engine. Initiate assembly of advanced concept additive manufacturing heat exchanger for small core engines. Initiate fabrication of recouperator for demonstration of increased core efficiency in small core engines. ***FY 2020 Plans:*** Complete several key risk reduction testing of components for small engines (200-800 lbs class). Initiate conceptual and preliminary design of small engine technology: Identify innovative architecture, critical technologies and component designs for efficient, recuperated turbo shaft engines. Continue assembly of advanced concept additive manufacturing heat exchanger for small core engines. Continue fabrication of recuperator for demonstration of increased core efficiency in small core engines. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $0.094 million. Justification for the increase is described in the plans above.	2.298	3.362	3.456
Title: Adaptive Turbine Engine Core Technologies ***Description:*** Design, fabricate, and demonstrate adaptive turbine engine cores to provide increased durability and affordability with lower fuel consumption for turbofan and for turboshaft engines. ***FY 2019 Plans:*** Complete Preliminary Design Review and procurement of long lead hardware for advanced air dominance adaptive core demonstrator and risk reduction rigs. Initiate detailed design advanced air dominance adaptive core demonstrator. Initiate component tests of advanced variable turbine and innovative compression rear block designed to accept flow variations caused by variable turbine operation. Complete the evaluation of application of high temperature polymer matrix composite and ceramic matrix composites to reduce system weight and improve cycle efficiency. Complete analyses of adaptive engine technologies operational mission impact. ***FY 2020 Plans:***	6.169	9.022	9.187

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 0603216F / *Aerospace Propulsion and Power Technology*	**Project (Number/Name)** 63681B / *Advanced Turbine Engine Gas Generator*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Complete conceptual design of adaptive engine technology and initiate technology rig tests to decrease risk in core technology testing. Continue component tests of advanced variable turbine and innovative compression rear block designed to accept flow variations caused by variable turbine operation. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2020 increased compared to FY 2019 by $0.165 million. Justification for the increase is described in the plans above.			
Accomplishments/Planned Programs Subtotals	14.803	21.652	21.831

	FY 2018	FY 2019
Congressional Add: Program increase - advanced turbine engine gas generator	0.000	7.000
FY 2018 Accomplishments: Not Applicable		
FY 2019 Plans: Conduct Congressionally directed efforts		
Congressional Adds Subtotals	0.000	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.