Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force											Date: February 2020	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*							
COST ($ in Millions)	**Prior Years**	**FY 2019**	**FY 2020**	**FY 2021 Base**	**FY 2021 OCO**	**FY 2021 Total**	**FY 2022**	**FY 2023**	**FY 2024**	**FY 2025**	**Cost To Complete**	**Total Cost**
Total Program Element	-	150.625	157.724	349.225	0.000	349.225	357.519	342.564	350.533	355.874	Continuing	Continuing
622401: *Aeromechanics and Structures Technology*	-	40.754	41.817	78.700	0.000	78.700	80.655	77.360	79.266	80.475	Continuing	Continuing
622403: *Flight Controls and Pilot-Vehicle Interface*	-	37.925	49.297	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
622404: *Aeromechanics and Integration*	-	29.036	28.595	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
622405: *High Speed Systems Technology*	-	42.910	38.015	53.578	0.000	53.578	55.932	53.583	54.771	55.598	Continuing	Continuing
622406: *Aerospace Power & Flight Control Technology*	-	0.000	0.000	72.653	0.000	72.653	76.366	72.548	74.338	75.467	Continuing	Continuing
623066: *Turbine Engine Technology*	-	0.000	0.000	73.887	0.000	73.887	73.705	70.860	72.425	73.523	Continuing	Continuing
624847: *Rocket Propulsion Technology*	-	0.000	0.000	62.855	0.000	62.855	63.217	60.717	62.075	63.025	Continuing	Continuing
625330: *Aerospace Fuel Technology*	-	0.000	0.000	7.552	0.000	7.552	7.644	7.496	7.658	7.786	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program investigates, develops, and analyzes aerospace vehicle technologies in the six primary areas of high speed systems, power and flight control technologies, rocket propulsion, turbine engine technologies, fuel sciences, and aeromechanics and structure systems. The effort has six projects, each focusing on a technology area critical to the Air Force. The High Speed Systems Technology project develops high speed/hypersonic aerospace vehicles as well as high-speed air breathing propulsion engines to include combined cycle, ramjet, and hypersonic scramjet technologies to enable revolutionary propulsion capability for the Air Force. The Power and Flight Control Technologies project develops technologies that enable maximum affordable capability from manned, remotely-piloted and autonomous aerospace vehicles while developing electrical and thermal control technologies for military applications that remove operational limitations and enable advanced vehicle designs and high-power mission systems. The Rocket Propulsion Technology project develops advances in rocket propulsion technologies for space access, space maneuver, missiles, the sustainment of strategic systems, and tactical rockets. The Turbine Engine Technology project develops and enables advanced engine architectures across small, medium, large thrust classes; to provide optimized performance, fuel efficiency, and integrated propulsion, power, and thermal capability, while enhancing affordability. Includes technology concepts for legacy and future, advanced turbine engines. The Aerospace Fuel Technology project evaluates hydrocarbon-based fuels for legacy and advanced turbine engines, scramjets, pulse detonation, and combined-cycle engines. The Aeromechanics and Structures project develops and exploits

new materials, fabrication processes, design techniques, and incorporating vehicle, inter-vehicle, and intra-vehicle control systems. Advanced aerodynamic vehicle configurations are developed and analyzed through simulations, experiments, and multi-disciplinary analyses.

In FY 2021, the Aerospace Systems RDT&E Budget Activity 02 (BA02) efforts and activities under PE 0602203F, Aerospace Propulsion, and PE 0602201F, Aerospace Vehicle Technologies, are realigned and consolidated into PE 0602201F, Aerospace Vehicle Technologies, to increase the efficiency and effectiveness of internal Air Force Research Laboratory Aerospace Systems Technology Directorate operations to finalize the 2012 merger of the Air Vehicles Directorate and Propulsion Directorate; and to better support the National Defense Strategy, Air Force Future Operating Concept, and the Air Force Science and Technology Strategy, April 2019.

All transfers detailed below are administrative realignments for consolidation, and not new starts. This work will continue to be executed by the Air Force Research Laboratory Aerospace Systems Technology Directorate located either in Wright Patterson Air Force Base, OH or Edwards Air Force Base, CA.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623048, Combustion & Mechanical Systems is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology.

In FY 2021, the entirety of PE 0603216F, Aerospace Propulsion & Power Technology, Project 632480, Aerospace Fuels is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 624847 , Rocket Propulsion Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology.

In FY 2021, the entirety of PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls & Pilot-Vehicle Interface is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622406, Aerospace Power & Flight Control Technology.

In FY 2021, the entirety of Program Element 0602201F, Aerospace Vehicle Technologies, Project 622404, Aeromechanics & Integration, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622401, Aeromechanics & Structures Technology.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623012, Advanced Propulsion Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622405, High Speed Systems Technology.

Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*

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, 0602202F, 0602203F, 0602204F, 0602602F, 0602605F, 0602788F, 1206601SF, and 0602298F.

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

B. Program Change Summary ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	160.461	147.724	150.700	0.000	150.700
Current President's Budget	150.625	157.724	349.225	0.000	349.225
Total Adjustments	-9.836	10.000	198.525	0.000	198.525
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	10.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-4.995	0.000			
• Other Adjustments	-4.841	0.000	198.525	0.000	198.525

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2019	FY 2020
Project: 622403: *Flight Controls and Pilot-Vehicle Interface*		
Congressional Add: *Program increase - human machine teaming*	3.876	0.000
Congressional Add: *Program increase - flight controls and pilot-vehicle interfaces*	4.844	0.000
Congressional Add Subtotals for Project: 622403	8.720	0.000
Project: 622405: *High Speed Systems Technology*		
Congressional Add: *Program increase - high speed systems technology*	5.813	0.000
Congressional Add: *Program increase - hypersonic vehicle structures*	9.689	10.000
Congressional Add: *Program increase - hypersonic wind tunnels*	4.844	0.000
Congressional Add Subtotals for Project: 622405	20.346	10.000
Congressional Add Totals for all Projects	29.066	10.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Air Force	Date: February 2020
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of $4.841 million is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

Increase in FY 2021 of $198.525 million is due to the following:

1) Civilian pay repricing adjustments

2) Realignment of the entirety of PE 0602203F, Aerospace Propulsion, to PE 0602201F, Aerospace Vehicle Technologies, to increase the efficiency and effectiveness of internal Aerospace Systems Technology Directorate operations to finalize the 2012 merger of the Air Vehicles Directorate and Propulsion Directorate.

3) Realignment of PE 0603216F, Aerospace Propulsion & Power Technology, Project 632480, Aerospace Fuels to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology to consolidate Aerospace RDT&E fuel research.

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force			Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622401 / *Aeromechanics and Structures Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622401: *Aeromechanics and Structures Technology*	-	40.754	41.817	78.700	0.000	78.700	80.655	77.360	79.266	80.475	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops advanced structures concepts to exploit new materials and fabrication processes and investigates new concepts and design techniques. New structural concepts include low cost design and fabrication techniques, incorporating subsystem hardware items and adaptive mechanisms into the aerospace structures and/or skin of the platform.

In FY 2021, Project 622401 is renamed from Structures to Aeromechanics and Structures Technology.

In FY 2021, the entirety of Project 622404, Aeromechanics & Integration is transferred to Project 622401, Aeromechanics & Structures Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Aircraft Service Life Technologies	21.250	15.109	16.887
Description: Develop an economic service life analysis capability comprised of analysis tools, methodologies, and structural health monitoring technologies.			
FY 2020 Plans: Complete methods for achieving lifing credit in advanced & enhanced metallic airframe components to extend structural life. Continue demonstration of Aircraft Digital Twin models and tools on legacy fleet aircraft. Complete development of impact damage analysis criteria and methods for advanced composite structures. Initiate lifing methods for durability and damage tolerance of aging composite structures on legacy fleet aircraft. Initiate development of digital maintenance models and virtual and augment reality maintenance tools.			
FY 2021 Plans: Complete demonstration of Aircraft Digital Twin models and tools on legacy fleet aircraft. Continue lifing methods for durability and damage tolerance of aging composite structures on legacy fleet aircraft. Complete development of digital maintenance models and virtual and augment reality maintenance tools.			
FY 2020 to FY 2021 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622401 / *Aeromechanics and Structures Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by $1.778 million. Funding increased due to additional emphasis in digital engineering and civilian pay repricing adjustments.			
Title: Vehicle Design Technologies ***Description:*** Develop methodologies to reduce the cost and time involved from design to full-scale testing of structural concepts and aerospace systems. ***FY 2020 Plans:*** Continue the development of advanced high fidelity aircraft design analysis tools. Continue the development of integrating cost, mission effectiveness, and affordable manufacturing methods into aircraft design analysis tools (completing methods on low cost attritable aircraft concepts in FY 2020 and starting methods for other aircraft systems). Continue the development of control effector designs for supersonic tailless aircraft. Initiate new design techniques to quantify and trade risk impacts against performance in aircraft designs. ***FY 2021 Plans:*** Continue the development of advanced high fidelity aircraft design analysis tools. Continue the development of integrating cost, mission effectiveness, and affordable manufacturing methods into aircraft design analysis tools. Complete the development of control effector designs for supersonic tailless aircraft. Continue new design techniques to quantify and trade risk impacts against performance in aircraft designs. Initiate the development of new design methods that link vehicle system requirements to mission operation performance. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $1.617 million. Funding increased due to additional emphasis on the development of new vehicle design methods and civilian pay repricing adjustments.	11.944	13.739	15.356
Title: Structural Concepts ***Description:*** Develop design methods, processes, and lightweight, adaptive, and multifunctional structural concepts to capitalize on new materials, multi-role considerations, and technology integration into aircraft systems. ***FY 2020 Plans:*** Continue development and verification of low cost attritable airframe concepts and manufacturing methods (completing wing structure developments in FY 2020 and starting concepts for the fuselage and complete airframe). Complete development of lightweight aircraft structural concepts to support Air Superiority 2030 and Advanced Mobility requirements. Continue development of innovative structural design methods to dramatically reduce weight and complexity of aircraft structures. Continue development	7.560	12.969	14.496

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622401 / *Aeromechanics and Structures Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
of fail-safe technologies for bonded unitized composite structures applicable to Mobility aircraft (completing durability requirements in FY 2020 and starting structural life component tests). ***FY 2021 Plans:*** Complete development and verification of low cost attritable airframe concepts and manufacturing methods. Continue development of innovative structural design methods to dramatically reduce weight and complexity of aircraft structures. Continue development of fail-safe technologies for bonded unitized composite structures applicable to Mobility aircraft. Initiate validation of impact damage analysis and methods for advanced fail-safe composite structures applicable to Mobility aircraft. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $1.527 million. Funding increased due to additional emphasis in low-cost aircraft design and manufacturing applicable to strike and mobility aircraft and civilian pay repricing adjustments.			
Title: Aerodynamic Systems Technologies ***Description:*** Develop aerodynamic assessment prediction methods centered on expanding the design capabilities of future air vehicles. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under Project 622404, Aeromechanics and Integration, Aerodynamics Systems Technologies effort. ***FY 2021 Plans:*** Continue development and assessment of low cost attritable unmanned air vehicle concepts. Initiate an assessment of design options to allow runway independence for low cost attritable unmanned air vehicle concepts. Continue design assessments of distributed propulsion concepts for next generation Mobility. Complete the development of a high fidelity aerodynamic analysis tool for the design of laser turrets applicable to Air Superiority 2030 requirements. Continue the assessment and development of incorporating active flow control techniques into advanced design to enable new aircraft configurations. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $7.161 million. Funding increased due to realignment of Aerodynamic Systems research from Project 622404, Aeromechanics and Integration, Aerodynamic Systems Technology effort, and civilian pay repricing adjustments.	0.000	0.000	7.161
Title: Next Generation Aerodynamic Technologies ***Description:*** Develop and assess technologies for the next generation of multi-role large aircraft. ***FY 2020 Plans:***	0.000	0.000	7.921

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622401 / *Aeromechanics and Structures Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
For FY 2020 and prior years, this work is performed under Project 622404, Aeromechanics and Integration, Next Generation Aerodynamic Technologies effort. ***FY 2021 Plans:*** Continue next generation tanker maturation and assess promising configurations in high and low speed wind tunnels. Complete wind tunnel tests of practical laminar flow treatments and coatings for highly swept wings applicable to Mobility applications. Continue the design of a small, pod-mounted tactical air refueling boom for future Mobility applications. Continue the development of advanced high fidelity aerodynamic analysis tools for aircraft conceptual design. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $7.921 million. Funding increased due to realignment of Next Generation Aerodynamic research from Project 622404, Aeromechanics and Integration, Next Generation Aerodynamic Technologies effort, and civilian pay repricing adjustments.			
Title: Aircraft Integration Technologies ***Description:*** Develop enabling technologies to allow efficient and effective integration of propulsion, weapons, and subsystems into current and future air vehicles. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under Project 622404, Aeromechanics and Integration, Aircraft Integration Technologies effort. ***FY 2021 Plans:*** Continue development of advanced kinetic and directed energy weapons integration technologies for Air Superiority 2030. Continue integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility and completing the full flow path demonstration design. Complete propulsion integrations component wind tunnels tests for Air Superiority 2030 requirements. Initiate design and analysis methods to allow rapid certification of stores separation for new small weapons on tactical aircraft. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $16.879 million. Funding increased due to realignment of Aircraft Integration research from Project 622404, Aeromechanics and Integration, Aircraft Integration Technologies effort, and civilian pay repricing adjustments.	0.000	0.000	16.879
Accomplishments/Planned Programs Subtotals	40.754	41.817	78.700

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622401 / *Aeromechanics and Structures Technology*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force			Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622403 / *Flight Controls and Pilot-Vehicle Interface*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622403: *Flight Controls and Pilot-Vehicle Interface*	-	37.925	49.297	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops technologies that enable maximum affordable capability from manned, remotely-piloted, and autonomous aerospace vehicles. Advanced control technologies are developed for maximum vehicle performance throughout the flight envelope and simulated in virtual environments. Resulting technologies contribute significantly towards the development of reliable autonomous or remotely piloted air vehicles, hypersonic aircraft, and extended-life legacy aircraft.

In FY 2021, the entirety of Project 622403, Flight Controls & Pilot-Vehicle Interface is transferred to, Project 622406, Aerospace Power & Flight Control Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Advanced Flight Controls Technologies	6.693	6.790	0.000
Description: Develop technologies for advanced control-enabled capabilities, including flight controls, components, integrated vehicle management systems, and software and system certification techniques for both manned/unmanned and remotely piloted aircraft. ***FY 2020 Plans:*** Continue the development, demonstration, and assessment of advanced flight control mechanization technologies for trusted and certifiable operations under adverse and contested environments. Complete the development of survivable and health-adaptive control system architecture. Continue the development of trusted autonomy approach, integrating certification processes, and autonomy development. ***FY 2021 Plans:*** For FY 2021 and future years, this work will be performed under Project 622406, Aerospace Power & Flight Control Technology, Advanced Flight Controls Technologies effort. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $6.790 million. Funding decreased due to realignment of Advanced Flight Controls research to Project 622406, Aerospace Power & Flight Control Technology, Advanced Flight Controls Technologies effort.			
Title: Manned and Unmanned Teaming Technologies	17.391	17.644	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622403 / *Flight Controls and Pilot-Vehicle Interface*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Description: Develop technology for flight control systems that will permit safe interoperability between manned and remotely piloted aircraft and effective teaming in adverse and contested environments. ***FY 2020 Plans:*** Continue development, demonstration, and assessment of advanced control automation techniques. Continue the development of mixed initiative control techniques for teams of remotely piloted aircraft and/or manned-unmanned teams in contested, dynamic mission environments, as well as for the integration of unmanned systems into controlled airspace and airbase operations. Continue the development of robust, affordable Unmanned Air Systems (UAS) operations in a terminal airspace environment. Complete the development of autonomous behaviors for safe, loyal wingman. Initiate the development of autonomous behaviors for safe, effective manned-unmanned teams. ***FY 2021 Plans:*** For FY 2021 and future years, this work will be performed under Project 622406, Aerospace Power & Flight Control Technology, Manned and Unmanned Teaming Technologies effort. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $17.644 million. Funding decreased due to realignment of Manned and Unmanned Teaming research to Project 622406, Aerospace Power & Flight Control Technology, Manned and Unmanned Teaming Technologies effort.			
Title: Flight Controls Technologies Modeling and Simulation ***Description:*** Develop tools and methods for capitalizing on simulation-based research and development of future aerospace vehicles. ***FY 2020 Plans:*** Continue modeling and simulation efforts to evaluate emerging autonomous and robust flight control technologies and concepts, as well as assess mission-level performance of integrated aerospace systems. Complete analyses of automated unmanned air systems and manned-unmanned teams in controlled airspace and airbase operations. Continue analyses of manned-unmanned teams in adversarial mission environments. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Continue manned-unmanned teaming evaluations including rapid development of new capabilities. Complete development of autonomy for tactical aircraft operations. ***FY 2021 Plans:***	5.121	5.196	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622403 / *Flight Controls and Pilot-Vehicle Interface*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
For FY 2021 and future years, this work will be performed under Project 622406, Aerospace Power & Flight Control Technology, Flight Controls Technologies Modeling and Simulation effort. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $5.196 million. Funding decreased due to realignment of Flight Controls Technologies Modeling and Simulation research to Project 622406, Aerospace Power & Flight Control Technology, Flight Controls Technologies Modeling and Simulation effort.			
Title: Future AF Capabilities Applied Research ***Description:*** Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/ unconventional weapons). The National Defense Strategy and Air Force Science and Technology (S&T) Strategy will inform investments over the FYDP. In FY 2019, this work was performed under multiple projects and efforts within the following Air Force S&T Programs: 0602102F, Materials; 0602201F, Aerospace Vehicle Technologies; 0602202F, Human Effectiveness Applied Research; 0602203F, Aerospace Propulsion; 0602204F, Aerospace Sensors; 1206601F, Space Technology; 0602602F, Conventional Munitions; 0602605F, Directed Energy Technology; and 0602788F, Dominant Information Science and Methods. ***FY 2020 Plans:*** Investigate and mature science and technology that enables future warfighting concepts to provide leap-ahead capabilities. The National Defense Strategy and Air Force S&T Strategy focus this science and technology toward, but not limited to, the following capabilities: 1) global persistent awareness; 2) resilient information sharing; 3) rapid, effective decision-making; 4) complexity, unpredictability, and mass; and 5) speed and reach of disruption and lethality. ***FY 2021 Plans:*** Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $19.667 million. Funding decreased due to realignment and consolidation of Future AF Capabilities Applied Research effort to PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise	0.000	19.667	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622403 / *Flight Controls and Pilot-Vehicle Interface*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Transformational Applied Research, Transformational Capability Incubator effort, to better align with the Air Force S&T Strategy SECAF April 2019 and provide Congress with increased transparency on transformational Air Force S&T activities.			
Accomplishments/Planned Programs Subtotals	29.205	49.297	0.000

	FY 2019	FY 2020
Congressional Add: Program increase - human machine teaming ***FY 2019 Accomplishments:*** Conducted Congressionally directed efforts. ***FY 2020 Plans:*** Not Applicable	3.876	0.000
Congressional Add: Program increase - flight controls and pilot-vehicle interfaces ***FY 2019 Accomplishments:*** Conducted Congressionally directed efforts. ***FY 2020 Plans:*** Not Applicable	4.844	0.000
Congressional Adds Subtotals	8.720	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force			Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622404 / *Aeromechanics and Integration*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622404: *Aeromechanics and Integration*	-	29.036	28.595	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops aerodynamic configurations of a broad range of revolutionary, affordable aerospace vehicles. It matures and applies modeling and numerical simulation methods for fast and affordable aerodynamics prediction and integrates and demonstrates multi-disciplinary advances in airframe, propulsion, weapon, and air vehicle control integration.

In FY 2021, the entirety of Project 622404, Aeromechanics & Integration is be transferred to Project 622401, Aeromechanics & Structures Technology, in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Aerodynamic Systems Technologies	7.680	6.407	0.000
Description: Develop aerodynamic assessment prediction methods centered on expanding the design capabilities of future air vehicles. ***FY 2020 Plans:*** Continue development and assessment of low cost attritable unmanned air vehicles concepts. Continue design assessments of distributed propulsion concepts for next generation Mobility. Continue the development of a high fidelity aerodynamic analysis tool for the design of laser turrets applicable to Air Superiority 2030 requirements (completing a sub-scale design in FY 2020 and starting a sub-scale build and full-scale turret design). Initiate the assessment and development of incorporating active flow control techniques into advanced design to enable new aircraft configurations. ***FY 2021 Plans:*** Starting in FY 2021, this work is performed in Project 622401, Aeromechanics and Structures Technology, Aerodynamic Systems Technologies effort. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $6.407 million. Funding decreased due to realignment of Aerodynamic Systems research to Project 624401, Aeromechanical and Structures Technology, Aerodynamic Systems Technology effort.			
Title: Next Generation Aerodynamic Technologies	9.256	7.087	0.000
Description: Develop and assess technologies for the next generation of multi-role large aircraft.			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622404 / *Aeromechanics and Integration*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
FY 2020 Plans: Continue next generation tanker maturation and assess promising configurations in high and low speed wind tunnels. Continue wind tunnel tests of practical laminar flow treatments and coatings for highly swept wings applicable to Mobility applications. Initiate the design of a small, pod-mounted tactical air refueling boom for future Mobility applications. Initiate the development of advanced high fidelity aerodynamic analysis tools for aircraft conceptual design. ***FY 2021 Plans:*** Starting in FY 2021, this work is performed in Project 622401, Aeromechanics and Structures Technology, Next Generation Aerodynamic Technologies effort. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $7.087 million. Funding decreased due to realignment of Next Generation research to Project 624401, Aeromechanical and Structures Technology, Next Generation Aerodynamic Technology effort.			
Title: Aircraft Integration Technologies ***Description:*** Develop enabling technologies to allow efficient and effective integration of propulsion, weapons, and subsystems into current and future air vehicles. ***FY 2020 Plans:*** Continue development of advanced kinetic and directed energy weapons integration technologies for Air Superiority 2030. Continue integrated full flow path demonstration of a medium bypass embedded engine for next generation mobility, completing the system requirements definition in FY 2020 and starting the full flow bath demonstration design. Continue propulsion integrations component wind tunnels tests for Air Superiority 2030 requirements. ***FY 2021 Plans:*** Starting in FY 2021, this work is performed Project 622401, Aeromechanics and Structures Technology, Aircraft Integration Technologies effort. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $15.101 million. Funding decreased due to realignment of Aircraft Integration research to Project 624401, Aeromechanical and Structures Technology, Aircraft Integration Technologies effort.	12.100	15.101	0.000
Accomplishments/Planned Programs Subtotals	29.036	28.595	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622404 / *Aeromechanics and Integration*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

Not Applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force			Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622405 / *High Speed Systems Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622405: *High Speed Systems Technology*	-	42.910	38.015	53.578	0.000	53.578	55.932	53.583	54.771	55.598	Continuing	Continuing

A. Mission Description and Budget Item Justification

This effort investigates, analyzes, and develops high speed/hypersonic aerospace vehicle technologies. Advanced high temperature structures concepts are explored and developed to exploit new materials, fabrication processes, and design techniques. Advanced aerodynamic vehicle configurations are developed and analyzed through simulations, experiments, and multi-disciplinary analyses. Advanced flight control technologies are developed and simulated for hypersonic vehicles. These technologies will enable future high speed weapons; intelligence, surveillance, and reconnaissance systems; and space access vehicles.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623012, Advanced Propulsion Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 622405, High Speed Systems Technology. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: High Speed Systems Technology	13.117	16.286	15.092
Description: Develop design analysis methods and technologies for high speed systems in for extreme flight conditions.			
FY 2020 Plans: Continue maturation of innovative structural concepts for high speed/hypersonic air vehicles. Continue development of analytical methods for predicting structural response needed for design and evaluation of hot primary structure for hypersonic vehicles. Continue to assess the impact of path dependent structural behavior on the service life prediction for hot structures encountering extreme environments. Continue to develop and integrate model uncertainty methods into multi-disciplinary simulations and quantify its impact on the structural margin. Continue development of structural analysis methods and technology for hot structure concepts under extreme environment loading conditions. Continue the assessment of the aerospace community to quantify the structural margins for extreme environment hot structure through experimental validation of ground test articles. Continue development of structural life prediction methodology for extreme environment structures and thermal protection systems. Continue development on novel designs and demonstration of integrated hot structures for hypersonic reusable air platforms.			
FY 2021 Plans: Continue to mature critical technologies for high speed/ hypersonic flight with greater emphasis on longer range flight and heavier payloads. Continue maturation of innovative structural concepts, analytical methods, service life predictions, and thermal management techniques for structure. Continue development of design/analysis techniques/ tools and experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622405 / *High Speed Systems Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
capabilities. Continue investigation of aeromechanic technologies to reduce drag and enable robust stability and control at all flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed component technologies through experimental ground and flight testing. Continue assessment of engagement, mission, and campaign-levels of effectiveness for promising high speed systems and refine concept designs to incorporate needed capabilities. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $1.194 million. Funding decreased due to a reduction in ground and flight testing.			
Title: Hypersonic Scramjet Technologies ***Description:*** Develop robust hydrocarbon fueled scramjet engine components and technologies to improve performance, operability, durability, and scalability for future platforms. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623012, Advanced Propulsion Technology, Hypersonic Scramjet Technologies effort. ***FY 2021 Plans:*** Continue to develop and demonstrate advanced engine components to improve scramjet operating margin, operating time, and to refine scramjet scaling laws for expendable and reusable applications. Continue to develop low internal drag flame stabilization devices and flight test engine components. Continue propulsion studies and design efforts required for the development and demonstration of an engine flight test that expands the flight environment of current high speed propulsion systems. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $27.617 million. Funding increased due to realignment of Hypersonic Scramjet research from PE 0602203F, Aerospace Propulsion, Project 623012, Advanced Propulsion Technology, Hypersonic Scramjet Technologies effort, and civilian pay repricing adjustments.	0.000	0.000	27.617
Title: High Speed Vehicle Aeromechanics and Integration ***Description:*** Develop new and improved components, concepts, and designs for sustained flight of high-speed/hypersonic expendable and re-useable vehicles. Conduct analyses of high speed/hypersonic vehicles to enable revolutionary capabilities. ***FY 2020 Plans:*** Continue to mature critical technologies for high speed/ hypersonic flight. Continue development of design/analysis techniques/ tools and experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary capabilities. Continue investigation of aeromechanic technologies to reduced drag and enable robust	9.447	11.729	10.869

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622405 / *High Speed Systems Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
stability and control at low dynamic pressure flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed technologies through experimental testing. Continue assessment of mission level effectiveness and refinement of definition of preferred high speed weapon alternatives and limited life hypersonic intelligence, surveillance, and reconnaissance vehicles. Continue assessment of campaign level benefits of preferred high speed weapon alternatives. ***FY 2021 Plans:*** Continue to mature critical technologies for high speed/ hypersonic flight with greater emphasis on longer range flight and heavier payloads. Continue development of design/analysis techniques/ tools and experimental approaches to enable enhanced high-speed air induction system starting, operability, and performance for propulsion integration concepts over a wide range of flight conditions. Continue development of high speed system concepts that provide revolutionary capabilities. Continue investigation of aeromechanic technologies to reduce drag and enable robust stability and control at all flight conditions. Continue efforts to characterize high-speed phenomena and develop and validate fundamental high-speed component technologies through experimental ground and flight testing. Continue assessment of engagement, mission, and campaign levels of effectiveness for promising high speed systems and refine concept designs to incorporate needed capabilities. Continue assessment of campaign level benefits of preferred high speed weapon alternatives. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $0.860 million. Justification for the decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	22.564	28.015	53.578

	FY 2019	FY 2020
Congressional Add: Program increase - high speed systems technology ***FY 2019 Accomplishments:*** Conducted Congressionally directed efforts ***FY 2020 Plans:*** Not Applicable	5.813	0.000
Congressional Add: Program increase - hypersonic vehicle structures ***FY 2019 Accomplishments:*** Conducted Congressionally directed efforts ***FY 2020 Plans:*** Conduct Congressionally directed efforts	9.689	10.000
Congressional Add: Program increase - hypersonic wind tunnels	4.844	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622405 / *High Speed Systems Technology*

	FY 2019	FY 2020
FY 2019 Accomplishments: Conducted Congressionally directed efforts. ***FY 2020 Plans:*** Not Applicable		
Congressional Adds Subtotals	20.346	10.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not Applicable

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force			Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 622406 / *Aerospace Power & Flight Control Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
622406: *Aerospace Power & Flight Control Technology*	-	0.000	0.000	72.653	0.000	72.653	76.366	72.548	74.338	75.467	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops integrated electrical and thermal management components, controls and systems for military aerospace applications. Power component technologies are developed to increase reliability, maintainability, commonality, affordability, and supportability of aircraft and flight line equipment. Research is conducted in energy storage and hybrid power system technologies to enable special purpose applications. Electrical power and thermal management technologies enable future military megawatt level power and thermal management needs. Controls and system integration technologies ensure the interoperability of aircraft, power, thermal, engine and other systems and subsystems. This project supports development of electrical power and thermal management components, controls and systems suitable for applications to legacy and future aircraft platforms including strike and mobility concepts. Lightweight power systems suitable for other aerospace applications are also developed. This project develops technologies that enable maximum affordable capability from manned, remotely-piloted and autonomous aerospace vehicles. Advanced control technologies are developed for maximum vehicle performance throughout the flight envelope and simulated in virtual environments. Resulting technologies contribute significantly towards the development of reliable autonomous or remotely piloted air vehicles, hypersonic aircraft, and extended-life legacy aircraft.

In FY 2021, Project 622406, Aerospace Power & Flight Control Technology, was created in order to realign technology areas that better support the National Defense Strategy and Air Force Future Operating Concept. Efforts in this project were previously accomplished under PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls & Pilot-Vehicle Interface and PE 0602203F, Aerospace Propulsion, Project 623145, Aerospace Power Technology.

This is an administrative realignment to provide increased execution flexibility and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: High Power System Technologies	0.000	0.000	40.448
Description: Develop integrated system architecture, controls, and component technologies to provide for the large amounts of electrical power needed, and concurrent thermal mitigation required, by current and future manned and unmanned systems.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623145, Aerospace Power Technology, High Power System Technologies effort.			
FY 2021 Plans: Continue development of system and component electrical power, electro-mechanical, and thermal technologies for high-power applications. Continue development of hybrid approaches to power generation, storage, and application as well as thermal			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622406 / *Aerospace Power & Flight Control Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
management. Continue testing of subsystems hardware in conjunction with continued platform level tip-to-tail modeling and simulation energy optimization. Continue development of advanced, safe energy storage, power distribution, and management systems to include Silicon Carbide applications and batteries. Continue power and thermal development toward demonstration of tactical aircraft high-power payload capability, e.g. laser weapon system. Continue analysis and development of adaptive power and thermal control systems for high-power aircraft. Continue weapon system contractor support for platform integration of advanced power and thermal system architectures. Initiate medium-scale propulsion, power and thermal system studies and development. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $40.448 million. Funding increased due to realignment of High Power Systems research from PE 0602203F, Aerospace Propulsion, Project 623145, Aerospace Power Technology, High Power Systems Technologies effort, and civilian pay repricing adjustments.			
Title: Advanced Flight Control Technologies ***Description:*** Develop technologies for advanced control-enabled capabilities, including flight controls, components, integrated vehicle management systems and software and system certification techniques for both manned/unmanned and remotely piloted aircraft. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls & Pilot-Vehicle Interface, Advanced Flight Control Technologies effort. ***FY 2021 Plans:*** Complete the development, demonstration, and assessment of advanced flight control mechanization technologies for trusted and certifiable operations under adverse and contested environments. Continue the development of trusted autonomy approach, integrating certification processes and autonomy development. Initiate the development, demonstration, and assessment of autonomy capabilities under adverse and contested environments. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $7.380 million. Funding increased due to realignment of Advanced Flight Control research from Project 622403, Flight Controls & Pilot-Vehicle Interface, Advanced Flight Control Technologies effort, and civilian pay repricing adjustments.	0.000	0.000	7.380
Title: Manned and Unmanned Teaming Technologies ***Description:*** Develop technology for flight control systems that will permit safe interoperability between manned and remotely piloted aircraft and effective teaming in adverse and contested environments.	0.000	0.000	19.178

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622406 / *Aerospace Power & Flight Control Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602201F, Aerospace Vehicle Technologies, Project 622403, Flight Controls & Pilot-Vehicle Interface, Manned and Unmanned Teaming Technologies effort. ***FY 2021 Plans:*** Continue development, demonstration, and assessment of advanced control automation techniques. Complete the development of mixed initiative control techniques for teams of remotely piloted aircraft and/or manned-unmanned teams in contested, dynamic mission environments, as well as for the integration of unmanned systems into controlled airspace and airbase operations. Complete the development of robust, affordable Unmanned Air Systems (UAS) operations in a terminal airspace environment. Continue the development of autonomous behaviors for safe, effective manned-unmanned teams. Initiate the development of tactical autonomy for manned-unmanned teams in contested, dynamic mission environments. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $19.178 million. Funding increased due to realignment of Manned and Unmanned Teaming Technologies research from Project 622403, Flight Controls & Pilot-Vehicle Interface, Manned and Unmanned Teaming Technologies effort, and civilian pay repricing adjustments.			
Title: Flight Controls Technologies Modeling and Simulation	0.000	0.000	5.647
Description: Develop tools and methods for capitalizing on simulation-based research and development of future aerospace vehicles. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under Project 622403, Flight Controls & Pilot-Vehicle Interface, Flight Controls Technologies Modeling and Simulation effort. ***FY 2021 Plans:*** Continue modeling and simulation efforts to evaluate emerging autonomous and robust flight control technologies and concepts, as well as assess mission level performance of integrated aerospace systems. Continue analyses of manned-unmanned teams in adversarial mission environments. Continue trade studies of vehicle concepts for strike, mobility and reconnaissance. Continue manned-unmanned teaming evaluations including rapid development of new capabilities. Initiate analyses of capability concepts for future advanced development programs. ***FY 2020 to FY 2021 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 622406 / *Aerospace Power & Flight Control Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by $5.647 million. Funding increased due to realignment of Flight Controls Technologies Modeling and Simulation research from Project 622403, Flight Controls & Pilot-Vehicle Interface, Flight Controls Technologies Modeling and Simulation Technologies effort and civilian pay repricing adjustments.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	72.653

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force			Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 623066 / *Turbine Engine Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
623066: *Turbine Engine Technology*	-	0.000	0.000	73.887	0.000	73.887	73.705	70.860	72.425	73.523	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops technology to increase turbine engine operational reliability, durability, mission flexibility, and performance, while reducing weight, fuel consumption, and cost of ownership. Analytical and experimental areas of emphasis are fans and compressors, high temperature combustors, turbines, internal flow systems, controls, augmentor and exhaust systems, integrated power and thermal management systems, engine inlet integration, mechanical systems, adaptive cycle technologies, and structural design. The project investigates advanced propulsion, power, and thermal management system for subsonic, supersonic, or hypersonic vision systems for the 2025-2035 timeframe to: Develop and demonstrate propulsion technologies for subsonic expendable and attritable air platforms; develop and validate targeted life component design, materials, and modeling tools for all engine classes; develop advanced turbine engine technologies to enable significantly increased range and dash speed; investigate durability, efficiency, and specific power with reduced cost of ownership for reusable engines; develop pervasive, hydrocarbon fueled pressure gain propulsion technologies that offer increased efficiency, reduced propulsion system volume/weight, and truly disruptive vehicle performance to the warfighter; evaluate lubricants, mechanical systems, and combustion concepts for advanced turbine engines, pressure gain propulsion, and combined cycle engines; analysis for an adaptive cycle engine architecture that provides both optimized performance and fuel efficiency for widely varying mission needs.

This project supports joint Department of Defense, agency, and industry efforts to focus turbine propulsion technology on national needs. The project plan is relevant across capability areas for global responsive air superiority, strike, tactical and global mobility, responsive space lift, and persistent intelligence, surveillance, and reconnaissance (ISR).

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology. In addition, the entirety of PE 0602203F, Aerospace Propulsion, Project 623048, Combustion & Mechanical Systems is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 623066, Turbine Engine Technology. These transfers support internal Technology Directorate operations and realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept, and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Turbofan/Turbojet Engine Technologies	0.000	0.000	30.795
Description: Develop core turbofan/turbojet engine components (i.e., fans, nozzles, compressors, combustors, and turbines and mechanical systems) for fighters, bombers, sustained supersonic/hypersonic cruise vehicles, and transports.			
FY 2020 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Core Technologies and Bearing Technologies efforts. ***FY 2021 Plans:*** Complete development and validation of modeling and simulation tools for the design and analysis of advanced turbine components with improved durability for advanced engines including: planning for a conceptual design, fabrication, and testing of component technology rigs, including bearing testing; exploring new approaches for advanced engine technologies, including use of high-temperature materials, integrated propulsion, power and thermal technologies and responsive controls; finalizing the concepts for achieving the product goals for increased fuel efficiency, power and thermal management and propulsive capability. Continue development of improved aerodynamic design tools and analysis methods to extend engine operability and efficiency. Continue developing physics-based bearing life model based on bearing alloy fatigue & microstructural investigations, including bearing life factors for advanced bearing materials. Continue incorporating fatigue life, fault evolution, and parametric heat generation of advanced material systems into the models. Continue development of oil-free bearing technology for Unmanned Air Systems. Complete development of active thrust-balance/prognostic health management system for large man-rated and medium-scale propulsion. Initiate the development and demonstration of propulsion technologies for subsonic expendable and attritable air platforms, small and medium scale propulsion technologies, and evaluate lubricants, mechanical systems, bearing technology and combustion concepts for advanced turbine engines. Initiate the development of fundamental knowledge of bearing material rolling contact fatigue failure mechanisms and lubricant interactions through microstructural investigations and failure analysis. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $30.795 million. Funding increased due to realignment of Turbofan/Turbojet Engine Core research from PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Core Technologies effort, Bearing Technologies effort, and civilian pay repricing adjustments.			
Title: Turboshaft/Turboprop and Small Turbofan Engine Technologies	0.000	0.000	11.621
Description: Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623066. Three efforts from PE 0602203F, Aerospace Propulsion are combined into a single effort in PE 0602201F, Aerospace Vehicle Technologies; Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies; Turbine Engine Technology, Missile and Remotely Piloted Aircraft Engine Technologies; and Turbine Engine Technology, Combustion Technologies efforts. ***FY 2021 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Continue to demonstrate advanced component designs in rig testing. Continue to utilize validation data to develop improved test protocol for small engine augmentor designs. Continue development and validation of modeling and simulation tools for the design and analysis of turbine components with mission-tailored aero-performance and highly efficient cooling geometries. Complete the development and validation of parameter, process, and performance modeling for components manufactured through additive technologies. Complete the development and validation of rules and tools to enable flexible design for targeted life applications. Continue the new innovative architectures, critical technologies, exploration of targeted life applications for small missile and remotely piloted aircraft applications; evaluate critical technologies that will increase range, performance, durability, electrical power and thermal capacity of these systems. Continue the exploration of new small engine technologies that can operate in high speed applications; Evaluate risk reduction technologies to increase usage time of systems. Complete development of computations, modeling and simulation, and research experimentation of advanced combustion concepts including pressure gain combustion components. Continue demonstrating advanced component designs and modeling tools in rig and engine testing. Continue to utilize validation data to develop improved test protocol for small engine designs. Continue development and validation of modeling and simulation tools for the design and analysis of engine components with new manufacturing processes. Continue the exploration of advanced integrated engine controls with potential for synergistic airframe system level benefits. Continue exploration of new small and medium size engine technologies for increased fuel efficiency, propulsive capability, power and thermal management, and reduced life cycle cost. Continue identification of new architectures and critical technologies for integrated power and thermal systems. Continue identification of requirements and develop models for simulation of highly integrated systems. Continue exploring interactions and effects of compressor and turbine components on the combustor and combustor materials to reduce engine weight and increase efficiency. Continue using advanced diagnostics tools to develop high-quality datasets for use by academia and industry for model development and verification. Continue the determination of necessary reference performance and operability combustion systems and metrics to decrease the cost of certifying new and alternative fuels in weapon systems. Continue to support development of advanced computational fluid dynamics (CFD) models to reduce combustor and augmentor design costs. Continue development of computations, modeling and simulation, and research experimentation of advanced combustion concepts including pressure gain combustion components and system level architectures. Continue to explore advanced combustion and flameholding concepts working towards improved understanding at relevant operating conditions such as sub-atmospheric (less than 1 atmosphere) and high pressure (greater than 10 atmospheres); this includes initiating fundamental combustion modeling and fluid-dynamic phenomena on high speed systems and rocket propulsion and advanced turbine engine applications, identifying modeling and simulation concepts/approaches to address combustion chemistry and physics and light/matter interactions, for high speed systems exploring turbulent combustion modeling in advanced configurations, exploring advanced combustion including pressure gain propulsion as it relates to new applications and architectures. Initiate the development and demonstration of new tools and use of new designs and materials to improve efficiency, power under quiet operations. Initiate investigation to identify and assess disruptive propulsion/power			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
concepts and evaluate concepts. Initiate development of new technologies for unmanned aircraft system propulsion/power systems for improved understanding at relevant operating conditions. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $11.621 million. Funding increased due to realignment of Turboshaft/Turboprop and Small Turbofan Engine research from PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turboshaft/Turboprop and Small Turbofan Engine Technologies effort, Missile and Remotely Piloted Aircraft Engine Technologies effort, Combustion Technologies and civilian pay repricing adjustments.			
Title: Diagnostic Technologies ***Description:*** Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary propulsion technologies. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623048, Combustion and Mechanical Systems, Diagnostic Technologies effort. ***FY 2021 Plans:*** Complete the development and demonstration of diagnostic systems for high-bandwidth kilohertz to megahertz measurement of combustion chemistry and physics. Complete the development of diagnostic techniques to include 1) time-division-multiplexed hyperspectral absorption spectroscopy, 2) pulse-burst lasers, and 3) ultrashort-pulse (picosecond, femtosecond) lasers. Complete the application of the insights gained to engine test cells and fielded systems including development and deployment of fiber-coupled sensor systems based on hyperspectral absorption spectroscopy. Continue supporting computational fluid dynamics combustion modeling by providing, insights for interpreting experimental results using existing Modeling & Simulation methodologies and applying recently developed high-speed, spatially resolved laser diagnostics to our representative, single-element combustion experiments in order to demonstrate and deliver measurements of key combustion species and flow properties under high pressure conditions. Continue development of diagnostic tools/methods for robust measurement capability in engine test cells and full annular ground test environments including; reacting and non-reacting spray experiments for liquid fuel spray model development, employing Nonintrusive optical diagnostics will be used to obtain accurate, spatially/temporally resolved data. This provides the local flow field data required for comparisons to results of numerical simulations. Complete the development of portable measurement capability for engine testing. Complete the advancement of algorithms for tomographic reconstruction and spatiotemporal nonlinear data analysis to assess the rich data sets generated in the fundamental experiments and system testing described above. Initiate the development of improved numerical methods and turbulent combustion models to guide design and development of experimental components and systems utilizing existing Modeling & Simulation methodologies. ***FY 2020 to FY 2021 Increase/Decrease Statement:***	0.000	0.000	0.918

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by $0.918 million. Funding increased due to realignment of Diagnostics research from PE 0602203F, Aerospace Propulsion, Project 623048, Combustion and Mechanical, Diagnostic Technologies effort; and civilian pay repricing adjustments.			
Title: Revolutionary Propulsion Technology ***Description:*** Develop, test, and evaluate revolutionary propulsion concepts for gas turbine, pressure gain propulsion, and combined cycle engines for missiles, manned and unmanned systems. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies effort. ***FY 2021 Plans:*** Complete development of modeling and simulation tools, for advanced turbine engine concepts. Complete advanced modeling and simulation tools for the design and analysis of advanced propulsion technologies to enable lower cost/weight systems with improved aero-performance for increased range and endurance at altitude. Complete analysis of advanced propulsion engines, such as rotating detonation engines and advanced high-speed concepts. Continue identification of control technology elements applicable to integrated propulsion/power/thermal solutions. Continue evaluation of power and thermal modeling of advanced architectures into aircraft system level multidisciplinary analysis and optimization tools: explore new control methods for integrated propulsion, power and thermal management; continue evaluation of integration of advanced augmentors and ramburners; continue exploration of new expendable and attritable architectures. Initiate the development and evaluation of advanced, integrated propulsion technologies for supersonic expendable, attritable, and reusable strike & ISR systems. Initiate studies for exploration of advanced propulsion technologies. Explore and evaluate innovative architectures for affordable & efficient air-launched propulsion capability from Mach 3 to Mach 5+, and turbine based combined cycle propulsion capability to Mach 5+. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $15.375 million. Funding increased due to realignment of Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies research from PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies effort; and civilian pay repricing adjustments.	0.000	0.000	15.375
Title: Missile and Unmanned Aerial System (UAS) Engine Technologies ***Description:*** Develop limited life engine components for missile and Unmanned Aerial System (UAS) applications, including long-range subsonic, supersonic and hypersonic vehicles.	0.000	0.000	12.000

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Turbofan/Turbojet Engine Fan, Low Pressure Turbine, and Integration Technologies effort. ***FY 2021 Plans:*** Complete development of modeling and simulation tools for advanced missile and unmanned aerial system concepts. Complete advanced modeling and simulation tools for the design and analysis of new systems to enable lower cost/weight systems with improved aero-performance for increased range and endurance at altitude. Continue identification of control technology elements applicable to integrated propulsion/power/thermal solutions. Continue evaluation of power and thermal modeling of advanced architectures into aircraft system level multidisciplinary analysis and optimization tools: explore new control methods for integrated propulsion, power and thermal management; continue evaluation of integration of advanced augmentors and ramburners; continue exploration of new expendable and attritable architectures. Initiate the development and evaluation of advanced, integrated propulsion technologies for supersonic expendable, attritable, and reusable strike & ISR systems. Explore new engine concepts for missile and unmanned systems. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $15.375 million. Funding increased due to realignment of Missile and Unmanned Aerial System(UAS) Engine Technologies research from PE 0602203F, Aerospace Propulsion, Project 623066, Turbine Engine Technology, Missile and Unmanned Aerial System Engine Technologies effort; and civilian pay repricing adjustments.			
Title: Lubricant Technologies ***Description:*** Develop, test, and qualify advanced turbine engine lubricants. Generate and maintain military specifications for aviation engine lubricants. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 623048, Combustion and Mechanical Systems, Lubricant Technologies effort. ***FY 2021 Plans:*** Continue developing innovative fluids by; defining target requirements for new polyol ester oils, conducts Research & Development for new/enhanced turbine engine oils for legacy & emerging engines, qualifies new & updated engine oil products for legacy & emerging engines. Complete identification and development on in-line mechanical system health monitoring sensor technology. Continue the development of lubricant modeling through characterization of heat generation, lubrication system cooling effectiveness, failure progression of bearing materials under relevant engine conditions, and overall system performance of advanced bearing concepts for model validation. Continue supporting the warfighter on field-related mechanical system issues.	0.000	0.000	3.178

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 623066 / *Turbine Engine Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Initiate performance validation study of advanced bearing designs/materials, lubricant & lubrication system components via full-scale high-fidelity laboratory parametric testing at representative engine operating conditions. Initiate the generation of the fatigue life database & assess fatigue growth characteristics of state of the art baseline, emerging, & advanced engine rolling element bearing materials thru sub-scale experimental investigations. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $3.178 million. Funding increased due to realignment of Lubricant research from PE 0602203F, Aerospace Propulsion, Project 623048, Combustion and Mechanical, Lubricant Technologies effort; and civilian pay repricing adjustments.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	73.887

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force			Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 624847 / *Rocket Propulsion Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
624847: *Rocket Propulsion Technology*	-	0.000	0.000	62.855	0.000	62.855	63.217	60.717	62.075	63.025	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops rocket propulsion technologies for space access, space maneuver, the sustainment of strategic systems (including solid boost/missile propulsion, post boost control, aging and surveillance efforts), and tactical missiles. Analytical and experimental areas of emphasis are propellants, propellant management, combustion, rocket material applications, technology for sustainment of strategic systems, and innovative space propulsion concepts. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of these systems. Develop technologies to reduce the weight and cost of components using new materials and improved designs and manufacturing techniques. All efforts in this project contribute to the sustainment of the rocket propulsion industry, providing rocket propulsion technology for the entire Department of Defense (DoD). Technologies under this project enable capabilities of interest to both DoD and National Aeronautics and Space Administration (NASA). Tasks include: modeling and simulation; proof of concept tests of critical components; advanced component development; and ground-based tests. Aging and surveillance tasks could reduce lifetime prediction uncertainties for individual motors by 50%, enabling motor replacement for cause. All thrusts are part of the Rocket Propulsion 21 (RP21) collaboration and are reviewed by a DoD level steering committee yearly for relevance to DoD missions and progress towards RP21 Goals.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 624847 , Rocket Propulsion Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 624847, Rocket Propulsion Technology, in order to realign technology areas that better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Fuel Technologies	0.000	0.000	12.669
Description: Develop, characterize, and test advanced hydrocarbons, energetics, solid propellants, and monopropellants to increase space launch payload capability and refine new synthesis methods.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Fuel Technologies effort.			
FY 2021 Plans: Continue to develop solid rocket propellant binder systems for use across operationally relevant conditions. Continue to devise, synthesize, scale-up, and characterize novel energetic ingredients for monopropellants, fuels, and oxidizers, for use across the span of space and missile applications including tactical, strategic, and in-space thrust and attitude control. Continue knowledge transfer for making green monopropellants to United States industrial base. Continue to formulate, scale-up, and evaluate			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
formulations of solid and liquid rocket propellants. Continue to identify, evaluate, and adapt 21st century material processing techniques and equipment to enable more rapid and agile development for more precise products. Continue research in high-temperature resins, insulators, and composite case fabrication techniques to enable high performance rocket motor cases. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $12.669 million. Funding increased due to realignment of Fuel Technology research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Fuel Technologies effort, and civilian pay repricing adjustments.			
Title: Liquid Engine Combustion Technologies ***Description:*** Develop advanced liquid engine combustion technology for improved performance, while preserving chamber lifetime and reliability needs for engine uses in heavy lift space vehicles. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Liquid Engine Combustion Technologies effort. ***FY 2021 Plans:*** Continue evaluation of methane multi-injector designs in hot-fire conditions. Continue hot fire tests in combustion stability rig. Continue combustion stability modeling critical for future hydrocarbon fueled liquid rocket engines. Complete the delivery of combustion stability codes with nearly complete set of validation data to rocket community, enabling more robust and stable engine designs. Continue developing understanding of hydrocarbon fuel production, expanding testing into methane fuels and other cryogenic cooling. Continue the employment of new fuel and material operating limitations, manufacturing processes, and launch goals in cycle analysis to identify trade space for future engines. Continue to develop and evaluate advanced material solutions for high temperature components in rocket propulsion. Continue installation of new test facility that will fill the current capability gap and allow for fast, low-cost testing of multi-injector designs and stability strategies at conditions relevant to the demands of both Department of Defense and industry for next-generation engines (including use of liquid oxygen and higher pressures and thrust). Continue development and payoff determination of rotating detonation rocket engine technologies. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $11.282 million. Funding increased due to realignment of Liquid Engine Combustion research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Liquid Engine Combustion Technologies effort, and civilian pay repricing adjustments.	0.000	0.000	11.282
Title: Advanced Liquid Engine Technologies	0.000	0.000	4.994

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Description: Develop advanced liquid engine technologies for improved performance, while increasing life and reliability needs for engine uses in expendable and reusable launch vehicles. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Advanced Liquid Engine Technologies effort. ***FY 2021 Plans:*** Complete exploring engine concepts for next generation, beyond 2035, launch vehicles and concepts to effect cost reductions. Continue sub-scale risk mitigation and technology maturation activities to incorporate into next generation engine concepts. Continue modular component integration and interaction research activities supporting next generation engine concepts. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $4.994 million. Funding increased due to realignment of Advanced Liquid Engine research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Advanced Liquid Engine Technologies effort, and civilian pay repricing adjustments.			
Title: On-Orbit Propulsion Technologies ***Description:*** Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for station-keeping, repositioning, and orbit transfer for satellites and satellite constellations. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, On-Orbit Propulsion Technologies effort. ***FY 2021 Plans:*** Continue advanced chemical propellants scale-up research focusing on transition of numerical tools and experimental methodologies for advanced monopropellants to spacecraft industry. Continue to support the maturation of advanced diagnostics for both chemical and electric propulsion thruster plumes with potential for integrated state-of-health application. Continue to expand the validation and verification programs (both experimental and flight) to quantify accuracy of modeling and simulation tools developed to support thruster-spacecraft integration. Continue transition and support of thruster/ plume modeling framework to spacecraft industry, with addition of advanced Electric Propulsion thruster models, to industry partners. Expanding exploration of advanced integrated electric propulsion and chemical thruster concepts and assess new spacecraft propulsion requirements. ***FY 2020 to FY 2021 Increase/Decrease Statement:***	0.000	0.000	7.696

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 increased compared to FY 2020 by $7.696 million. Funding increased due to realignment of On-orbit propulsion research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, On-orbit Propulsion Technologies effort, and civilian pay repricing adjustments.			
Title: Ballistic and Tactical Propulsion Technologies ***Description:*** Develop missile propulsion technologies and aging & surveillance technologies for ballistic and tactical missiles. ***FY 2020 Plans:*** For Fiscal Year 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Space Access and Strike Applications and Ballistic Missile Technologies efforts. ***FY 2021 Plans:*** Continue to apply next generation of chemical and mechanical aging mechanism modeling, simulation, and analysis tools, sensor schemes and tools, to user needs and unique challenges. Continue development of advanced sensor, non-destructive evaluation, modeling and supporting technology development efforts to detect and explain phenomena further improve data acquisition and reduce uncertainty in tactical, hypersonic, and ballistic missile solid rocket motor service life predictions. Continue long-term validation of tools through long-term aging and testing of sub-scale motors. Continue to develop advanced tactical propulsion and concepts. Continue propellant development efforts including long-life and other novel propellant systems. Continue development, evaluation, verification, and validation of next generation of updated, physics-based modeling, simulation, and analysis tools for rapid and agile missile propulsion design, analysis, and production to include designs for 21st century material processing techniques and equipment. Continue to develop advanced component technologies for missile propulsion applications for strategic and strike systems helping to ensure their long-term sustainment. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $26.214 million. Funding increased due to realignment of Space Access and Strike Applications and Ballistic Missile Technologies research from PE 0602203F, Aerospace Propulsion, Project 624847, Rocket Propulsion Technology, Space Access and Strike Applications and Ballistic Missile technologies effort, and civilian pay repricing adjustments.	0.000	0.000	26.214
Accomplishments/Planned Programs Subtotals	0.000	0.000	62.855

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 624847 / *Rocket Propulsion Technology*

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force			Date: February 2020
Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602201F / *Aerospace Vehicle Technologies*	Project (Number/Name) 625330 / *Aerospace Fuel Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
625330: *Aerospace Fuel Technology*	-	0.000	0.000	7.552	0.000	7.552	7.644	7.496	7.658	7.786	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project evaluates hydrocarbon-based fuels for legacy and advanced turbine engines, scramjets, pressure gain propulsion and combined cycle engines. This project also considers fuel related concepts that can increase turbine engine operational reliability, durability, mission flexibility, energy efficiency, and performance while reducing weight, fuel consumption, and cost of ownership. Applications include missiles, aircraft, sustained high-speed vehicles, and responsive space launch. Analytical and experimental areas of emphasis include evaluations of fuel properties and characteristics of alternative fuels developed from unconventional sources (such as coal, natural gas, biomass, and combinations thereof), unique/alternate fuels and components used in integrated thermal and energy management systems including high heat sink fuel capability, fuels logistics and associated vulnerabilities, and combustion diagnostics and engine emissions measurements.

In FY 2021, the entirety of PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology. In addition, the entirety of Project 632480, Aerospace Fuels in PE 0603216F, Propulsion & Power Technology, is transferred to PE 0602201F, Aerospace Vehicle Technologies, Project 625330, Aerospace Fuel Technology. These transfers realign and consolidation Aerospace Fuel research and realign technology areas to better support the National Defense Strategy, Air Force Future Operating Concept and Air Force Science and Technology Strategy, April 2019. This is an administrative realignment for consolidation, and not a new start.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Integrated Thermal and Energy Management	0.000	0.000	1.606
Description: Develop and demonstrate advanced components and conduct performance assessments of advanced aircraft integrated thermal and energy management systems for engines and aircraft.			
FY 2020 Plans: For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Integrated Thermal and Energy Management effort.			
FY 2021 Plans: Continue the evaluation of advanced additives, catalysts, and fuel composition approaches to minimize endothermic fuel coking for hypersonic applications; Evaluate the impact of additively-manufactured parts and selected proposed industry "hot fuel" conditions by FY 2024. Continue model development for integrated thermal and energy management to include designs and evaluation of vehicle fuel systems, prototype sensors to monitor the fuel chemistry that produces coke deposits and characterization of system-level impacts from thermally-stressed fuel. These products will enable the hypersonics community to develop next generation systems that require hot fuels for thermal management. Initiate the development of fuel models			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 625330 / *Aerospace Fuel Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
for system design and evaluation. Initiate the development of online sensors for monitoring chemistry that causes deposits. Characterize system-level impacts of emerging aviation technologies. Initiate new and continue existing studies using fuel as a thermal management fluid to meet AF requirements, including impact on combustor performance and emissions. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $1.606 million. Funding increased due to realignment of Integrated Thermal and Energy Management research from PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Integrated Thermal and Energy Management effort, and civilian pay repricing adjustments.			
Title: Advanced Fuels ***Description:*** Develop endothermic hydrocarbon fuels and catalysts for hypersonic applications. Evaluate heat sink of endothermic fuels under relevant conditions. Evaluate stability and performance of high-energy-density fuels. Develop nano-energetic approaches to high-altitude ignition and fuel energy density improvement. ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 625330. Three efforts from PE 0602203F, Aerospace Propulsion, are combined into a single effort in PE 0602203F Aerospace Fuel Technology. The three efforts are: Combustion Emissions and Performance; Fuel-Related Thermal Management; Aerospace Fuel Technology, Gas Turbine Combustion, Emissions, and Performance; and Alternative Jet Fuels efforts. ***FY 2021 Plans:*** Continue aviation fuels combustion tests to identify fuel composition performance impacts. Continue investigation of fuel heat sink approaches for thermal management of advanced engines, and other systems evaluating integrated power and thermal management approaches. Continue investigation of heat exchangers including additive manufactured units and its reaction to fuels. Continue developing integrated test rigs to tests these approaches and assess efficiency of these approaches. Continue evaluating advanced high-mach fuel concepts. Evaluate fuel reaction models that enable high temperature systems for evaluating endothermic fuels. 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, including the development and utilization of the analytical methods and knowledge discovery tools necessary to understand fundamental fuel composition and its impact across the operational domain to ensure readiness across the operational domain for the AF. Complete alternative fuel specification for commercial jet fuels with Federal Aviation Agency. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $3.452 million. Funding increased due to realignment of Advanced Fuels research from PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Combustion Emissions and	0.000	0.000	3.452

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 625330 / *Aerospace Fuel Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Performance effort, Fuel-Related Thermal Management effort, Gas Turbine Combustion, Emissions, and Performance effort, Alternative Jet Fuels effort and civilian pay repricing adjustments.			
Title: Fuel Logistics & Sustainment ***Description:*** Study and evaluate low-cost approaches to reduce fuel logistics footprint to reduce cost. Study fuel logistics vulnerabilities and develop detection and mitigation technologies. Identify, develop, and demonstrate low-cost approaches to reducing the fuel logistics footprint for the Air Force ***FY 2020 Plans:*** For FY 2020 and prior years, this work is performed under PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Fuel Logistics effort and PE 0603216F, Aerospace Propulsion & Power Technology, Project 632480, Aerospace Fuels, Fuel Logistics effort. ***FY 2021 Plans:*** Continue supporting fuel sustainment issues as needed, to understand problems and work to find solutions. Continue determining fuel temperature limits and other fuel technology approaches (additives, deoxygenation) for full-life fuel systems for advanced applications. Identify new approaches to be able to capture fuel stability limiters to minimize logistics vulnerabilities, work on bio-detection and mitigation to support logistics readiness, coordinate and collaborate with Army and Navy in identification and development of fuel sensing technologies. Continue the development of fuel composition in-situ sensors to ensure thermal stability throughout platform mission. Continue the development of fuel sensors and mitigation products to detect and mitigate fuel bio-contamination. Continue development of compositional analysis that can be verified across services and leverages a database of specification and extended compositional information to advance data visualization and analytics. Continue to analyze to develop fuels, fuel blends and catalyst formulations that provide endothermic cooling capacity for hypersonic applications. Initiate and expand study of fuel models for next generation vehicles. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $2.494 million. Funding increased due to realignment of Fuel Logistics research from PE 0602203F, Aerospace Propulsion, Project 625330, Aerospace Fuel Technology, Fuel Logistics effort, and PE 0603216F, Aerospace Propulsion & Power Technology, Project 632480, Aerospace Fuels, Fuel Logistics effort, and civilian pay repricing adjustments.	0.000	0.000	2.494
Accomplishments/Planned Programs Subtotals	0.000	0.000	7.552

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Air Force		Date: February 2020
Appropriation/Budget Activity 3600 / 2	**R-1 Program Element (Number/Name)** PE 0602201F / *Aerospace Vehicle Technologies*	**Project (Number/Name)** 625330 / *Aerospace Fuel Technology*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A