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 0602605F / *Directed Energy 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**
Total Program Element	-	129.579	124.379	128.113	0.000	128.113	129.514	124.873	127.831	130.111	Continuing	Continuing
624866: *Lasers & Imaging Technology*	-	98.961	92.359	96.826	0.000	96.826	93.172	88.826	90.934	91.547	Continuing	Continuing
624867: *Advanced Weapons & Survivability Technology*	-	30.618	32.020	31.287	0.000	31.287	36.342	36.047	36.897	38.564	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program covers research in Directed Energy (DE) technologies, primarily High Energy Lasers (HEL); including devices, subcomponents, and novel materials; optical beam control; laser system integration; target laser lethality/vulnerability assessments; ground-based optical Space Situational Awareness (SSA); and high power microwaves (HPM). Laser research includes moderate to high power laser devices that are applicable to a wide range of applications, optical technologies to propagate laser beams through the atmosphere, and integration of these technologies into demonstration packages. Space Situational Awareness research uses the Starfire Optical Range (SOR) and the Maui Space Surveillance System (MSSS) to develop and implement technologies to identify visual characteristics such as status and health of orbiting space objects. In high power microwaves this research examines technologies for applications such as counter-electronics and non-lethal weapons. This program conducts research into other novel Directed Energy applications; conducts Directed Energy vulnerability/lethality assessments; develops protection technologies versus Directed Energy; conducts research into other advanced non-conventional/innovative weapons; develops and uses tools to compare solutions to determine the most effective and efficient Directed Energy technologies to meet Air Force needs; coordinates efforts through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

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

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 0602605F / *Directed Energy Technology*		
B. Program Change Summary ($ in Millions)	**FY 2019**	**FY 2020**	**FY 2021 Base**	**FY 2021 OCO**	**FY 2021 Total**
Previous President's Budget	141.800	124.379	124.693	0.000	124.693
Current President's Budget	129.579	124.379	128.113	0.000	128.113
Total Adjustments	-12.221	0.000	3.420	0.000	3.420
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-2.648	0.000			
• Other Adjustments	-9.573	0.000	3.420	0.000	3.420

Change Summary Explanation

Decrease in FY 2019 in Other Adjustments of $9.573 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 $3.420 million is due to civilian pay reprice adjustments.

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 0602605F / *Directed Energy Technology*	Project (Number/Name) 624866 / *Lasers & Imaging 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
624866: *Lasers & Imaging Technology*	-	98.961	92.359	96.826	0.000	96.826	93.172	88.826	90.934	91.547	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project explores the technical feasibility of moderate to high power lasers, including beam control, for applications such as aircraft protection, force protection, and precision engagement from Air Force platforms. This project investigates the effects of laser weapons on a wide range of systems and components as well as producing, modifying, validating and applying Directed Energy and non-Directed Energy concept development and assessment tools to determine which technology solutions to pursue. Additionally, this project conducts research supporting ground-based optical space situational awareness.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: High Energy Laser Technologies and Directed Energy Assessments	75.499	65.641	70.117

Description: Develop and demonstrate High Energy Laser device technologies for Air Force applications. Develop and demonstrate laser beam control technologies including atmospheric propagation and pointing and tracking. Perform laser system level modeling and simulation validated by laser effects and vulnerability testing. Develop tools and perform assessments which allow comparisons among concepts and tradeoffs between Directed Energy and non-Directed Energy solutions. Integrate optical beam control technologies with laser device technologies and demonstrate the combined technologies. Develop and use modeling, testing and diagnostic technologies to better understand the vulnerability of adversary weapon systems to High Energy Lasers.

FY 2020 Plans:

Continue to develop beam control technologies including aero-effects mitigation techniques based on supersonic data from laboratory and flight tests. Continue to power scale monolithic fiber amplifiers using advanced fibers. Continue with effects testing to establish system requirements and validate models. Complete integration of beam control subsystems into pod for FY 2020 pod-mounted low power ground and airborne laser demonstration. Begin ground demonstration of Phase I low power laser podded system. Complete development of moderate power system into a pod for Phase 2 moderate power aircraft self-protect demonstration vs representative targets in FY 2021. Complete prototype module for fully packaged ultra-compact fiber amplifier laser. Continue to transition the functionality of the Integrated Weapons Environment for Analysis engagement level model into the Advanced Framework for Simulation model for engagement and mission level analysis for internal and external users and utilize the Advanced Framework for Simulation model as the weapons server in an advanced framework to support Air Force-wide modeling, simulation, and analysis. Continue to assess directed energy weapon and/or synergistic directed energy weapon/kinetic energy weapon capabilities to help users plan weapon investments. Continue to model and characterize foreign high energy laser threats, and provide information to develop mitigation techniques to protect blue assets.

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 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624866 / *Lasers & Imaging Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Continue to develop beam control technologies including aero-effects mitigation techniques based on transonic and supersonic data from laboratory and flight tests. Continue to power scale monolithic fiber amplifiers using advanced fibers. Continue with laser effects testing to establish system requirements and validate models. Complete System Requirements Review/Concept Design Review (SRR/CoDR) for 150 kW compact laser system. Continue to transition the functionality of the Integrated Weapons Environment for Analysis engagement level model into the Advanced Framework for Simulation model for engagement and mission level analysis for internal and external users. Transition the models to the Department of Defense and Industry Modeling, Simulation and Analysis community. Utilize the Advanced Framework for Simulation model as the weapons server in an advanced framework to support Air Force-wide modeling, simulation, and analysis. Continue to assess directed energy weapon and/or synergistic directed energy weapon/kinetic energy weapon capabilities to help users plan weapon investments. Continue to model and characterize foreign high energy laser threats, and provide information to develop mitigation techniques to protect blue assets. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $4.476 million. Funding increased due to additional emphasis on the development of the 150 kW compact laser system and civilian pay reprice adjustment.			
Title: Optical Space Situational Awareness and Satellite Vulnerability	23.462	26.718	26.709
Description: Develop advanced, long-range, electro-optical technologies that enable ground-based optical Space Situational Awareness (SSA) and quantum-based optical communications. Develop and use technologies to understand the vulnerability of blue satellite systems and components to lasers. Operate the Starfire Optical Range (SOR) to conduct research meeting internal and customer requirements. ***FY 2020 Plans:*** Continue fielding the dynamic telescope subsystem that searches the geosynchronous satellite belt visible from the mid-Pacific multiple-times per night, enabling a periodic comprehensive census of dim objects in the geobelt. Continue to mature daylight detection of geosynchronous satellites thus allowing custody through daytime hours when satellites cannot normally be detected by our ground-based optical systems. Continue to mature component technologies for 24/7 real-time optical imaging of near-earth and geosynchronous objects enabling characterization on tactical timelines. Continue investigation through modeling and simulation the susceptibility of satellite components to laser threats to inform practical designs for protection equipment and for tactically rapid course-of-action decision-making enabling protection methods. Continue development of laser-enabled space situational awareness (SSA) research focused on full-dark imaging using laser illumination. Investigate laser-enabled options for both ranging to and imaging of geosynchronous satellites from apertures smaller than 3 meters. Continue development of long-range secure optical communications technologies leveraging quantum science for free space lasercom channels. Continue project to apply machine-learning to automatically identify geosynchronous-orbit objects more accurately and rapidly than current "hard-wired" algorithms can. Continue to maintain Starfire Optical Range (SOR) facility and experimental equipment in a mission-ready state.			

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 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624866 / *Lasers & Imaging Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
In FY 2020, the work under the Optical Space Situational Awareness and the Satellite Vulnerability effort in PE 06036505F, Project 633151, High Power Solid State Laser Technology transferred to this effort to consolidate Optical Space Situational Awareness and Satellite Vulnerability research efforts. ***FY 2021 Plans:*** Continue fielding the dynamic telescope subsystem that searches the geosynchronous satellite belt visible from the mid-Pacific multiple-times per night, enabling a periodic comprehensive census of dim objects in the geobelt. Continue to mature daylight detection of geosynchronous satellites thus allowing custody through daytime hours when satellites cannot normally be detected by our ground-based optical systems. Continue to mature component technologies for 24/7 real-time optical imaging of near-earth and geosynchronous objects enabling characterization on tactical timelines. Continue investigation through modeling and simulation the susceptibility of satellite components to laser threats to inform practical designs for protection equipment and for tactically rapid course-of-action decision-making enabling protection methods. Continue development of laser-enabled space situational awareness (SSA) research focused on full-dark imaging using laser illumination. Investigate laser-enabled options for both ranging to and imaging of geosynchronous satellites from apertures smaller than 3 meters. Continue development of long-range secure optical communications technologies leveraging quantum science for free space lasercom channels. Continue project to apply machine-learning to automatically identify geosynchronous-orbit objects more accurately and rapidly than current "hard-wired" algorithms can. Continue to maintain the Starfire Optical Range (SOR) and Maui Space Surveillance Site (MSSS) facilities and experimental equipment in a mission-ready state. Continue research on laser-ranging to objects in geosynchronous orbit using active sensing techniques. Starting in FY 2021, work in Program Element 0603605F, Project 633151, High Power Solid State Laser Technology, Optical Space Situational Awareness and Satellite Vulnerability efforts will be performed under in Program Element 0602605F, Directed Energy Technology, Project 624866, Lasers & Imaging Technology, Optical Space Situational Awareness and Satellite Vulnerability effort to consolidate Optical Space Situational Awareness and Satellite Vulnerability research efforts. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 decreased compared to FY 2020 by $0.009 million. Justification for the decrease is described in the plans above.			
Accomplishments/Planned Programs Subtotals	98.961	92.359	96.826

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 0602605F / *Directed Energy Technology*	Project (Number/Name) 624867 / *Advanced Weapons & Survivability 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
624867: *Advanced Weapons & Survivability Technology*	-	30.618	32.020	31.287	0.000	31.287	36.342	36.047	36.897	38.564	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project explores the use of High Power Microwave and other unconventional/innovative weapon concepts to support applications such as nonlethal counter-personnel and electronic warfare including disruption, degradation, and damage of electronic infrastructure on Air Force platforms. This research includes weapon technology that can provide covert effects and/or no collateral or human damage. The project also investigates the effects of potential adversary High Power Microwave weapons and how to mitigate those effects on US assets, as well as producing and applying Directed Energy and non-Directed Energy concept development and assessment tools to determine which technology solutions to pursue. This project includes but is not limited to high power microwaves, plasmas, particle beams and millimeter waves.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: High Power Microwave and Unconventional Weapon Technologies	11.176	9.316	7.555
Description: Investigate technologies for High Power Microwave and unconventional weapon components. Investigate High Power Microwave and other unconventional weapon concepts using innovative technologies. Investigate advanced technologies that support force protection tactical applications, including non-kinetic/non-lethal counter-electronics applications.			
FY 2020 Plans: Assess the military utility of an ultra-short pulsed laser system. Conduct effects testing on electronics based on the target classes for the joint high power microwave program with the Navy. Develop and test high power microwave components for ground and aerial high power microwave demonstrators. Develop and test smaller, higher power, source technology for the joint Air Force-Navy high power microwave demonstration.			
FY 2021 Plans: Define measures of effectiveness and performance of an ultra-short pulsed laser system. Continue effects testing on electronics based on the target classes for the joint high power microwave program with the Navy. Continue to develop and test high power microwave components for ground and aerial high power microwave demonstrators. Continue to develop and test smaller, higher power, source technology for the next generation Air Force high power microwave demonstration. Continue to support the modeling, simulation, and analysis (MS&A) tools that have been transitioned to the broader modeling, simulation, and analysis community.			
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 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624867 / *Advanced Weapons & Survivability Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
FY 2021 decreased compared to FY 2020 by $1.761 million. Funding decreased due to schedule rephasing of the Joint High Power Microwave program with the Navy based on higher Air Force priorities.			
Title: High Power Microwave Effects and Mitigation Research	19.442	22.704	23.732
Description: Assess the effects/lethality of High Power Microwave technologies. Develop and apply sophisticated models to enhance the development of High Power Microwave and related technology. Develop tools and perform assessments which allow comparisons among Directed Energy concepts and tradeoffs between Directed Energy and non-Directed Energy solutions. Investigate technologies to counter the effects of High Power Microwaves. ***FY 2020 Plans:*** Transition software applications that are hosted in the directed energy High Performance Computing Software Applications Institute for a broad spectrum directed energy sources. Conduct end-to-end modeling and weapon utility assessments to incorporate high power microwave weapon technology into various platforms for multiple target prosecutions. Conduct synergistic weapon concept assessments that merge kinetic energy and non-kinetic weapon investments. Continue to support the modeling, simulation, and analysis tools that have been transitioned to the broader modeling, simulation, and analysis community. ***FY 2021 Plans:*** Validate and update software applications that are hosted in the directed energy High Performance Computing Software Applications Institute for a broad spectrum directed energy sources. Develop a data base of high power sources. Assess military utility of high power microwave weapon technology that is integrated into various platforms for multiple target engagements using end-to-end modeling. Assess synergistic weapon concepts that merge kinetic energy and non-kinetic weapon capabilities into one weapon system. Validate and update the modeling, simulation, and analysis tools that have been transitioned to the broader modeling, simulation, and analysis community. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY 2021 increased compared to FY 2020 by $1.028 million. Funding increased due to development of a data base of high power sources and additional emphasis on modeling and simulation to ground future Air Force directed energy requirements for the warfighter.			
Accomplishments/Planned Programs Subtotals	30.618	32.020	31.287

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 0602605F / *Directed Energy Technology*	**Project (Number/Name)** 624867 / *Advanced Weapons & Survivability Technology*

D. Acquisition Strategy

Not Applicable