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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Air Force **Date:** April 2022

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>
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COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
Total Program Element	-	122.816	116.456	109.302	0.000	109.302	112.221	114.681	117.236	119.837	Continuing	Continuing
624866: <i>Lasers & Imaging Technology</i>	-	92.746	0.000	25.305	0.000	25.305	25.925	26.369	26.952	27.518	Continuing	Continuing
624867: <i>Advanced Weapons & Survivability Technology</i>	-	30.070	51.185	60.896	0.000	60.896	62.286	64.766	65.954	67.576	Continuing	Continuing
625173: <i>Laser Technology</i>	-	0.000	65.271	23.101	0.000	23.101	24.010	23.546	24.330	24.743	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; 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. High power microwaves 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.

Funds in this PE may be used to investigate specified technology advancements in air, space and/or cyber domains.

As directed in the FY 2018 NDAA, Sec 825, amendment to PL 114-92 FY 2016 NDAA, Sec 828 Penalty for Cost Overruns, the FY 2019 Air Force penalty total is \$50.0M. The calculated percentage reduction to each research, development, test and evaluation and procurement account will be allocated proportionally from all programs, projects, or activities under such account.

This program is in Budget Activity 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.

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B. Program Change Summary (\$ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	130.375	121.869	0.000	0.000	0.000
Current President's Budget	122.816	116.456	109.302	0.000	109.302
Total Adjustments	-7.559	-5.413	109.302	0.000	109.302
• 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	-5.413			
• Reprogrammings	-0.001	0.000			
• SBIR/STTR Transfer	-2.434	0.000			
• Other Adjustments	-5.124	0.000	109.302	0.000	109.302

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

Project: 624866: *Lasers & Imaging Technology*

Congressional Add: *DE Center of Excellence*

Congressional Add Subtotals for Project: 624866

Congressional Add Totals for all Projects

	FY 2021	FY 2022
	2.453	-
	2.453	-
	2.453	-

Change Summary Explanation

Decrease in FY 2021 reflects reprogramming 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).

Decrease in FY 2022 reflects Air Force's Request to transfer \$5.413M to Space Force RDT&E Line 1 for Civilian Pay.

The FY 2022 President's Budget submittal did not reflect FY 2023 through FY 2026 funding. Therefore, an explanation of the change between the two budget positions for FY2023 cannot be made in a relevant manner.

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Air Force										Date: April 2022		
Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>				Project (Number/Name) 624866 / <i>Lasers & Imaging Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
624866: <i>Lasers & Imaging Technology</i>	-	92.746	0.000	25.305	0.000	25.305	25.925	26.369	26.952	27.518	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 the Department of the 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.

In FY 2022, A portion of PE 0602605F, the optical space domain awareness and satellite vulnerability efforts of PE 0602605F, Directed Energy Technology, Project 624866, Lasers & Imaging Technology, was transferred to Appropriation 3620, Research, Development, Test & Evaluation, Space Force, PE 1206601SF, Space Technology, Project 624866, Lasers & Imaging Technology from Appropriation 3600, Budget Activity 2 due to the creation of a new Appropriation for Space Force. In addition the funds associated with High Energy Laser Technologies and Directed Energy Assessments were moved to PE 0602605F, Project 625173.

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

	FY 2021	FY 2022	FY 2023
Title: High Energy Laser Technologies and Directed Energy Assessments	63.652	0.000	25.305
Description: This effort 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 the Department of the 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.			
FY 2022 Plans: For FY 2022, this effort moved to BA2, Program 060205F, Directed Energy Technology, Project 625173, Laser Technology. Funds moved as a result of the creation of the Space Force.			
FY 2023 Plans: For FY 2023, this effort moved to BA2, Program 060205F, Directed Energy Technology, Project 625173, Laser Technology. Funds are supposed to be moved as a result of the creation of the Space Force.			
FY 2022 to FY 2023 Increase/Decrease Statement: FY22 increased from zero in FY22 to 25.305M in FY23 are intended to support Laser Technology (BPAC 625173). The combined value of BPACs 625173 and 624866 is a decrease from FY22 of \$16.865M which reflects the activities supporting the Space Force and the increased emphasis on High Power Microwave effectors.			
Title: Optical Space Situational Awareness and Satellite Vulnerability	26.641	0.000	0.000

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Appropriation/Budget Activity 3600 / 2	R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>	Project (Number/Name) 624866 / <i>Lasers & Imaging Technology</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
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<p>Description: Develop advanced, long-range, electro-optical technologies that enable ground-based optical Space Domain Awareness (SDA) 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.</p> <p>FY 2022 Plans: This research activity is transferring to United States Space Force Program Element C6601SF.</p> <p>Continue to mature daylight detection of satellites allowing custody through daytime hours when satellites cannot normally be detected by 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 research & development of laser-enabled space domain awareness (SDA) focused on full-dark imaging using laser illumination. Continue development of 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) facilities and experimental equipment in a mission-ready state.</p> <p>FY 2023 Plans: Non Applicable. BPAC moved to USSF PE 1206601SF</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Non Applicable. BPAC moved to USSF PE 1206601SF</p>			
Accomplishments/Planned Programs Subtotals	90.293	0.000	25.305

	FY 2021	FY 2022
Congressional Add: DE Center of Excellence	2.453	-
FY 2021 Accomplishments: Perform directed work under congressional add		
Congressional Adds Subtotals	2.453	-

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

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Appropriation/Budget Activity	R-1 Program Element (Number/Name)	Project (Number/Name)
3600 / 2	PE 0602605F / <i>Directed Energy Technology</i>	624866 / <i>Lasers & Imaging Technology</i>

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

Remarks

D. Acquisition Strategy

N/A

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Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>				Project (Number/Name) 624867 / <i>Advanced Weapons & Survivability Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
624867: <i>Advanced Weapons & Survivability Technology</i>	-	30.070	51.185	60.896	0.000	60.896	62.286	64.766	65.954	67.576	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 non-lethal counter personnel and electronic warfare including disruption, degradation, and damage of electronic infrastructure on the Department of the 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 2021	FY 2022	FY 2023
Title: High Power Microwave and Unconventional Weapon Technologies	12.237	19.641	23.522
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 2022 Plans: Develop system engineering plan to develop an ultra-short pulsed laser system. Initiate research and development to integrate High Power Microwave technology into an airborne platform for the next generation Air Force airborne High Power Microwave technology demonstration. 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 Department of the 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 2023 Plans: Conduct effects testing and propagation experiments to define the performance requirements to develop an ultra-short pulsed laser system. Continue to design and develop High Power Microwave technology that will be integrated into an airborne platform for the next generation Department of the Air Force airborne High Power Microwave technology demonstration. Continue to develop and test high power microwave components for ground and aerial high power microwave demonstrators.			

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2021	FY 2022	FY 2023
<p>4) Integrate smaller, higher power, source technology with all support components to enable the next generation Department of the Air Force high power microwave demonstration. Support the modeling, simulation, and analysis (MS&A) tools that have been transitioned to the broader modeling, simulation, and analysis community.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: FY 2023 increased by \$3.881M compared to FY 2022. Justification for this increase is described in the plans above.</p>				
<p>Title: High Power Microwave Effects</p> <p>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.</p> <p>FY 2022 Plans: Complete validation of software applications that are hosted in the directed energy High Performance Computing Software Applications Institute for a broad spectrum directed energy sources. Continue to populate data base of high power sources. Continue to assess military utility of high power microwave weapon technology that is integrated into various platforms for multiple target engagements using end-to-end modeling. Continue to assess synergistic weapon concepts that merge kinetic energy and non-kinetic weapon capabilities into one weapon system. Complete validation of the modeling, simulation, and analysis tools that have been transitioned to the broader modeling, simulation, and analysis community.</p> <p>FY 2023 Plans: Support software applications that are hosted in the directed energy High Performance Computing Software Applications Institute for a broad spectrum directed energy sources. Continue to populate data base of high power sources. Complete military utility assessment of high power microwave weapon technology that is integrated into various platforms for multiple target engagements using end-to-end modeling. Continue to assess synergistic weapon concepts that merge kinetic energy and non-kinetic weapon capabilities into one weapon system. Support the modeling, simulation, and analysis tools that have been transitioned to the broader modeling, simulation, and analysis community. Continue to assess military utility of high power microwave weapon technology that is integrated into various platforms for multiple target engagements using end-to-end modeling. Complete validation of the modeling, simulation, and analysis tools that have been transitioned to the broader modeling, simulation, and analysis community.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: FY 2023 increased by \$5.830M compared to FY 2022. Justification for this increase is described in the plans above.</p>		17.833	31.544	37.374
Accomplishments/Planned Programs Subtotals		30.070	51.185	60.896

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

N/A

Remarks

D. Acquisition Strategy

Not Applicable

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Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602605F / <i>Directed Energy Technology</i>				Project (Number/Name) 625173 / <i>Laser Technology</i>			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
625173: <i>Laser Technology</i>	-	0.000	65.271	23.101	0.000	23.101	24.010	23.546	24.330	24.743	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 the Department of the 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.

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

	FY 2021	FY 2022	FY 2023
Title: Laser Technology	0.000	65.271	23.101
Description: Develop and demonstrate High Energy Laser device technologies for the Department of the 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 2022 Plans: Continue to incorporate physics-based modeling tools to establish a predictive physics-based End-to-End model that covers all elements of laser weapon systems (LWS)-photon "birth to death". In FY 2022, the End-to-End model will incorporate a high fidelity surrogate model for laser systems & damage effects. In FY 2022, continue to develop novel high energy laser technologies including power scaling of monolithic fiber amplifiers and advancing individual fiber components of the system to increase overall performance. In FY 2022, transition data package on 8kW single all-fiber amplifier (bandwidth 50-100GHz) to other DoD services. Continue development of fiber optic amplifiers that are more resistant to nonlinear effects. Continue advanced modeling to evaluate fiber designs, manufacturing maturity efforts for microstructure and nano-doped glass fibers. In FY 2022, complete effort for micro-structure fiber development to overcome the nonlinearities that occur when power scaling fibers to the multi-kW level. Continue to develop laser vulnerability models for high-priority emerging threat systems. Begin testing of novel beam-control components in relative atmospheric and turbulence environments. Demonstrate high reflectivity coating for High Brightness LWIR Quantum Cascade Lasers in order to provide prototype devices			
FY 2023 Plans: Continue development and validation of the predictive physics-based End-to-End model that covers all elements of laser weapon systems (LWS)-photon "birth to death". Complete testing of the effects of a 2um wavelength laser on targets of interest and make			

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
decision on path for improving compactness and power. Demonstrate 100 W average power for Beacon Illuminating Laser used for target acquisition. Continue development of fiber optic amplifiers that are more resistant to nonlinear effects. Continue to develop laser vulnerability models for high-priority emerging threat systems. Complete fiber optic gyro to enable next generation optical Inertial Reference Unit (IRU). Continue to transition the models to the Department of Defense and Industry Modeling, Simulation and Analysis community. Conduct table top exercises and focused wargames to develop concepts of employment for directed energy weapons in representative scenarios and vignettes. <i>FY 2022 to FY 2023 Increase/Decrease Statement:</i> FY 2023 decreased by \$42.170M due to transfer of funds in FY 2022 to BPAC 624866 and Space Force. This value is not representative of the full PB23 investment in High Energy Laser Technology.			
Accomplishments/Planned Programs Subtotals	0.000	65.271	23.101

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

N/A

Remarks

D. Acquisition Strategy

Non Applicable