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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Office of the Secretary Of Defense **Date:** April 2022

Appropriation/Budget Activity 0400: <i>Research, Development, Test & Evaluation, Defense-Wide I BA 2: Applied Research</i>					R-1 Program Element (Number/Name) PE 0602890D8Z I <i>High Energy Laser Development</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
Total Program Element	0.000	0.000	45.852	48.587	0.000	48.587	49.663	50.673	51.711	52.745	Continuing	Continuing
890: <i>High Energy Laser Development</i>	0.000	0.000	45.852	48.587	0.000	48.587	49.663	50.673	51.711	52.745	Continuing	Continuing

Note

New Start (Y/N): No

In order to better align resources and program management to functional, organizational sponsorship, the High Energy Laser Research Initiatives program has transferred from the Air Force (PE 0602890D8Z) to the Office of the Secretary of Defense starting in FY 2022. This Program will focus on Applied Research for Directed Energy (DE) technologies divided into the following areas: (1) DE Sources; (2) Beam Control; (3) Lethality and Vulnerability; and (4) Power and Thermal Management to reflect the OSD S&T priorities for Directed Energy.

A. Mission Description and Budget Item Justification

This program supports the Department's initiatives to Defend the Homeland, Deter Aggression and Prevail in Conflict, and Build Sustainable and Long-Term Advantage.

This program funds Department of Defense Directed Energy applied research through the Joint Directed Energy Transition Office. This program is part of an overall Department of Defense Directed Energy Science and Technology program. DE weapons systems have many potential advantages, including speed-of-light time-to-target, high precision, low incremental cost per kill, and a magazine that is recharged through on-board, fuel-based power and thermal management systems that reduce logistics requirements in contrast to stocks of munitions or warheads. Directed Energy weapon systems have the potential to perform a wide variety of military missions, including high value asset and base protection, precision strike and platform self-protection versus a wide variety of missile, rocket, artillery, mortar and air platforms. Efforts under this program are generally chosen for their potential to have an impact on multiple Directed Energy weapon systems and multiple Service missions while complementing Service efforts that are directed for specific service needs. A broad range of technologies are addressed in key areas, such as laser sources, microwave sources, laser beam control, antennas, waveguides, modeling and simulation, and lethality mechanisms. This program provides the enabling technology necessary to demonstrate advanced concepts for high power microwave (HPM) sources, antennas and waveguides for mission areas not considered to date. The high power microwave lethality, hardware and software improvements and modeling and simulation advances provided by this program are essential to expand and build upon current architectures. Efforts in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program 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	0.000	45.997	0.000	0.000	0.000
Current President's Budget	0.000	45.852	48.587	0.000	48.587
Total Adjustments	0.000	-0.145	48.587	0.000	48.587
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• FFRDC	-	-0.145	-	-	-
• Adjustments to Budget Year	-	-	46.911	-	46.911
• Economic Assumption	-	-	1.676	-	1.676

Change Summary Explanation

FY 2023 funding increase reflects the fact that the FY 2022 President's Budget request did not include out-year funding.

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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
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Note

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A. Mission Description and Budget Item Justification

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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. Accomplishments/Planned Programs (\$ in Millions)

Title: Directed Energy Sources	FY 2021	FY 2022	FY 2023
Description: Mature technologies that will provide system level performance commensurate with fieldable directed energy devices.	-	12.028	14.176
FY 2022 Plans:			

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2021	FY 2022	FY 2023
<p>- Develop high-reliability, lower-cost, efficient, and high-temperature diode pump sources. Scale alternate laser wavelengths to additional militarily relevant uses and power levels. Investigate next generation high power fiber technologies. Reduce technical risk in solid state lasers for inclusion in future laser weapon systems. Conduct trade space analyses to understand performance, fielding, robustness and integration issues for military platforms.</p> <p>- Investigate, analyze trade space, and reduce technical risk for high power microwave devices. Conduct analyses and trades studies to determine the most effective microwave source parameters.</p> <p>- Explore advanced concepts for technologies that will improve efficiency and decrease size and weight for future Directed Energy (DE) weapon sources. Evaluate materials for high energy laser and high power microwave weapons applications. Improve understanding of laser technologies to include material interaction and propagation. Scale electrically pumped lasers to higher kilowatt-class power levels.</p> <p>FY 2023 Plans:</p> <p>- Develop high-reliability, lower-cost, efficient diode pump sources. Scale alternate laser wavelengths to additional militarily relevant uses and power levels. Investigate next generation high power fiber technologies. Collaborate with the national and international directed energy community on progress in the development and application of high energy laser technologies for military missions. Reduce technical risk in solid state lasers for inclusion in future laser weapon systems. Conduct trade space analyses to understand performance, fielding, robustness and integration issues of the various architecture types for military platforms. Advance investments in illuminator laser sources and laser gain media and explore nontraditional fiber designs and materials for revolutionary increases in fiber performance, exploiting benefits of alternative wavelengths were possible.</p> <p>- Investigate, analyze trade space, and reduce technical risk for high power microwave devices. Conduct analyses and trades studies to determine the most effective microwave source parameters. Collaborate with the national and international directed energy community on progress in the development and application of high power microwave technologies for military missions.</p> <p>- Explore advanced concepts for technologies that will improve efficiency and decrease size and weight for future Directed Energy (DE) weapon sources. Evaluate materials for high energy laser and high power microwave weapons applications. Improve understanding of laser technologies to include material interaction and propagation. Scale electrically pumped lasers to higher kilowatt-class power levels.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: Resourcing level increase due to year to year fluctuation.</p>				
Title: Beam Control and Propagation		-	27.464	28.000

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
<p>Description: Develop technologies that support improving beam control and beam propagation for DE weapon systems.</p> <p>FY 2022 Plans:</p> <ul style="list-style-type: none"> - Develop beam control technologies for high energy laser weapon use across all domains of the Department. Develop technologies to improve the beam director throughput efficiency, optimize size and weight, and improve tracking and compensation through the atmosphere. - Characterize and understand the physics of high energy laser atmospheric propagation in adverse environmental conditions such as fog, rain, smoke and dust. Collaborate with the international directed energy community on progress in the development and application of high energy laser technologies for military missions. Validate predictive models through analysis of atmospheric propagation data and measurements. - Provide maintenance, verification, validation, and accreditation for updated system level atmospheric propagation and high energy laser system models. Collaborate with Service-sponsored field-test planning to correlate model predictions with measured data for surface, maritime and aerospace environments. Incorporate atmospheric data into theater models to support performance characterization tables. Continue the development of a predictive avoidance fire control system for use on multiple platforms. Develop kill assessment technologies. - Develop theoretical physical models describing the propagation of a high power microwave (HPM) pulse through the atmosphere to understand the reflection characteristics of the HPM propagation. Study and understand the dynamic behavior of the propagation of high-power microwave pulses and the effects on the intensity, frequency, and width of the pulse and the physical processes occurring during the interaction of the pulse with the air. Develop kill assessment technologies. Develop hardware and technologies to improve throughput efficiency of the antenna, decrease component weight, and improve tracking and compensation through the atmosphere. - Characterize and understand the physics of high power microwave propagation in adverse environmental conditions. Collaborate with the international directed energy community on progress in the development and application of high power directed energy weapon (DEW) technologies for military missions. <p>FY 2023 Plans:</p> <ul style="list-style-type: none"> - Develop beam control technologies for high energy laser weapon use across all domains of the Department. Develop technologies to improve the beam director throughput efficiency, optimize size and weight, and improve/automate tracking and compensation through the atmosphere. Invest in atmospheric sensor innovation, field test evaluations, and next-generation models. 			

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
<p>- Characterize and understand the physics of high energy laser atmospheric propagation in adverse environmental conditions such as fog, rain, smoke and dust. Improve cameras and track illuminators to enable target engagement at longer ranges and enable improvements to shorten engagement timelines. Develop AI based tracking systems that show promise for automation of target recognition, aimpoint selection and maintenance as well as tracking in clutter. Explore Digital Holography to enable wavefront compensation with improved deformable mirrors for HEL propagation through severe turbulence and reducing SWaP</p> <p>- Collaborate with the national and international directed energy community on progress in the development and application of high energy laser technologies for military missions. Validate predictive models through analysis of atmospheric propagation data and measurements.</p> <p>- Provide maintenance, verification, validation, and accreditation for updated system level atmospheric propagation and high energy laser system models. Collaborate with Service-sponsored field-test planning to correlate model predictions with measured data for surface, maritime and aerospace environments. Incorporate atmospheric data into theater models to support performance characterization tables. Continue the development of a predictive avoidance fire control system for use on multiple platforms.</p> <p>- Develop theoretical physical models describing the propagation of a high power microwave (HPM) pulse through the atmosphere to understand the reflection characteristics of the HPM propagation. Study and understand the dynamic behavior of the propagation of high-power microwave pulses and the effects on the intensity, frequency, and width of the pulse and the physical processes occurring during the interaction of the pulse with the air. Develop hardware and technologies to improve throughput efficiency of the antenna, decrease component weight, and improve tracking and compensation through the atmosphere.</p> <p>- Characterize and understand the physics of high power microwave propagation in adverse environmental conditions. Collaborate with the national and international directed energy community on progress in the development and application of high power directed energy weapon (DEW) technologies for military missions.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: There is no significant change between FY 2022 and FY 2023.</p>			
<p>Title: Lethality and Vulnerability</p> <p>Description: Conduct directed energy vulnerability experiments on materials, components, and targets. Develop a lethality database, and integrate into a systems-level architecture plan and lethality models.</p> <p>FY 2022 Plans:</p>	-	6.360	6.411

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023
<p>- Integrate lethality and target imagery data into campaign-level high energy laser system models. Conduct high energy laser vulnerability experiments on materials, components, and targets. Develop a suite of high energy laser weapon tools to be used in a database from which the warfighter can assess target vulnerabilities and mission utility for a given high energy laser weapon platform and engagement. Develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards.</p> <p>- Develop new predictive modeling software tools to assess the effectiveness of high power microwave (HPM) weapons on electronic systems of interest for blue-on-red or red-on-blue engagements. Evaluate statistical and deterministic cavity coupling algorithms to estimate the temporal and spectral characteristics of the HPM energy coupled into complicated enclosures. Leverage advancements in predictive circuit effects, garnered through several Service and Agency-funded programs, to model and predict the response of complicated electronics to the incident HPM stimulus. Develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards.</p> <p>- Collaborate with Service and Agency sponsored High Power microwave survivability / lethality community's interest in, and use of, high power microwave (HPM) engagement models. Continue to provide maintenance, verification, validation, and accreditation for updated system level standalone model that can be used to estimate the probability of electronic upset or damage as a function of the HPM power density on the target and associated range. Develop warfighter tools to determine the power density required on a target to produce a functional kill and understand the required parameters of the HPM, such as power, frequency/ wavelength, modulation, and engagement angle for the kill.</p> <p>FY 2023 Plans:</p> <p>- Integrate lethality and target imagery data into campaign-level high energy laser system models. Conduct high energy laser vulnerability experiments on materials, components, and targets. Conduct laser lethality effects testing and modeling specifically focused on subsonic / supersonic threats, assessment of threat aim-points, development of sophisticated techniques to rapidly determine threat vulnerability and techniques to accurately predict time-to-kill. Evaluate the utility of CW vs Pulsed laser effects in c-CM and c-Hypersonic missile defense. Develop a suite of high energy laser weapon tools to be used in a database from which the warfighter can assess target vulnerabilities and mission utility for given high energy laser weapon platform and engagement. Develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards.</p> <p>- Develop new predictive modeling software tools to assess the effectiveness of high power microwave (HPM) weapons on electronic systems of interest for blue-on-red or red-on-blue engagements. Evaluate statistical and deterministic cavity coupling algorithms to estimate the temporal and spectral characteristics of the HPM energy coupled into complicated enclosures. Leverage advancements in predictive circuit effects, garnered through several Service and Agency-funded programs, to model</p>			

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2021	FY 2022	FY 2023
<p>and predict the response of complicated electronics to the incident HPM stimulus. Develop warfighter tools employing Service and Agencies metrics and criteria such as the Joint Munitions Effectiveness Standards.</p> <p>- Collaborate with Service and Agency sponsored High Power microwave survivability / lethality community's interest in, and use of, high power microwave (HPM) engagement models. Continue to provide maintenance, verification, validation, and accreditation for updated system level standalone model that can be used to estimate the probability of electronic upset or damage as a function of the HPM power density on the target and associated range. Develop warfighter tools to determine the power density required on a target to produce a functional kill and understand the required parameters of the HPM, such as power, frequency/ wavelength, modulation, and engagement angle for the kill.</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: There is no significant change between FY 2022 and FY 2023.</p>				
Accomplishments/Planned Programs Subtotals		-	45.852	48.587
C. Other Program Funding Summary (\$ in Millions)				
N/A				
Remarks				
N/A				
D. Acquisition Strategy				
N/A				