Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Office of the Secretary Of Defense	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*

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	929.510	171.891	464.850	315.090	-	315.090	304.538	273.127	216.984	219.162	-	-
091: *High Speed Systems Test*	317.128	93.001	191.463	111.362	-	111.362	112.682	106.624	79.395	80.983	-	-
092: *Spectrum Efficient Technology*	78.296	4.700	39.376	9.975	-	9.975	10.053	10.192	9.586	9.777	-	-
093: *Electronic Warfare Test*	114.592	13.200	121.171	119.265	-	119.265	105.055	71.619	40.073	40.874	-	-
094: *Advanced Instrumentation Systems Technology*	87.301	15.420	11.209	12.180	-	12.180	12.462	12.710	12.977	13.237	-	-
095: *Directed Energy Test*	82.937	7.800	21.568	11.322	-	11.322	11.475	11.705	11.950	12.188	-	-
096: *C4I & Software Intensive Systems Test*	129.746	14.610	12.128	13.088	-	13.088	13.246	13.511	13.794	14.070	-	-
097: *Autonomy and Artificial Intelligence Test*	66.149	8.450	11.087	22.742	-	22.742	24.028	30.858	32.752	31.248	-	-
098: *Cyberspace Test*	53.361	14.710	13.348	14.431	-	14.431	14.707	15.000	15.315	15.620	-	-
099: *Space Test*	0.000	0.000	43.500	0.725	-	0.725	0.830	0.908	1.142	1.165	-	-

Note

New Start (Y/N): No

A. Mission Description and Budget Item Justification

This program supports the Department's initiatives to defend the homeland, deter strategic attacks and aggression, prevail in conflict, build enduring advantage, and build a resilient joint force and defense eco system. The Test and Evaluation/Science and Technology (T&E/S&T) program seeks out and develops test technologies to keep pace with evolving weapons technologies. Aligned with the National Defense Strategy, this program is critical to ensure that the Department of Defense (DoD) has the ability to adequately test the advanced systems that will be fielded in the future, building a more lethal force. To meet this objective, the T&E/S&T Program performs the following activities:

- Exploits new technologies and processes to meet important test and evaluation (T&E) requirements.
- Expedites the transition of new technologies from the laboratory environment to the T&E community.
- Leverages industry advances in equipment, modeling and simulation, and networking to support T&E.

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Office of the Secretary Of Defense	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603941D8Z *I Test and Evaluation Science and Technology*

Additionally, the T&E/S&T Program examines emerging T&E requirements resulting from Joint Service initiatives to identify T&E technology needs and develop a long-range roadmap for technology insertion. The program leverages and employs applicable applied research efforts from the highly developed technology base in theDoD laboratories and test centers, other Government agencies, and industry to accelerate development of new test capabilities. The program outreaches and engages academia to address test technology challenges in DoD testing, advancing Science, Technology, Engineering and Mathematics (STEM) initiatives at Historically Black Colleges and Universities (HBCU) and other minority serving institutions. This program provides travel funds for T&E/S&T program oversight, special studies, analyses, and strategic planning related to test capabilities and infrastructure. The T&E/S&T Program aligns with the science and technology (S&T) Communities of Interest (COI) to prepare the T&E community to test warfighting capabilities that emerge from priority S&T investments. The T&E/S&T Program utilizes Advanced Technology Development funding because which supports the development and demonstration of high payoff technologies for current and future DoD test capabilities.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	171.891	267.161	0.000	-	0.000
Current President's Budget	171.891	464.850	315.090	-	315.090
Total Adjustments	0.000	197.689	315.090	-	315.090
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Program Adjustment	-	-	10.496	-	10.496
• Joint Artificial Intelligence Test and Evaluation Infrastructure Capability	-	-	10.685	-	10.685
• Congressional Adjustment	-	198.000	-	-	-
• FFRDC Adjustment	-	-0.311	-	-	-
• Budget Year Adjustment	-	-	293.909	-	293.909

Change Summary Explanation

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

FY 2022 Congressional addition of $198.000M improves the following capabilities: 1) upgrade space ground testing facilities by developing new test technologies enabling space systems to be more reliably and accurately tested on the ground prior to launch; 2) upgrade space test lab and range infrastructure to validate space domain awareness enhancements, as well as capabilities to support dedicated tracking and imaging of systems as part of the development of a National Space Test and Training Complex; 3) advance large energy national shock tunnels to assess aerothermal and dynamic event effects on hypersonic, ballistic missile defense, and strategic systems and advanced sensors; 4) upgrade electromagnetic spectrum lab and test range infrastructure to prototype 5G test environments needed to assess commercial 5G operation impacts on critical test data transmission in operationally relevant test environments; 5) upgrade

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Office of the Secretary Of Defense	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603941D8Z *I Test and Evaluation Science and Technology*

directed energy lab and test range infrastructure to develop required instrumentation on the missile and sUAS target to assess High Power Microwave (HPM) effects; 6) upgrade target lab and test range infrastructure to continue the development and fielding of next-generation aerial target platforms; 7) improve capacity for hypersonics flight test to augment hypersonic launch capabilities and continue the prototype development of rapid, responsive flight test capabilities; FY 2022 decrease of $10M reflects a congressionally directed reduction of funds due to excessive growth.

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603941D8Z / *Test and Evaluation Science and Technology*	Project (Number/Name) 091 / *High Speed Systems Test*	

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
091: *High Speed Systems Test*	317.128	93.001	191.463	111.362	-	111.362	112.682	106.624	79.395	80.983	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

High-speed/hypersonic weapons are being developed to ensure the continued military superiority and strike capability of the United States including freedom of movement and freedom of action in areas protected by anti-access/area denial defenses. Current weapon system demonstrations and technology development programs include high-speed and hypersonic air-breathing missiles, maneuvering reentry and boost-glide weapons, hypersonic gun-launched projectiles, and air-breathing space access vehicles. These systems require development of conventional and high-speed turbine, ramjet, scramjet, and combined cycle engines; high temperature materials; thermal protection systems (TPS); and thermal management systems. The High Speed Systems Test (HSST) project addresses test technology needs including propulsion, aerodynamic and aerothermal testing, so the test community has the technology to support the required test scenarios for concepts under development in the S&T community. The technology developments within the HSST project align with the Department of Defense (DoD) S&T priority investments. As such, the HSST project is developing, validating and transitioning advanced T&E technologies for ground test, open-air range flight test, and advanced computational tools, along with instrumentation and diagnostics systems for use in both ground tests and flight tests of high speed systems.

The HSST project develops technologies to enable robust, accurate, and timely T&E of these future weapon systems. DoD acquisition regulations require weapon systems to undergo a thorough T&E process to detect deficiencies early and to ensure system suitability and survivability. However, the extreme environments in which these weapons operate preclude accurate determination of their performance and operability with today's T&E assets. Current national test capabilities have deficiencies in data accuracy, flight condition replication and simulation, test methods, productivity, modeling and simulation (M&S) fidelity, and range safety.

The HSST mission is to address these national test capability gaps by providing test technology solutions that will enable high-speed and hypersonic weapon systems to be successfully developed through accurate, robust, and efficient T&E.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: High Speed Systems Test	93.001	191.463	111.362
Description: The HSST project continued to advance ground and flight test technologies, techniques, instrumentation, and modeling and simulation capabilities required for the development of hypersonic weapon systems. In F 20Y21, HSST continued to address critical technology shortfalls for hypersonic test and evaluation in aerothermal and propulsion ground testing capabilities and advanced instrumentation to support hypersonic flight tests. Several other technology development efforts also progressed through the year. To address the technology shortfall involving aerothermal and propulsion testing, HSST is developing a new test facility that utilizes clean-air heat addition (non-vitiated air) and a variable Mach number (VMN) capability to provide the representative high-			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 091 / *High Speed Systems Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
temperature conditions for characterizing weapon systems, including air-breathing propulsion capabilities. The clean-air heat addition is especially important to the characterization of air-breathing propulsion systems, as previous HSST efforts demonstrated that vitiated air provides different gas properties than clean air found in the atmosphere and thus is not representative of what the vehicle would experience in flight. This significantly affects the engine's performance and operability in the test environment and results in erroneous flight predictions. Additionally, characterization of advanced sensors for hypersonic systems also benefits from clean-air heat addition as it provides a more representative environment for the sensor to operate in. The variable Mach number capability provides a more representative trajectory simulation for the system under test, permitting more accurate predictions before conducting flight tests. The new test facility, called the Hypersonic Aerothermal and Propulsion Clean-Air Testbed (HAPCAT), was checked out at the upper envelope and the facility was configured to demonstrate test techniques that determine the combined aerodynamic and aerothermal effects on advanced hypersonic sensors performance. All of the efforts associated with HAPCAT also serve as pathfinders for the development of a larger-scale, more capable facility at the AEDC. Upgrades and development efforts associated with aerothermal testing also continued in FY 2021. HSST continued multiple efficiency upgrades to the AEDC arc heaters to increase throughput in response to significant test demand. HSST also initiated new aerothermal test technology development efforts to prototype alternative high enthalpy test technologies, to include a plasmatron test capability. Significant progress was achieved in the development of the SkyRange capability, an unmanned aerial vehicle-based range to support hypersonic flight tests and other missions for the Department of Defense. SkyRange provides a more agile, flexible, and cost-effective method for providing support to hypersonic flight tests with increased data collection capabilities beyond the current state-of-the-art. It also addresses a critical throughput shortfall for supporting the number of hypersonic flight tests required, as a sufficient number of existing assets does not exist. RQ-4 Global Hawks and MQ-9 Reapers comprise the platforms used for SkyRange. SkyRange augments existing air, sea, and land test support assets referred to as the "string of pearls," reducing the high costs associated with traditional flight test support. Novel sensors are being developed in the areas of telemetry capture and relay, multispectral imaging, atmospheric sensing, terminal scoring, and other areas to aid in the development of hypersonic systems. Several of these sensors are being developed through HSST for integration into the SkyRange capability. Achievements were made for both SkyRange aircraft platforms in FY 2021. Work continued on the modification of three RQ-4s to facilitate sensor package integration as part of SkyRange. Upon completion, this will result in three operational RQ-4s for SkyRange. For the MQ-9s, six aircraft were acquired and stationed at the main operating base in California. These MQ-9s will be used for integrating various sensors, generally through the use of pylon-carried pods.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 091 / *High Speed Systems Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The development, integration, and operation of a phased-array telemetry capability continued as part of SkyRange. The telemetry antenna underwent flight testing and subsequent improvements to subsystem operability and reliability. RQ-4s will be available to collect flight test mission telemetry data in early FY 2023, proving telemetry antenna initial operational capability. RangeLynx module installation is underway on two RQ-4 aircraft to provide real-time satellite-based telemetry relay to ground stations. Progress continued on the development of a high-fidelity automated and reconfigurable multispectral imaging tracking system for integration into an RQ-4 Global Hawk as part of the overall SkyRange capability. Ground checkouts of the system were successful, and system modifications are being designed for integration onto the aircraft. The development is scheduled for system integration in FY 2022. The High-Altitude LIDAR Atmospheric Sensing (HALAS) system remains installed on a Gulfstream G-IV business jet. The G-IV continued to support flight test missions by collecting atmospheric data. The data collected informs the design of the HALAS system for integration on an unmanned RQ-4 Global Hawk as part of the overall SkyRange capability. A ground based multispectral thermal imaging prototype continued to collect thermal imagery in the terminal phase of a hypersonic flight tests for thermal protection system evaluation. The system was deployed to the Pacific to support terminal phase data collection for a hypersonic flight test, and the prototype successfully acquired thermal imagery data that was subsequently provided to the weapon system program. The system was then brought back to CONUS, where an enclosure was fabricated and installed on the unit to increase reliability. The system was then redeployed to the Pacific to support additional flight tests. Additional upgrades and technology development continued at the CUBRC hypersonic shock and expansion wind tunnels to support hypersonic ground testing. These included the implementation of a fast-response force and moment balances for use in the CUBRC facilities, and multiple non-intrusive diagnostic systems for evaluation of hypersonic systems. In addition to these upgrades, a new wave rotor facility development was initiated, starting with a small scale prototype wave rotor based multi-shock heater to demonstrate representative conditions at hypersonic speeds for aero-optic and thermal protection system testing. ***FY 2022 Plans:*** The HAPCAT will achieve full operational capability, providing support to hypersonic weapon system programs test capabilities for aerothermal, propulsion, and combined effects advanced sensor characterization. Other test techniques to support directed energy and other propulsion system characterizations will also be developed.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 091 / *High Speed Systems Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
SkyRange will demonstrate operation using multiple aircraft platforms, including RQ-4s and MQ-9s. Support will be provided to hypersonic flight tests using the telemetry, multispectral imaging, and atmospheric sensing sensor packages. This will involve the integration of the multispectral imaging sensor onto the RQ-4 and completion of the atmospheric sensing capability. Additionally, development of terminal scoring capabilities deployed from SkyRange assets will continue. Further technology upgrades to arc heaters and new aerothermal test capabilities will continue to address throughput and capability shortfalls. Other test and evaluation gaps associated with ground and flight test, modeling and simulation, and instrumentation will be addressed through new efforts. FY 2022 Congressional addition of $83M improves shock tunnels and hypersonic flight testing. The improvements upgrade the large energy national shock tunnel capability to assess aerothermal and dynamic event effects on hypersonic, ballistic missile defense, and strategic systems and advanced sensors. The enhancements will deliver a prototype high-Mach, high-enthalpy ground test capability increasing the run time for high Mach, high enthalpy ground test capability matching flight conditions up to Mach 8. In addition, the Congressional increase will improve hypersonic flight test throughput will augment hypersonic launch capabilities and continue the prototype development of rapid, responsive flight test capabilities enabling an increase in the number of hypersonic flight test capabilities available to programs. These improvements will reduce schedule bottlenecks currently limiting hypersonic flight test throughput ***FY 2023 Plans:*** The HAPCAT will continue providing support to hypersonic weapon system programs test capabilities for aerothermal, propulsion, and combined effects seeker/sensor characterization. The HAPCAT will continue risk reducing test technologies as a pathfinder for the development of the larger-scale, more capable facility at the AEDC. Other test techniques to support directed energy and other propulsion system characterizations will also be developed. SkyRange will demonstrate initial capability using multiple aircraft platforms, including RQ-4s and MQ-9s. Support will be provided to hypersonic flight tests using the telemetry, multispectral imaging, and atmospheric sensing sensor packages. SkyRange will support terminal data collection for hypersonic flight tests by demonstrating terminal scoring capabilities deployed from SkyRange assets. Further technology upgrades to aerothermal test capabilities will continue. Other test and evaluation gaps associated with ground and flight test, modeling and simulation, and instrumentation will be addressed through new efforts. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 091 / *High Speed Systems Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 to FY 2023 decrease reflects FY 2022 congressional addition of $83M to improve large energy national shock tunnels hypersonic ground test facilities and hypersonic flight test throughput.			
Accomplishments/Planned Programs Subtotals	93.001	191.463	111.362

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603941D8Z / *Test and Evaluation Science and Technology*	Project (Number/Name) 092 / *Spectrum Efficient Technology*	

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
092: *Spectrum Efficient Technology*	78.296	4.700	39.376	9.975	-	9.975	10.053	10.192	9.586	9.777	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

Weapon systems have become increasingly complex in recent years, resulting in the need for significantly more data to be passed among these systems as well as between the systems and our test infrastructure. A vast amount of data must be collected, transmitted, and analyzed, which requires a large amount of radio frequency (RF) spectrum resources. However, the amount of RF spectrum designated to support test and evaluation (T&E) is decreasing, most notably due to reallocation of spectrum for commercial use. The combination of decreasing RF spectrum and increasing data requirements results in an urgent need to develop test technologies that maximize the use of spectrum resources for the Department of Defense (DoD) T&E operations.

The L- and S- Band frequencies are the traditional spectrum allotted for military T&E use. The explosive need for spectrum in the commercial sector has resulted in reallocation of portions of these bands to industry. To compensate, the DoD is now authorized to use the C-Band spectrum which offers numerous benefits, including the potential for a large increase in available bandwidth, but the C-Band spectrum comes with technical challenges and regulatory constraints. Most notably, our current test infrastructure for telemetry is not designed to accommodate C-Band and the band is heavily shared for alternate uses. Technologies are required to implement innovative techniques that efficiently facilitate our use of C-Band without a major overhaul to our national test infrastructure. For instance, commercial telemetry transmitters operate in C-Band but do not have the form factor (size, weight and power) nor ruggedized packaging to survive airborne test applications.

Traditional telemetry applications employ streaming telemetry where data is moved one-way from the instrumented system under test to our test range infrastructure. Modern network based telemetry and cellular based telemetry capabilities enable more robust, efficient bidirectional transfer of data. The DoD strategy is to create technologies for implementing a telemetry capability in C-Band, using the legacy L- and S-Bands for both streaming and networked telemetry, and researching the feasibility of using higher frequency bands to augment telemetry operations.

The Spectrum Efficient Technology (SET) project is developing test technologies that enable more efficient use of legacy telemetry bands and expansion into non-traditional areas of the RF and optical spectra at DoD test ranges. The technology development efforts within the SET project have been prioritized to align with the Department of Defense guidance on science and technology priority investments. As such, the SET project is focusing on growing data requirements of warfighting systems and the limited availability of spectrum for testing. The SET project is structured to develop test technologies to advance range communications, networked and cellular based telemetry capabilities, and enhanced management of spectrum at DoD test ranges.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Spectrum Efficient Technology	4.700	39.376	9.975

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 092 / *Spectrum Efficient Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The SET project transitioned the software tool capable of accurately estimating current and future spectrum needs. The tool accounted for actual versus scheduled utilization of the spectrum and quantified the cost and schedule implications of the loss of needed spectrum. The spectrum efficient metrics tool provides spectrum managers a planning tool and also provides justification data needed to retain spectrum. The SET project continued to mature technologies required for network and cellular based telemetry. Airborne phased array telemetry antenna technologies were matured for both manned and unmanned platforms, to include demonstration of airborne phased array telemetry data collection. The SET project completed development and integration of a small, lightweight data recorder and data transmission scheme integrated onto unmanned airborne platforms to support long range flight test telemetry data collection. The data recorder addressed long range flight test requirements for data recording and storage during flight testing. ***FY 2022 Plans:*** The SET project will further advance development of technologies required for network and cellular based telemetry. Airborne phased array telemetry antenna technologies will continue to be matured for both manned and unmanned platforms by optimizing antenna designs for specific long range flight test requirements. Ground based phased array telemetry antenna technologies to support large footprint flight test events will continue to be matured. The SET project will also continue to leverage cellular technologies to support aeronautical telemetry requirements. The FY 2022 Congressional addition of $30M will initiate efforts to prototype 5G test environments needed to assess commercial 5G operation impacts on critical test data transmission in operationally relevant test environments. This enables the DoD to replicate, assess, and address the impacts of a congested 5G environment in test, training, and operational exercises relevant to wartime theater conditions. ***FY 2023 Plans:*** The SET project will continue development of technologies required for network and cellular based telemetry. The SET project will begin transition of cellular technologies to support aeronautical telemetry requirements at open air test ranges. Airborne and ground based phased array telemetry antenna technologies will continue to be matured. Ground based phased array telemetry antenna technologies to support large footprint test events will be demonstrated. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** FY 2022 to FY 2023 decrease reflects FY 2022 congressional addition of $30M to prototype 5G test environments, and improve spectrum usage during test events.			
Accomplishments/Planned Programs Subtotals	4.700	39.376	9.975

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 092 / *Spectrum Efficient Technology*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603941D8Z / *Test and Evaluation Science and Technology*	Project (Number/Name) 093 / *Electronic Warfare Test*	

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
093: *Electronic Warfare Test*	114.592	13.200	121.171	119.265	-	119.265	105.055	71.619	40.073	40.874	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

In order to establish dominance in the modern battlespace, our offensive and defensive electronic warfare systems must be capable against advanced radio frequency (RF) directed threats and electro-optic (EO) guided threats, which include infrared (IR) guidance. Ensured dominance in these areas requires more robust test and evaluation (T&E) with technologies that are rapidly adaptable to changing threats.

Readily available, IR seeking, man-portable air defense systems (MANPADS) are difficult to detect and pose an imminent and lethal threat to military aircraft of all types. Our ability to counter such threats is essential to owning the battlespace in theater. Therefore, the ability to test missile warning systems (MWS), hostile fire indicator (HFI) systems, IR countermeasures (IRCM), and advanced threat sensors is critical to our national defense. Additionally, a new generation of enemy RF missile seekers is both currently fielded and in further development, requiring a correspondingly new generation of test technologies to test the latest countermeasures. The T&E community is required to test IRCM and RF countermeasure systems in a repeatable manner with ground-truth data before and after integration into warfighting systems. Without new test technologies, the Department of Defense (DoD) will be unable to perform adequate T&E of advanced warning and countermeasure systems.

The Electronic Warfare Electronic attack and Electronic protect (EP) community is developing jammers and EP measures that are more sophisticated and take advantage of newer technology that allows adaptive waveforms and artificial intelligence and autonomy to respond to threats more rapidly and robustly. In addition, the testing of these systems in realistic many on many environments that are more threat representative requires new technology investment.

The technology development efforts within the Electronic Warfare Test (EWT) project have been prioritized to align with DoD guidance on science and technology priority investments. As such, the EWT project is focusing on the test needs in both the EO, including IR, and the RF threat domains. Additionally, development of core test technologies in this area can be leveraged to meet other EO and RF test requirements, such as in fire control systems; intelligence, surveillance and reconnaissance (ISR) sensors, and weapon seekers.

The EWT project develops test technologies to stimulate IRCM and RF system sensors through the high-fidelity simulation of scenes viewed by the sensors. Stimulation can be as simple as testing to see if a system under test responds to an image or as complex as simulating complex battle space phenomena to measure the response of a system under test in a more relevant, cluttered scenario. Simulations and stimulations are used at open air ranges and in installed system test facilities (ISTF), and in hardware-in-the-loop (HWIL) test beds.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Electronic Warfare Test	13.200	121.171	119.265

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 093 / *Electronic Warfare Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The EWT project continued to develop high fidelity scene generation technology for both EO and RF environments. Work continued on the development of hardware and software that generates large number of independent radar targets in a high fidelity hardware- in-the-loop facility. This enabled chamber testing of radars in more dense target environments by generating large numbers of dissimilar false targets. Work continued on high temperature IR scene projectors. The EWT project developed a dynamic infrared (IR) scene projector to enable chamber testing of missile warning systems and directional infrared countermeasure systems. The new scene projector creates scenes with higher temperatures and higher resolution creating a more threat representative environment for sensor test. The effort transitioned and delivered scene projectors to the Air Force Guided Weapons Evaluation Facility (GWEF). Work continued on increasing the efficiency of LED pixels for use in IR scene projectors. Work continued on development of interfaces for use of Active Electronically scanned arrays for open air range threat simulators. ***FY 2022 Plans:*** The EWT project will continue investments in Digital RF memory for adaptive waveforms. The EWT project will invest in technologies related to Cyber and EW convergence. The EWT project will invest in technologies related to Cognitive EW, Cognitive Radar, and EW sensors that feed Artificial Intelligence uses of EW data. Investments in open air range threat emitter prototypes to enable wider frequency coverage featuring frequency agility to replicate modern threat system behaviors for operational test will be initiated. EWT will conduct studies to improve Ground EW systems and cUAS EW testing. FY 2022 Congressional addition of $41M improves the technologies needed to test 5th/6th generation aircraft. These upgrades will continue the prototype development of an aerial target system to adequately replicate adversary 5th generation stealth aircraft with representative attributes such as low observability, maneuverability, size, and electronic warfare payload capabilities. These upgrades will also initiate the prototype development of an instrumented, threat-representative small unmanned aircraft system (sUAS) threat for counter-sUAS testing. The development and deployment of these capabilities allows the Department to test and train against representative targets to accurately assess blue force lethality and survivability ***FY 2023 Plans:*** The EWT project will continue investments in technologies related to Cognitive EW, Cognitive Radar, and EW sensors that feed Artificial Intelligence uses of EW data. EWT will initiate technology developments to improve Ground EW systems and cUAS EW testing. Prototype open air range threat emitter with wider frequency coverage and agility will be demonstrated. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 093 / *Electronic Warfare Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 to FY 2023 increase reflects FY 2022 congressional addition of $41M to upgrade target lab and test range infrastructure combined with program increases to better address modern adversarial electronic warfare threats in lab and range test environments.			
Accomplishments/Planned Programs Subtotals	13.200	121.171	119.265

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603941D8Z / *Test and Evaluation Science and Technology*	Project (Number/Name) 094 / *Advanced Instrumentation Systems Technology*	

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
094: *Advanced Instrumentation Systems Technology*	87.301	15.420	11.209	12.180	-	12.180	12.462	12.710	12.977	13.237	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Advanced Instrumentation Systems Technology (AIST) project addresses the test technology gaps resulting from emerging weapon systems that need to be assessed at the Department of Defense (DoD) installed systems test facility and hardware-in-the-loop testing (ISTF/HITL) and open-air range (including tropospheric, land-based, open-ocean, and undersea ranges) test facilities. Instrumentation requirements for systems under test are increasing exponentially for new weapons systems. System-borne, warfighter-wearable, and remote sensing instrumentation packages are required. This instrumentation is for sensing and collecting critical performance data; determining accurate time, space, position information (TSPI)and attitude information; interfacing with command and control data links; monitoring and reporting system-wide communications; recording human operator physical and cognitive performance; and storing and transmitting data.

The technology development efforts within the AIST project have been prioritized to align with the DoD guidance on science and technology (S&T) communities of interest (COIs). The AIST project is focused on developing technologies for advanced TSPI instrumentation (especially with limited or no availability of Global Positioning System (GPS) signals), advanced sensors, advanced energy and power systems for instrumentation, non-intrusive instrumentation, mitigating range encroachment issues, and measuring warfighter physical and cognitive performance. The AIST project addresses requirements for miniaturized, non-intrusive instrumentation suites with increased survivability in harsh environments. Such instrumentation is an urgent need because minimal space is available to add instrumentation to new or existing weapon systems subsequent to their development; furthermore, additional weight and power needs for instrumentation can adversely affect weapon system signature and performance. Instrumentation for humans-in-the-loop, especially dismounted warfighters, must not adversely affect performance, induce artificiality in the test environment, nor create any operational burdens. New technologies can be exploited to integrate small, non-intrusive instrumentation (micro-technology) into emerging platforms during design and development, and, in some cases, into existing platforms. This class of instrumentation will provide critical system performance data during operational test (OT) and continuous assessment throughout a system's lifecycle. Technology developed under AIST can also benefit training and combat missions by enabling a continual feedback loop between the developer, training staff, operators, and commanders.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Advanced Instrumentation Systems Technology	15.420	11.209	12.180
Description: Major thrusts included initiating and continuing efforts in advanced sensors, and TSPI instrumentation. The AIST projected initiated two efforts to design a test technology for weapon testing use cases impacting the broad ocean area to collect TSPI, lethality, and scoring data; one technology will use optics, and the other will leverage an imaging radar and subsurface acoustic sensors.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 094 / *Advanced Instrumentation Systems Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The AIST project initiated an effort to develop a sensor to collect acceleration measurement data during high-speed flight tests, enabling the gathering of accurate position and attitude, 6 Degrees of Freedom (6DOF) data over very long ranges and into the exo-atmosphere to measure the aerodynamics and internal guidance and control systems of new munitions in an ultra-high dynamic environment. The AIST project continued an effort to support testing of military aircraft using externally mounted sound pressure instrumentation to gather data for analysis in all weather conditions, to overcome current constraints to flight testing in dry environments. The AIST project continued a portable technology development effort using acoustic signatures to measure weapon location and attitude to characterize high dynamic weapon end-game maneuvers, and to evaluate impact location & velocity of attacking projectiles and resolving (scoring) very large quantities of impacts occurring closely spaced in position and/or time. The AIST project completed an effort in developing a high fidelity model which takes into account the noisier acoustic properties of shallow water environments for littoral T&E. The model supports early evaluation of undersea test range technologies (e.g., hydrophone arrays, new communication signals/modulations, transducers, and portable instrumentation). The AIST project completed an effort related to electro-releasable attachment technology development. This included the investigation of new adhesive formulations that employ an electrically-releasing tape to allow for the attachment of sensors to non-conductive, painted surfaces of aircraft and other combat vehicles and significantly reduce the time to restore the system under test to its operational configuration. Efforts improved adhesion strength and ease of use. This effort was successfully tested in a relevant environment in field testing onboard M1-Abrams Tanks at Aberdeen Test Center, and F-15 Fighter Jets at Edwards Air Force Base, respectively. ***FY 2022 Plans:*** The AIST project will complete the technology development of a portable end-game scoring system implementing deep ocean synchronized acoustic recorders, and continue developing a broad ocean area test technology suite. The AIST project will initiate a mobile undersea tracking effort to provide TSPI on subsurface weapons and vehicles. The AIST project will also continue the investigation and development of advanced instrumentation technologies to support lethality testing and end-game scoring in the broad ocean area.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 094 / *Advanced Instrumentation Systems Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The AIST project will continue to develop a sensor to collect acceleration measurement data during high-speed flight tests, enabling the gathering of accurate position and attitude, 6DOF data over very long ranges and into the exo-atmosphere to measure the aerodynamics and internal guidance and control systems of new munitions in an ultra-high dynamic environment ***FY 2023 Plans:*** The AIST project will continue development of: multi-disciplinary technologies addressing T&E requirements for real-time casualty assessment (RTCA) of warfighter and weapon engagements, sensors to support advanced hypervelocity projectile testing, TSPI data fusion algorithms and technologies, high precision range radar technology, improved energy and power density systems for T&E, advanced non-intrusive data management techniques, and mitigation technologies for monitoring effects from encroachment on test ranges. The AIST project will also continue the investigation and development of advanced instrumentation technologies to support lethality testing and end-game scoring in the broad ocean area. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** There were no significant changes between FY 2022 and FY 2023.			
Accomplishments/Planned Programs Subtotals	15.420	11.209	12.180

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603941D8Z / *Test and Evaluation Science and Technology*	Project (Number/Name) 095 / *Directed Energy Test*	

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
095: *Directed Energy Test*	82.937	7.800	21.568	11.322	-	11.322	11.475	11.705	11.950	12.188	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Department of Defense (DoD) is exploring the military utility, safety, and suitability of directed energy weapons. A robust test capability to assess directed energy weapons is essential to understanding their effectiveness and limitations, including determining their effectiveness in performing counter improvised explosive device (C-IED) operations and counter UAS operations. Such assessments will depend upon knowledge acquired through the test and evaluation (T&E) of directed energy technologies and testing of operational concepts. Directed energy weapon technologies, primarily consisting of high energy lasers (HEL) and high powered microwaves (HPM), are outpacing available test capabilities. Traditional test techniques for evaluating conventional munitions (with flight times ranging from seconds to minutes) are not sufficient for the T&E of directed energy weapons that place energy on target instantaneously. Consequently, new test technology solutions are needed to ensure that adequate developmental, live-fire, and operational test capabilities are available when directed energy programs are ready to test.

Directed energy system and component testing requires three principal assessments: (1) energy or power on target; (2) the effects on the target; and (3) the propagation of the directed energy to the target through the atmosphere. In addition, the vulnerabilities of DoD systems to directed energy threats are required to be characterized, such as those requirements captured in Military Standard (MIL-STD)-464C. Equally as important, current test capabilities do not provide the detailed data required to understand U.S. directed energy system performance and effects. The technology development efforts within the Directed Energy Test (DET) project have been prioritized to align with DoD guidance on science and technology priority investments. As such, the DET project is developing the technologies necessary for quantitative assessment of United States (U.S.) HEL and HPM performance, as well as the vulnerability of DoD weapon systems to enemy directed energy threats.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Directed Energy Test	7.800	21.568	11.322
Description: The DET project continued efforts to measure HEL energy on small targets such as mortars, rockets, artillery, and UAS. The effort designed a recoverable mortar prototype to address Army and Navy requirements and an Air Force requirement for a missile-mounted target board. The DET project continued efforts to develop M&S capability for assessing effects of threat HEL systems on blue aircraft. The DET project completed efforts to mature a dense plasma focus technology to produce strategically relevant, ultra-short pulse neutron fluence levels for nuclear vulnerability testing. The DET project successfully demonstrated neutron production and dense plasma focus technology development continues to be optimized to support neutron production rates scalable to a test facility to be developed by the Central Test and Evaluation Investment Program (CTEIP). A larger chamber was integrated into the facility to test obtaining higher			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 095 / *Directed Energy Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: The DET project will continue developments in HEL test technologies and HPM test technologies to characterize the performance and effectiveness of HEL and HPM systems as they engage small targets, such as enemy rockets, missiles, artillery, and unmanned aerial vehicles, as well as electronic systems and other targets of interest and expand into larger UAS classes. This will include sensor and associated data collection systems that can survive an HPM environment. DET will complete atmospheric modelling work that will allow the development of HEL predictive atmospheric propagation. DET will complete developing wide band HPM sources for assessing the performance of US systems in a hostile HPM environment. The DET project will continue the development of software and measurements to assess the survivability of DoD aircraft against HEL threats. DET will invest in aero-optics effects characterization tools. DET will invest in lower noise, broader band E-field measurement sensors for HPM characterization. DET will continue development and transition of capability at the High Energy Laser Systems Test Facility (HELSTF) to engage missile targets for a demonstration in late 2022. FY 2022 Congressional addition initiate efforts to develop required instrumentation on the missile and sUAS target to assess High Power Microwave (HPM) effects. Upgrades will also include development of off-board sensors that can assess the performance of the HPM weapon system's detection, identification, tracking, fire control, and battle damage assessment. Upgrades will enable mobile, relocatable testing infrastructure (whereas currently HPM test facilities can only support static testing). Upgrades will also focus on the development and employment of validated models of HPM effects to accurately predict the effects of HPM on missile and sUAS systems and embedded electronics. Validated models are needed to inform HPM waveform developers as they optimize the HPM effect on target. ***FY 2023 Plans:*** The DET project will continue developments in HEL test technologies and HPM test technologies to characterize the performance and effectiveness of HEL and HPM systems as they engage small targets, such as enemy rockets, missiles, artillery, and unmanned aerial vehicles, as well as electronic systems and other targets of interest and expand into larger UAS classes. This will include sensor and associated data collection systems that can survive an HPM environment. Finally, the DET project will continue development of HELSTF capability to engage missile targets for a demonstration in FY 2023 against supersonic targets. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** FY 2022 to FY 2023 decrease reflects FY 2022 congressional addition of $11M to upgrade directed energy lab and test range infrastructure.			
Accomplishments/Planned Programs Subtotals	7.800	21.568	11.322

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 095 / *Directed Energy Test*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603941D8Z / *Test and Evaluation Science and Technology*	Project (Number/Name) 096 / *C4I & Software Intensive Systems Test*	

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
096: *C4I & Software Intensive Systems Test*	129.746	14.610	12.128	13.088	-	13.088	13.246	13.511	13.794	14.070	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Command, Control, Communications, Computers, Intelligence (C4I) and Software Intensive Systems (SIS) (C4T) project addresses test technology gaps in the rapid advancement of C4T warfighting systems. The C4T technology gaps are driven by the more complex environments and distributed systems (e.g. Anti-Access Arial Denial (A2AD); Manned and Unmanned Systems (MUM-T)); big data and intelligence (e.g. Artificial General Intelligence (AGI) and Machine Learning Algorithms (MLA)); and more software intensive systems (e.g. F-35). The technology development efforts within the C4T project have been prioritized to align with DoD guidance on S&T Communities of Interest (CoIs) and the National Defense Strategy. The C4T is developing technologies, including leveraging advancements in machine learning, to analyze and evaluate the increasing mass of structured and unstructured data generated by C4I and SIS testing. The technologies are required when testing sensor platforms, command and control systems and weapon platforms that support the kill chain in a Joint operation. These systems must be evaluated for their ability to provide the accurate, timely transfer of data (e.g. target tracks, weapons allocation, mission tasking, and situational awareness) as the data passes among the Services and coalition participants. The technologies within C4T will remove undesired distributed testing biases while improving test agility and the tester's ability to effectively support knowledge management, rapid analysis of "Big Data," and automated test reporting. The C4T project advances test technologies for next generation resilient, survivable, federated networks and information ecosystems (information superiority) from the tactical level up to strategic planning; as well as Big Data collection, analysis, and visualization that enable the virtual integration of Department of Defense (DoD) weapon laboratories and open air ranges. Using Modeling and Simulation (M&S) along with hardware-in-the-loop (HWIL) laboratories, the effectiveness of Joint missions can be assessed in terms of system-of-systems interoperability and effectiveness in executing Joint mission operations, including testing of weapons and C4I and SIS systems accessing and providing information.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: C4I and Software Intensive Systems Test	14.610	12.128	13.088
Description: The C4T project completed development of AI technologies in multiple areas of "Big Data" rapid analytics of large structured and unstructured datasets in support of F-35 Test and Evaluation (T&E). This includes developing technology that employs unsupervised machine learning to assist humans to analyze, extract, & manage actionable knowledge from many varied large data sets (not just F-35); using Human-Like reasoning to identify insights from structured and unstructured data; enable distributed testers to use shared knowledge to identify critical test information. This effort transitioned to the JSF Joint Program Office and Edwards AFB Test Pilot School. The C4T project completed development of M&S technologies to support real-time assessments of torpedo performance in complex undersea environments, specifically for shallow water (<50 meters). These technologies provide an acoustic propagation model for both narrow and broad band, of sufficient fidelity to be used for the next generation of torpedo development as well as			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 096 / *C4I & Software Intensive Systems Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
testing torpedo performance in various maritime tactical environments that cannot be assessed with live in-water testing. The model includes a real-time simulation/emulation system for design and testing the next generation of torpedo sonar systems in multiple bathometry, biological and threat environments. This effort transitioned to naval undersea weapons and unmanned vehicle programs. The C4T project completed development of a network M&S to achieve configuration optimization of test support networks. Technologies included planning expeditionary tests, managing bandwidth and spectrum contention with a networked system under test, managing power consumption providing a continuous re-planning capability. These technologies will address deficiencies in Army Operational Test (OT) for network-enabled technologies to support the Operational Test Command at Ft. Hood, Texas. The C4T project initiated the development of several big data analytics (BDA) efforts implementing artificial intelligence/ machine learning (AI/ML) techniques for multi-variant time series sensor datasets, unstructured dataset analytics (audio, video, and imagery), and advanced visualization of large T&E datasets. These efforts include: traditional statistical and machine learning techniques to deal with massive complex datasets; containerized microservices architecture to support systemic analysis utilizing advanced analytics (ML/AI algorithms); advanced data synchronization and fusion framework and services allowing users to correlate and assess multivariate data types for operational test analysis; cloud-based microservices framework to speed synchronization of text format outputs by ML models and accompanying metrics on precision and recall for audio, video, and imagery large T&E datasets; collection, analysis and visualization of multi-variate data across system lifecycle; advanced visualization techniques; browser-based visualization technology to easily ingest massive data sets from multiple sources, store data locally for enrichment purposes, and export data and analytical products; and browser-based client-server Data Observatory visualization technology that reinvents the presentation of information by abstracting data into particles to optimally exploit current vision and neuroscience research allowing the analyst to receive the most information without focusing on each piece individually. These technologies are being developed to support test and evaluation of future warfighter C4I and Software Intensive Systems (4th and 5th generation military platforms). ***FY 2022 Plans:*** The C4T project will continue the development of several big data analytics (BDA) efforts implementing artificial intelligence/ machine learning (AI/ML) techniques for multi-variant time series sensor datasets, unstructured dataset analytics (audio, video, and imagery), and advanced visualization of large T&E datasets. These efforts will continue work targeted at technologies for analysis of large test databases for the F-35 and will become tailored for use by ranges supporting live testing for the aircraft along with technologies to assist analysts with the reduction of large complex TSPI datasets. These technologies will continue being			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 096 / *C4I & Software Intensive Systems Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
developed to support the test and evaluation of future warfighter C4I and Software Intensive Systems (4th and 5th generation military platforms). ***FY 2023 Plans:*** The C4T project will continue to advance test technology development to enable the next generation resilient, survivable, federated networks and information ecosystems (information superiority) from the tactical level up to strategic planning across three domains: BDA, Live and Simulated Environments, and Test Automation. The C4T project will continue to focus on testing more advanced technologies to assess big data warfighter systems implementing advanced algorithms and computer architectures. The C4T project will investigate the increased use of live and simulated test environments using test environment driven M&S validation techniques. The C4T project will investigate the increased use of test automation utilizing virtualization and cloud environments. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Program Adjustments			
Accomplishments/Planned Programs Subtotals	14.610	12.128	13.088

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603941D8Z / *Test and Evaluation Science and Technology*	Project (Number/Name) 097 / *Autonomy and Artificial Intelligence Test*	

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
097: *Autonomy and Artificial Intelligence Test*	66.149	8.450	11.087	22.742	-	22.742	24.028	30.858	32.752	31.248	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

Unmanned and autonomous systems support every domain of warfare -- operating in space, in air, on land, on the sea surface, undersea, and in subterranean conditions to support a vast variety of missions. The emergence of Artificial Intelligence (AI) brings a host of revolutionary capabilities that will profoundly influence warfare, and bring special challenges for testers of Artificial Intelligence systems. The Unmanned Autonomous System Test (UAST) project addresses current and emerging challenges associated with the test and evaluation (T&E) of unmanned systems, particularly in testing autonomy, artificial intelligence, and machine learning. As such, the UAST project is developing test technologies to simulate, stimulate, instrument, measure, and assess an autonomous system's ability to perceive its environment, process information, adapt to dynamic conditions, make decisions, and effectively act on those decisions in the context of mission execution.

The AAIT project will provide the test technologies to effectively measure performance and characterize risk, thereby increasing warfighter trust in autonomous systems and artificial intelligence tools. The current DoD test capabilities and methodologies are insufficient to address the testing of increasingly autonomous units operating in unstructured, dynamic, battlespace environments. Furthermore, advancements are being made in developing collaborating, system-of-autonomous-systems that will work in concert as a swarm or pack, and in close proximity with humans. New test technologies are needed to stress the collective set of autonomous systems under realistic conditions, predict emergent behavior of autonomous systems, emulate the complex environment, and assess mission performance of these highly-coupled and artificially-intelligent systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Autonomy and Artificial Intelligence Test	8.450	11.087	22.742
Description: The AAIT Project continued test technology development supporting the DoD Unmanned Systems such as, integrating the DoD unmanned systems within the National Airspace and safely operating unmanned aerial systems within the Major Range and Test Facility Bases (MRTFB). The AAIT project collaborated with the Autonomy Community of Interest (COI) Test and Evaluation, Verification and Validation (TEVV) Working Group to ensure that the AAIT project is investing in technologies relevant to the future of autonomous systems. The AAIT Project seeks solutions for legacy topics (test planning, test execution, safety, and performance assessment) but has also expanded our interest to ensure solutions for Artificial Intelligence and Machine Learning systems, topics identified by the intelligence community, and any other topics that are priority for TRMC and OUSD(R&E). The AAIT project continued the Assured DevSecOps of Autonomous Systems (ADAS) effort. ADAS addresses the unique challenges of Autonomy test & evaluation to provide enterprise solutions in support of future programs and joint initiatives. ADAS			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
addresses autonomy test and evaluation verification and validation (TEV&V) needs across the life cycle beginning with mission analysis and engineering and ending with the mission operations. ADAS is a leading pathfinder effort to address gaps identified by the National Security Commission on Artificial Intelligence. The AAIT Project continued investments in robustness testing technology to detect and predict safety-related vulnerabilities and failures within UAS software. The AAIT project is risk reducing Autonomy, Integration, and Teaming (AIT) test capability development, by providing autonomy test tools to be demonstrated on the Airborne Collision Avoidance System (ACAS-Xu) on Triton, and to test the Guardian Ground Based Detect and Avoid software, which will allow it to achieve certification for use during live test (DO-278A/NAVAIR Cert). The same technologies are risk reducing Autonomous Systems Test Capability (ASTC) development. The AAIT project used DARPA Collaborative Operations in Denied Environments (CODE) as a test case for this robustness technology, identifying and reporting on safety vulnerabilities found deep within the software, further identifying the conditions required to trigger the safety defects. The AAIT Project completed development of technology to improve test planning for ground and air autonomy using optimization algorithms to rapidly generate salient test scenarios. The integrated autonomy simulation will be used to validate AAIT technologies in the ground domain. New architecture and state-space designs better support multiple domains of autonomy testing. Unmanned Ground Vehicle and Undersea Vehicle domains test technology development will risk reduce the CTEIP autonomous test capability development efforts. The AAIT Project initiated development of technology to create machine-learned, behavioral copies of autonomy software. This technology creates faster-than-real-time versions of a given autonomy that can then be tested in an accelerated timeline in a simulated environment, and can also be cloned to be tested in parallel-processing fashion. This technology will provide faster, better, and more statistically significant testing data for testers. ***FY 2022 Plans:*** The AAIT Project will continue to establish initial operational capability for ground based UAS detect and avoid capability to facilitate integration of UAS testing into federal (manned/unmanned) airspace. The AAIT project will also continue prototyping hardware in the loop test environments for safety of flight for fully autonomous UAS at Edwards AFB, CA. The AAIT project will continue investments in robustness testing technology to detect and predict safety-related vulnerabilities and failures within UAS software. The AAIT Project will continue development of technology to create machine-learned, behavioral copies of autonomy software. ***FY 2023 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 097 / *Autonomy and Artificial Intelligence Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The AAIT Project will initiate technology development to generate relevant synthetic data to train AI algorithms. AAIT will also develop and deploy new test techniques, referred to as data collection at the edge, to automate the collection, storage, tagging, and analysis of data during live DoD test events with systems under test employing autonomy and artificial intelligence algorithms. The AAIT Project will continue to initiate and develop technologies to support test planning, test execution, and performance assessment of unmanned, autonomous, artificial intelligence, and machine learning systems. ADAS will continue to deliver pathfinding solutions of transformational capabilities addressing the full spectrum of TEV&V needs. AAIT will continue to transition technologies to end users at the labs and ranges of the MRTFB. AAIT will continue to risk reduce test capability development. AAIT will investigate concepts to verify the autonomy design models against design requirements using formal methods, and a Test-Case Execution Environment based on AI-guided Testing, using machine-learning in the test planning process to make recommendations of test conditions for evaluation of machine learning image classifiers. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** FY 2023 funding increase reflects improving test tools and algorithms for trusted artificial intelligence (AI) and autonomous systems to accelerate initiatives in partnership with the Joint Artificial Intelligence Center.			
Accomplishments/Planned Programs Subtotals	8.450	11.087	22.742

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603941D8Z / *Test and Evaluation Science and Technology*	Project (Number/Name) 098 / *Cyberspace Test*	

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
098: *Cyberspace Test*	53.361	14.710	13.348	14.431	-	14.431	14.707	15.000	15.315	15.620	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Department of Defense (DoD) ability to use cyberspace for rapid communication and information sharing in support of operations is a critical enabler of DoD military missions. Advancements in utilizing cyberspace are outpacing the technologies needed for test and evaluation (T&E). The Cyberspace Test Technology (CTT) project develops advanced technologies and methodologies to test and evaluate DoD capabilities and information networks to defend and conduct full-spectrum military operations across cyberspace. Current cyberspace T&E capabilities are insufficient to support the continual experimental, contractor, developmental, operational, and live-fire testing requirements of warfighter systems operating in cyberspace. Many of the test tools and infrastructure items required for systems in cyberspace will require advancement and maturation of nascent test technologies. The CTT project will address test technology shortfalls in cyberspace testing, including planning cyberspace tests, creating representative cyberspace threats and test environments, executing cyberspace tests, and performing cyberspace test analysis and evaluation.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Cyberspace Test	14.710	13.348	14.431

Description: The CTT project continued development of technologies to detect, monitor, and analyze malware behavior during cyber-attacks in a virtualized T&E environment. This technology development works to enable analysis and threat assessments to understand impacts to systems under test. The CTT project continued development of a capability to systemically verify (attest) that all persistent storage in an aircraft's avionics subsystems have not been altered. This technology development works to ensure that a weapon system has not been modified by malicious action or legitimate cyber T&E activities.

The CTT project is developing a next generation Traffic Generation and Content System that uses modern Artificial Intelligence techniques and detailed network, human social, and work flow models to generate traffic. This technology development works to ensure host and network traffic that is easily distinguished from human generated traffic. The CTT project is developing the novel capability to fuzz target's virtual machine state. This technology enables exploring an entirely new class of attacks compared to existing fuzzers which fuzz only the program inputs. The CTT project is developing a framework to provide the red team and other DoD test organizations an automated attack capability. This technology development enables red team personnel to focus on more challenging problems and other test organizations to conduct automated testing.

FY 2022 Plans:

The CTT project will continue to develop test technology addressing needs in Cyber-Physical Systems, in Tactical Edge Networks, and in Enterprise Information Systems. The CTT project will continue development of cyber test tools enabling black-box fuzzing

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 098 / *Cyberspace Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
of arbitrary software in a virtualized environment. The CTT project will complete the development of a test technology capable of verifying that an aircraft's avionics have not been altered from a cyber attack. CTT will continue developing test tools and architectures to provide cyber red teams and other DoD cyber test organizations an automated attack capability. The CTT project will continue to develop a new traffic generation and content system that uses modern techniques to generate traffic realistic network traffic. ***FY 2023 Plans:*** The CTT project will continue to pursue technology developments addressing needs in Cyber-Physical Systems, in Tactical Edge Networks, and in Enterprise Information Systems. This includes the development of tools to measure the efficacy of cyber testing events and share anonymized results for all DoD testing. CTT also plans to develop more tools for red team automation. In addition CTT plans to demonstrate the new traffic generation and content system in a relevant test environment. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Program Adjustments.			
Accomplishments/Planned Programs Subtotals	14.710	13.348	14.431

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603941D8Z / *Test and Evaluation Science and Technology*	Project (Number/Name) 099 / *Space Test*	

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
099: *Space Test*	0.000	0.000	43.500	0.725	-	0.725	0.830	0.908	1.142	1.165	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

As a new start in FY 2022, the Space Test project mission is to address national test capability gaps by providing accurate, robust, and efficient T&E solutions to successfully develop, validate, and inform the employment of new space control systems. The space domain has become a competitive, congested, and contested environment dominated by global economics and key to national security. The Department of Defense (DoD) is prioritizing investments to maintain space superiority and increase resiliency of legacy space systems as well as new space control systems. Current developments focus on deploying capabilities and systems to deter aggression and maintain freedom of action in space for the US, allies, and partner nations. Current testing infrastructure and methodologies to assess space system resilience against emerging threats is limited. The Space Test project addresses test technology needs for adequate realism for space systems and aligns with the DoD S&T priority investments. The Space Test project is developing a strategic roadmap and investment strategy to establish live and virtual range environments, develop space and ground-based threat emulation capabilities. The Space Test project develops technologies to enable robust, accurate, and timely T&E of future space weapon systems, and to ensure system suitability and survivability. Current test resource capability and capacity preclude accurate determination of future space system lethality and survivability.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Space Test	0.000	43.500	0.725

Description: The Space Test (ST) project is conducting a test infrastructure gap analysis on the needs of testing space systems and is developing a time-phased investment strategy based on those requirements. Work includes engaging the space test community on needs and gaps to ensure traceability of test technology development to strategic objectives.

FY 2022 Plans:

Stand up a Space Test project within the T&E/S&T Program to pursue technology developments addressing test technology needs in Space Systems across DoD and National Organizations. The Space Test project will identify test technology needs from the Space T&E investment roadmap. The Space Test project will also initiate the detailed design of a prototype space based telemetry system to support long range flight test objectives and data collection needs.

FY 2022 Congressional addition of $43M will initiate efforts to upgrade space test facilities with new test technologies enabling space systems to be more reliably and accurately tested on the ground prior to launch. The project will also upgrade capabilities to validate space domain awareness enhancements, as well as capabilities to support dedicated tracking and imaging of systems as part of the development of a National Space Test and Training Complex. There is no live space range for test analogous to test ranges for other warfighting domains, and the ability to have instrumentation to track space range activity is foundational to a

Exhibit R-2A, RDT&E Project Justification: PB 2023 Office of the Secretary Of Defense		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603941D8Z / *Test and Evaluation Science and Technology*	**Project (Number/Name)** 099 / *Space Test*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
test range capability. These upgrades support the acceleration and validation of critical enabling technologies to improve space domain awareness and resiliency in the contested space environment. ***FY 2023 Plans:*** The Space Test project will begin to address test technology needs identified in the Space T&E investment roadmap and time-phased investment strategy. Continued design and initial development of a space based telemetry system to support long rang flight test needs will continue. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** FY 2022 to FY 2023 decrease reflects FY 2022 congressional addition of $43M to upgrade space ground testing facilities and to upgrade space test lab and range infrastructure.			
Accomplishments/Planned Programs Subtotals	0.000	43.500	0.725

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A