Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Army											Date: February 2020	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602150A *I Air and Missile Defense Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2019**	**FY 2020**	**FY 2021 Base**	**FY 2021 OCO**	**FY 2021 Total**	**FY 2022**	**FY 2023**	**FY 2024**	**FY 2025**	**Cost To Complete**	**Total Cost**
Total Program Element	-	0.000	95.771	56.298	-	56.298	51.609	41.272	41.729	42.006	0.000	328.685
AC9: *High Energy Laser Tactical Vehicle Demonstrator Te*	-	0.000	11.114	9.349	-	9.349	0.000	0.000	0.000	0.000	0.000	20.463
AD2: *High Energy Laser (HEL) Enabling and Support Techn*	-	0.000	7.963	10.113	-	10.113	8.278	8.444	8.538	8.539	0.000	51.875
AD3: *Maneuver Air Defense Technology*	-	0.000	4.200	13.227	-	13.227	10.264	2.304	3.564	5.825	0.000	39.384
AD5: *Next Generation Fires Radar Technology*	-	0.000	9.256	5.336	-	5.336	5.421	3.961	4.005	4.005	0.000	31.984
AD7: *Missile Fire Control Sensors Technology*	-	0.000	1.608	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	1.608
AD9: *Close Combat High Energy Laser Technology*	-	0.000	7.357	8.696	-	8.696	20.354	21.009	21.244	21.457	0.000	100.117
AE2: *Unconventional Countermeasures-Survivability Tech*	-	0.000	5.756	6.588	-	6.588	3.976	2.160	2.180	2.180	0.000	22.840
AE4: *Collaborative ISR Sensors Technology*	-	0.000	3.517	2.989	-	2.989	3.316	3.394	2.198	0.000	0.000	15.414
BN6: *Advanced Weapons Components (CA)*	-	0.000	45.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	45.000

Note

In Fiscal Year (FY) 2020, this Program Element (PE) was realigned with continuity of effort from the following PEs:
* 0602120A Sensors and Electronic Survivability
* 0602303A Missile Technology
* 0602307A Advanced Weapons Technology
* 0602705A Electronics and Electronic Devices
* 0602784A Military Engineering Technology

Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Army	Date: February 2020
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*

A. Mission Description and Budget Item Justification

Work in this PE investigates and develops Air and Missile Defense (AMD) technologies to enable defense of ground forces and selected geopolitical assets from aerial attack, missile attack, and surveillance. Major focus areas for AMD Science and Technology include: Missiles, Directed Energy, Gun-Based Air Defense Technologies, and Battlefield Sensors and Supporting AMD Technologies. Missiles Applied Research investigates and develops a broad range of Missile technologies to enhance Army integrated AMD capabilities at extended range. Directed Energy Applied Research investigates and develops critical High Energy Laser (HEL) technologies to explore performance against Air Defense threats and for other Directed Energy applications across Army Modernization Priorities. Gun-Based Air Defense Technologies Applied Research investigates and develops Combined Arms for Air Defense (CAFAD) technologies and components in a laboratory environment. Sensors and Supporting AMD Technologies Applied Research investigates and develops Battlefield Sensor and radar technologies required for detection, acquisition and tracking of air defense targets as well as supporting technologies that enhance AMD.

Work in this PE complements PE 0603466A (Air and Missile Defense Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work is performed by the United States Army Futures Command (AFC), the United States Army Space and Missile Defense Command/Army Strategic Forces Command (SMDC/ARSTRAT), and the United States Army Rapid Capabilities and Critical Technologies Office (RCCTO).

B. Program Change Summary ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	0.000	50.771	58.558	-	58.558
Current President's Budget	0.000	95.771	56.298	-	56.298
Total Adjustments	0.000	45.000	-2.260	-	-2.260
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	45.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• Adjustments to Budget Years	-	-	-2.260	-	-2.260

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2019	FY 2020
Project: BN6: *Advanced Weapons Components (CA)*		
Congressional Add: *Sustainable Energy Materials and Manufacturing*	-	12.000
Congressional Add: *High-Energy Laser Hardware in the Loop*	-	20.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Army	Date: February 2020
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602150A *I Air and Missile Defense Technology*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2019	FY 2020
Congressional Add: *COE in High-Energy Laser and Optical Technology*	-	3.000
Congressional Add: *Cybersecurity and Supply Chain Risk Management*	-	10.000
Congressional Add Subtotals for Project: BN6	-	45.000
Congressional Add Totals for all Projects	-	45.000

Change Summary Explanation

FY20 increase related to FY20 Congressional Adds.

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602150A / *Air and Missile Defense Technology*	Project (Number/Name) AC9 / *High Energy Laser Tactical Vehicle Demonstrator Te*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
AC9: *High Energy Laser Tactical Vehicle Demonstrator Te*	-	0.000	11.114	9.349	-	9.349	0.000	0.000	0.000	0.000	0.000	20.463

Note

In Fiscal Year 2020 (FY20) this Project was realigned from:
Program Element (PE) PE 0602307A Advanced Weapons Technology
* Project 042 High Energy Laser Technology

A. Mission Description and Budget Item Justification

This Project investigates component technologies for mobile high energy laser (HEL) weapon systems in solid state lasers (SSL) for use in protecting fixed and semi-fixed sites from Rocket, Artillery, and Mortars (RAM), Unmanned Aerial Systems (UAS) and advanced Air Defense threats. The Project researches advanced technologies for HEL weapon systems to enable more efficient laser systems with significantly greater power output for future HEL weapons to augment current kinetic Air Defense Artillery (ADA) systems and address additional missions with a low cost-per-kill exchange ratio. This includes technologies to support development of alternate laser sources, precision optical pointing and tracking components and adaptive optics to overcome laser degradation due to atmospheric effects to gain great lethality permitting expansion of threats set. Additionally development of compact and lighter weight energy generation and storage devices, and more efficient thermal management systems to remove excess heat will permit integrating laser weapons on additional combat platforms.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AD1 (High Energy Laser Tactical Vehicle Demonstrator Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy and supports the Army's future capability opportunities for leap-ahead technology for directed energy.

Work is performed by the United States (US) Army Rapid Capabilities and Critical Technologies Office (RCCTO).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: High Energy Laser Tactical Vehicle Demonstrator Technology	-	11.114	9.349
Description: This effort develops technologies for robust beam control and SSL subsystems in the HEL Tactical Vehicle Demonstrator (TVD). Technologies developed under this effort will enable lighter, more agile beam control systems for tactical Army platform development and SSL technologies that enhance effectiveness against emerging air defense threats and increase efficiencies, enabling reductions in size, weight and power (SWaP) and improving the ability to integrate SSL systems into multiple Army weapon platforms.			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AC9 / *High Energy Laser Tactical Vehicle Demonstrator Te*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
FY 2020 Plans: Will complete development of the gimbal, telescope and main optics bench for the HEL TVD beam control system; Will utilize knowledge/design from FY19 Adaptive Optics component demonstration and incorporate state-of-the-art optical focal planes to extend effectiveness of laser system in challenging environments to make the HEL TVD beam control system more robust; Will prepare beam control subsystem for integration with other subsystems in the system integration laboratory; Will complete development of the 100 kW laser subsystem for the HEL TVD; Will prepare laser system for integration with beam control, power and thermal subsystems in the system integration laboratory. ***FY 2021 Plans:*** Will conduct experimentation with prototype HEL TVD surrogate beam control system to characterize the performance of the base design: assess Adaptive Optics (AO) component demonstration and incorporate state-of-the-art optical focal planes to extend effectiveness of laser system in challenging environments to inform the HEL TVD beam control system design; Will prepare beam control subsystem for integration with other subsystems in the system integration laboratory; Will continue investigation, modeling & simulation, assessment, and development of laser subsystems (e.g. laser sources, power and thermal subsystems) necessary for defeat of emerging and advanced air defense threats for the HEL TVD. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funds moved within this PE to Project AD2 (High Energy Laser Enabling and Support Technology) in order to further develop the Mobile Beam Control Systems Integration Laboratory (MBC SIL).			
Accomplishments/Planned Programs Subtotals	-	11.114	9.349

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602150A / *Air and Missile Defense Technology*	Project (Number/Name) AD2 / *High Energy Laser (HEL) Enabling and Support Techn*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
AD2: *High Energy Laser (HEL) Enabling and Support Techn*	-	0.000	7.963	10.113	-	10.113	8.278	8.444	8.538	8.539	0.000	51.875

Note

In Fiscal Year 2020 (FY20) this Project was realigned from:
Program Element (PE) 0602307A Advanced Weapons Technology
* Project Code 042 High Energy Laser Technology
PE 0602705A Electronics and Electronic Devices
* Project EM8 High Power And Energy Component Technology

A. Mission Description and Budget Item Justification

This Project conducts static and dynamic High Energy Laser (HEL) vulnerability and lethality analyses and investigates advanced component technologies to enhance performance of future HEL weapons systems against advanced threats. In addition, this Project includes laboratory efforts for HEL applied research as well as concepts analysis for Army core competencies in directed energy. This Project also investigates advanced laser technologies based on unconventional solid-state laser concepts, architectures, and thermal/power management schemes for the development of low size, weight, and power (SWaP) Army directed energy (DE) weapons and tactical laser developers.

Work in this effort compliments other Army Directed Energy efforts conducted under PE 0602150A (Air and Missile Defense Technology) and PE 0603466A (Air and Missile Defense Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, the Army Modernization Strategy, and supports the Army's future capability opportunities for leap-ahead technology for directed energy.

Work is performed by the United States Army Space and Missile Defense Command - Technical Center (USASMDC-TC) and the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: High Energy Laser Enabling and Support Technology	-	6.774	8.032
Description: This effort provides the underlying data for future high energy laser weapons to effectively engage an array of threats. The data includes prioritized aim points on each threat as well as time to defeat the threats for each aim point. This activity includes the full spectrum of target lethality investigations and engagement of flying targets in relevant scenarios. This activity is primarily executed at the Solid State Laser Testbed (SSLT) facility at White Sands Missile Range, New Mexico. This effort also focuses on developing core Army expertise through laser and beam control technology assessments, applied research and			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AD2 / *High Energy Laser (HEL) Enabling and Support Techn*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
other technical core competencies.This effort focuses on developing in-house expertise in Adaptive Optics (AO), Beam Control, laser diodes, target illuminators lasers and beacon illuminator lasers, laser diagnostics and new tracking algorithms. These technologies can be integrated into the High Energy Laser Tactical Vehicle Demonstrator (HEL TVD), and the Multi Mission High Energy Laser (MMHEL), or future laser systems to locate, identify and engage critical targets. Results of this research may reduce the SWaP requirements, and the efficacy of laser weapons systems on Army platforms in the future. ***FY 2020 Plans:*** Will complete an assessment of rocket, artillery and mortar (RAM) fuzes vulnerability to laser weapons; Will complete vulnerability modules and lethality database inputs for Groups 1, 2, and 3 Unmanned Aerial Systems. Will continue development of lethality data base input for RAM threats supporting HEL TVD and MMHEL. Will begin data collection on vulnerability of manned fixed- and rotary-wing aircraft components. ***FY 2021 Plans:*** Will conduct experiments to inform fixed wing threat assessment and develop defeat methodologies; will begin preliminary assessment of high energy laser effectiveness against Anti-Tank Guided Missile threats; will continue development of lethality database for RAM threats supporting the Maneuver - Short Range Air Defense (M-SHORAD) mission. Continue to evaluate and conduct experiments with advanced AO algorithms for deep turbulence atmospheric conditions. Integrate the Enhanced Tracking Sensor for Acquisition Tracking onto the MBC SIL for dynamic experiments. Complete Candidate Sensor Technology analysis for HEL Fine Tracking and Aimpoint designation in a pulsed illuminator and gated sensor configuration. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Resources realigned in FY21 to increase focus on laser defeat techniques against Anti-Tank Guided Missile threats.			
Title: High Energy Laser Enabling Technologies for Tactical Directed Energy Weapons	-	1.189	2.081
Description: Research novel solid-state laser concepts, architectures, and components in support of the Army?s HEL weapons strategy; exploit breakthroughs in laser technology, develop and employ innovative laser gain material, and utilize photonics to meet the stringent weight/volume requirements for Army platforms, especially to enhance and improve the generation, transmission, and reception of lasers. ***FY 2020 Plans:*** Will investigate advanced ?crystalline core/crystalline cladding? designs (a.k.a. CCCC = C4) to enable single transverse mode HEL with single fiber laser power scaling potential 10X over the current state of the art; will explore directly diode-cladding pumped			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AD2 / *High Energy Laser (HEL) Enabling and Support Techn*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Raman fiber laser architectures enabling power scaling out of a single fiber laser for 10X improvement over the current state of the art; and will conduct feasibility experiments of optical-phased arrays to beam steer and condition the phase of laser emissions. ***FY 2021 Plans:*** Will investigate the potential of true-continuous wave fiber laser power scaling with crystalline core/crystalline cladding fibers; will investigate power scaling potential of directly diode-cladding pumped Raman fiber laser. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Resources realigned in FY21 to increase and accelerate focus on advanced fiber laser technologies.			
Accomplishments/Planned Programs Subtotals	-	7.963	10.113

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602150A / *Air and Missile Defense Technology*	Project (Number/Name) AD3 / *Maneuver Air Defense Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
AD3: *Maneuver Air Defense Technology*	-	0.000	4.200	13.227	-	13.227	10.264	2.304	3.564	5.825	0.000	39.384

Note

In Fiscal Year 2020 (FY20) this Project was realigned from:
Program Element (PE) 0602303A Missile Technology
* Project 214 Missile Technology

A. Mission Description and Budget Item Justification

This Project directly supports Army Modernization Priority Air and Missile Defense capabilities by investigating and developing critical missile technologies and components necessary for an affordable short range air defense interceptor capability to defeat Cruise Missile (CM), Rotary Wing (RW), Tactical / Lethal Unmanned Aerial System (UAS), and Fixed Wing (FW) threats. This effort also designs and develops technologies to provide reduced size weight and power and cost for Maneuver Short Range Air Defense (MSHORAD), Short Range Air Defense (SHORAD), and Lower Tier essential to maintain overmatch against mid-/far-term threats.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AD4 (Maneuver Air Defense Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Maneuver Air Defense Technology	-	4.200	10.994
Description: Investigates and develops critical missile technologies and components necessary for an affordable short range air defense interceptor capability to defeat RW, Tactical / Lethal UAS, and FW threats.			
FY 2020 Plans: Will conduct MSHORAD trade studies to develop the system concept and derive system level requirements for interceptor sub-systems; will determine the optimum launcher configuration to maximize magazine depth on a maneuver platform; Investigate and develop critical missile technologies and components that support the development of an interceptor capability for the MSHORAD requirement; and evaluate application of common guidance electronic unit and low cost RF seeker. Characterization of threat signatures and develop Hardware In the Loop (HWIL) techniques to emulate them.			
FY 2021 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AD3 / *Maneuver Air Defense Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Will continue development of critical missile technologies for detection and tracking of hovering RW targets; will develop and investigate an active radar seeker with integrated warhead fuzing capabilities through HWIL techniques for emulating hovering RW targets and other large MSHORAD targets in a laboratory environment. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Increase in funding required to develop, fabricate, integrate and validate technologies in laboratory and HWIL environments.			
Title: Future Air Defense Missile Enabling Technology ***Description:*** Designs and develops reduced cost advanced Air Defense missile critical components essential to maintain overmatch against Mid/Far term Maneuver-Short Range Air Defense threats. ***FY 2021 Plans:*** Will perform component level trade studies and explore and develop new technologies to address emerging Maneuver-Short Range Air Defense threats and reduce space, weight, power and cost for future Air Defense missile guidance/maneuverability/ control, aerostructures, and propulsion technologies. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Efforts realigned from Project AD7 (Missile Fire Control Sensors Technology) in this PE and focused on future air defense missile component technologies that are essential to engage and defeat increasingly stressing threats at extended ranges.	-	-	2.233
Accomplishments/Planned Programs Subtotals	-	4.200	13.227

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602150A / *Air and Missile Defense Technology*	Project (Number/Name) AD5 / *Next Generation Fires Radar Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
AD5: *Next Generation Fires Radar Technology*	-	0.000	9.256	5.336	-	5.336	5.421	3.961	4.005	4.005	0.000	31.984

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602303A Missile Technology:
* Project 214 Missile Technology
PE 0602120A Sensors and Electronic Survivability
* Project H16 S3I Technology
PE 0602705A Electronics and Electronic Devices
* Project H94 Elect & Electronic Devices

A. Mission Description and Budget Item Justification

This Project directly supports Army Modernization Priority Air and Missile Defense capabilities by investigating and developing advanced radar technologies for insertion into Multi-Mission Army Radar systems. This Project addresses challenges facing simultaneously achieving high linearity and efficiency at high frequencies, accuracy in the underlying high frequency device and circuit models, integration of new material into Silicon complementary metal-oxide-semiconductor (CMOS) processing flows, and electronics reliability that appear as new semiconductor materials are developed and feature sizes shrink.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AD6 (Next Generation Fires Radar Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States Army Futures Command (AFC)

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Advanced Fire Control Radar Technologies	-	4.000	-
Description: This effort develops advanced radar technologies for insertion into Multi- Mission Army Radar systems			
FY 2020 Plans: Will further develop Digital Array Radar technologies; will complete the design and development the full array hardware and begin testing with Radio Frequency (RF) characterization, digital beam forming evaluations, and algorithm and scenario development;			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AD5 / *Next Generation Fires Radar Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
begin implementation of Future Fires Radar open systems architecture back-end processing; will refine and increase capabilities for target identification and discrimination algorithms utilizing threat flight dynamics and multiple sensors. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding decrease due to realignment to support higher priority Army Science and Technology (S&T) efforts.			
Title: Multi-Mode Air Defense Radar ***Description:*** This research supports the technical challenges associated with air defense radar technology. In particular, this effort will analyze current and emerging RF spoofing, RF jamming, and RF signature management technologies to determine their impact on the performance of air defense radars. Electromagnetic modeling, RF measurements, and experiments will be used to identify mitigation techniques for spoofing and jamming, and to identify useful signature management technologies. This will also include research in electronic devices, sub-assembly design, and laboratory experiments to advance the state-of-the-art of air defense radars operating in contested electronic environments. ***FY 2020 Plans:*** Will research techniques and algorithms for the calibration of digital phased array radars and create electromagnetic models of performance; and will assure algorithms are compatible with an existing Army open software architecture in support of air defense radar mission. ***FY 2021 Plans:*** Will develop algorithms for digital radar on laboratory hardware and assess compatibility with Army digital radar designs and testbeds; will develop and model techniques and algorithms for survivable, cognitive, and distributed radar and quantify implications for radar device technology. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding update to reflect project lifecycle status.	-	1.510	1.522
Title: Antennas and RF Device Components for Advanced Electronic Systems ***Description:*** This effort designs, characterizes, and validates high performance antennas, microwave components, and software for multifunction radar, RF sensing, and communication and position/timing systems. Research areas include scanning techniques, broadbanding, beamforming, polarization, platform integration, and affordability. For microwave components, research areas include software defined radios, analog-to-digital conversion rates, bandwidth resolution, bit accuracy, circuit design and affordability. ***FY 2020 Plans:***	-	3.746	3.814

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AD5 / *Next Generation Fires Radar Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Will demonstrate counter-RF jamming algorithms utilizing digital RF hardware; will characterize meta-ferrite antennas for enhanced RF situational awareness; will design and develop antennas, front end technologies, and enabling devices and integrated circuits operating at millimeter wave frequencies (at/near 5G frequencies) to support directional communications; will mature RF microelectromechanical systems (MEMS) components to enable frequency agile operation of tactical communication and next generation fires radar using reconfigurable impedance matching between disparate RF components and antenna tuning; and will explore and develop machine learning techniques and algorithms for RF modulation recognition and target classification. ***FY 2021 Plans:*** Will validate additively manufactured RF antenna arrays for scalability; will validate efficient, multi-band, and survivable high power components and research ultra-wide bandgap semiconductor device technology for meeting power efficiency challenges. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding update to reflect project lifecycle status.			
Accomplishments/Planned Programs Subtotals	-	9.256	5.336

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602150A / *Air and Missile Defense Technology*	Project (Number/Name) AD7 / *Missile Fire Control Sensors Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
AD7: *Missile Fire Control Sensors Technology*	-	0.000	1.608	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	1.608

Note

In Fiscal Year 2020 (FY20) this Project was realigned from:
Program Element (PE) 0602303 Missile Technology:
* Project 214 Missile Technology

In FY21 this Project is realigned to:
PE 06702150A Air and Missile Defense Technology:
* Project AD3 Maneuver Air Defense Technology

A. Mission Description and Budget Item Justification

This Project directly supports Army Modernization Priority Air and Missile Defense capabilities by designing and developing technologies for advancements in next generation fire control sensor technology and target signature modeling.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AD6 (Next Generation Fires Radar Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Missile Fire Control Sensors Technology	-	1.608	-
Description: Design and develop technologies for advancements in next generation fire control sensor technology and target signature modeling.			
FY 2020 Plans: Will continue to develop modulated waveforms for next generation radars and seekers in order to improve target resolution and discrimination for challenging air defense scenarios; will develop engagement planning algorithms to include target identification			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AD7 / *Missile Fire Control Sensors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
and discrimination based on emerging threat information, advanced capabilities of emerging sensors, and future interceptor capabilities. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** FY21 efforts realigned to PE 0602150A (Air and Missile Defense Technology)/Project AD3 (Maneuver Air Defense Technology)			
Accomplishments/Planned Programs Subtotals	-	1.608	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602150A / *Air and Missile Defense Technology*	Project (Number/Name) AD9 / *Close Combat High Energy Laser Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
AD9: *Close Combat High Energy Laser Technology*	-	0.000	7.357	8.696	-	8.696	20.354	21.009	21.244	21.457	0.000	100.117

Note

In Fiscal Year 2020 (FY20) this Project was realigned from:
Program Element (PE) 0062307A Advanced Weapons Technology
* Project 042 High Energy Laser Technology

A. Mission Description and Budget Item Justification

This Project investigates and develops technologies for compact, highly efficient lasers, and compact beam control for close-combat platforms. This project investigates and develops advanced technologies for High Energy Laser (HEL) weapon systems to enable more efficient laser systems with greater power output, which in-turn enables laser weapons on smaller vehicles for additional missions. This includes technologies to support development of alternate laser sources, precision optical pointing and tracking components, adaptive optics to overcome laser degradation due to atmospheric effects, more compact and lighter weight energy generation and storage devices, and more efficient thermal management systems to remove excess heat.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology) / Project AE1 (Close Combat High Energy Laser Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas, and the Army Modernization Strategy, and supports the Army's future capability opportunities for leap-ahead technology for directed energy.

Work is performed by the United States (US) Army Rapid Capabilities and Critical Technologies Office (RCCTO).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Close Combat High Energy Laser Technology	-	7.117	8.696
Description: This effort develops laser and beam control technologies with extremely low size, weight, and power (SWaP) requirements enabling high energy lasers in small, agile close combat platforms. Extremely low SWaP laser systems will expand the laser weapons mission set. Reduction in SWaP also provides for higher power systems on the large tactical vehicles that enable countering the current threat set at longer ranges as well as laser-hardened threats.			
FY 2020 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AD9 / *Close Combat High Energy Laser Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Will continue developing and validating laser and beam control technologies with extremely low SWaP to integrate on a risk-reduction platform. Will begin defining risk-reduction system for data collection and validation of technology suitability for Close-Combat Platform risk reduction effort. ***FY 2021 Plans:*** Will continue developing and validating laser and beam control technologies with extremely low SWaP to integrate on a risk reduction platform. Will conduct modeling & simulation to inform experimentation and conduct experimentation with instrumented risk-reduction platform for collecting and analyzing data for validation of technology and assessing its suitability for a Close Combat Platform risk reduction effort. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Increased cost in FY21 to refine models for CCHEL mission set and completes platform instrumentation and data collection tools that enables the risk reduction demonstration.			
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.240	-
Accomplishments/Planned Programs Subtotals	-	7.357	8.696

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602150A / *Air and Missile Defense Technology*	Project (Number/Name) AE2 / *Unconventional Countermeasures-Survivability Tech*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
AE2: *Unconventional Countermeasures-Survivability Tech*	-	0.000	5.756	6.588	-	6.588	3.976	2.160	2.180	2.180	0.000	22.840

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602784A Military Engineering Technology:
* Project T40 Mob/Wpns Eff Tech

A. Mission Description and Budget Item Justification

This Project designs and develops technologies to deter tactical surveillance and targeting by adversarial area denial systems and munitions. The Project investigates methods to increase survivability of critical assets against precision-guided near-peer advanced weapons threats, investigates and develops tonedown methods for signature management, and computationally develops novel countermeasures. This Project also develops a suite of high-fidelity, physics-based modeling and simulation tools for the design and development of unconventional countermeasures and survivability enhancers applicable to a wide range of operating environments.

Work in this Project complements PE 0603466A (Air and Missile Defense Advanced Technology)/Project AE3 (Unconventional Countermeasures-Survivability Advanced Technology).

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the Engineer Research and Development Center (ERDC) and coordinated with the Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Development of Unconventional Countermeasures for Enhanced Survivability (DeUCES)	-	3.168	4.230
Description: This effort investigates and develops countermeasures to defeat near-peer advanced weapons through computational modeling and enhanced tonedown measures.			
FY 2020 Plans: Complete experiments to develop novel tonedown techniques for critical fixed and semi-fixed assets to include novel application of commercial off the shelf materials.			
FY 2021 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AE2 / *Unconventional Countermeasures-Survivability Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Will conduct experiments to investigate techniques and materials for hyperspectral and tone down response and validate their use on critical assets as either integrated systems or temporary coatings for various environments. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Increased resources required in FY21 as this Science and Technology (S&T) Project builds toward transition from Applied Research to Advanced Technology Development portion of the effort.			
Title: Model-Based Assessment of Sensors and Countermeasures ***Description:*** This effort develops a suite of high-fidelity, physics-based modeling and simulation tools for the design and development of unconventional countermeasures with electro-optical/infrared (EO/IR) sensors for a wide range of operating environments; develops tools for threat detection and object identification using machine learning tools for EO/IR sensors; and builds superior target/threat recognition algorithms. ***FY 2020 Plans:*** Develop sensor models for EO/IR sensors and generate imagery for machine learning tools; will develop and optimize an initial unconventional countermeasure capability. ***FY 2021 Plans:*** Will develop and investigate computational environments for sensor-algorithm performance in a range of simulated environments. These efforts will couple large scale physics based sensor models with high resolution environmental test beds to develop medium-to short-range sensor performance models for guided weapons. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects the planned lifecycle of this effort.	-	2.515	2.358
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.073	-
Accomplishments/Planned Programs Subtotals	-	5.756	6.588

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AE2 / *Unconventional Countermeasures-Survivability Tech*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602150A / *Air and Missile Defense Technology*	Project (Number/Name) AE4 / *Collaborative ISR Sensors Technology*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
AE4: *Collaborative ISR Sensors Technology*	-	0.000	3.517	2.989	-	2.989	3.316	3.394	2.198	0.000	0.000	15.414

Note

In Fiscal Year (FY) 2020 this Project was realigned from:
Program Element (PE) 0602270A Electronic Warfare Technology
* Project 906 Tactical Electronic Warfare Applied Research

A. Mission Description and Budget Item Justification

This Project directly supports Army Modernization Priority Air and Missile Defense capabilities by designing and developing Intelligence, Surveillance, Reconnaissance (ISR) sensors with extended range threat detection and enhanced survivability by cooperative sensing while on-the-move.

Work in this Project complements PE 0603466A Air and Missile Defense Advanced Technology / Project AD6 Next Generation Fires Radar Advanced Technology.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: Collaborative ISR Sensors Technology	-	3.357	2.989
Description: Design and develop ISR sensors with extended range threat detection and enhanced survivability by cooperative sensing while on-the-move.			
FY 2020 Plans: Will investigate techniques and waveforms that enable Multi-Domain Battlefield (Land/Air) operations between platforms with non-traditional Radar sensing. Will research the best technology enablers that provide a Multi- Domain capability while identifying novel techniques to exploit those enablers. Investigate methods that improve platform and sensor survivability against emerging future threats in a spectrally complex environment.			
FY 2021 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army		Date: February 2020
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602150A / *Air and Missile Defense Technology*	**Project (Number/Name)** AE4 / *Collaborative ISR Sensors Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Will continue to develop techniques and waveforms for clutter suppression and synchronization between platforms with non-traditional Radar sensing; will develop algorithms to perform data collections to validate test cases; will research non-traditional Radar sensing; and will continue to research best technology enablers for Multi-Domain Operations capability ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding change reflects the planned lifecycle of this effort.			
Title: FY 2020 SBIR/STTR Transfer ***Description:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 Plans:*** Funding transferred in accordance with Title 15 USC ?638 ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Funding transferred in accordance with Title 15 USC ?638	-	0.160	-
Accomplishments/Planned Programs Subtotals	-	3.517	2.989

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Army			Date: February 2020
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602150A / *Air and Missile Defense Technology*	Project (Number/Name) BN6 / *Advanced Weapons Components (CA)*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
BN6: *Advanced Weapons Components (CA)*	-	0.000	45.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	45.000

Note

Congressional Interest Item funding provided for Advanced Weapons Components.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding provided for Advanced Weapon Components.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020
Congressional Add: Sustainable Energy Materials and Manufacturing	-	12.000
FY 2020 Plans: Sustainable Energy Materials and Manufacturing		
Congressional Add: High-Energy Laser Hardware in the Loop	-	20.000
FY 2020 Plans: High-Energy Laser Hardware in the Loop		
Congressional Add: COE in High-Energy Laser and Optical Technology	-	3.000
FY 2020 Plans: COE in High-Energy Laser and Optical Technology		
Congressional Add: Cybersecurity and Supply Chain Risk Management	-	10.000
FY 2020 Plans: Cybersecurity and Supply Chain Risk Management		
Congressional Adds Subtotals	-	45.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A