Department of Defense
Fiscal Year (FY) 2023 Budget Estimates

April 2022

Defense Advanced Research Projects Agency

Defense-Wide Justification Book Volume 1 of 5

Research, Development, Test & Evaluation, Defense-Wide

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Defense Threat Reduction Agency.....Volume 5

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Department of Defense
FY 2023 President's Budget
Exhibit R-1 FY 2023 President's Budget
Total Obligational Authority
(Dollars in Thousands)

30 Mar 2022

Appropriation	FY 2021 (Base + OCO)	FY 2022 Less Supplementals Enactment	FY 2022 Division B Division C P.L.117-43 Enactment*	FY 2022 Division B P.L.117-70 Enactment**	FY 2022 Division A P.L. 117-86 Enactment***	FY 2022 Division N P.L. 117-103 Enactment****
Research, Development, Test & Eval, DW	3,504,048	3,855,290				12,500
Total Research, Development, Test & Evaluation	3,504,048	3,855,290				12,500

R-123PBP: FY 2023 President's Budget (Total Base Published Version), as of March 30, 2022 at 14:45:28
*Includes enacted funding pursuant to the Extending Government Funding and Delivering Emergency Assistance Act (Public Law 117-43).
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Department of Defense
FY 2023 President's Budget
Exhibit R-1 FY 2023 President's Budget
Total Obligational Authority
(Dollars in Thousands)

30 Mar 2022

Appropriation	FY 2022 Total Supplemental Enactment	FY 2022 Total Enactment	FY 2023 Request
Research, Development, Test & Eval, DW	12,500	3,867,790	4,119,194
Total Research, Development, Test & Evaluation	12,500	3,867,790	4,119,194

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Department of Defense
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(Dollars in Thousands)

30 Mar 2022

Summary Recap of Budget Activities	FY 2021 (Base + OCO)	FY 2022 Less Supplementals Enactment	FY 2022 Division B Division C P.L.117-43 Enactment*	FY 2022 Division B P.L.117-70 Enactment**	FY 2022 Division A P.L. 117-86 Enactment***	FY 2022 Division N P.L. 117-103 Enactment****
Basic Research	506,864	521,360				
Applied Research	1,306,407	1,529,405				
Advanced Technology Development	1,491,510	1,718,640				12,500
Management Support	199,267	85,885				
Total Research, Development, Test & Evaluation	3,504,048	3,855,290				12,500
Summary Recap of FYDP Programs						
Research and Development	3,504,048	3,855,290				12,500
Total Research, Development, Test & Evaluation	3,504,048	3,855,290				12,500

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Department of Defense
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(Dollars in Thousands)

30 Mar 2022

Summary Recap of Budget Activities	FY 2022 Total Supplemental Enactment	FY 2022 Total Enactment	FY 2023 Request
Basic Research		521,360	482,744
Applied Research		1,529,405	1,650,891
Advanced Technology Development	12,500	1,731,140	1,884,054
Management Support		85,885	101,505
Total Research, Development, Test & Evaluation	12,500	3,867,790	4,119,194

Summary Recap of FYDP Programs			
Research and Development	12,500	3,867,790	4,119,194
Total Research, Development, Test & Evaluation	12,500	3,867,790	4,119,194

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(Dollars in Thousands)

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Defense-Wide
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(Dollars in Thousands)

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Appropriation	FY 2021 (Base + OCO)	FY 2022 Less Supplementals Enactment	FY 2022 Division B Division C P.L.117-43 Enactment*	FY 2022 Division B P.L.117-70 Enactment**	FY 2022 Division A P.L. 117-86 Enactment***	FY 2022 Division N P.L. 117-103 Enactment****
Defense Advanced Research Projects Agency	3,504,048	3,855,290				12,500
Total Research, Development, Test & Evaluation	3,504,048	3,855,290				12,500

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Appropriation	FY 2022 Total Supplemental Enactment	FY 2022 Total Enactment	FY 2023 Request
Defense Advanced Research Projects Agency	12,500	3,867,790	4,119,194
Total Research, Development, Test & Evaluation	12,500	3,867,790	4,119,194

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Total Obligational Authority
(Dollars in Thousands)

30 Mar 2022

Appropriation: 0400D Research, Development, Test & Eval, DW

Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Less Supplementals Enactment	FY 2022 Division B Division C P.L.117-43 Enactment*	FY 2022 Division B P.L.117-70 Enactment**	FY 2022 Division A P.L. 117-86 Enactment***	FY 2022 Division N P.L. 117-103 Enactment****	Sec
2	0601101E	Defense Research Sciences	01	449,322	443,842					U
5	0601117E	Basic Operational Medical Research Science	01	57,542	77,518					U
	Basic Research			506,864	521,360					
11	0602115E	Biomedical Technology	02	98,319	108,698					U
17	0602303E	Information & Communications Technology	02	405,789	480,363					U
18	0602383E	Biological Warfare Defense	02	26,082	31,421					U
22	0602702E	Tactical Technology	02	230,211	207,515					U
23	0602715E	Materials and Biological Technology	02	238,215	308,024					U
24	0602716E	Electronics Technology	02	307,791	393,384					U
	Applied Research			1,306,407	1,529,405					
40	0603286E	Advanced Aerospace Systems	03	216,283	194,043					U
41	0603287E	Space Programs and Technology	03	144,463	181,524					U
60	0603739E	Advanced Electronics Technologies	03	92,989	140,716					U
61	0603760E	Command, Control and Communications Systems	03	220,184	251,794					U
62	0603766E	Network-Centric Warfare Technology	03	628,540	655,771				12,500	U

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30 Mar 2022

Appropriation: 0400D Research, Development, Test & Eval, DW

Line No	Program Element Number	Item	Act	FY 2022 Total Supplemental Enactment	FY 2022 Total Enactment	FY 2023 Request	Sec
2	0601101E	Defense Research Sciences	01		443,842	401,870	U
5	0601117E	Basic Operational Medical Research Science	01		77,518	80,874	U
	Basic Research				521,360	482,744	
11	0602115E	Biomedical Technology	02		108,698	106,958	U
17	0602303E	Information & Communications	02		480,363	388,270	U
18	0602383E	Biological Warfare Defense	02		31,421	23,059	U
22	0602702E	Tactical Technology	02		207,515	221,883	U
23	0602715E	Materials and Biological Technology	02		308,024	352,976	U
24	0602716E	Electronics Technology	02		393,384	557,745	U
	Applied Research				1,529,405	1,650,891	
40	0603286E	Advanced Aerospace Systems	03		194,043	253,135	U
41	0603287E	Space Programs and Technology	03		181,524	81,888	U
60	0603739E	Advanced Electronics Technologies	03		140,716	250,917	U
61	0603760E	Command, Control and Communications Systems	03		251,794	305,050	U
62	0603766E	Network-Centric Warfare Technology	03	12,500	668,271	678,562	U

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Line No	Program Element Number	Item	Act	FY 2021 (Base + OCO)	FY 2022 Less Supplementals Enactment	FY 2022 Division B Division C P.L.117-43 Enactment*	FY 2022 Division B P.L.117-70 Enactment**	FY 2022 Division A P.L. 117-86 Enactment***	FY 2022 Division N P.L. 117-103 Enactment****	Sec
63	0603767E	Sensor Technology	03	189,051	294,792					U
		Advanced Technology Development		1,491,510	1,718,640				12,500	
148	0605001E	Mission Support	06	75,246	73,145					U
162	0605502E	Small Business Innovative Research	06	109,867						U
171	0605898E	Management HQ - R&D	06	14,154	12,740					U
		Management Support		199,267	85,885					
Total Research, Development, Test & Eval, DW				3,504,048	3,855,290				12,500	

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Line No	Program Element Number	Item	Act	FY 2022 Total Supplemental Enactment	FY 2022 Total Enactment	FY 2023 Request	Sec
63	0603767E	Sensor Technology	03		294,792	314,502	U
		Advanced Technology Development		12,500	1,731,140	1,884,054	
148	0605001E	Mission Support	06		73,145	86,869	U
162	0605502E	Small Business Innovative Research	06				U
171	0605898E	Management HQ - R&D	06		12,740	14,636	U
		Management Support			85,885	101,505	
Total Research, Development, Test & Eval, DW				12,500	3,867,790	4,119,194	

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5	0601117E	Basic Operational Medical Research Science	01	57,542	77,518					U
Basic Research				506,864	521,360					
11	0602115E	Biomedical Technology	02	98,319	108,698					U
17	0602303E	Information & Communications Technology	02	405,789	480,363					U
18	0602383E	Biological Warfare Defense	02	26,082	31,421					U
22	0602702E	Tactical Technology	02	230,211	207,515					U
23	0602715E	Materials and Biological Technology	02	238,215	308,024					U
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Applied Research				1,306,407	1,529,405					
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Basic Research					521,360	482,744	
11	0602115E	Biomedical Technology	02		108,698	106,958	U
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62	0603766E	Network-Centric Warfare Technology	03	12,500	668,271	678,562	U
63	0603767E	Sensor Technology	03		294,792	314,502	U

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	Advanced Technology Development			1,491,510	1,718,640				12,500	
148	0605001E	Mission Support	06	75,246	73,145					U
162	0605502E	Small Business Innovative Research	06	109,867						U
171	0605898E	Management HQ - R&D	06	14,154	12,740					U
	Management Support			199,267	85,885					
Total Defense Advanced Research Projects Agency				3,504,048	3,855,290				12,500	

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148	0605001E	Mission Support	06		73,145	86,869	U
162	0605502E	Small Business Innovative Research	06				U
171	0605898E	Management HQ - R&D	06		12,740	14,636	U
		Management Support			85,885	101,505	
		Total Defense Advanced Research Projects Agency		12,500	3,867,790	4,119,194	

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Program Element Table of Contents (by Budget Activity then Line Item Number)

Appropriation 0400: Research, Development, Test & Evaluation, Defense-Wide

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5	01	0601117E	BASIC OPERATIONAL MEDICAL SCIENCE	Volume 1 - 39

Appropriation 0400: Research, Development, Test & Evaluation, Defense-Wide

Line #	Budget Activity	Program Element Number	Program Element Title	Page
11	02	0602115E	BIOMEDICAL TECHNOLOGY	Volume 1 - 47
17	02	0602303E	INFORMATION & COMMUNICATIONS TECHNOLOGY	Volume 1 - 57
18	02	0602383E	BIOLOGICAL WARFARE DEFENSE	Volume 1 - 91
22	02	0602702E	TACTICAL TECHNOLOGY	Volume 1 - 95
23	02	0602715E	MATERIALS AND BIOLOGICAL TECHNOLOGY	Volume 1 - 119
24	02	0602716E	ELECTRONICS TECHNOLOGY	Volume 1 - 139

Appropriation 0400: Research, Development, Test & Evaluation, Defense-Wide

Line #	Budget Activity	Program Element Number	Program Element Title	Page
40	03	0603286E	ADVANCED AEROSPACE SYSTEMS	Volume 1 - 167
41	03	0603287E	SPACE PROGRAMS AND TECHNOLOGY	Volume 1 - 177
60	03	0603739E	ADVANCED ELECTRONICS TECHNOLOGIES	Volume 1 - 183
61	03	0603760E	COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS	Volume 1 - 195
62	03	0603766E	NETWORK-CENTRIC WARFARE TECHNOLOGY	Volume 1 - 207
63	03	0603767E	SENSOR TECHNOLOGY	Volume 1 - 225

Appropriation 0400: Research, Development, Test & Evaluation, Defense-Wide

Line #	Budget Activity	Program Element Number	Program Element Title	Page
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162	06	0605502E	SMALL BUSINESS INNOVATION RESEARCH	Volume 1 - 239
171	06	0605898E	MANAGEMENT HQ - R&D	Volume 1 - 243

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Program Element Title	Program Element Number	Line #	BA	Page
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ADVANCED ELECTRONICS TECHNOLOGIES	0603739E	60	03	Volume 1 - 183
BASIC OPERATIONAL MEDICAL SCIENCE	0601117E	5	01	Volume 1 - 39
BIOLOGICAL WARFARE DEFENSE	0602383E	18	02	Volume 1 - 91
BIOMEDICAL TECHNOLOGY	0602115E	11	02	Volume 1 - 47
COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS	0603760E	61	03	Volume 1 - 195
DEFENSE RESEARCH SCIENCES	0601101E	2	01	Volume 1 - 1
ELECTRONICS TECHNOLOGY	0602716E	24	02	Volume 1 - 139
INFORMATION & COMMUNICATIONS TECHNOLOGY	0602303E	17	02	Volume 1 - 57
MANAGEMENT HQ - R&D	0605898E	171	06	Volume 1 - 243
MATERIALS AND BIOLOGICAL TECHNOLOGY	0602715E	23	02	Volume 1 - 119
MISSION SUPPORT	0605001E	148	06	Volume 1 - 237
NETWORK-CENTRIC WARFARE TECHNOLOGY	0603766E	62	03	Volume 1 - 207
SENSOR TECHNOLOGY	0603767E	63	03	Volume 1 - 225
SMALL BUSINESS INNOVATION RESEARCH	0605502E	162	06	Volume 1 - 239
SPACE PROGRAMS AND TECHNOLOGY	0603287E	41	03	Volume 1 - 177
TACTICAL TECHNOLOGY	0602702E	22	02	Volume 1 - 95

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*

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	-	449.322	443.842	401.870	-	401.870	396.555	439.811	447.586	447.640	-	-
CCS-02: *MATH AND COMPUTER SCIENCES*	-	273.633	293.845	224.416	-	224.416	208.185	248.752	264.013	256.785	-	-
ES-01: *ELECTRONIC SCIENCES*	-	28.681	16.361	17.645	-	17.645	29.153	34.178	52.200	52.410	-	-
ES-02: *BEYOND SCALING SCIENCES*	-	57.365	65.145	70.188	-	70.188	58.923	58.940	43.250	53.540	-	-
MS-01: *MATERIALS SCIENCES*	-	53.663	40.303	58.356	-	58.356	82.602	89.818	80.000	76.782	-	-
TRS-01: *TRANSFORMATIVE SCIENCES*	-	35.980	28.188	31.265	-	31.265	17.692	8.123	8.123	8.123	-	-

A. Mission Description and Budget Item Justification

The Defense Research Sciences Program Element is budgeted in the Basic Research Budget Activity because it provides the technical foundation for long-term National Security enhancement through the discovery of new phenomena and the exploration of the potential of such phenomena for Defense applications. It supports the scientific study and experimentation that is the basis for more advanced knowledge and understanding in information, electronic, mathematical, computer, and materials sciences. This Program Element also supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA funded technologies take root in the U.S. and provide new capabilities for national defense.

The Math and Computer Sciences project supports scientific study and experimentation on new mathematical and computational algorithms, models, and mechanisms in support of long-term national security objectives. Modern analytic and information technologies enable important new military capabilities and drive the productivity gains essential to U.S. economic competitiveness. Conversely, new classes of threats, in particular threats that operate in or through the cyber domain, put military systems, critical infrastructure, and the civilian economy at risk. This project aims to magnify these opportunities and mitigate these threats by leveraging emerging mathematical and computational capabilities including artificial intelligence (AI), computational social science, machine learning and reasoning, data science, quantum science, complex systems modeling and simulation, and theories of computation and programming. The basic research conducted under the Math and Computer Sciences project will produce breakthroughs that enable new capabilities for national and homeland security.

The Electronic Sciences project is for basic exploration of electronic and optoelectronic devices, circuits, and processing concepts to meet the military's need for near real-time information gathering, transmission, and processing. In seeking to continue the phenomenal advancement in microelectronics innovation that has characterized the last few decades, the project should provide DoD with new, improved, or potentially revolutionary device options for accomplishing these critical functions. The resulting technologies should help maintain knowledge of the enemy, communicate decisions based on that knowledge, and substantially improve the cost and performance of military systems. Research areas include: analog, mixed signal, and photonic circuitry for communications and other applications; alternative computer

architectures; and magnetic components to reduce the size of Electromagnetic (EM) and sensing systems. Other research could support field-portable electronics with reduced power requirements, ultra-high density information storage "on-a-chip", and new approaches to nanometer-scale structures, molecules, and devices.

The Beyond Scaling Sciences project supports investigations into materials, devices, and architectures to provide continued improvements in electronics performance with or without the benefit of Moore's Law (silicon transistor scaling). Within the next ten years, traditional scaling will start to encounter the fundamental physical limits of silicon, requiring fresh approaches to new electronic systems. Over the short term, DoD will therefore need to unleash circuit specialization in order to maximize the benefit of traditional silicon. Over the longer term, DoD and the nation will need to engage the computer, material, and mechanical sciences to explore electronics improvements through new non-volatile memory devices that combine computation and memory, and new automated design tools using machine learning. Other memory devices could also leverage an emerging understanding of the physics of magnetic states, electron spin properties, topological insulators, or phase-changing materials. Beyond Scaling programs will address fundamental exploration into each of these areas.

The Materials Sciences project provides the fundamental research that underpins the design, development, assembly, and optimization of advanced materials, devices, and systems for DoD applications in areas such as robust diagnostics and therapeutics, novel energetic materials, and complex hybrid systems.

The Transformative Sciences project supports research and analysis that leverages converging technological forces and transformational trends in information-intensive subareas of the social sciences, life sciences, and manufacturing. The project integrates these diverse disciplines to eliminate reliance on foreign sources for critical materials, improve military adaptation to sudden changes in requirements, threats, and emerging/converging trends, especially trends that have the potential to disrupt military operations or threaten National Security. Specific research in this project will investigate technologies to enable detection of novel threat agents (e.g., bacterial pathogens) and maintain warfighter health and improve recovery. This project also includes efforts to create innovative materials of interest to the military, as well as biological platforms for fabrication.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	474.158	395.781	0.000	-	0.000
Current President's Budget	449.322	443.842	401.870	-	401.870
Total Adjustments	-24.836	48.061	401.870	-	401.870
• Congressional General Reductions	0.000	-1.939			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	50.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-9.569	0.000			
• SBIR/STTR Transfer	-15.267	0.000			
• Adjustments to Budget Year	-	-	401.870	-	401.870

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide I* BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601101E *I DEFENSE RESEARCH SCIENCES*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: CCS-02: *MATH AND COMPUTER SCIENCES*		
Congressional Add: *Foundational Artificial Intelligence - Congressional Add*	5.000	-
Congressional Add: *Alternative Computing - Congressional Add*	3.000	-
Congressional Add: *AI Cyber Data Analytics (AI) - Congressional Add*	-	10.000
Congressional Add: *AI Cyber Data Analytics (Cyber) - Congressional Add*	-	10.000
Congressional Add: *AI Cyber Data Analytics (Data) - Congressional Add*	-	10.000
Congressional Add Subtotals for Project: CCS-02	8.000	30.000
Project: ES-02: *BEYOND SCALING SCIENCES*		
Congressional Add: *ERI 2.0 Congressional Add*	-	20.000
Congressional Add Subtotals for Project: ES-02	-	20.000
Congressional Add Totals for all Projects	8.000	50.000

Change Summary Explanation

FY 2021: Decrease reflects reprogrammings and SBIR/STTR transfer.
FY 2022: Increase reflects Congressional adds for ERI 2.0 and AI Cyber & Data Analytics offset by a decrease for Sec. 8027 FFRDC.
FY 2023: FY 2023 funding increase reflects the fact that the FY 2022 President's Budget request did not include out-year funding.

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 1	R-1 Program Element (Number/Name) PE 0601101E / *DEFENSE RESEARCH SCIENCES*	Project (Number/Name) CCS-02 / *MATH AND COMPUTER SCIENCES*	

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
CCS-02: *MATH AND COMPUTER SCIENCES*	-	273.633	293.845	224.416	-	224.416	208.185	248.752	264.013	256.785	-	-

A. Mission Description and Budget Item Justification

The Math and Computer Sciences project supports scientific study and experimentation on new mathematical and computational algorithms, models, and mechanisms in support of long-term national security objectives. Modern analytic and information technologies enable important new military capabilities and drive the productivity gains essential to U.S. economic competitiveness. Conversely, new classes of threats, in particular threats that operate in or through the cyber and information domain, put military systems, critical infrastructure, and the civilian economy at risk. This project aims to magnify these opportunities and mitigate these threats by leveraging emerging mathematical and computational capabilities including artificial intelligence (AI), computational social science, machine learning and reasoning, data science, quantum science, complex systems modeling and simulation, and theories of computation and programming. The basic research conducted under the Math and Computer Sciences project will produce breakthroughs that enable new capabilities for national and homeland security.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Foundational Artificial Intelligence (AI) Science	60.420	58.050	43.692
Description: The Foundational Artificial Intelligence (AI) Science thrust is developing a fundamental scientific basis for understanding and quantifying performance expectations and limits of AI technologies. Current AI technologies are challenged in handling uncertainty and incompleteness of training protocols and data. This has prevented the successful integration of AI technology into many transformative DoD applications. To address these limitations, the Foundational AI Science thrust will focus on the development of new learning architectures that enhance AI systems' ability to handle uncertainty, reduce vulnerabilities, and improve robustness for DoD AI systems. One focus area of this thrust is the ability to detect and accommodate novelty - i.e., violations of implicit or explicit assumptions - in AI applications. Another focus area is the development of a model framework for quantifying performance expectations and limits of AI systems as trusted human partners and collaborators. A third focus area is the development of new tools and methodologies that enable AI approaches for accelerated scientific discovery. The technology advances achieved under the Foundational AI Science thrust will ultimately remove technical barriers to exploiting AI technologies for scientific discovery, human-AI collaboration, accommodating novelties, and other DoD relevant applications. ***FY 2022 Plans:*** - Continue development of novelty generators and novelty-robust AI techniques to create and identify rapidly and respond appropriately to new agents, actions, relations, and interactions. - Demonstrate and evaluate novelty generators and novelty-robust AI techniques compared to non-robust methods performing on known tasks incorporating new agents, actions, relations, and interactions. - Develop methods to accurately correlate data across multiple sources, such as lab notebooks, tables, figures, and experimental databases.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** CCS-02 / *MATH AND COMPUTER SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Develop prediction models across multiple molecular properties of interest. - Demonstrate closed-loop feedback between experimental platforms and AI models to facilitate process optimization and inverse molecular design. - Demonstrate competency-aware machine learning behaviors and capabilities on integrated application platforms. - Experimentally test small-scale prototype hardware capable of information processing near the theoretical limit of energy efficiency and quantify the utility of quantum information processing systems for tasks related to machine learning. - Initiate investigation of how organizational culture affects AI systems generated by those organizations. - Demonstrate the accuracy of AI models for pneumothorax classification on a portable device. - Develop analysis tools to characterize patterns of open-source software contributor ascendency, identify critical code contributions, and map relevant social activity timelines to important code decisions in order to uncover key trends. - Demonstrate a basic capability to characterize and quantify the effectiveness of the information control techniques used by repressive governments to stifle free speech on the Internet. - Develop techniques to predict the behavior of deep neural networks applied to images using high-dimensional geometric tools, with emphasis on manifolds, manifold learning, and nonlinear dimensionality reduction. - Develop AI mediation technologies to encourage positive behavioral norms within a virtual social environment. - Examine approaches to preserve and promote positive factors of engagement in online discourse while minimizing the risk of negative social and psychological impacts. - Evaluate and refine AI agents and toolkit to understand nuanced communications and combine this with situational understanding to inform improved strategic decision-making and collaboration. - Initiate formulation of AI negotiation agents for multi-party interaction environments that include untrustworthy partnerships and dynamic goals. - Describe the technical approach for 1) intelligent array operations, 2) application development in a tensor-based programmable language, and 3) hardware implementation. - Develop a model that demonstrates the combined array and machine learning (ML) algorithms and how the intelligent array algorithms are abstracted to hardware-independent operations. Report on use cases descriptions of the new array-ML architecture. - Continue efforts to explore frontiers in Artificial Intelligence with a focus on third wave AI.			
FY 2023 Plans: - Demonstrate fully autonomous, closed-loop feedback between experimental platforms and AI models to facilitate process optimization and inverse molecular design. - Identify molecular design domains of greatest applicability for developed AI models and data representations. - Design baseline computational approaches for quantifying the alignment of an algorithmic decision maker with a reference group of human decision makers.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** CCS-02 / *MATH AND COMPUTER SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Initiate efforts to utilize information about the impact of organizational culture on AI systems. - Examine the feasibility of AI-enabled accelerated search of advanced functional materials without training dataset. - Demonstrate and evaluate novelty generators and novelty-robust AI techniques compared to non-robust methods performing on known tasks incorporating new rules, goals, and events. - Develop techniques for quantifying the uniqueness and stability of functions learned over manifolds, and formulate approaches for using these techniques to address issues related to adversarial, explainable, and trustworthy AI. - Further develop and test refined hybrid artificial intelligence (AI) models of climate processes, and explore their advantages over conventional models for rapid scenario analysis as well as for global and regional predictions. - Develop new AI architectures and ecosystems of "small AI" building blocks, enabling unconventional experimentation of AI ideas by individuals and small organizations. - Continue efforts to explore frontiers in Artificial Intelligence with a focus on third wave AI. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY2023 decrease reflects a shift in focus from design and development to technology demonstrations.			
Title: Alternative Computing	24.000	33.000	28.000
Description: The Alternative Computing thrust is exploring and developing new computational primitives for modeling and simulating complex systems. Despite decades of rapid advancement in electronic computing, there remain important national security relevant challenge problems that do not lend themselves to achieving tractable solutions under size, weight, and power (SWaP) constrained conditions. For example, simulation of complex nonlinear phenomena such as turbulence, fluid flow, and plasma dynamics can be challenging even using currently available high power computing resources. Building on technologies developed under the Advanced Tools for Modeling and Simulation thrust, also in this PE/Project, the goal of the Alternative Computing thrust is to develop novel architectural and algorithmic approaches to enable fast and accurate simulations for problems that are practically intractable using electronic computers. Approaches considered under this thrust include the following: (1) analog computing substrates for efficiently simulating systems governed by complex non-linear phenomena; (2) multi-functional spin-based devices for scalable, efficient neuromorphic computing; (3) computing approaches that exploit the capacity of nonlinear systems to simulate nonlinear dynamical systems; and (4) quantum enabled optimization of complex systems. ***FY 2022 Plans:*** - Demonstrate the use of a near term quantum computer for solving combinatorial optimization problems. - Perform benchmarking of the quantum processor performance against the best classical system. - Initiate efforts to create new hardware agnostic benchmarks for quantum information processing performance that quantitatively measure progress towards specific, transformational computational challenges.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** CCS-02 / *MATH AND COMPUTER SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Initiate development of scalable testing techniques for measuring progress in quantum information processing towards addressing specific, transformational computational challenges. - Initiate efforts to verify and validate at least one approach to fault-tolerant quantum computing. - Demonstrate a closed-loop verification system for fine-grained measurement of networks in which every packet is stamped by the forwarding elements to indicate the path it took, the queueing delay it experienced, and the rules it matched. ***FY 2023 Plans:*** - Experimentally demonstrate quantum optimization algorithms for combinatorial optimization problems for larger problem sizes. - Perform benchmarking of quantum optimization algorithms against the best classical method to demonstrate and quantify quantum advantage. - Select specific problems to focus on when developing hardware agnostic benchmarks for quantum information processing performance, prioritizing problems with the potential for transformational impact. - Identify core enabling mathematical operations underlying each of the selected hardware agnostic quantum benchmarks. - Establish initial hardware resource estimates for quantum computers that would be needed to solve specific problems with the potential for transformational impact. - Field and evaluate a closed-loop, verified, geographically dispersed network with operational nodes at multiple sites. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift in focus from technology exploration to design and fabrication.			
Title: Agile Artificial Intelligence (AgAI)	-	21.000	22.000
Description: The Agile Artificial Intelligence (AgAI) program aims to create the capability to rapidly stand-up AI in domains important to national security. In many significant domains with potentially urgent mission needs, labeled data may be sparse and costly to acquire, sensors and other data sources may be rapidly evolving in their capabilities, and requirements for reliability and traceability may be significant. Building on emerging technical opportunities in machine learning and symbolic reasoning, AgAI will create scientific and technological foundations for the agile creation and evolution of AI-based capabilities. Emerging technical areas that are critical to AgAI include explicit domain models, harmonization of statistical and symbolic approaches, hybridization of multiple AI methods with techniques including game theory and optimization, and meta-cognition to support rapid improvement of the AI capabilities themselves. The AgAI program will also combine emerging techniques for mathematical modeling and for explanation to enhance reliability and traceability of AI capabilities. ***FY 2022 Plans:*** - Explore the potential for a flexible, broadly-scoped AI development environment to support and facilitate the agile creation, maintenance, and improvement of AI and machine learning based systems across diverse application domains.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Formulate repeatable approaches for harmonization of statistical and symbolic approaches, hybridization of multiple AI methods with techniques such as game theory and optimization, and meta-cognition to support rapid improvement of the AI capabilities themselves. - Conceptualize approaches for combining emerging techniques for mathematical modeling and for explanation to enhance reliability and traceability of the developed AI capabilities. ***FY 2023 Plans:*** - Develop a flexible, broadly-scoped AI development environment to support and facilitate the agile creation, maintenance, and ongoing improvement of AI and machine learning based systems across diverse application domains. - Develop integrated statistical-symbolic approaches, hybrid AI/game theory/optimization techniques, and meta-cognition for diverse applications such as strategic planning, modeling and simulation, knowledge management, transactional infrastructure, and financial services in austere environments. - Develop techniques for mathematical modeling and explanation generation to enhance reliability and traceability of the developed AI capabilities. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.			
Title: Perceptually-Enabled Task Guidance (PTG)	6.330	12.234	17.300
Description: The Perceptually-Enabled Task Guidance (PTG) program is developing artificial intelligence (AI) technology that guides users in the performance of a wide range of cognitively challenging physical tasks. PTG leverages recent advances in machine perception, automated reasoning, and augmented reality. The program will connect perception to reasoning and reasoning to augmented reality (AR) so as to create personalized, real-time feedback and contextualized assistance. To connect perception and reasoning, PTG will develop AI technologies for (1) perceptual grounding, to create a shared vocabulary for perception and reasoning, and (2) perceptual attention, to select important information from large volumes of perceptual data. To connect reasoning with AR, PTG will develop AI technologies for (3) knowledge transfer, to derive task models from instructions intended for humans, and (4) user modeling, to determine if, when, and how to best convey task information to the user. Together, the PTG technologies will lay the foundation for perceptually-enabled guidance and a qualitatively new type of AI device that enables mechanics, medics, and other military specialists to perform physical tasks within and beyond their skillsets with greater accuracy and efficiency. ***FY 2022 Plans:*** - Explore rule-based and statistical AI approaches for perceptual grounding, to create a shared vocabulary for perception and reasoning, and perceptual attention, to select important information from the large volumes of perceptual data.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Formulate approaches for connecting reasoning with AR, focusing on AI technologies for knowledge transfer, to derive task models from instructions intended for humans, and user modeling, to determine if, when, and how to best convey task information to the user. - Identify and collaborate with military stakeholders on high-priority task use cases, potentially involving repair of systems or emergency medical care, for demonstration and evaluation of integrated perceptual agent prototype systems. ***FY 2023 Plans:*** - Develop approaches for perceptual grounding as required for perceptually-enabled intelligent agents capable of learning how to recognize task-related terms, including objects, actions, and settings. - Devise new techniques for combining visual and audio examples scraped from multimedia knowledge sources and transferring them into task models, and for inferring model visual and audio properties from the properties of related model classes. - Develop knowledge transfer approaches for taking the knowledge that currently is available only in human-oriented task instructions such as checklists, procedure manuals, and training materials and representing that knowledge in machine-processable form. - Initiate integration of perceptual grounding, perceptual attention, knowledge transfer, and user modeling technologies and demonstrate and evaluate prototypes on a surrogate task use case, while working with military stakeholders on realistic high-priority task use cases. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects continued effort to develop foundational techniques for perceptually-enabled intelligent agents and increased efforts to integrate and demonstrate the techniques on surrogate and military task use cases.			
Title: Machine Common Sense (MCS)	16.500	18.000	17.000
Description: The Machine Common Sense (MCS) program is exploring approaches to enable common sense reasoning by machines. Recent advances in machine learning have resulted in new artificial intelligence (AI) capabilities in areas such as image recognition, task-focused natural language processing, and strategy games such as Chess, Go, and Poker. In all of these application domains, the machine reasoning is narrow and highly specialized, and the machine must be carefully trained or programmed for every situation. This program addresses the challenge of general machine reasoning on par with common sense human cognition. MCS is developing computational models that mimic core systems of human cognitive development that are grounded in perceptual, motor, and memory modalities; a simulated interaction and learning environment to support machine manipulation of grounded concept models; and common sense knowledge repositories to support AI system development. AI systems that are capable of human-like reasoning will be able to behave more appropriately in unforeseen situations and to learn with reduced requirements for training data. ***FY 2022 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Develop core cognitive models with enhanced experience task learning capabilities, and evaluate model performance against experience learning tasks requiring elements of intuitive physics, navigation, and basic models of intentional agents. - Explore enhancements to core cognitive models, such as models of self-supervised intentional agents used by human infants, and evaluate model performance on prediction tasks. - Augment the simulation environment to support dynamic evaluation of a diverse set of machine learning methods, cognitive capabilities, prediction tasks, and experience learning tasks, including problems that require sensemaking, human-machine collaboration, or knowledge transfer. - Extend common knowledge capabilities to improve performance on common sense tasks with increased complexity, and develop novel common sense challenge problem benchmark suites for use in environments with complexity, noise, and novelty. ***FY 2023 Plans:*** - Develop agent models focused on understanding other agent intentions and demonstrate intentional agent reasoning. - Augment cognitive models with expanded experience learning capabilities, and enable self-evaluation modes for scenarios that require agent sensemaking, human-machine collaboration, and knowledge transfer. - Create evaluation techniques for generative question-answering for commonsense reasoning tasks, and extend capabilities to utilize cross-modal (text, image, video) data to improve performance. - Use the dynamic simulation environment to assess performance on benchmark common sense challenge problem suites in environments exhibiting high complexity, noise, and novelty. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects ramping down of work to develop machine common sense technologies and the simulation environment, and continued work to refine techniques and assess performance against benchmark common sense challenge problem suites.			
Title: Guaranteeing AI Robustness against Deception (GARD)	15.400	17.500	17.000
Description: The Guaranteeing AI Robustness against Deception (GARD) program is developing techniques to defend against deception and other adversarial attacks on machine learning (ML) and artificial intelligence (AI) systems. GARD addresses the need to defend against deception attacks, whereby an adversary inputs engineered data into an ML system intending to cause the system to produce erroneous results. Deception attacks can enable adversaries to take control of autonomous systems, alter conclusions of ML-based decision support applications, and compromise tools and systems that rely on ML and AI technologies. Current techniques for defending ML and AI have proven brittle due to a focus on individual attack methods and weak methods for testing and evaluation. The GARD program is developing techniques that address the current limitations of defenses and produce ML and AI systems suitable for use in adversarial environments. The GARD program is also developing theory regarding potential fundamental limits on achievable ML robustness.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** CCS-02 / *MATH AND COMPUTER SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: - Develop defenses against novel types of adversarial inputs, with particular interest in inputs that can be implemented in the physical world. - Develop and validate novel measures of attack strength, and integrate these measures into the evaluation framework. - Extend evaluation framework for testing ML defenses for adaptive-adversary scenarios, and implement and test ML defenses for use against an AI-enabled adversary. ***FY 2023 Plans:*** - Develop and validate measures of adversary costs and enhance defense methods to impose asymmetric costs on the adversary. - Demonstrate model training methods that reduce vulnerability to data poisoning. - Extend evaluation framework to support simulation environments and test physically plausible threat models. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Young Faculty Award (YFA)	17.000	17.000	17.000
Description: The goal of the Young Faculty Award (YFA) program is to encourage junior faculty at universities and their equivalent at non-profit science and technology research institutions to participate in sponsored research programs that will augment capabilities for future defense systems. This program focuses on cutting-edge technologies for greatly enhancing microsystems technologies, biological technologies, and defense sciences. The long-term goal for this program is to develop the next generation of scientists, engineers, and mathematicians in key disciplines who will focus a significant portion of their careers on DoD and national security issues. The aim is for YFA recipients to receive deep interactions with DARPA program managers, programs, performers, and the user community. Current activities include research in fifteen topic areas spanning from Machine Learning and Many Body Physics, to Wideband Transmitter-Antenna Interfaces and Multi-Scale Models of Infectious Disease Dynamics. A key aspect of the YFA program is DARPA-sponsored military visits; all YFA Principal Investigators are expected to participate in one or more military site visits to help them better understand DoD needs. ***FY 2022 Plans:*** - Award new FY 2022 grants for new two-year research efforts across the topic areas, establishing a new set of appropriate technologies to solve current DoD problems. - Continue FY 2021 research on new concepts for microsystem, biological, strategic, and tactical technologies; information innovation; and defense sciences by exercising second year funding and by providing continued mentorship by program managers.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** CCS-02 / *MATH AND COMPUTER SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Award Director's Fellowships for top FY 2020 participants to refine technology further and align to DoD needs. ***FY 2023 Plans:*** - Award new FY 2023 grants for new two-year research efforts across the topic areas, establishing a new set of appropriate technologies to solve current DoD problems. - Continue FY 2022 research on new concepts for microsystem, biological, strategic, and tactical technologies; information innovation; and defense sciences by exercising second year funding and by providing continued mentorship by program managers. - Award Director's Fellowships for top FY 2021 participants to refine technology further and align to DoD needs.			
Title: Knowledge Management at Scale ***Description:*** The Knowledge Management at Scale thrust is focused on the development of knowledge management tools that can efficiently capture, analyze and reason with expertise, experience and data. The technology development under this thrust will help address a critical need for assimilating and preserving critical national security knowledge and expertise that is currently being lost due to attrition and other factors. Specific objectives include the following: 1) effective, trustworthy, and easily accepted approaches for domain agnostic knowledge acquisition at scale; 2) capabilities to identify correlations or hidden factors relating to knowledge acquired from different sources; and 3) techniques for incorporating domain models and other data sources for more extensive reasoning-based applications. Example approaches towards achieving these objectives include identifying and demonstrating robust knowledge acquisition tools, exploiting Artificial Intelligence (AI) techniques to establish a framework for knowledge analysis and causal reasoning, and developing automation tools that effectively elicit and impart acquired knowledge via user friendly interfaces. ***FY 2022 Plans:*** - Develop novel AI tools capable of recognizing and representing implicit and explicit context of human tasks. - Develop automated methods to identify and capture, fuse, and disseminate knowledge across organizations as part of existing workflows. - Design and evaluate comfortable, trusted, and enticing software tools to be used by groups of non-technical people to capture, resolve, and apply effectively and timely different and overlapping aspects of their shared experiences at multiple time scales. - Use context to provide effective and appropriate knowledge from prior experience to current tasks. - Evaluate methods and tools in diverse task domains. ***FY 2023 Plans:*** - Extend novel AI tools capable of recognizing and representing implicit and explicit context of human tasks to scale to large organizations and diverse tasks. - Incorporate audio/video as input modalities into novel AI tools.	6.000	9.061	16.300

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Evaluate novel AI tools in common domain of potential military interest. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects a shift from initial technology development to explorations of application spaces.			
Title: Artificial Social Intelligence for Successful Teams (ASIST)	17.000	15.000	14.300
Description: The Artificial Social Intelligence for Successful Teams (ASIST) program is developing intelligent software agents that can create shared mental models to enable effective teaming with humans. Theory of mind and the ability to create shared mental models are key elements of human social intelligence. Together these capabilities enable human collaboration and teamwork at all scales, whether the setting is a playing field or a military mission. The ASIST program aims to develop technologies to enable machines to exhibit similar capabilities for collaboration and teamwork with humans, capabilities which can be termed artificial social intelligence. These include the capability to infer the goals and situational knowledge of human partners, to predict what human partners will need, and to formulate context-aware actions having high value to team outcomes. The ASIST program is developing proof-of-concept software agents that demonstrate a machine theory of mind and the capability to participate with humans in an effective team by representing and helping to maintain shared mental models. ASIST aims to provide the basis for machines that can participate effectively with humans on tasks where teamwork is required. ***FY 2022 Plans:*** - Demonstrate and test prototype computational agents that exhibit machine theory of mind and the ability to contribute to effective human teams in specialized environments. - Derive performance, trust, and acceptance predictions for computational agents capable of advising and guiding humans in the performance of complex tasks, thereby reducing the collective cognitive load. - Scale virtual testbed for evaluation of computational agents with artificial social skills in complex environments with teams of humans. ***FY 2023 Plans:*** - Develop and demonstrate computational agents that understand human social intelligence in a team context, can predict what is needed by partners, and intervene as an effective partner. - Develop agents able to handle perturbations in task, team, mission, and environment as needed for fast adaptation and team resilience. - Conduct experiments in multiple virtual testbed environments to demonstrate generalization across domains and relevance to DoD missions such as urban search and rescue, information operations, and cyber operations. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** CCS-02 / *MATH AND COMPUTER SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 decrease reflects minor program repricing.			
Title: Human Social Systems	20.250	15.000	10.000
Description: The social sciences provide essential theories and models that can enable deeper understanding of human social systems and behaviors relevant to national security such as humanitarian aid, disaster relief, and stability support missions, as well as tactical, operational, strategic, and policy-level decision-making across the DoD. However, current limitations to the speed, scalability, and reproducibility of empirical social science research continue to hamper its practical use by the DoD. Additionally, current social behavioral models often fail to accurately interpret social behaviors because they do not sufficiently capture diversity of context. The Human Social Systems thrust will address these limitations by focusing on the following technical challenges: (1) developing and validating new methods, models and tools to perform rigorous, reproducible experimental research at scales necessary to understand emergent properties of human social systems; (2) identifying methods to better characterize and quantify properties, dynamics, and behaviors of different social systems to enable better and more confident forecasting of changes in social systems, particularly when under stress; (3) developing an understanding of the complex effect of context and incorporating these effects into social science models; and (4) developing strategic forecasting and operational decision aiding capabilities that account for local contextual and cultural factors to assess the likely effectiveness of and/or responses to actions within an Area of Operations. This research thrust will provide DoD with new, reliable strategies to better understand and respond to social system issues at multiple scales (from small group to cities and/or regions) and will significantly improve DoD stabilization, deterrence, and/or gray zone mission outcomes. ***FY 2022 Plans:*** - Test algorithms for automatically assigning quantitative confidence scores to social and behavioral science research. - Analyze expert and non-expert usability and explainability of algorithms for automatically assigning quantitative confidence scores. - Validate increased efficiency of algorithms for automatically assigning quantitative confidence scores to social and behavioral science research. - Evaluate the accuracy of developed causal models of regional socioeconomic systems in representing the collective implicit casual models held by locals to the region. - Investigate the amount of information that can be gathered remotely versus what must be gathered locally to create accurate, causal models of local socioeconomic systems. - Demonstrate that mechanisms developed for engaging local populations are compatible with local infrastructure. - Scope testbed for developing and understanding what metrics are appropriate for measuring the impact of actions such as in Influence Operations. - Explore external and internal validity of social influence metrics within testbed. ***FY 2023 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Test the accuracy of causal models of regional socioeconomic systems derived from collective local understandings for predicting event outcomes compared to the current state of practice. - Evaluate the efficiency of methodologies for developing causal models of regional socioeconomic systems derived from collective local understanding compared to the current state of practice. - Continue to demonstrate that mechanisms developed for engaging local populations are compatible with local infrastructure and generate sufficient quality data to generate predictive causal models. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from development to demonstration.			
Title: Safe Documents (SafeDocs)	15.000	12.000	8.000
Description: The Safe Documents (SafeDocs) program is developing software technologies that constrain syntactic complexity in data exchange formats, and improve the capability to reject invalid and maliciously crafted data in electronic documents and streaming data. The high complexity and unmanaged evolution of electronic document formats and streaming data protocols greatly increase the computational attack surface. The SafeDocs program is rationalizing existing data exchange formats significant to the defense mission, with attention to compatibility, and advancing the state of the art in the security of document and data format parsers. SafeDocs advances will enable automated code verification, assure that the conditions of data validity are enforced, and secure documents and streaming data. ***FY 2022 Plans:*** - Create methods for comparing multiple distinct classes of analytical information of parsing behaviors and rules, and develop techniques to merge and tag control flow graph blocks with derived semantics for streaming format parsers. - Develop machine-readable feedback mechanisms from format verification tools to improve system automation. - Automate testing methodologies and demonstrate safe parser construction using the developed tools. ***FY 2023 Plans:*** - Refine, improve, and validate the software parser prototypes for enterprise features relevant to both commercial and military systems. - Scale the test corpus to the size representative of a large enterprise and test the parsers for usability, predictability, and stability. - Refine and harden the technology to meet transition partner requirements and coordinate with industry and other stakeholders to standardize the simplified safe formats. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 decrease reflects ramping down of efforts to develop safe formats for electronic documents and streaming data and verified functionally correct, efficient parsers, and focus shifting to demonstration and transition of techniques.			
Title: Learning with Less Labeling (LwLL) ***Description:*** The Learning with Less Labeling (LwLL) program is developing technology to greatly reduce the amount of labeled data required to train machine learning (ML) systems. In supervised ML, a system learns through the use of labeled training examples to recognize and categorize attributes of images, text, or speech. Humans provide these training-data examples to ML systems and, with enough labeled data, it is generally possible to build useful models. Obtaining large amounts of labeled data can be costly, particularly for national security applications. LwLL is addressing this problem by creating ML algorithms that learn and adapt more efficiently than current ML approaches, and by formally deriving the limits of machine learning and adaptation. These algorithms achieve the goals through training with a combination of labeled and unlabeled data. LwLL aims to create ML systems that are easier to train for use in variable, unpredictable, real-world environments where training data is costly or sparse. ***FY 2022 Plans:*** - Develop approaches to optimize label reduction in ML algorithms and to simultaneously achieve performance near theoretical limits. - Demonstrate new ML algorithms that retain state-of-the-art performance even with several orders of magnitude reduction in labeled training data. - Demonstrate the generalization capability of new ML algorithms across multiple tasks. ***FY 2023 Plans:*** - Demonstrate ML systems that require less labeled training data in multiple domains relevant to the DoD, and transition technology to the DoD and industry. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects conclusion of development of ML techniques that require less labeled data for effective training, and focus shifting to demonstration and transition of techniques to the DoD and industry.	15.000	12.500	4.324
Title: Pipelined Reasoning of Verifiers Enabling Robust Systems (PROVERS) ***Description:*** The Pipelined Reasoning of Verifiers Enabling Robust Systems (PROVERS) program aims to advance the capability, scope, and usability of scalable mathematically based technologies, tools, and practices to achieve continuous reasoning about complex systems that can support software development pipelines. These mathematically based techniques, or formal methods, enable rigorous modeling, reasoning, and proving diverse properties of software code or design models, for example the absence of a specific type of defect or security vulnerability. PROVERS will integrate formal methods into a modern incremental and iterative development process by running tools at each code commit and delivering results to developers when	-	-	9.500

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
they can most effectively remediate discovered issues. To achieve this, PROVERS will focus on creating and sustaining a body of evidence that can co-evolve with the system under change to support continuous assessment and ensure that the system remains free of identified categories of defects and security vulnerabilities through its lifetime. Key PROVERS objectives include enabling proof maintenance and repair capabilities at a cost that is proportionate to code change; integration of formal methods with code, properties, and proofs in a single workflow that reduces human involvement; providing improved explanations to facilitate proof repair; and automating formal methods-based software analysis to support software developers that are not formal methods experts. PROVERS technologies will facilitate the agile development and continuous improvement of mission-critical software systems that meet the high security and quality standards required by the DoD. ***FY 2023 Plans:*** - Explore formal methods approaches and develop tools and data management techniques appropriate for pipelined software development processes and incremental proof maintenance and repair. - Formulate mathematical approaches for proof engineering at scale including techniques such as distributed proofs. - Identify candidate mission-critical software applications and systems for controlled formal-methods-based experiments with the goal of quantifying the improvements in development productivity and system security. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: World Modelers ***Description:*** The World Modelers program is creating explanatory models for complex natural and human-mediated systems at regional and global scales. Because of macro-economic interdependence, widespread consequences can result from the disruption of natural resources, supply chains, and production systems. World Modelers capabilities are focused on regional and global systems with the goal of generating timely indications and warnings. Water and food security are application domains of particular interest, as persistent drought may cause crops to fail, leading to migration and regional conflicts. The World Modelers program aims to develop techniques for automating the creation, maintenance, and validation of large-scale integrated models using publicly available news and analyst reports as a structuring mechanism, and government and commercial data as quantitative inputs. ***FY 2022 Plans:*** - Integrate software capabilities applicable to the diverse data and modeling tasks encountered in high-priority use cases. - Demonstrate modeling modalities in support of analytic workflows in diverse domains and optimize techniques in response to user feedback.	13.700	12.000	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Harden technologies and perform evaluations in collaboration with transition partners. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Analyzing Software to Protect against Evolving Cyber Threats (ASPECT) ***Description:*** The Analyzing Software to Protect against Evolving Cyber Threats (ASPECT) program is developing technologies to enable software developers to pose in-depth queries of code under development and sustainment in order to discover negative patterns, capture the semantic features of vulnerability classes, and characterize undesirable behaviors. ASPECT technologies will enable developers to generate the types of evidence required for confident certification, thereby improving software quality and assurance. At present, software faults and vulnerabilities are often unwittingly propagated throughout the software ecosystem because they are not easily discovered in codebases and because developers have strong incentives to re-use code and programming patterns. Moreover, searching for faults and vulnerabilities in software is impractical because these flaws are not manifest through the syntax of the source code but rather through the behaviors encoded in the software, i.e., in the software semantics. ASPECT will enable developers to query software at this deeper semantic level by developing modeling languages for the semantics of code and programs; representing code and programs in terms of their semantics; and identifying negative patterns, potential vulnerabilities, and undesirable behaviors. ***FY 2022 Plans:*** - Develop semantically-based metrics of software quality and evidence management techniques that provide actionable or otherwise useful information for software developers. - Identify categories of latent vulnerabilities including syntactically-distinct but semantically-equivalent instances. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	4.000	8.500	-
Title: Advanced Tools for Modeling and Simulation ***Description:*** The Advanced Tools for Modeling and Simulation thrust is developing foundational mathematical, computational, and multi-physics theories, approaches, and tools to better represent, quantify, and model complex DoD systems from multimodal data analysis through part/system design and fabrication. One focus area of this thrust is developing a unified mathematical framework to enable better visualization and analysis of massive, complex data sets. Rigorous mathematical theories are also being developed to address uncertainty in the modeling and design of complex multi-scale physical and engineering systems, incorporating capabilities to handle noisy data and model uncertainty that are well beyond the scope of current capabilities. Other work in this thrust focuses on developing the mathematical and computational tools required to generate and better manage the enormous complexity of design, ultimately allowing designers to more easily discover non-intuitive (yet realizable) designs that	6.765	3.000	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
fully leverage new materials and advanced manufacturing approaches now available. Outcomes from this thrust will improve the speed and accuracy of modeling and simulation, as well as enable management of complexity across DoD devices, parts, and systems. Another focus area of this thrust is multi-physics models for predicting behavior and non-intuitive failure pathways for complex, dynamic physical systems. ***FY 2022 Plans:*** - Explore applications of multi-basis imaging techniques via modeling and simulation. - Explore the effectiveness of modelling and simulating complex correlated systems using quantum-inspired mathematical techniques. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease is due to program completion.			
Title: Synergistic Discovery and Design (SD2) ***Description:*** The Synergistic Discovery and Design (SD2) program developed data-driven methods to accelerate scientific discovery and robust design in domains that lack complete models. Engineers regularly use high-fidelity simulations to create robust designs in complex domains such as aeronautics and integrated circuits. In contrast, robust design remains elusive in domains such as synthetic biology, neuro-computation, and synthetic chemistry due to the lack of high-fidelity models. The SD2 program developed technologies to collect raw experimental data into a data and analysis hub, computational techniques that extract scientific knowledge directly from experimental data, and data sharing tools and metrics that facilitate collaborative design. SD2 application domains include synthetic biology, solar cell chemistry, and protein design, which will impact future DoD capabilities in areas such as chemical and biological defense, and warfighter readiness.	16.000	-	-
Title: Complex Hybrid Systems ***Description:*** The Complex Hybrid Systems program was focused on exploring fundamental science, mathematics, and computational approaches to collectives, complex hybrid (e.g., human-machine) systems and systems-of-systems across a variety of DoD-relevant domains. Efforts include development of foundational, quantitative theories and algorithms for the analysis and design of complex systems, as well as novel testing capabilities for assessing the value of these theories using experimental verification across multiple problem domains. Results from this program better enabled the systematic design of complex hybrid systems helping to achieve unprecedented resilience and adaptability in unexpected environments.	7.300	-	-
Title: Communicating With Computers (CWC) ***Description:*** The Communicating With Computers (CWC) program advanced the state-of-the-art in human-computer interaction by enabling computers to comprehend language, gesture, facial expression, and other communicative modalities in context.	4.968	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Human language is inherently ambiguous, so humans depend on additional communication pathways, including perception of the physical world and shared context, to communicate efficiently. CWC developed techniques to provide computers with analogous capabilities to sense and encode aspects of the physical world in a perceptual structure, and to use this structure to disambiguate language. To accomplish this, CWC applied and extended research in language, vision, gesture recognition and interpretation, dialog management, cognitive linguistics, and the psychology of visual encoding. CWC also extended the communication techniques developed for physical contexts to nonphysical contexts and virtual constructs.			
Accomplishments/Planned Programs Subtotals	265.633	263.845	224.416

	FY 2021	FY 2022
Congressional Add: Foundational Artificial Intelligence - Congressional Add ***FY 2021 Accomplishments:*** - Developed and applied symbolic and statistical Artificial Intelligence (AI) techniques to understand collaborative open-source software development activities at scale and to detect patterns of manipulation that have the potential to expose critical information, defeat mitigations even as they are being implemented, or otherwise degrade security.	5.000	-
Congressional Add: Alternative Computing - Congressional Add ***FY 2021 Accomplishments:*** - Assessed point designs in the lossy, noisy regime for a commercial quantum computing architecture to strengthen understanding of the viability of the approach.	3.000	-
Congressional Add: AI Cyber Data Analytics (AI) - Congressional Add ***FY 2022 Plans:*** Explore the feasibility of so-called adaptive de-learning by machine learning systems, whereby learning that was performed using invalid data can be backed out of the system without retraining the entire system from scratch.	-	10.000
Congressional Add: AI Cyber Data Analytics (Cyber) - Congressional Add ***FY 2022 Plans:*** Develop high assurance computing architectures suitable for mission-critical systems that must operate with resilience in contested environments.	-	10.000
Congressional Add: AI Cyber Data Analytics (Data) - Congressional Add ***FY 2022 Plans:*** Develop high assurance computing architectures suitable for mission-critical systems that must operate with resilience in contested environments.	-	10.000
Congressional Adds Subtotals	8.000	30.000

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C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
ES-01: *ELECTRONIC SCIENCES*	-	28.681	16.361	17.645	-	17.645	29.153	34.178	52.200	52.410	-	-

A. Mission Description and Budget Item Justification

The Electronic Sciences project is for basic exploration of electronic and optoelectronic devices, circuits, and processing concepts to meet the military's need for near real-time information gathering, transmission, and processing. In seeking to continue the phenomenal advancement in microelectronics innovation that has characterized the last few decades, the project should provide DoD with new, improved, or potentially revolutionary device options for accomplishing these critical functions. The resulting technologies should help maintain knowledge of the enemy, communicate decisions based on that knowledge, and substantially improve the cost and performance of military systems. Research areas include analog, mixed signal, and photonic circuitry for communications and other applications; alternative computer architectures; and magnetic components to reduce the size of Electromagnetic (EM) and sensing systems. Other research could support field-portable electronics with reduced power requirements, ultra-high density information storage "on-a-chip", and new approaches to nanometer-scale structures, molecules, and devices.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Atomic-Photonic Integration (A-PhI)	14.681	9.361	9.000
Description: The Atomic-Photonic Integration (A-PhI) program is reducing the size, weight, and power of atomic clocks and gyroscopes for position, navigation, and timing (PNT) applications through the development of integrated photonics. Specifically, A-PhI will demonstrate that a compact photonic integrated chip can replace the optical assembly for trapped atomic gyroscopes and clocks without degrading the performance of the device. PNT is a critical resource for all DoD missions such as communications, navigation, reconnaissance, and electronic warfare. While PNT needs usually are met by using the global positioning system (GPS), GPS signals are vulnerable to a variety of disruption modalities and a fallback from GPS is essential. In the absence of GPS, tactical grade clocks and tactical/navigation grade inertial measurement units (IMUs) currently can provide GPS-like accuracy only for the short term, and longer-term GPS independent strategies are highly desirable. A-PhI will enable long-term GPS independence and enable better-than-GPS PNT accuracy for short durations.			
FY 2022 Plans: - Demonstrate an atomic clock physics package meeting size, frequency stability, and phase noise metrics. - Improve atom trap gyroscope sensitivity.			
FY 2023 Plans: - Demonstrate a trapped atom gyroscope with single measurement angle rate resolution and scale factor exceeding commercial gyroscopes. - Test integrated photonics based atomic clock by referencing to civilian and military time standards at National Institute of Standards and Technology (NIST) and United States Naval Observatory (UNSO).			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Initiate research into other reference frequency sources, such as sub-millimeter wave oscillators, with the potential to achieve atomic clock-level accuracy, precision, and stability. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Ultra-Wide Bandgap Semiconductors (UWBG) ***Description:*** The Ultra-Wide Bandgap Semiconductors (UWBG) program will seek to develop an entirely new class of semiconductor materials that will offer performance breakthroughs for a range of applications when compared to existing compound semiconductors. Electrical bandgap determines a material breakdown voltage, intrinsic charge carrier density, and color (wavelength) of light emission, and also impacts the maximum output power and operating frequency of a transistor made from the material. Consequently, wide bandgaps have considerable interest for the DoD due to the high operating temperatures, currents, voltages, and frequencies often required by emerging high power, agile Radio Frequency (RF) sources for radar, communications, directed energy, and electronic warfare. This program will overcome the fundamental materials and device challenges that currently prevent implementation of UWBG materials into power, RF, and optoelectronic devices and systems. These challenges include reliably manufacturing low-defect substrates, heteroepitaxial material growth, and high concentration p-type and n-type doping. ***FY 2022 Plans:*** - Design low-energy heterogeneous epitaxially-grown UWBG devices. - Develop theoretical models of high-energy performance and avalanche breakdown in UWBG materials. ***FY 2023 Plans:*** - Characterize low-energy heterogeneous epitaxially-grown UWBG devices. - Experimentally verify theoretical models of high-energy performance and avalanche breakdown in UWBG materials. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects transition from basic design efforts to characterization and experimental verification of devices and models.	1.000	7.000	8.645
Title: Magnetic Miniaturized and Monolithically Integrated Components (M3IC) ***Description:*** The Magnetic Miniaturized and Monolithically Integrated Components (M3IC) program integrated magnetic components onto semiconductor materials, improving the size and functionality of electromagnetic (EM) systems for communications, radar, and electronic warfare (EW). The M3IC program was divided into three technical areas: integration of magnetic materials and systems with semiconductor technology, accurate and efficient modeling of magnetic phenomena from	8.000	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
the molecular to the system level, and exploitation of magnetic phenomena in innovative component designs relevant to DoD EM systems.			
Title: A MEchanically Based Antenna (AMEBA) ***Description:*** The A MEchanically Based Antenna (AMEBA) program developed and demonstrated efficient radio frequency (RF) transmitters operating in the Ultra-Low Frequency (ULF) and Very Low Frequency (VLF) ranges for portable applications in underground and underwater communications. Whereas traditional antennas generate electromagnetic waves by driving current through a conductive material, AMEBA took the novel approach of mechanically moving an electrical charge or magnet to generate electromagnetic waves at ULF and VLF. AMEBA focused on developing both the materials and precision-controlled electromechanical systems required for an efficient transmitter system. This new capability enables a range of applications including wireless communications for use over very long distances and short-range underground and underwater RF links. Other potential applications include terrestrial navigation systems for GPS-denied environments and ground-penetrating radar for detecting unexploded ordnance, underground facilities, and tunnels.	5.000	-	-
Accomplishments/Planned Programs Subtotals	28.681	16.361	17.645

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
ES-02: *BEYOND SCALING SCIENCES*	-	57.365	65.145	70.188	-	70.188	58.923	58.940	43.250	53.540	-	-

A. Mission Description and Budget Item Justification

The Beyond Scaling Sciences project supports investigations into materials, devices, and architectures to provide continued improvements in electronics performance with or without the benefit of Moore's Law (silicon transistor scaling). Within the next ten years, traditional scaling will start to encounter the fundamental physical limits of silicon, requiring fresh approaches to new electronic systems. Over the short term, DoD will therefore need to unleash circuit specialization in order to maximize the benefit of traditional silicon. Over the longer term, DoD and the nation will need to engage the computer, material, and mechanical sciences to explore electronics improvements through new non-volatile memory devices that combine computation and memory, and new automated design tools using machine learning. Other memory devices could also leverage an emerging understanding of the physics of magnetic states, electron spin properties, topological insulators, or phase-changing materials. Additionally, new design and manufacturing advances for three-dimensional microelectronics integration will underpin continued performance improvements as silicon transistor scaling plateaus. Beyond Scaling programs will address fundamental exploration into each of these areas.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Beyond Scaling - Materials	11.000	5.000	-
Description: The Beyond Scaling - Materials program investigates new materials to support next-generation logic and memory components. The program pursues potential enhancements in electronics that do not rely on Moore's Law, i.e. silicon transistor scaling, including research into new materials and into the implications of those materials at the device, algorithm, and packaging levels. These basic explorations include novel mechanisms for computation based on inherent material properties and innovative processes to vertically integrate these materials with others to realize superior computational mechanisms. Applied research for this program is funded within PE 0602716E, Project ELT-02. ***FY 2022 Plans:*** - Design energy efficient in-memory computing processing units with high energy efficiency per operation. - Design advanced compute units for advanced DoD-relevant machine learning applications. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Low Temperature Logic Technology (LTLT)*	-	3.000	13.000
Description: *Previously part of Beyond Scaling - Materials The Low Temperature Logic Technology (LTLT) program will exploit the unique device and material performance characteristics of state-of-the-art silicon transistors at cryogenic temperatures. Current silicon transistors are performance and power limited			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
when operating at room temperature or higher. This program removes these limitations through modifying the design of existing silicon transistors to optimize their performance at cryogenic temperatures. These devices will be compatible with current complementary metal-oxide-semiconductor (CMOS) fabrication process flows and will offer significant increases in performance and power efficiency over room temperature devices. This program has applied research efforts funded in PE 0602716E, Project ELT-02. ***FY 2022 Plans:*** - Initiate simulations of transistor, memory, and interconnects for low temperature circuits. - Simulate and analyze transistor, memory, and interconnect performance at low temperature for low temperature circuits. ***FY 2023 Plans:*** - Perform initial design of low temperature transistors, memory, and interconnects for low temperature circuits. - Refine simulations of transistor, memory, and interconnect performance at low temperature for low temperature circuits. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects the program moving from simulation and analysis to design of low temperature circuits.			
Title: Beyond Scaling - Architectures and Designs	10.000	6.645	-
Description: The Beyond Scaling - Architectures and Designs program investigates circuit architectures and design tools at both the integrated circuit and board level to provide enhanced performance and security with or without the benefit of continued silicon transistors scaling (Moore's Law). Currently, improvements in electronics largely depend on a regular reduction in the size of silicon components. As Moore's Law slows and the nation loses the benefit of free, exponential improvements in electronics performance, DoD will need to maximize the benefits of available silicon technologies through circuit specialization. This program investigates the potential for lowering the barriers to designing specialized circuits and to incorporating privacy and security protections. Approaches include the use of machine learning and automated design tools to program specialized hardware blocks, integrate them into existing designs, and deploy them in complex systems. This program will also support a new DoD capability to create secure and specialized hardware that does not depend on continued improvements in silicon transistors. Applied research for this program is funded within PE 0602716E, Project ELT-02. ***FY 2022 Plans:*** - Fabricate and test automatically generated digital and analog integrated circuits created using program-developed open source software tools. - Develop specialized machine designed hardware, and benchmark against general purpose machine learning chips. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** ES-02 / *BEYOND SCALING SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 decrease reflects program completion.			
Title: Guaranteed Architectures for Physical Security (GAPS)*	4.000	4.000	9.000
Description: *Previously part of Beyond Scaling - Architectures and Design The Guaranteed Architectures for Physical Security (GAPS) program is developing hardware security and software architectures with provable security interfaces. These interfaces will physically isolate high-risk transactions during both system design and system build, and will ensure that such protections are enforced at run-time. GAPS will reduce the inherent complexity through the development of hardware and software that is open, extendible, and compatible with size, weight, and power constrained environments to enable security across DoD and commercial systems. The program will substantially lower the barrier to safely enabling high-risk transactions, thus allowing for fast computer-to-computer transactions, physical spatial isolation reducing the need for unreliable software partitioning solutions, and more complex missions without putting sensitive data at risk. This program has applied research efforts funded in PE 0602716E, Project ELT-02. ***FY 2022 Plans:*** - Demonstrate the implementation of novel provably-secure hardware with computation overheads that are practical for real-world use. - Perform design for the integration of provably-secure hardware into multi-level security architecture. ***FY 2023 Plans:*** - Demonstrate integration of provably-secure hardware into multi-level security architecture. - Perform initial testing of integrated provably-secure hardware. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects the program moving from design to integration and testing.			
Title: Ferroelectric Computing (FC)	-	3.000	10.188
Description: The Ferroelectric Computing (FC) program will develop advanced complementary metal oxide semiconductor (CMOS)-compatible ferroelectric transistor technology, compute-in-memory element, and memory compute array technologies for critical data-intensive DoD applications such as radar processing, signal intercept and identification, and image processing. Current compute-in-memory devices are not compatible with advanced CMOS, and are too large to be scaled to the performance and efficiency levels necessary to support these applications. This program will address this shortfall by developing CMOS-compatible ferroelectric transistor technology for next-generation power-efficient, dense, and scalable compute-in-memory accelerators. This program has applied research efforts funded in PE 0602716E, Project ELT-02. ***FY 2022 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** ES-02 / *BEYOND SCALING SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Analyze material properties and device characteristics to evaluate suitability for use in a ferroelectric transistor. ***FY 2023 Plans:*** - Simulate performance of ferroelectric transistors and analyze potential impact for high efficiency processing. - Perform initial designs of ferroelectric transistor architectures from simulation data. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects additional fundamental research activities in ferroelectric materials and transistors.			
Title: Next Generation Microelectronics - Advanced Manufacturing Science ***Description:*** Next Generation Microelectronics - Advanced Manufacturing Science addresses the fundamental science of advanced design, fabrication, packaging, assembly, and testing for complex microsystems. This area also addresses leveraging the underlying device physics of novel material systems to enable electronics that operate in extreme environments, such as environments with high voltage, high current, high temperature, low temperature, and radiation exposure. This effort will build upon a fundamental understanding of the materials, interconnects, and device technologies to enable the design, assembly, testing, and digital emulation of three-dimensional heterogeneous integration (3DHI) in microsystems, and their use in both standard and extreme environments. The physics of interfaces between similar and dissimilar materials and the ability to characterize and reduce defect densities will be critical to the future of 3DHI approaches. In addition, the physics of electron transport, photon transport, and heat dissipation are key areas of study. Materials advances and metrology that improve the reliability of heterogeneously integrated microsystems will be addressed, including those that enable high current density for power delivery. Applied research related to this effort is funded within PE 0602716E, Project ELT-02. ***FY 2023 Plans:*** - Investigate electrical characterization techniques and metrology for three-dimensionally interconnected microsystems and thermally hardened microsystems. - Identify the surface and interface physics to allow precisely aligned, high-density interconnects for digital components. - Explore novel materials and material systems to extend temperature operation range and to improved management of thermal interfaces, leveraging artificial intelligence (AI) and additive manufacturing. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.	-	-	20.000
Title: Joint University Microelectronics Program 2.0 (JUMP 2.0) ***Description:*** The Joint University Microelectronics Program 2.0 (JUMP 2.0) program will develop and demonstrate innovative next-generation microelectronics technologies through public-private partnership with universities, the defense industrial base, and the semiconductor industry. The JUMP 2.0 program addresses the grand technical challenges of our increasingly connected	-	-	18.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** ES-02 / *BEYOND SCALING SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
world that must be overcome including: the need for innovation in analog hardware, increasing demand for more memory and data storage, the imbalance between data generation and communication capacity, the emerging security vulnerabilities in highly-interconnected Artificial Intelligent systems, and the unsustainable growth in energy demands for computing. Therefore, the JUMP 2.0 program sponsors academic research teams focused on related key technology areas that will not only impact future defense and national security capabilities but also strengthen U.S. leadership in information and communication technology. The JUMP 2.0 program will push fundamental technology research themes in cognition, communications, sensing to action, computing and processing, memory and storage, integration and packaging, and high-performance energy efficient devices to enable key disruptive advances in microelectronic technology. ***FY 2023 Plans:*** - Launch university research teams to study technical areas with long-term impacts to government and industry. - Explore high-performance energy-efficient materials, devices, and 3D integration technology for future microsystems. - Investigate cognition, communications, sensing to action, computing and processing, integration and packaging, and high-performance energy efficient devices. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Joint University Microelectronics Program (JUMP) ***Description:*** The Joint University Microelectronics Program (JUMP) is a government-industry joint research program to explore computing, sensing, communication, and data storage innovations for applications beyond the 2030 horizon. The program recognizes that the densely interconnected microsystems of the future will be built through the use of groundbreaking materials, revolutionary devices, advanced architectures, and unconventional computing. Therefore, JUMP sponsors academic research teams focused on related key technology areas that will impact future DoD capabilities and national security. The JUMP program will not only push fundamental technology research but also establish long-range microelectronic research themes with greater emphasis on end-application and systems-level computation. By discovering the science underlying new technologies and overcoming engineering challenges, JUMP will enable DoD applications to exploit the entire electromagnetic spectrum from radio frequency (RF) to terahertz (THz) and to employ both distributed and centralized computing with embedded intelligence and memory. ***FY 2022 Plans:*** - Advance materials, power efficient RF, THz, digital, and storage devices for technology adoption or transition.	18.000	18.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** ES-02 / *BEYOND SCALING SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Demonstrate next-generation distributed and centralized computing architectures and subsystems with enhanced efficiency of information extraction, processing, and autonomous control. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Lifelong Learning Machines (L2M) ***Description:*** The Lifelong Learning Machines (L2M) program is researching and developing fundamentally new machine learning mechanisms, enabling machines that learn continuously as they operate. Current learning machines are fully configured in advance of deployment, and so have difficulty accounting for in-the-field mission changes or unexpected deviations in the data being processed. To overcome this limitation, L2M will pursue learning approaches inspired by biological systems, which continuously learn and improve their skills without losing previous knowledge. L2M will explore network structures that improve performance by processing new data seen in the field, learn new tasks without forgetting previous tasks, and incorporate context into their understanding of the environment. These capabilities would impact a broad array of military applications that require processing and understanding data in real-time, often have limited data sets for training, and must be deployed in environments where unpredictable events may occur. ***FY 2022 Plans:*** - Demonstrate integrated L2M systems in multiple domains. - Transition L2M algorithms into selected applications. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	14.365	5.500	-
Accomplishments/Planned Programs Subtotals	57.365	45.145	70.188

	FY 2021	FY 2022
Congressional Add: ERI 2.0 Congressional Add	-	20.000
FY 2022 Plans: - Initiate developing new material systems to extend temperature operation range for thermally-hardened and high-reliability microsystems. - Initiate developing new materials for three-dimensional heterogeneous integration (3DHI) photonics. - Identify new materials and structures for passive components for 3DHI power modules. - Develop novel materials for reducing losses in vertical high frequency interconnects for 3DHI microsystems.		
Congressional Adds Subtotals	-	20.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** ES-02 / *BEYOND SCALING SCIENCES*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 1	R-1 Program Element (Number/Name) PE 0601101E / *DEFENSE RESEARCH SCIENCES*	Project (Number/Name) MS-01 / *MATERIALS SCIENCES*	

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
MS-01: *MATERIALS SCIENCES*	-	53.663	40.303	58.356	-	58.356	82.602	89.818	80.000	76.782	-	-

A. Mission Description and Budget Item Justification

The Materials Sciences project provides the fundamental research that underpins the design, development, assembly, and optimization of advanced materials, devices, and systems for DoD applications in areas such as robust diagnostics and therapeutics, novel energetic materials, and complex hybrid systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Molecular Systems and Materials Assembly	5.500	10.000	24.900

Description: The Molecular Systems and Materials Assembly thrust is exploring new approaches for the synthesis, assembly, characterization and application of molecules and materials for a variety of DoD applications from the atomic to the product scale. Ultimately, materials and methods developed in this thrust will support a wide range of DoD applications that span electrochemical energy storage, corrosion resistant materials, data storage and nutrient generation. Specific approaches include understanding and controlling interfacial phenomena, developing technologies for microbial production of macronutrients (e.g., proteins and carbohydrates) and exploiting molecules for use in data storage and computing. Efforts in this thrust range from fundamental science to better understand the chemistry and physics related to each application, to developing means to utilize such capabilities in future test systems and prototype devices.

FY 2022 Plans:

- Assess novel approaches to use local energy gradients to sense onset of damage and enable restoration of morphology and function in electrochemical interfaces.
- Initiate efforts to enable production of food on demand at point of consumption that addresses supply line vulnerabilities.

FY 2023 Plans:

- Discover or design novel materials and materials-architectures that can self-regulate morphology in electrochemical interfaces.
- Assess system level persistence improvements in solid-state batteries such as (number of charge/recharge cycles) due to morphology regulation.
- Assess material systems improvements for corrosion resistant materials such as galvanic corrosion and corrosion fatigue due to morphology regulation.
- Achieve simultaneous production of four human macronutrients in microbial food.
- Demonstrate integration of all component processes required to produce microbial food in the field.
- Demonstrate ability to flavor microbial food.

FY 2022 to FY 2023 Increase/Decrease Statement:

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** MS-01 / *MATERIALS SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase is due to a shift from initial designs to development and demonstration.			
Title: Fundamental Limits	30.103	20.203	19.500
Description: Understanding the Fundamental Limits (i.e., achievable boundaries) of scientific principles, processes and technologies is critical to better anticipate technological surprise for our adversaries and ourselves. This thrust explores boundaries across fields such as physics, chemistry, mathematics, biology, and engineering to address critical questions for national security, addressing foundational theory and approaches that include, for example, the fundamental limitations of optical technologies, potential implications for basic biology on national security, and the ability for modeling and simulation to provide a better understanding of complex systems. ***FY 2022 Plans:*** - Replicate ionospheric total electron content signatures caused by meteorological and geophysical transient disturbances using next generation modeling and simulation. - Discover and characterize the nature of atmospheric background conditions through experimental campaigns in the mesospheric region. - Commence development of new multimodal whole-of-atmosphere sensors to identify atmospheric transient disturbances produced by meteorological and geophysical sources. - Demonstrate improved sensitivity of atomic vapor-based electric field sensors in the millimeter wave frequency range. - Demonstrate an atomic vapor cell-based vector magnetometer with improved sensitivity and accuracy in a reduced physics package size. - Demonstrate the potential for improving the atom-photon interaction strength and quantum coherence of vapor quantum devices. - Identify DoD relevant applications for room temperature, vapor cell-based electric and magnetic field sensors and quantum atom-light interfaces. ***FY 2023 Plans:*** - Complete development of new multimodal whole-of-atmosphere sensors to identify atmospheric transient disturbances produced by meteorological and geophysical sources. - Demonstrate using the atmosphere as a sensor to discover sources of transient disturbances in real-world conditions relevant to national security. - Continue to improve sensitivity of atomic vapor-based electric and magnetic field sensors. - Continue to increase the atom-photon interaction strength and quantum coherence of vapor-based quantum devices. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from component development and integration to system demonstration and refinement.			
Title: Basic Photon Science	10.060	10.100	13.956

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** MS-01 / *MATERIALS SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The Basic Photon Science thrust is examining the fundamental science of photons and their interactions in integrated devices for potential DoD-applications such as communications, signal processing, spectroscopic sensing and imaging. Research efforts will explore development of a complex theoretical framework for maximum information extraction from complex scenes to guide development of new imaging technologies. Work in this thrust will establish the first-principles limits of photon detector performance in a variety of detector technologies to enable better, more sensitive detectors. ***FY 2022 Plans:*** - Characterize measurement hyperdiversity techniques to generate novel sensor designs needed for autonomous ground systems to operate at high speed at night without a detectable signal. - Create initial predictions of the vehicle speeds that are theoretically supported by completely passive infrared sensors in off-road environments. ***FY 2023 Plans:*** - Fabricate novel sensors that use measurement hyperdiversity for passive sensing and range estimation. - Demonstrate stationary ranging in a laboratory setting using ambient thermal radiation. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects a shift from system characterization to fabrication and demonstration.			
Title: Non-Equilibrium Materials ***Description:*** The Non-Equilibrium Materials thrust explored materials and materials structures that acquired novel properties when driven far from equilibrium. Work in this thrust examined the physical underpinnings and applications of these systems in areas of interest to the DoD, including next generation electronics, high-performance computing, and sensing. Efforts included the development of topologically protected excitations in electronic materials and fundamental studies of exotic quantum states of matter in periodically driven solid-state systems.	8.000	-	-
Accomplishments/Planned Programs Subtotals	53.663	40.303	58.356

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 1	R-1 Program Element (Number/Name) PE 0601101E / *DEFENSE RESEARCH SCIENCES*	Project (Number/Name) TRS-01 / *TRANSFORMATIVE SCIENCES*	

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
TRS-01: *TRANSFORMATIVE SCIENCES*	-	35.980	28.188	31.265	-	31.265	17.692	8.123	8.123	8.123	-	-

A. Mission Description and Budget Item Justification

The Transformative Sciences project supports research and analysis that leverages converging technological forces and transformational trends in information-intensive subareas of the social sciences, life sciences, and manufacturing. The project integrates these diverse disciplines to eliminate reliance on foreign sources for critical materials, improve military adaptation to sudden changes in requirements, threats, and emerging/converging trends, especially trends that have the potential to disrupt military operations or threaten National Security. Specific research in this project will investigate technologies to enable detection of novel threat agents (e.g., bacterial pathogens), maintain warfighter health, and improve recovery. This project also includes efforts to create innovative materials of interest to the military, as well as biological platforms for fabrication. This Program Element also supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA-funded technologies take root in the U.S. and provide new capabilities for national defense.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Biology for Security (BIOSEC)	11.672	9.351	7.535
Description: The Biology for Security (BIOSEC) program seeks to investigate novel approaches to address the DoD need for rapid detection of unknown and/or emerging biological threats from state actors or violent extremist organizations (VEOs). This program will investigate approaches for identifying pathogens based on specific behaviors, or phenotypes, such as niche finding or cell toxicity. Unlike current methods, which rely on a priori knowledge of the pathogen and cannot detect or otherwise analyze unknown threats, this approach will handle scenarios involving engineered or undiscovered bacterial pathogens that do not have known hallmarks. Advances in this area will produce a completely new capability to assess the emergence of pathogens and to detect pathogens that have been specifically engineered to evade detection by traditional methods. Resulting systems may be used to alert deployed military personnel operating around the world to new biothreats, or in response to a U.S.-based discovery, outbreak, or pandemic.			
FY 2022 Plans: - Develop isolation and interrogation platforms on sterilized real-world samples spiked with 50-100 different types of bacteria. - Develop algorithms that combine trait scoring for predictive threat identification. - Develop decision tree optimization algorithm and demonstrate increased pipeline efficiency. - Demonstrate ability to map pathogenic traits to single bacteria.			
FY 2023 Plans: - Demonstrate integrated platforms that identify pathogens from unknown consortia. - Transition technology to U.S. government partners tasked with preventing or responding to pathogen outbreaks.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** TRS-01 / *TRANSFORMATIVE SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Complete independent verification and validation (IV&V) analysis of integrated platforms. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the shift from research and development activities to testing integrated systems on real-world samples in conjunction with transition partners.			
Title: Rapid Healing for Warfighter Injuries	13.430	16.587	20.421
Description: The Rapid Healing for Warfighter Injuries effort is addressing the DoD need for improving warfighter recovery from injury by developing technologies that can accelerate the restoration and repair of complex tissues. This program will develop approaches that combine high-resolution biosensors to track the healing process in real-time with bioactuators to stimulate restoration where and when needed. The primary challenge to achieving this is the lack of a closed-loop interface that can manipulate highly complex signaling pathways in wounds and the developmental interdependencies that scale from cell to tissue. The program will develop new methods to convert dense multi-modal information into the body's native repair processes, and will leverage artificial intelligence to guide the delivery of the signals necessary for healing. Advances from this program will produce bioactuators that can release diverse stimuli with high spatial and temporal resolution, and biosensors that provide the requisite in situ measurement to guide the healing process. ***FY 2022 Plans:*** - Demonstrate biocompatibility, reliable operation of sensors and actuators, and tracking and control of at least two physiological processes in animal models. - Produce an in vivo sensor system that can accurately report the wound state to be delivered to the independent verification and validation (IV&V) team. - Demonstrate that the model predicts the wound stage from in vivo test data with 80% accuracy. - Demonstrate closed-loop control over at least one physiological process. - Demonstrate improved wound healing for one wound healing stage. - Develop an initial integrated model for multi-systems interventions. ***FY 2023 Plans:*** - Integrate sensors and actuators for one physiological process into a single platform. - Demonstrate that predictions made by the machine-learning algorithms occur at therapy-relevant time scales without sacrificing accuracy. - Initiate independent verification and validation (IV&V) of in vivo biocompatibility of integrated systems. - Demonstrate improved wound healing for two stages of wound healing. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** TRS-01 / *TRANSFORMATIVE SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase reflects conducting in vivo experiments in large animal models, integrating all components into a single platform, and conducting IV&V assessment of the technology.			
Title: Engineered Living Materials (ELM)	2.200	2.250	3.309
Description: The Engineered Living Materials (ELM) program is pursuing new approaches to engineer complex biological systems for enhanced capabilities and functional materials to improve military infrastructure design and logistics, sensors, and platforms. Complex biological materials and systems have unique properties (e.g., controlled porosity, high strength-to-weight ratios, magnetic, optical) not only because of the inherent components but also because of how those components are assembled together across length scales. Engineering biology tools and techniques are now at a stage to pursue the production, organization, and function of biomaterial systems for a variety of improved capabilities. This program is developing underlying technological platforms to enable information-driven assembly of hierarchical biological systems as well as alternate approaches for the advanced development of critical molecules and materials. Advances in this program will impact next-generation material design for optical and electronic applications; military approaches to infrastructure design in austere environments; as well as established methods for the manufacture and maintenance of military platforms. ***FY 2022 Plans:*** - Characterize biological and mechanical properties of material for durability and reliability under various operational scenarios. - Investigate methods to develop alternate approaches to produce critical molecules and materials for use in austere environments. - Exploit microbial processes and biomolecules to control the incorporation of rare earth elements (REEs) into inorganic materials with magnetic and optical characteristics. ***FY 2023 Plans:*** - Demonstrate methods for alternate approaches to identify, engineer, and develop critical molecules and materials for use in austere environments. - Engineer biological systems that predictably control the composition, size, and architecture of REE-containing nanoparticles that exhibit optical and magnetic properties. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects development in technologies to advance development of critical molecules and materials in austere environments.			
Title: Social Simulation (SocialSim)	8.678	-	-
Description: The Social Simulation (SocialSim) program developed computational models to simulate the future spread and evolution of information in the online environment including multiple global and regional social media platforms. The global			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** TRS-01 / *TRANSFORMATIVE SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
information environment is radically changing how and at what rate information spreads and evolves. Both nation-state and sub-state actors are incorporating messaging into their operations to great advantage. Existing approaches to modeling online information spread have been narrow in scope and focused on keywords or social networks. SocialSim combined models of holistic platform activity with models of anonymized users and networks to capture social media engagement and spread for better simulation and understanding of how information spreads through various platforms and is impacted by events in the real world. This capability will support assessment and prediction of adversary or U.S. information campaign spread and development of realistic, synthetic social media for training and other purposes.			
Accomplishments/Planned Programs Subtotals	35.980	28.188	31.265

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601117E / *BASIC OPERATIONAL MEDICAL SCIENCE*

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	-	57.542	77.518	80.874	-	80.874	67.204	67.738	90.378	80.321	-	-
MED-01: *BASIC OPERATIONAL MEDICAL SCIENCE*	-	57.542	77.518	80.874	-	80.874	67.204	67.738	90.378	80.321	-	-

A. Mission Description and Budget Item Justification

The Basic Operational Medical Science Program Element will explore and develop basic research in medical-related information and technology leading to fundamental discoveries, tools, and applications critical to overcoming DoD challenges. Programs in this Program Element address the Department's identified medical gaps in warfighter care related to restorative function of the body, blood loss, sleep restriction, and prevention and treatment of infectious disease. Efforts will draw upon computational modeling and experimental data to discover properties of biological systems that cross multiple scales of biological architecture and function, from the molecular and genetic level through cellular, tissue, organ, and whole organism levels. To enable in-theater continuous monitoring, protection, and treatment of warfighters, this Program Element will explore multiple diagnostic and therapeutic approaches, including developing techniques to protect against emerging pathogens; exploring methods to prevent pathological infection; increasing the longevity of effective therapeutics against pathogenic threats; and leveraging fundamental and engineered biological mechanisms to enhance tolerance to insults such as pain, altitude, and chronic loss of sleep. This Program Element also supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA-funded technologies take root in the U.S. and provide new capabilities for national defense.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	53.730	76.018	0.000	-	0.000
Current President's Budget	57.542	77.518	80.874	-	80.874
Total Adjustments	3.812	1.500	80.874	-	80.874
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	1.500			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	5.542	0.000			
• SBIR/STTR Transfer	-1.730	0.000			
• Adjustments to Budget Year	-	-	80.874	-	80.874

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: MED-01: *BASIC OPERATIONAL MEDICAL SCIENCE*		

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601117E / *BASIC OPERATIONAL MEDICAL SCIENCE*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Congressional Add: *Novel analytical and empirical approaches to the prediction and monitoring of disease transmission - Congressional Add*	-	1.500
Congressional Add Subtotals for Project: MED-01	-	1.500
Congressional Add Totals for all Projects	-	1.500

Change Summary Explanation

FY 2021: Increase reflects reprogrammings offset by SBIR/STTR transfer.
FY 2022: Increase reflects Congressional add for Project Increase - novel analytical and empirical approaches to the prediction and monitoring of disease transmission.
FY 2023: FY 2023 funding increase reflects the fact that the FY 2022 President's Budget request did not include out-year funding.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Early Battlefield Interventions (EBI)	13.302	15.150	12.918

Description: The Early Battlefield Interventions (EBI) program is exploring new methods to slow and limit damage caused by acute trauma, injury, and infection often suffered by warfighters under far-forward conditions. Research efforts will apply advances in molecular and cellular biology, cell signaling, and biomaterials to develop new tools to alter the time course of pathological processes associated with infection and tissue damage. This tactic is a departure from traditional therapeutic approaches that seek to control symptoms associated with active infections or innate physiological responses to tissue trauma. Advances in this area may be applied to the development of both prophylactic and therapeutic medical countermeasures to forward-deployed service members.

FY 2022 Plans:
- Observe the effects of biostasis-inducing agents on cell function (e.g., toxicity, metabolism, DNA damage, etc.) and evaluate mechanisms of biostasis.
- Establish intervention approaches to focus on inducing and reversing biostasis in increasingly complex, multicellular systems.
- Evaluate biological uptake and distribution of biostasis interventions, and characterize molecular mechanisms of interventions.
- Begin to characterize time course of biostasis induction and reversibility of cellular stasis.

FY 2023 Plans:
- Demonstrate biostasis induction at observable and molecular levels in complex, multicellular biological systems.
- Evaluate the time course of biostasis induction and reversibility in multicellular systems.

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Detail mechanisms underlying biostasis, as well as potential negative effects (e.g., toxicity, DNA damage, etc.) in multicellular biological systems. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of discovery efforts and movement towards final demonstration experiments to validate candidate effects.			
Title: Improved Interventions ***Description:*** The Improved Interventions program seeks to develop novel pharmacological interventions to quickly and holistically optimize the performance of the healthy warfighter. The status quo for pharmacological intervention is one drug, one target, which often has many undesirable side effects. This program will create a platform to develop pharmacological interventions capable of modulating multiple targets within biological systems of the body, which will reduce side effects and promote safety. Research will focus on the integration of novel bioinformatics approaches, high-content physiological model systems, and new bio-orthogonal chemical synthesis methods to treat the system in order to achieve desired physiological effects. Progress in this area will lead to new pharmacological discovery and design principles that will lead to products that can be used to augment physical fitness training and maintenance for military populations. ***FY 2022 Plans:*** - Begin validation of novel drug target network by predicting and testing drug combinations in a complex model system. - Collect molecular response profiles to target drugs developed for the indications of interest. - Test novel chemical compounds in appropriate biological model systems and compare to current single drug therapy. - Accelerate the timeline to network assembly and drug synthesis platform. ***FY 2023 Plans:*** - Analyze drug combination effects and compare to single drug therapy. - Optimize novel multi-target drugs for activity based on response profiles. - Identify protein targets and synthesize drugs in less than 60 days. - Use biological model systems to validate multi-target drug actions for therapeutic use. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.	15.137	15.733	15.912
Title: Physiological Overmatch ***Description:*** Warfighters must operate under extreme physiological conditions with limited resources, acclimating quickly to austere environments. The Physiological Overmatch program is investigating innovative approaches to leverage biological systems to adapt to environmental challenges during deployment. The program will initiate work in aiding the deployed soldier's	12.262	17.365	18.195

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
ability to defend against biological pathogens, resist fatigue, and receive adequate nutrition and hydration. Advances in engineered cells, bioelectronics, and cellular feedback circuits will enable the controlled, in vivo release of therapies as needed by the warfighter. This approach represents a significant enhancement to warfighter performance by providing internal protection from novel threats. ***FY 2022 Plans:*** - Demonstrate inducible biosynthesis enabling the delivery of a beneficial biomolecule at a clinically relevant level. - Test biosynthesis of at least one therapy in vivo. - Demonstrate communication with the carrier in vivo or through realistic models (e.g., phantom tissue). - Validate biocompatibility of the carrier device in vivo. - Begin high-resolution data collection for characterization of fatigue states. ***FY 2023 Plans:*** - Demonstrate localization of the carrier device within a realistic model, such as phantom tissue. - Validate that a beneficial biomolecule can be delivered in vivo. - Confirm biocompatibility of the carrier device for at least 30 days in a large animal model. - Develop a prototype sensor for tracking circadian rhythm. - Initiate development of approaches to improve resilience to fatigue. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.			
Title: Combatting Anti-Microbial Resistant Pathogens	6.717	15.999	15.875
Description: The Combatting Anti-Microbial Resistant Pathogens program is investigating fundamental methods for using innate host machinery as a technology to create medical countermeasures that degrade or deactivate pathogen targets. The DoD has long recognized the warfighter's outsized risk of exposure to biological threat agents and to infectious disease, including the increasing prevalence of antimicrobial-resistant (AMR) organisms that are ranked as a Tier 1 threat to the U.S. military. Similarly, the danger posed by bacterial biothreats persists with few countermeasures available. Key advances expected from this research include identifying methods to discover and develop new classes of therapeutics for AMR bacteria, bacterial biothreats, and other DoD-relevant diseases and threats. These approaches represent a significant departure from conventional therapeutics, which typically rely on a limited number of small molecules with a narrow set of targets and mechanism of action. Advances in this area may be applied to the mitigation of known, new, and emerging diseases that impact military readiness and pose a global health threat. ***FY 2022 Plans:***			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Investigate the ability of chimeric molecules to inhibit DoD-relevant pathogen threats in vitro. - Develop methods to model the kinetics and outcomes of chimeric molecules against pathogens. - Investigate the mechanism of action for chimeric molecules engaging new host machinery. - Develop rapid ligand identification and screening approaches for pathogen targets and host machinery. ***FY 2023 Plans:*** - Demonstrate effective host and threat binding ligands and generalizable discovery and design strategies. - Demonstrate generalizable therapeutic candidate discovery and optimization approaches. - Develop chimeric molecules showing specificity and efficacy against DoD-relevant pathogen threats in cell culture. - Refine rapid drug identification and screening approaches for degradation or deactivation of novel pathogen targets. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Preventing the Emergence of Disease (PED)	5.664	4.882	2.716
Description: Many emerging infectious disease outbreaks have origins in animal reservoirs and occur in areas where DoD personnel are deployed, putting them at high risk of endemic and emerging diseases. The Preventing the Emergence of Disease (PED) program is investigating how animal pathogens are transmitted to humans and exploring novel approaches to prevent these events. Tools such as detailed molecular analysis and bioinformatics will be leveraged. Researchers will develop models to quantify the probability of pathogen disease transmission from animals to humans. Promising intervention approaches will be developed to prevent viral species jumps from animal reservoirs to humans. Predicting such jumps is a key capability to mitigating outbreaks originating in animal reservoirs. ***FY 2022 Plans:*** - Demonstrate safety, efficiency, and efficacy of scalable countermeasure delivery platform in vitro and in animal models. - Demonstrate efficacy of a vaccine to prevent Lassa fever virus spillover in controlled laboratory tests. - Demonstrate efficacy of ecological countermeasures to protect against spillover of henipaviruses from animal reservoirs in controlled laboratory tests. ***FY 2023 Plans:*** - Identify optimal thermostabilizing properties, delivery formulations, and storage conditions to ensure vaccine stability, safety and efficacy. - Validate phylodynamic and multi-scale modeling for other host species and diseases. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 decrease reflects completion of medical countermeasure and predictive modeling validation, and finalizing independent verification and validation efforts.			
Title: Outpacing Infectious Disease	4.460	6.889	2.501
Description: Military readiness and national security depend on the health and well-being of military service members. Unfortunately, today's antivirals and vaccines are often circumvented by fast-mutating viruses that evolve to develop drug resistance. Military service members often deploy to areas with such diseases that require new protective measures to maintain readiness. The Outpacing Infectious Disease program is investigating fundamental methods for using biology as a technology to create adaptive therapeutic response mechanisms to outpace viral diseases such as enabling co-evolution and co-transmission of newly developed therapeutics to ultimately outcompete the pathogen. Key advances expected from this research include identifying methods to discover and develop new classes of dynamic therapeutics for fast-mutating viruses. This approach represents a significant departure from conventional antiviral therapies, which typically rely on static solutions and continuous re-formulation and re-development in attempt to keep pace with emerging strains and disease variants. Advances in this area may be applied to the mitigation of known, new, or emerging diseases that impact military readiness and pose a national security risk as a potential pandemic. ***FY 2022 Plans:*** - Submit pre-Investigational New Drug (IND) package for clinical trial for therapeutic interfering particles (TIPs). - Initiate studies to facilitate clinical safety trials for TIPs. - Determine spatial distribution and co-localization of TIPs and viruses in animal models. - Identify alternative methods for discovery and development of prophylactics to increase the longevity of protection for known, new, or emerging diseases. ***FY 2023 Plans:*** - Submit IND package for clinical trials for TIPs. - Complete current Good Manufacturing Practice (cGMP) production of TIPs for clinical trial. - Initiate clinical safety trial for TIPs. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the completion of cGMP production of TIPs for clinical trial and submission of IND package.			
Title: Assessing Immune Memory (AIM)	-	-	12.757
Description: Warfighter defense against pathogens is reliant on multiple vaccinations administered repeatedly to maintain effective protection. Building upon initial discoveries and technology development under the Outpacing Infectious Disease program, the Assessing Immune Memory (AIM) program will seek to increase the longevity of infectious disease protection in			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
warfighters by establishing tools that can be employed in new prophylactic development pipelines. Specifically, this program will develop a research and evaluation (R&E) tool to predict vaccine duration through the understanding of critical host factors and immune responses. Further, the tool will evaluate prophylaxis candidates and leverage effective modalities for delivery against emerging, re-emerging, or entirely unknown pathogens. Advances in this program will enable the DoD to increase the number of effective and long-lasting vaccines for warfighters, ensuring broader and consistent immunity in field-forward environments. ***FY 2023 Plans:*** - Initiate studies to uncover host mechanisms that lead to the production of long-lasting immune memory cells after antigen presentation. - Determine immune system challenge and appropriate biological model for profiling approaches. - Initiate characterization of established immune responses to selected antigens. - Begin to collect and compare molecular profiles of stimulated immune response. - Begin developing computational frameworks required for analyzing large collections of molecular and phenotypic data. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Accomplishments/Planned Programs Subtotals	57.542	76.018	80.874

	FY 2021	FY 2022
Congressional Add: Novel analytical and empirical approaches to the prediction and monitoring of disease transmission - Congressional Add ***FY 2022 Plans:*** - Conduct research in novel analytical and empirical approaches to the prediction and monitoring of disease transmission.	-	1.500
Congressional Adds Subtotals	-	1.500

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
Total Program Element	-	98.319	108.698	106.958	-	106.958	120.671	141.371	161.215	151.066	-	-
BT-01: *BIOMEDICAL TECHNOLOGY*	-	98.319	108.698	106.958	-	106.958	120.671	141.371	161.215	151.066	-	-

A. Mission Description and Budget Item Justification

This Biomedical Technology Program Element focuses on applied research for medical related technology, information, processes, materials, systems, and devices. Successful battlefield medical and neural interface technologies developed within this Program Element address a broad range of DoD challenges to ensure warfighter readiness, including resilience to infectious disease, evidence-based techniques for readiness assessment, and neurotechnology for improved warfighter performance. To maintain warfighter health, battlefield medical technologies research in this project will investigate novel biothreat detection, injury, and therapeutic response. Example programs include the development of a platform for the identification of early infection biomarkers to diagnose and prevent widespread infection in-theater, new methods to rapidly develop medical countermeasures in response to an emerging biothreat, and in-theater manufacturing capabilities for field-relevant pharmaceuticals to reduce the logistical burden and infrastructure requirements. To improve warfighter performance, this project will characterize and assay biological traits driving performance and readiness as well as develop new neural architectures and data processing algorithms to interface the nervous system with multiple devices, facilitating human machine interaction. Additionally, advanced evidence-based techniques will be developed to supplement warfighter healthcare, including rapid battlefield triage of injury, development of shelf stable blood products, protection from traumatic brain injury (TBI), and treatment of spinal cord injury. This Program Element also supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA-funded technologies take root in the U.S. and provide new capabilities for national defense.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	107.568	108.698	0.000	-	0.000
Current President's Budget	98.319	108.698	106.958	-	106.958
Total Adjustments	-9.249	0.000	106.958	-	106.958
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-5.788	0.000			
• SBIR/STTR Transfer	-3.461	0.000			
• Adjustments to Budget Year	-	-	106.958	-	106.958

Change Summary Explanation

FY 2021: Decrease reflects reprogrammings and SBIR/STTR transfer.

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

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Neural Signal Interfaces and Applications (NSIA)	15.074	16.205	9.716
Description: As part of their daily duties, many military personnel must handle large volumes of data and interact with complex systems. These tasks could be made less difficult with advanced neurotechnology platforms, but all such devices currently require invasive surgery to implement. The Neural Signal Interfaces and Applications (NSIA) program is developing non-invasive neurotechnologies able to interface with the nervous system with high resolution and precision without surgery. NSIA is utilizing recent advances to transduce neural signals through tissue. Resulting technologies will restore function in wounded warriors and facilitate standard human-machine interfaces for improved workload balance between man and machine. ***FY 2022 Plans:*** - Evaluate system ability to input multiple channels of information into a single volume of neural tissue. - Quantify system latency when used in real time. - Assess performance of read and write components on tissue of varying thickness. - Conduct initial in vivo tests evaluating system use for controlling multiple outputs. ***FY 2023 Plans:*** - Conduct studies to collect safety data to enable regulatory approval for clinical system evaluations. - Submit safety evaluation data and documentation to request regulatory approval for further system evaluations. - Conduct refined tests evaluating control of multiple outputs in real-time. - Conduct refined tests evaluating reception of multiple channels of information in real-time. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of system development activities to focus on final testing and transition activities.			
Title: Pandemic Prevention	19.550	8.521	5.450
Description: Military personnel are deployed all over the world for traditional operations that can involve exposure to endemic infectious disease, and are often specifically called upon in response to emerging or re-emerging disease outbreaks with pandemic potential (e.g., Ebola). In both instances, the DoD needs effective countermeasures to protect its deployed forces and maintain warfighter readiness. The Pandemic Prevention program is focusing on novel methods to accelerate countermeasure discovery, pre-clinical testing, and manufacturing. This program seeks to advance and integrate newly developed approaches including bioinformatics assessment of genetic sequencing and nucleic acid-based vaccines and to address technology bottlenecks associated with each stage of medical countermeasure development. Additional research will investigate new			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
methods improving the manufacturability, distribution, and delivery of novel therapeutics. Pandemic Prevention will enable an integrated therapeutic development platform that leverages state-of-the-art technologies to prevent disease outbreaks. ***FY 2022 Plans:*** - Initiate a Phase I clinical safety study of a gene-encoded antibody. - Complete clinical monitoring of patients in a Phase I antibody clinical safety study. - Investigate antibody medical countermeasure products that bind and neutralize more than one target. - Integrate methodologies for mitigating viral mutant escape from candidate antibodies. - Investigate alternative nucleic acid antibody delivery strategies. ***FY 2023 Plans:*** - Investigate novel mRNA formulations for increased stability. - Initiate a Phase I clinical study of an antibody product that binds and neutralizes more than one target. - Complete clinical monitoring of patients in a Phase I gene-encoded antibody clinical safety study. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of clinical safety study for Phase I gene-encoded antibody.			
Title: Forensic Indicators of Threat Exposure (FITE) ***Description:*** The Forensic Indicators of Threat Exposure (FITE) program is developing a field-deployable resource for indicators of an individual's exposure history to Weapons of Mass Destruction (WMD) and WMD precursors. FITE will investigate the ability to characterize epigenetic signatures in an individual's genome caused by specific exposures. The program will create the framework for modular technology capable of performing forensic or diagnostic analysis using epigenetic information to provide high specificity of the type of exposure and when it occurred. This novel capability could serve as a field-forward forensic tool for use by the DoD to assist in Chemical, Biological, Radiological, and Nuclear (CBRN) threat detection and response. ***FY 2022 Plans:*** - Perform pressure tests to assess the ability to distinguish viral from bacterial host-based epigenetic signatures in clinical samples. - Perform pressure tests to assess the ability to identify time since exposure on collected samples. - Expand the number and type of human exposure signatures based on collected samples. - Build platform prototype and perform initial tests for module integration in field forward device. ***FY 2023 Plans:*** - Finalize development of human exposure signatures based on collected samples. - Finalize analytical methods to increase sensitivity and specificity for validated human exposure signatures.	11.436	12.957	5.251

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Perform tests on platform prototype for module integration and workflow implementation in militarily relevant, field forward settings. - Assess ability of field forward device to analyze epigenetic signatures with optimum sensitivity and specificity from biological samples in the field. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of significant research efforts to focus on final system and device demonstration.			
Title: Improved Personnel Placement (IPP) ***Description:*** The Improved Personnel Placement (IPP) program aims to improve force lethality and overmatch by identifying and training candidates for specialized military positions and developing biological assays for readiness in order to maximize performance and resilience, while minimizing attrition. IPP will study the relationships between genotype and phenotype to identify unique physical, cognitive, and behavioral traits associated with a broad spectrum of military specialties. The program will link these phenotypic traits to underlying biological gene expression circuits driving performance. This knowledge will help individualize training and readiness assessment for specialized roles, while providing training cadres greater precision for identifying the correct candidates without bias. Measuring an individual's biological system will ensure that they achieve their maximum potential while facilitating readiness and resilience for the DoD. ***FY 2022 Plans:*** - Refine the mathematical and computational tools used to perform in silico analysis of phenotypic and biological variables. - Refine protocols to measure phenotypic traits and biological features. - Validate phenotypes linked to elite performance. - Validate expression circuits related to detected phenotypes. ***FY 2023 Plans:*** - Finalize and implement protocols for measuring phenotypic traits and biological features. - Demonstrate validated phenotypic and biological measurements linked to elite performance. - Automate data acquisition and computational tools used to perform in silico analysis of phenotypic and biological features. - Research biomarkers that correlate with readiness and identify physical and/or cognitive tasks used as proxies for performance in real-world deployment settings. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of significant research efforts to focus on system integration and transition activities.	19.317	16.866	14.971
Title: Deployable Medical Countermeasures for Warfighter Readiness	13.578	16.877	16.133

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: Maintaining robust protection and treatment against infectious disease threats during stabilization operations (e.g., Humanitarian and Disaster Relief [HADR]) can cause a drug discovery, manufacturing and supply chain burden. A major limitation of our current response to emerging biological and chemical threats is the lack of immediate availability of ideal medical countermeasures (MCMs) for rapid response. The Deployable Medical Countermeasures for Warfighter Readiness program aims to develop an on-demand deployable platform to manufacture nucleic acid drugs at scale, in short timeframes. The platform will be comprised of a fully contained system capable of selectively manufacturing relevant doses of current Good Manufacturing Process (cGMP) grade nucleic acid therapeutics at or near the point of care. This on-demand platform will enable countermeasures capable of combating novel threats, allowing a small force to prevent regional outbreaks from becoming global emergencies. ***FY 2022 Plans:*** - Determine the most effective methods for nucleic acid synthesis. - Initiate stability studies for enzymes, intermediate nucleic acid products, and/or reaction components. - Demonstrate automation of each of the modules for nucleic acid synthesis, purification, and formulation. - Develop schematics for integration of modules for nucleic acid synthesis, purification, and analysis into an alpha prototype. ***FY 2023 Plans:*** - Demonstrate assembly and amplification of nucleic acids using breadboard instrumentation and large-scale amplification. - Select final formulation characteristics and production process for suitable medical countermeasure safety, efficacy, and stability. - Select full panel of in-line analytical methods. - Initiate development of an integrated alpha-prototype instrument for nucleic acid synthesis and purification. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Bridging the Gap after Spinal Cord Injury	15.997	16.754	16.016
Description: The Bridging the Gap after Spinal Cord Injury program is developing and integrating technologies to heal and restore function associated with spinal cord injuries. This program will significantly advance treatment technologies by developing implantable, adaptive devices to address different stages of spinal cord injury (acute, sub-acute, and chronic). For early phases of injury, this program will develop technologies for real-time biomarker tracking and delivery of therapies to stabilize or rebuild nerve connections at the injury site. For final phase of injury, the Bridging the Gap after Spinal Cord Injury program will develop and integrate a network of devices deployed across the body to effectively create a synthetic nervous system and "bridge the gap" of the spinal cord injury to restore function and sensory feedback. The Bridging the Gap after Spinal Cord Injury program will dramatically improve the quality of life for wounded warfighters and veterans suffering from spinal cord injuries.			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: - Complete critical design review for implantable devices for spinal cord injury. - Initiate experiments toward achieving regulatory approval for the system sub-components. - Initiate test of system of systems for spinal cord injury stabilization and restoration of function. - Integrate machine learning algorithms and biological data to enable sensors to monitor the spinal cord injury progression and intervene appropriately. ***FY 2023 Plans:*** - Improve device design and performance features based on results from prototype testing. - Integrate risk mitigation strategies for nervous system access to aid functional restoration. - Initiate studies in an animal model to establish safety of prototype devices and therapies to meet regulatory requirements. - Initiate efficacy experiments in an animal model for the integrated system of systems to mitigate spinal cord injury. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Distributed Access to Critical Biotherapeutics for Warfighters	-	10.273	10.020
Description: The goal of the Distributed Access to Critical Biotherapeutics for Warfighters program is to ensure DoD access to critical medical countermeasures (MCMs) by establishing the foundational technologies needed for fully distributable, on-demand manufacturing of protein-based MCMs and critical reagents. To achieve this, investments will be made in technologies that enable immediate, high-yield synthesis of bioactive protein MCMs. This technology will allow the DoD to rapidly secure access to therapeutic proteins and to enzymes needed for nucleic-acid based MCM synthesis without reliance on complex supply chains or slow development cycles. ***FY 2022 Plans:*** - Investigate novel biological platforms to produce protein-based MCMs and reagents. - Investigate processes to ensure the quality of protein-based MCMs and reagents. - Initiate development of technologies to increase the production yield of protein-based MCMs and reagents. ***FY 2023 Plans:*** - Determine the yield of multiple classes of protein-based MCMs or reagents using novel production platforms. - Establish baseline lead time to protein production using the novel production platforms. - Establish process that adds one type of protein modification to enhance the quality of the protein-based MCM.			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Determine ability of novel biological platform to produce therapeutic proteins that are equivalent to state of the art in terms of functionality and quality. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Next-Generation Combat Casualty Care ***Description:*** The Next-Generation Combat Casualty Care program will develop advances in critical efforts to preserve warfighter life and well-being in the battlefields of the future. This research will directly address a leading cause of potentially preventable battlefield casualties by investigating new approaches for developing whole blood substitutes for traumatic injury that can be deployed on the battlefield in far forward settings. Additional potential uses apply to disaster relief, mass casualty events, and stabilization missions. Advances within this program will ensure that the U.S. remains able to care for service members in peer and near-peer conflict by addressing gaps in combat casualty care. ***FY 2022 Plans:*** - Begin to develop in vitro models for rapid product prototyping, testing, and evaluation. - Begin to investigate approaches for stabilizing the products to enable storage in field conditions. - Begin to investigate key biological functions of a whole blood substitute for trauma settings. - Develop initial therapeutic formulations. ***FY 2023 Plans:*** - Initiate efficacy assessments of therapeutic formulations against hemorrhage using in vitro models. - Demonstrate safety of stabilized products using in vitro models. - Provide initial proof-of-concept for stabilization and manufacturing approach of products. - Prepare for initial in vivo studies to demonstrate efficacy against hemorrhage. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.	-	10.245	10.733
Title: Rapid Battlefield Triage ***Description:*** The Rapid Battlefield Triage program will advance capabilities to quickly triage warfighters requiring urgent life-saving medical intervention and enable medical resources to provide an appropriate response in current and future battlefields. Today, triage at point-of-injury is limited by subjective assessments, tools that are manually intensive, and physiological signatures with little diagnostic and prognostic value. This program will build on recent biomarker discoveries and innovations in sensing platforms to develop field-portable technologies that support triage in the most challenging operational environments. By optimizing allocation of scarce medical resources and scaling to multiple casualties, these devices will help far-forward units	-	-	8.907

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
maximize their fighting strength against adversaries that inflict large numbers of casualties and constrain evacuation to advanced medical facilities. ***FY 2023 Plans:*** - Investigate novel physiological signatures of injury type and severity. - Begin to develop algorithms to clean and process sensor data. - Correlate physiological signatures of injury and severity with sensor outputs. - Develop experimental models to test sensor technologies. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Neuroprotection from Brain Injury ***Description:*** Building upon technologies discovered under the Restoring Cognitive Capability program (budgeted in PE 0602715E, Project MBT-02), the Neuroprotection from Brain Injury program will transform our defense against traumatic brain injury (TBI), for example as a result of exposure to blast. This program will further develop a mechanistic understanding of early molecular events following injury. Additionally, the program will develop technologies to rapidly deliver prophylactic countermeasures, ultimately preventing severe brain injury. These novel technologies will change the paradigm for treatment of TBI by preventing injury rather than attempting to reverse or repair it. ***FY 2023 Plans:*** - Evaluate biological events immediately following TBI. - Identify candidate biological events that can be targeted for developing protective or immediate treatment countermeasures. - Link the first biological events to downstream cellular or molecular cascades known to result in cognitive, psychological, or behavioral symptoms of TBI. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.	-	-	9.761
Title: Restoration of Auditory and Visual Function After Injury ***Description:*** The Restoration of Auditory and Visual Function After Injury program developed neurotechnology to mitigate the effects of physical injury to the auditory and visual systems of military personnel. Research focused on understanding various forms of sensing and actuation to improve outcomes. Technologies developed through this program provided foundational neural interface technology for restoring lost capability, improving situational awareness, and enhancing cognitive and physical effectiveness.	3.367	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602115E / *BIOMEDICAL TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Accomplishments/Planned Programs Subtotals	98.319	108.698	106.958

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS 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	-	405.789	480.363	388.270	-	388.270	377.426	352.139	372.784	379.890	-	-
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	-	14.710	25.000	11.250	-	11.250	15.000	18.750	15.000	15.000	-	-
IT-03: *CYBER SECURITY*	-	240.074	252.089	183.786	-	183.786	158.669	130.205	128.157	135.353	-	-
IT-04: *ARTIFICIAL INTELLIGENCE AND HUMAN-MACHINE SYMBIOSIS*	-	151.005	203.274	193.234	-	193.234	203.757	203.184	229.627	229.537	-	-

A. Mission Description and Budget Item Justification

The Information and Communications Technology Program Element is budgeted in the Applied Research budget activity because it is directed toward the application of advanced, innovative computing systems and communications technologies. This Program Element also supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA funded technologies take root in the U.S. and provide new capabilities for national defense.

The High Productivity, High-Performance Responsive Architectures project focuses on developing the computer hardware and associated software technologies required for future computationally- and data-intensive national security applications. Powerful new approaches are needed to manage the rapid growth in available sensor data, to leverage advances in machine learning, artificial intelligence, and quantum computing, and to maintain the security of DoD information systems. The project therefore aims not only to create new computing platforms to include quantum technology, but also to efficiently extract information out of large and chaotic data sets with embedded and low-size, weight, and power systems. Advances in these areas will allow for DoD electronic systems to collaboratively manage scarce resources, such as the electromagnetic spectrum, and to adapt to new requirements and situations. Further, the resulting technologies, by being accessible to a wide range of application developers, will support new, sustainable computing systems for a broad spectrum of scientific and engineering applications.

The Cyber Security project is developing the computing, networking, and cyber security technologies required to protect DoD, U.S. government, and U.S. civilian information, information infrastructure, and mission-critical information systems. Information technologies enable important new military capabilities and drive the productivity gains essential to U.S. industry. Meanwhile, cyber threats grow in sophistication and number, and put sensitive data, classified computer programs, mission-critical information systems, and U.S. economic competitiveness at risk. The technologies developed in this project will enhance the resilience of information systems to current and emerging cyber threats, enable broad situational awareness of the cyber domain, and provide the basis for accurate, calibrated, and safe cyber response.

The Artificial Intelligence and Human-Machine Symbiosis project develops technologies to enable machines to function not only as tools that facilitate human action but as trusted partners to human operators. Of particular interest are systems that can understand human speech and extract information contained in diverse media;

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602303E *I INFORMATION & COMMUNICATIONS TECHNOLOGY*

answer questions, reach conclusions, and propose explanations; and learn, reason, and apply knowledge gained through experience to respond intelligently to new and unforeseen events. Enabling computing systems with such human-like intelligence is now of critical importance because the tempo of military operations in emerging domains exceeds that at which unaided humans can orient, understand, and act. The technologies developed in the Artificial Intelligence and Human-Machine Symbiosis project will enable warfighters to make better decisions in complex, time-critical, battlefield environments; intelligence analysts to make sense of massive, incomplete, and contradictory information; software developers and certifiers to design, implement, evaluate, and accredit cyber-physical systems and other complex software-reliant systems with greater efficiency and confidence; and unmanned systems and semi-autonomous agents to perform critical missions in contested physical and virtual environments safely and reliably.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	420.920	430.363	0.000	-	0.000
Current President's Budget	405.789	480.363	388.270	-	388.270
Total Adjustments	-15.131	50.000	388.270	-	388.270
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	50.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-1.578	0.000			
• SBIR/STTR Transfer	-13.553	0.000			
• Adjustments to Budget Year	-	-	388.270	-	388.270

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*		
Congressional Add: *Quantum Computing Acceleration - Congressional Add*	-	25.000
Congressional Add Subtotals for Project: IT-02	-	25.000
Project: IT-03: *CYBER SECURITY*		
Congressional Add: *AI Cyber Data Analytics (Cyber) - Congressional Add*	-	15.000
Congressional Add Subtotals for Project: IT-03	-	15.000
Project: IT-04: *ARTIFICIAL INTELLIGENCE AND HUMAN-MACHINE SYMBIOSIS*		
Congressional Add: *AI Cyber Data Analytics (AI) - Congressional Add*	-	10.000
Congressional Add Subtotals for Project: IT-04	-	10.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602303E *I INFORMATION & COMMUNICATIONS TECHNOLOGY*

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

	FY 2021	FY 2022
Congressional Add Totals for all Projects	-	50.000

Change Summary Explanation

FY 2021: Decrease reflects reprogrammings and SBIR/STTR transfer.
FY 2022: Increase reflects Congressional adds for Quantum Computing Acceleration and AI, Cyber, Data Analytics.
FY 2023: FY 2023 funding increase reflects the fact that the FY 2022 President's Budget request did not include out-year funding.

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-02 / *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	

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
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	-	14.710	25.000	11.250	-	11.250	15.000	18.750	15.000	15.000	-	-

A. Mission Description and Budget Item Justification

The High Productivity, High-Performance Responsive Architectures project focuses on developing the computer hardware and associated software technologies required for future computationally- and data-intensive national security applications. Powerful new approaches are needed to manage the rapid growth in available sensor data, to leverage advances in machine learning, artificial intelligence, and quantum computing, and to maintain the security of DoD information systems. The project therefore aims not only to create new computing platforms to include quantum technology, but also to efficiently extract information out of large and chaotic data sets with embedded and low-size, weight, and power systems. Advances in these areas will allow for DoD electronic systems to collaboratively manage scarce resources, such as the electromagnetic spectrum, and to adapt to new requirements and situations. Further, the resulting technologies, by being accessible to a wide range of application developers, will support new, sustainable computing systems for a broad spectrum of scientific and engineering applications.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: RF Machine Learning Systems (RFMLS) ***Description:*** The RF Machine Learning Systems (RFMLS) program addressed the performance limitations of conventional radio frequency (RF) systems such as radar, signals intelligence, electronic warfare, and communications. The objective of the RFMLS program was to both develop these foundational technologies and to apply them to relevant DoD systems.	14.710	-	-
Title: Underexplored Systems for Utility-Scale Quantum Computing (US2QC) ***Description:*** It has been credibly hypothesized - but not proven - that a fault-tolerant quantum computer of sufficient size would revolutionize multiple commercial industries and scientific disciplines. It is currently expected that this type of machine will not be realized for at least 10 years and as long as 40 years. As a result, the unexpected and near-term development of a scalable, fault-tolerant quantum computer represents a strategic surprise for the United States. In addition, if quantum computers are shown to have transformative potential for critical problems facing the United States, it is in the Government's interest to foster and accelerate commercial progress towards a truly useful, "utility-scale" quantum computer. Initiated under Alternative Computing to both reduce strategic risk and realize transformative opportunity, the US2QC thrust will (1) evaluate disruptive designs for utility-scale, fault-tolerant quantum computers, specifically, systems that can be constructed in less than 10 years; (2) demonstrate each of the enabling sub-systems and components for these designs; and (3) construct a prototype fault-tolerant quantum computer that demonstrates that utility-scale design is viable.	-	-	11.250

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-02 / *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2023 Plans: - Evaluate system engineering point designs for at least one approach to building a fault-tolerant quantum computer. - Continue development of a testing and evaluation framework to determine if a disruptive approach to building a fault-tolerant quantum computer can succeed within a near-term timeframe. - Create a testing and evaluation framework for the critical components and sub-systems required to achieve utility-scale quantum computing within a near-term timeframe. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY2023 increase reflects program initiation.			
Accomplishments/Planned Programs Subtotals	14.710	-	11.250

	FY 2021	FY 2022
Congressional Add: Quantum Computing Acceleration - Congressional Add	-	25.000
FY 2022 Plans: - Accelerate efforts to verify and validate at least one approach to fault-tolerant quantum computing. - Initiate efforts to create a testing and evaluation framework to evaluate system designs for approaches to building a fault-tolerant quantum computer within the near-term. - Initiate government-driven applications exploration for utility-scale quantum computing, with the eventual goal of developing better metrics for verification and validation.		
Congressional Adds Subtotals	-	25.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	Project (Number/Name) IT-03 / *CYBER SECURITY*	

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
IT-03: *CYBER SECURITY*	-	240.074	252.089	183.786	-	183.786	158.669	130.205	128.157	135.353	-	-

A. Mission Description and Budget Item Justification

The Cyber Security project is developing the computing, networking, and cyber security technologies required to protect DoD, U.S. Government, and U.S. civilian information, information infrastructure, and mission-critical information systems. Information technologies enable important existing and new military capabilities, and drive the productivity gains essential to U.S. industry. Meanwhile, cyber threats grow in sophistication and number, and put sensitive data, classified computer programs, mission-critical information systems, and U.S. economic competitiveness at risk. The technologies developed in this project will enhance the resilience of information systems to current and emerging cyber threats, enable broad situational awareness of the cyber domain, and provide the basis for accurate, calibrated, and safe cyber response.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Open, Programmable, Secure 5G (OPS-5G)	13.300	21.000	28.300
Description: The Open, Programmable, Secure 5G (OPS-5G) program is developing open source, 5G network software that ensures security and stimulates innovation in mobile wireless hardware. Current trends in mobile wireless technology development are unfavorable in that the U.S. and allies are increasingly dependent on proprietary technologies offered by foreign suppliers. OPS-5G will develop standards-compliant software for 5G mobile wireless networks that is open source, programmable, and secure by design. The availability of open source software for 5G will have the additional benefit of opening the mobile wireless hardware market to new participants, stimulating innovation and competition. The OPS-5G program aims to move the mobile wireless market off its current model of opaque, proprietary, and vertically-integrated technology provided by a small number of dominant vendors to a more robust model with increased transparency and open source technology created by a diverse ecosystem of academic and commercial software and hardware developers. OPS-5G will be coordinated with existing open-source 5G efforts and U.S. Government, DoD, and industry stakeholders. ***FY 2022 Plans:*** - Implement and evaluate prototype systems that address 5G security challenges, such as eavesdropping at access points and denial of service. - Implement and evaluate prototype software for automatically extracting information relevant to software implementations including software structure, service interfaces, timing parameters, flow diagrams, and protocol graphs from electronic 5G standards. - Implement, evaluate, and demonstrate 5G node and network security technologies and tools for integrity checks, attack prevention, remote diagnosis, and service recovery.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-03 / *CYBER SECURITY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Assess and develop information protection techniques suitable for current and future mobile wireless systems to support DoD operational security needs. ***FY 2023 Plans:*** - Develop and evaluate security architectures capable of defending Internet-of-Things-class devices with low size, weight, and power characteristics. - Scale programmability-based network defenses to handle large-scale distributed denial-of-service attacks. - Deploy and evaluate security architectures on multiple DoD sites, and demonstrate secure voice call capabilities over untrusted network nodes to commercial vendors and service providers, the DoD, and other U.S. Government stakeholders. - Test and validate integrated information protection techniques suitable for current and future mobile wireless systems to support DoD operational security needs. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects ramping up of development and implementation of 5G network security technologies, and expanded demonstration and evaluation in collaboration with industry, DoD, and U.S. Government stakeholders.			
Title: Program Analysis for Capability Excellence (PACE)	10.400	19.250	23.000
Description: The Program Analysis for Capability Excellence (PACE) program will develop tools and techniques to autonomously identify adversary compromise of software, mitigate negative effects of adversary capabilities, and restore the integrity of compromised software. PACE will enable rapid, autonomous response to cyber attacks without using source code or requiring recompilation. ***FY 2022 Plans:*** - Implement emerging software compromise identification and mitigation techniques in an initial proof-of-concept autonomous system. - Demonstrate techniques for attack-specific mitigations that can be rapidly generated and deployed with minimal human assistance. - Assess autonomous system performance against synthetic attacks representative of real world threats. ***FY 2023 Plans:*** - Develop a system to identify and mitigate software compromise for a range of technical targets of increasing complexity. - Demonstrate the autonomy of the system by increasing the scale of software under attack and the sophistication of the simulated attacker. - Assess autonomous system performance against real-world attacks, including both automated adversaries and human experts. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-03 / *CYBER SECURITY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase reflects continued development of techniques for autonomously identifying and mitigating compromise and expanded efforts related to implementation and assessment.			
Title: Verified Security and Performance Enhancement of Large Legacy Software (V-SPELLS)	9.800	14.750	19.000
Description: The Verified Security and Performance Enhancement of Large Legacy Software (V-SPELLS) program is creating methods and tools to recover succinct models of domain data abstractions and logic from source code, add enhancements to the models, and convert them to performant new component implementations verified to be compatible and secure. DoD has a critical need for replacing or reworking components of existing software with more secure and more performant code, including cases where a key performance or security benefit comes from moving parts of the software to new hardware, such as utilizing hardware accelerators, isolation enclaves, offload processors, and distributed computation. However, at present, enhancing legacy software components faces high risk that the new software will not be fully compatible with the existing larger environment. Moreover, verified software is currently written from scratch, starting with a formal specification, rather than incrementally added to a system as provably compatible enhancements. V-SPELLS will address these problems by combining novel concepts in verified programming with recent developments in domain specific languages (DSLs) and systems architecture. V-SPELLS aims to enable piecewise, compatible-by-construction improvement of software components in legacy DoD systems, providing to incremental software (re)engineering the benefits of formal software verification currently available only to clean-slate development efforts. ***FY 2022 Plans:*** - Implement automated techniques for decomposing legacy code into functional modules with domain data structure and operation definitions, untangling of legacy code into low-level domain operation implementations and higher-level application logic, and lifting of legacy code into an extracted DSL. - Develop and formally ground software compartmentalization techniques for subdividing software systems into isolated compartments with limited interconnections intended to minimize privilege and thereby mitigate the impact of software compromise. - Create an initial development environment for convergent DSL programming, including compatibility-centric program analysis techniques that provide efficient, intelligible feedback and refined counterexamples to developers. - Identify DoD software environments that would benefit from recoding selected legacy components using DSLs for packet filtering, data, signal, and image processing, and other latency-sensitive/security-critical functions. ***FY 2023 Plans:*** - Formulate a quantitative assessment framework for cyber risk factors, encompassing threat, consequence, and vulnerability, to enable more rigorous assessments of architectural alternatives and guide choices in software systems engineering. - Refine automated techniques for decomposing legacy code into functional modules with domain data structure and operation definitions, enabling safe replacement and enhancement of targeted components with high-level DSL code.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-03 / *CYBER SECURITY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Integrate development environment for convergent DSL programming with decomposition tools that automate program understanding and downstream compilation tools that produce executable artifacts. - Apply tools to DoD legacy components in order to enhance security and performance while ensuring compositional correctness and safety. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects ramping up of work to develop automated techniques for decomposing legacy code into functional modules, compilation techniques for DSL virtual machine stacks, and an initial development environment.			
Title: Securing Information for Encrypted Verification and Evaluation (SIEVE)	14.500	16.000	17.500
Description: The Securing Information for Encrypted Verification and Evaluation (SIEVE) program is developing technology to enable the creation of mathematically verifiable public statements derived from sensitive information that remains hidden. To accomplish this, SIEVE will produce advances in a cryptographic technique known as zero knowledge (ZK) proofs, which simultaneously enable mathematical verification of public statements while provably hiding the sensitive information from which the statement is derived. The advances produced by SIEVE will make it possible and operationally feasible to verify statements substantially more complex than the current ZK state of the art supports, for example, statements about a software vulnerability that do not reveal details of how the vulnerability can be exploited. ***FY 2022 Plans:*** - Extend ZK proof compilers by adding problem classes as well as reducing representation size of proof statements by orders of magnitude. - Optimize post-quantum analyses to reduce theoretical proof complexity for important use cases. - Enhance techniques to permit optimization for any subset of prover computation, verifier computation, total communication, and total number of communication rounds. - Apply ZK proof techniques to additional DoD and U.S. Government use cases and evaluate their functionality, information leakage potential, and robustness to attack in collaboration with potential transition partners. ***FY 2023 Plans:*** - Extend ZK proof compilers to additional problem classes and to accommodate probabilistic problem statements. - Further enhance post-quantum analyses to reduce theoretical proof complexity for important use cases and potential transition partners. - Scale-up ZK proof techniques to realistic DoD and U.S. Government use cases and evaluate their functionality, information leakage, and robustness to attack in collaboration with potential transition partners.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-03 / *CYBER SECURITY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Determine the feasibility of efficient, end to end verifiable, distributed architectures for private data communication that can be leveraged by overseas personnel and compatible with existing state and federal policies and regulations. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects additional effort to evaluate ZK proof techniques on realistic use cases.			
Title: Assured Micropatching (AMP) ***Description:*** The Assured Micropatching (AMP) program is developing technologies to enable the rapid production of targeted micropatches to repair legacy program binaries with strong guarantees. At present, the emergency patching of legacy software, even if all relevant information is available, creates too much uncertainty and takes far too long to validate, leaving critical systems with known flaws vulnerable to adversary attack. AMP will create the capability to analyze, modify, and fix legacy software in binary form even when the original source code and/or build process is not fully available. The AMP technical approach involves automatic discovery of known vulnerable components, goal-driven decompilation to isolate and analyze the vulnerable binary components, and minimal-change patching and recompilation to rebuild affected binaries with strong guarantees that the patch will not impair the functions of the system. The technologies developed by AMP aim to enable cyber defenders to quickly and accurately patch legacy binaries in the deployed software systems upon which our military depends. ***FY 2022 Plans:*** - Develop a modeling capability to infer compiler optimization effects on the call graph structure, and probabilistic graph-matching and inference algorithms to produce candidate matches between the target binary procedures and most likely source code procedures. - Develop extensions to commonly used binary analysis tools to interactively show the effects of an applied micropatch. - Conduct a challenge event using a commodity controller and data logger based on a widely-used commercial data bus architecture. ***FY 2023 Plans:*** - Enable and demonstrate the automatic patching of vulnerabilities where exploitation does not involve memory corruption. - Improve and optimize the existing intermediate representations and optimize the location of the provided patch within the original binary. - Conduct a challenge event using a real-time control device in use in a cyber physical system. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.	16.410	17.000	16.200
Title: Fast Network Interface Cards (FastNICs)	12.000	13.500	13.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-03 / *CYBER SECURITY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The Fast Network Interface Cards (FastNICs) program is creating new networking technologies to accelerate the computation of distributed applications. Today's network and computing subsystems are badly out of balance with each other, a result of incremental technology advances in networking and computing market silos. This has produced a bottleneck at the network interface used to connect a machine to an external network, severely limiting the input/output capability. FastNICs will develop new input/output technologies based on more realistic models of complex multiprocessor compute, interconnect, and memory subsystems. FastNICs aims to enable a dramatic increase in computational throughput for distributed applications such as training of machine learning systems. ***FY 2022 Plans:*** - Evaluate network interface architecture alternatives such as busses and parallelism. - Demonstrate versions of widely used distributed systems software and operating systems that accommodate massively parallel input data streams. - Demonstrate and evaluate distributed computing applications of interest to the DoD such as training deep learning systems. ***FY 2023 Plans:*** - Scale performance and demonstrate network interface hardware on multi-core central processing units (CPU's). - Evaluate versions of widely used distributed systems software and operating systems that accommodate massively parallel input data streams. - Evaluate and demonstrate machine learning applications to commercial vendors, the DoD, and IC. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Resilient Anonymous Communication for Everyone (RACE) ***Description:*** The Resilient Anonymous Communication for Everyone (RACE) program is developing cryptographic and communication obfuscation technologies to enable anonymous, attack-resilient, mobile communications within a network environment. RACE is developing a mobile communication application and distributed systems that provide a secure message-passing service by combining advances in distributed system tasking with communication protocol encapsulation methods. The RACE system will maintain confidentiality, integrity, and availability of messaging while preventing large-scale compromise of the system. RACE security is based on rigorous security arguments or statistical arguments based on realistic simulations, and not on ad hoc estimates of security. ***FY 2022 Plans:*** - Enable the system to scale to a thousand or more users by improving the efficiency of techniques for computing on encrypted routing information.	14.160	14.700	10.700

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Integrate enhanced components into the secure message-passing system with improved capability to counter a cyber adversary who has access to communication protocol information and communication nodes. - Enhance the testbed and demonstrate the integrated secure message-passing system against a simulated cyber adversary that has knowledge of the system. ***FY 2023 Plans:*** - Improve the efficiency of techniques for computing on encrypted routing information to enable the system to scale an additional order of magnitude. - Integrate enhanced components into the secure message-passing system with improved capability to counter a cyber adversary who has the capability to manipulate communication protocol information and interfere with communication nodes. - Enhance the testbed and demonstrate the integrated secure message-passing system against a simulated cyber adversary that has full knowledge of and access to the system. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects ramping down of development of obfuscation and encryption technologies, continued implementation of a secure message-passing system and testbed, and continued work to evaluate the system against a simulated cyber adversary.			
Title: Cyber-Hunting at Scale (CHASE)	16.140	15.100	7.100
Description: The Cyber-Hunting at Scale (CHASE) program is developing data-driven tools for real-time cyber threat detection, characterization, and protection within enterprise-scale networks. U.S. computer networks are continually under attack, but at present there are few capabilities to efficiently extract and analyze the right data from the right device at the right time for DoD-scale information networks. For example, analysis of an in-memory exploit requires detailed data from a few devices, while analysis of a global botnet attack requires summary data from a great many devices. CHASE is developing novel algorithms and analysis tools to dynamically collect data from across the network, actively hunt for advanced threats that evade routine security measures, and automatically disseminate protective measures that bolster the collective cyber defense posture. ***FY 2022 Plans:*** - Develop an analyst interface to enable automated cyber report generation, and evaluate the utility of the interface for cyber threat detection and protective measure dissemination. - Develop techniques for quantifying and reducing the risk of cyber operations. - Identify transition opportunities for validated threat detection, threat characterization, and data planning algorithms. ***FY 2023 Plans:*** - Integrate threat detection, data retention, and global analysis methods, and harden capabilities for transition to DoD stakeholders.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Transition cyber threat detection and protective measure dissemination technologies to DoD stakeholders. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease is the result of development and integration work ramping down, and the focus shifting to demonstration, hardening, and transition of cyber protection technologies to DoD stakeholders.			
Title: Memory Optimization (MemOp) ***Description:*** The Memory Optimization (MemOp) program is developing technology to optimize memory transactions in large scale computing systems. The demand for computing services is growing within both the U.S. Government and commercial industry. In response, new technical approaches are being developed to provide massive computation efficiently and cost effectively. In particular, distributed data centers with high-speed interconnects and customizable hardware, including graphics processing units (GPU) and field programmable gate arrays (FPGAs), are being used by service providers to achieve greater efficiency and improved processing performance. MemOp is exploring new memory architectures that more fully leverage emerging customizable hardware to deliver computing services reliably and at reduced cost. The more promising MemOp memory architectures will be implemented and evaluated in hardware and software. The technologies developed in MemOp will provide enhanced efficiency and improved performance for large scale computing systems. ***FY 2022 Plans:*** - Refine and leverage algorithm scaling for task mapping in large scale memory systems, and optimize software implementations. - Evaluate and refine integration of memory and accelerated processing pipelines. - Evaluate memory transaction implementation and develop improvements on program testbed. - Optimize algorithms and architectures for memory transaction performance in hardware and software, and evaluate on testbed. ***FY 2023 Plans:*** - Optimize integration of memory and accelerated processing pipelines and evaluate improvements on program testbed. - Harden and transition memory optimization technologies to industry and DoD. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects ramping down of development of memory optimization methods and accelerated processing pipelines, and continued use of the evaluation testbed.	18.000	17.000	8.007
Title: Computers and Humans Exploring Software Security (CHESS) ***Description:*** The Computers and Humans Exploring Software Security (CHESS) program is developing technologies to enable computers and humans to reason collaboratively over software artifacts, such as source code and compiled binaries, with the goal of finding vulnerabilities more rapidly and accurately than unaided human operators. CHESS envisions a future in which high-intensity cyber operations are conducted by computer-human teams. CHESS capabilities will be designed for use by humans of	15.320	12.400	6.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
varying skill levels, even those with minimal previous cyber experience or relevant domain knowledge. Achieving the necessary scale and timelines in vulnerability discovery will require innovative combinations of automated program analysis techniques with support for mixed-initiative computer-human collaboration. CHESS aims to enable U.S. operational cyber superiority by combining human-generated insight into the vulnerability discovery process with the speed and scale of computational analysis. ***FY 2022 Plans:*** - Scale techniques for emitting a proof of vulnerability to confirm existence of a vulnerability, and for generating a non-disruptive, specific patch to neutralize the vulnerability, to programs of the size and complexity found in military systems. - Enhance representations of information gaps revealed by expanded cyber reasoning techniques to enable non-experts in vulnerability discovery to advance in efficacy and expertise. - Incorporate improved cyber reasoning capabilities and additional operator-requested refinements in an end-to-end, integrated computer-human software reasoning system for the DoD and IC. ***FY 2023 Plans:*** - Quantify the degree to which the cyber reasoning techniques enable non-experts in vulnerability discovery to approach expert-level efficacy. - Harden an end-to-end, integrated computer-human software reasoning system and transition to the DoD and IC. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects ramping down of work to develop and integrate technologies in a proof-of-concept, computer-human software reasoning system, and focus shifting to hardening, demonstration, and transition to the DoD and IC.			
Title: Cora ***Description:*** The Cora program is developing technologies to enable machines to read heterogeneous text-based data sources, extract key entities and activities, and characterize cyber threats. Large volumes of text-based data contain scattered clues about the activities of cyber threats. Automated machine reading and analysis capabilities are required due to the extreme rates at which this text-based data is generated. In addition, the connections between extracted entities and their activities can be very subtle and, because they are buried in noise, difficult to detect and correlate. The Cora technologies will benefit cyber analysts by providing them with pre-processed cyber leads that otherwise might not be available. ***FY 2022 Plans:*** - Demonstrate scalability and performance of analytical capabilities on relevant large-scale data sets. - Evaluate machine-learning-based methods for identifying cyber threats across heterogeneous data, in multiple languages. - Harden cyber analytical software technologies and incorporate refinements requested by cyber operators. ***FY 2023 Plans:***	11.000	10.740	5.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Demonstrate machine-learning-based methods for identifying geographic and cultural dependencies in cyber threats and for gaining situational awareness of adversary influence operations. - Deploy software to transition partner environments. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects ramping down of efforts to implement and evaluate an integrated cyber analytical system, and focus shifting to demonstration and transition to operational partners.			
Title: Searchlight ***Description:*** The Searchlight program is developing technologies to ensure that quality-of-service (QoS) guarantees are met for distributed applications operating across the Internet. The increasing use of Internet-based distributed applications creates risks as surges in network use can result in resource shortfalls. Searchlight will develop novel approaches for allocating inherently limited network resources to optimize the performance of distributed applications. Searchlight techniques and systems aim to enable organizations to adapt the QoS for their low-priority traffic resulting in improved QoS for their high-priority traffic without affecting traffic from other Internet users. Searchlight technologies will become increasingly important as 5G systems provide advanced capabilities for organizations to adapt their QoS guarantees. ***FY 2022 Plans:*** - Improve integrated QoS management system performance in terms of scale, application identification accuracy, and application responsiveness. - Demonstrate the integrated QoS management system and evaluate its capability on heterogeneous applications distributed across wide area networks of realistic scale and complexity. - Work with transition partners to optimize the QoS management system to relevant use cases, applications, and network characteristics. ***FY 2023 Plans:*** - Demonstrate techniques for topology discovery of multiplexing sites. - Demonstrate an integrated QoS management prototype on relevant use cases and transition to DoD and commercial network service providers. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects ramping down of work to develop QoS management techniques and focus shifting to transition to the DoD and industry.	5.400	6.300	4.800
Title: Active Social Engineering Defense (ASED)	10.800	6.600	5.179

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The Active Social Engineering Defense (ASED) program is developing technologies to automatically identify, disrupt and investigate social engineering attacks via bot-mediated communications. Social engineering attacks, such as phishing and spear-phishing, typically gain user trust via impersonation to induce behaviors or elicit sensitive information that compromise security of an information system. At present, defending against social engineering attacks falls largely to human users. ASED aims to prevent social engineering attacks by creating counter-social-engineering bots that act on behalf of users to mediate and aggregate communications and auto-identify attackers. ASED aims to greatly reduce the effectiveness of adversary social engineering attacks and improve the security of DoD information systems. ***FY 2022 Plans:*** - Demonstrate and evaluate a machine-learning-based social engineering attack detection system, including automated attribution of social engineering attacks, against advanced simulated adversaries who disguise their attacks. - Harden a modular social engineering attack detection and attribution system for use by U.S. Government, DoD, and industry. ***FY 2023 Plans:*** - Deploy social engineering attack detection software to a transition partner environment. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from development of counter-social-engineering bot technologies to technology hardening and transition to U.S. Government, DoD, and industry.			
Title: Hardening Development Toolchains Against Emergent Execution Engines (HARDEN)	-	5.000	10.000
Description: The Hardening Development Toolchains Against Emergent Execution Engines (HARDEN) program, building on results derived in the Foundational Artificial Intelligence (AI) Science program (PE 0601101E, Project CCS-02), will develop techniques and tools to anticipate, isolate, and mitigate emergent system behaviors and thereby improve security of complex integrated software. Today's software development toolchains and testing methodologies provide very limited means for reasoning about adversarial reuse of code as written and designed. This results in unwitting creation of stable, reliable patterns of emergent behaviors within systems that adversaries can reuse in attacks. Examples include web browser exploits, which co-opt the browser's memory management algorithms and web scripts; the Spectre family of exploits; and modern bootkits, which leverage the trusted computing system management modes. In each case, attackers program emergent behaviors already present within the target system. The HARDEN approach to preventing such adversarial code reuse is to create techniques, tools, metadata, and instrumentation for reasoning about emergent execution at all stages of the software development life cycle (SDLC), and for flagging code segments and design patterns where there is high potential for adversarial reuse and emergent execution. To assess their utility, HARDEN technologies will be applied to critical system elements such as bootloaders and to integrated software systems. If successful, the technologies developed by HARDEN will facilitate efficient mitigation of complex code-			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
reuse and emergent-execution vulnerabilities at early SDLC stages, and provide the stronger roots-of-trust required by zero-trust architectures and high-assurance integrated military software systems. ***FY 2022 Plans:*** - Formulate approaches for instrumenting the development toolchain for reasoning about emergent behaviors at all available layers of abstraction, from the compiled binary code through the compiler abstractions and intermediate representations, to the highest levels of architectural abstraction. ***FY 2023 Plans:*** - Develop models and mitigations for composable emergent behaviors and for the reliable chaining of exploit primitives even where the effects of any single behavior or flaw are reduced by security mitigations. - Explore automated techniques for identifying implementations that are likely to result in composable emergent behaviors, and for suggesting transformations of implementations that, while semantically equivalent, mitigate emergent composability and thereby disrupt exploit programming. - Initiate application of concepts and techniques to critical system elements such as bootloaders and high-assurance integrated military software systems with the goal of demonstrating the capability to mitigate complex code-reuse/emergent-execution vulnerabilities at early SDLC stages. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects ramping up of work to develop techniques to mitigate emergent behaviors and initial applications of the technology to military and commercial software systems.			
Title: Signature Management using Operational Knowledge and Environments (SMOKE) ***Description:*** The Signature Management using Operational Knowledge and Environments (SMOKE) program seeks to develop signature management technologies that generate evasive cyber infrastructure by incorporating counter-attribution techniques into the design process; quantitatively measuring attribution risk in real-time; and by maintaining evasiveness after infrastructure changes in order to accelerate red team cyber operations (CO) and eliminate signatures as a source of attribution. ***FY 2023 Plans:*** - Formulate approaches for quantifying the detection and attribution risks associated with CO infrastructure development and operation. - Develop techniques for identifying patterns characteristic of CO. - Perform red team assessments of CO protection capabilities in collaboration with potential transition partners. ***FY 2022 to FY 2023 Increase/Decrease Statement:***	-	-	10.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase reflects program initiation.			
Title: Hardware Optimization (HOP) ***Description:*** The Hardware Optimization (HOP) program is developing hardware optimizations for national security purposes. Specifically, HOP will enable new national security workloads in high performance microelectronic hardware. This research will produce end-to-end hardware optimization toolkits to enhance hardware designs. These toolkits will be comprised of algorithms, digital design files, documentation, and binaries. ***FY 2022 Plans:*** - Evaluate hardware optimizations to address algorithmic improvements and address scalability and performance opportunities. - Design and develop initial alternative implementations for hardware optimizations. - Provide initial hardware optimizations for performance assessments and evaluations. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	8.000	17.100	-
Title: Harnessing Autonomy for Countering Cyber-adversary Systems (HACCS) ***Description:*** The Harnessing Autonomy for Countering Cyber-adversary Systems (HACCS) program is developing safe and reliable autonomous software agents that can neutralize botnet implants and similar large-scale malware in networked devices. HACCS is developing technologies to (1) identify and characterize botnet-conscripted networks of devices to determine the types of devices and the software services running on them with sufficient precision to infer the presence of known vulnerabilities; (2) generate software exploits for a large number of known vulnerabilities that can be used to establish initial presence in each botnet-conscripted network without disrupting system functionality; and (3) create high-assurance software agents that can autonomously navigate within botnet-conscripted networks, identify botnet implants, and curtail their ability to operate while minimizing side effects to systems and infrastructure. HACCS technologies aim to enable U.S. agencies possessing the appropriate authorities to safely conduct Internet-scale counter-botnet operations. ***FY 2022 Plans:*** - Enhance botnet-tracking algorithms to provide near-real-time assessment for the global identification and tracking of all major classes of botnet-conscripted networks. - Collaborate with transition partners to tailor and evaluate HACCS counter-botnet technology in realistic environments. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	16.800	9.240	-
Title: Intent-Defined Adaptive Software (IDAS)	10.200	7.059	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The Intent-Defined Adaptive Software (IDAS) program is developing technologies to represent the intent of software and its abstract constraints separately from its concrete instantiation, for the purpose of enabling rapid code synthesis and continual adaptation. Modern weapons platforms are increasingly dependent on complex software, increasing the risk of system failures and creating new attack surfaces for adversaries. Software engineers often manage complexity by choosing a particular option that fulfills the immediate needs of the development effort (e.g., by concretization). IDAS will develop techniques for deferring software concretizations until uncertainties are resolved, either at build time or during run time, for complex systems. IDAS technology aims to significantly reduce software development time and maintenance costs, thereby enabling DoD to acquire, sustain, and improve software-based capabilities more cost-effectively. ***FY 2022 Plans:*** - Mature algorithmic techniques that permit verified optimization of multiple implementations, and demonstrate more efficient encoding of quality goals and operational constraints. - Demonstrate a prototype of a partially coupled implementation of a military system that has the performance of a highly-coupled, exquisitely engineered system, and the maintainability of a decoupled, modular system. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Configuration Security	11.400	6.050	-
Description: The Configuration Security program is developing technologies to analyze, monitor, and modify the configuration of composed cyber-physical-human systems to identify system vulnerabilities and minimize the attack surface while maintaining functionality and performance. Complex cyber-physical systems, such as ships, airplanes, and critical infrastructure, increasingly make use of multiple commodity information technology components. The manual configuration necessary to enable each component to interoperate introduces exploitable cyber vulnerabilities, as do the standard operating procedures that system operators follow. The Configuration Security program will develop capabilities to automate the appropriate configuration of such systems within the operational context, ensure secure configuration settings, and prevent malicious changes to these settings. ***FY 2022 Plans:*** - Scale and optimize automatic generation of contextualized secure configurations for operationally relevant, complex cyber-physical-human systems, including the translation of multi-vendor, human-readable artifacts into machine-understandable formats. - Demonstrate algorithms to automatically and rapidly reconfigure a representative military operational system to a baseline that is safer, more secure, and more quickly achieved. - Demonstrate a reconfigured system that provides required functionality with automatically-generated human-readable explanations.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Transition a capability to detect and prevent malicious modification of configurations from the system-generated baseline for a shipboard communication system, and to assist system operators in changing between operational contexts. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Cyber Assured Systems Engineering (CASE) ***Description:*** The Cyber Assured Systems Engineering (CASE) program is developing the design, analysis and verification tools needed to allow systems engineers to design-in cyber resiliency and manage tradeoffs as they do other quality attributes when designing complex embedded computing systems. The current state of practice for cyber resilience utilizes penetration testing after system construction to drive post-design re-engineering. The CASE technical approach formulates cyber resilience as an explicitly engineered property, similar to other holistic properties such as safety, durability, and reliability now standard in systems engineering. The challenge of resiliency is that it cannot be established through conventional testing methods. CASE is focusing on the following technical areas: techniques to derive resilience-related requirements before system design and construction; architectural design and analysis tools to design-in the derived resilience requirements while providing feedback to the human designer to allow for informed tradeoffs between resilience and other system design goals; tools to adapt existing software to support system-level resilience requirements; and inference engines, satisfiability solvers, and provers scalable to complex networked cyber-physical systems. CASE technologies will enable the design of cyber-physical systems that robustly execute their intended function despite the efforts of sophisticated cyber adversaries. ***FY 2022 Plans:*** - Harden technologies for cyber security systems engineering and transition to DoD stakeholders. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	10.050	3.000	-
Title: Enhanced Attribution ***Description:*** The Enhanced Attribution program is developing technologies to associate malicious cyber actions with individual adversary operators, and to publicly reveal these actions without compromising sources and methods. The program focuses on new approaches for identifying malicious cyber operators, analyzing their software tools and actions, and confirming this information with commercial and public sources of data. As the attribution techniques are developed and show promise, they will provide the basis for new cyber capabilities such as indications and warning of adversary cyber actions. These technologies will be implemented in tools for evaluation by potential transition partners. ***FY 2022 Plans:***	8.600	3.000	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Harden the attribution platform and transition to operational partners. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Dispersed Computing ***Description:*** The Dispersed Computing program is developing techniques to distribute computing tasks across network computing elements to enable more efficient utilization of enterprise and Internet-based storage, processing, and networking resources. At present, enterprises and Internet-based information technology service providers are increasingly adopting the cloud model, with data storage and computer processing concentrated in large data centers. This brings economies of scale and cost savings to storage and processing, but creates problems for the network and for latency-sensitive applications due to the need to backhaul data to (often distant) data centers for processing. The Dispersed Computing program is developing a dispersed computing architecture that results in more efficient utilization of storage, processing, and networking resources. A key enabler is the recent introduction by vendors of network elements that can be dual-purposed as computational elements. These dual-purpose network-compute elements make it possible to eliminate bottlenecks/chokepoints and to mitigate impossible backhaul requirements by opportunistically moving code to data, given network conditions and available network-compute elements. With Dispersed Computing technology, the network becomes the cloud, and computation is performed where it is most efficient to do so. ***FY 2022 Plans:*** - Harden and transition integrated network-compute capabilities to government and commercial network providers. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	4.000	2.300	-
Title: Rapid Attack Detection, Isolation and Characterization Systems (RADICS) ***Description:*** The Rapid Attack Detection, Isolation and Characterization Systems (RADICS) program developed technology to enable a black start recovery of the U.S. power grid amidst a cyber attack on the energy sector's critical infrastructure. RADICS technologies enable skilled cyber and power engineers to rapidly restore electrical service after an attack that challenges the recovery capabilities of the impacted organizations (e.g., utilities, balancing authorities, independent system operators, bulk power markets). The potential for a cyber-enabled attack on the U.S. power grid is a national security issue, as the ability of the military to deploy and project force is dependent on the effective and efficient functioning of civilian logistics and supply systems. The program developed technologies to monitor heterogeneous distributed networks, detect anomalies that require rapid assessment, isolate compromised system elements, establish secure emergency communications networks, characterize attacks, and detect	3.794	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
sensor spoofing. RADICS was coordinated with and transitioned technology to U.S. Government elements responsible for the defense of critical infrastructure.			
Accomplishments/Planned Programs Subtotals	240.074	237.089	183.786

	FY 2021	FY 2022
Congressional Add: AI Cyber Data Analytics (Cyber) - Congressional Add	-	15.000
FY 2022 Plans: Develop high assurance computing architectures suitable for mission-critical systems that must operate with resilience in contested environments.		
Congressional Adds Subtotals	-	15.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
IT-04: *ARTIFICIAL INTELLIGENCE AND HUMAN-MACHINE SYMBIOSIS*	-	151.005	203.274	193.234	-	193.234	203.757	203.184	229.627	229.537	-	-

A. Mission Description and Budget Item Justification

The Artificial Intelligence and Human-Machine Symbiosis project develops technologies to enable machines to function not only as tools that facilitate human action but also as trustworthy partners to human operators. Of particular interest are systems that can understand human language and extract information and reliably categorize content contained in diverse media; answer questions, reach conclusions, and propose explanations; and learn, reason, and apply knowledge gained through experience to respond intelligently to new and unforeseen events. Enabling computing systems with such human-like intelligence is now of critical importance because the tempo of military operations in emerging domains exceeds that at which unaided humans can orient, understand, and act. The technologies developed in the Artificial Intelligence and Human-Machine Symbiosis project will enable warfighters to make better decisions in complex, time-critical, battlefield environments; intelligence analysts to make sense of massive, incomplete, and contradictory information; software developers and certifiers to design, implement, evaluate, and accredit cyber-physical systems and other complex software-reliant systems with greater efficiency and confidence; and unmanned systems and semi-autonomous agents to perform critical missions in contested physical and virtual environments safely and reliably.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Accelerating Artificial Intelligence (AAI)	39.000	35.100	32.000
Description: The Accelerating Artificial Intelligence (AAI) program seeks to go beyond commercially-driven advances in AI and to address important national security challenge applications. In particular, this program is focused on improving human-AI collaborations to mitigate current bottlenecks in DoD's ability to rapidly adapt and deploy new technologies and capabilities. If successful, research efforts under this program will significantly accelerate the pace of innovation in many important DoD domains while also reducing the time and cost associated with approval and certification processes needed to transition and deploy new technologies. One technical challenge to be addressed in this program is the need to assess current developmental, approval, and certification processes and identify tasks or sub-tasks amenable to greater automation with minimal human intervention. Other challenges include the need to develop social context aware AI systems and to ensure robustness of AI systems, particularly in novel and/or unanticipated situations. Approaches to addressing these challenges will leverage recent advances at the frontiers of AI research in transfer learning, causal reasoning and associated models. AAI application areas include the following: (1) machine-enabled techniques to efficiently capture, generate, and analyze disparate data sources to accelerate design and development of new materials and chemistries for DoD specific applications; and (2) knowledge management tools that can efficiently capture and disseminate an organization's expertise, experience and data; and (3) social context informed AI approaches to enable reliable and robust forecasting and decision aiding tools for stabilization, deterrence and gray zone operations.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-04 / *ARTIFICIAL INTELLIGENCE AND HUMAN-MACHINE SYMBIOSIS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: - Extend evaluation of novelty generators and novelty-robust AI techniques in military application domains to include new rules, goals, and events. - Demonstrate effectiveness in military applications of novelty-robust AI techniques. - Initiate transition of molecular design systems from academia and industry to DoD partners to evaluate performance in DoD applications. - Define and validate parameters for inverse design of molecules with relevance to DoD applications. - Initiate research in methods to improve human operators' ability to partner with their AI-enabled platforms in off-nominal scenarios. - Start modeling the situational awareness demands imposed by yet-to-be-built autonomous systems. - Initiate development of design tools to enable full-system human machine interface compositions. - Begin development of rapidly reconfigurable human machine interface test environments for highly automated and AI-enabled platforms. - Quantify competency-aware capabilities with relevance to DoD applications, and identify DoD experimental platforms and partners to demonstrate competency-aware capabilities. - Initiate efforts to develop a new understanding of how preconscious signals can be used to measure what people believe to be true. - Demonstrate emulated 250-milliwatt megapixel for a full format sensor with programmable in-pixel circuitry to instantiate front-end AI algorithms with outputs to back end AI processing using realistic device parameters. - Construct proof-of-concept demonstration and measure reduction in learning time increased and effectiveness of learning. - Develop means to understand concepts through grounding them in real world experiences as represented in image and video, and for automatically acquiring novel concepts representing objects and events. - Develop formal models of the structure of uncertainty in financial data sets, together with an ensemble of metrics for inconsistency among multiple data sets. - Develop techniques for identifying the specific processor likely to execute particular code segments based on control blocks identified in schematics. - Explore the use of AI and machine learning (ML) to support, and if possible automate, the generation, maintenance, and repair of proofs used in the formal verification of software. - Initiate Legal, Moral, and Ethical (LME) planning activities and develop an understanding of how escalation of force can and should be appropriately applied in the context of supervised autonomous systems. - Continue efforts to accelerate Artificial Intelligence with a focus on third wave AI.			
FY 2023 Plans: - Demonstrate competency-aware machine learning behaviors and capabilities on DoD-relevant application platforms.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Evaluate research in methods to improve human operators' ability to innovate with their AI-enabled platforms during off-nominal scenarios. - Test and refine models of the situational awareness demands imposed by yet-to-be-built autonomous systems. - Test and refine design tools to enable full-system human machine interface compositions. - Continue construction of rapidly reconfigurable human machine interface test environments for highly automated and AI-enabled platforms. - Extend efforts to measure and aggregate an individual's preconscious neural and physiological responses into actionable evidence regarding that individual's beliefs. - Develop approaches for composing identified techniques into scalable proof generation and repair capabilities within development platforms for increasing assurance of systems. - Continue LME working groups and engagements with industry and university performers to provide technical, academic, and operation expertise and advise on best practices and DoD ethical AI principles. - Continue efforts to accelerate Artificial Intelligence with a focus on third wave AI. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from development and prototyping to testing.			
Title: Symbiotic Design ***Description:*** The Symbiotic Design program is developing artificial intelligence-based approaches to augment human teams in the design of cyber-physical systems (CPS), and thereby significantly reduce time to deployment and improve the quality of deployed systems. The current generation of DoD systems and platforms integrate cyber and physical subsystems, but the capability of the engineering teams has not scaled with the enormous complexity of modern CPS. Engineering organizations require large teams of engineers that collectively possess the necessary domain knowledge (of component technologies, theories, and tools), but the prolonged timelines of the development process for modern CPS hinders DoD's ability to counter emerging threats. The Symbiotic Design program will address this challenge by transforming the human-focused, model-based design flows used today into a symbiotic process of collaborative analysis by humans and continuously-learning artificial intelligence (AI)-based co-designers. The program will create technologies essential for AI co-design: design space construction, design composition, and design space exploration. The program will demonstrate the approach at realistic scales by a sequence of CPS design challenges of increasing complexity, and quantify the results with respect to development time, system performance, quality, and innovation metrics. ***FY 2022 Plans:*** - Develop scalable design mining engines and feature extractors to enable query generation from seed designs and expand scope and domain coverage of design mining engines to allow incremental construction of design spaces.	23.040	28.100	33.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-04 / *ARTIFICIAL INTELLIGENCE AND HUMAN-MACHINE SYMBIOSIS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Develop approaches in machine-assisted knowledge management to establish traceable connections between software models and documentation through discovery, extraction, and linking over text, equations, tables, figures, and code. - Develop prototype tools to accelerate high fidelity model analysis and simulation, visualize and understand high dimensional design spaces, and shape and guide design exploration. - Produce design challenge problems related to sub-systems and systems of interest to the DoD, and evaluate the effectiveness of symbiotic design technologies. ***FY 2023 Plans:*** - Develop multi-domain inferencing techniques to automate multi-domain reasoning and model learning. - Scale up techniques for exploration of high-dimensional, multi-domain, combinatorial, and parametric design spaces. - Conduct design hackathons to study productivity of designers and quality of design using conventional engineering tools in comparison to when an AI co-designer and symbiotic design technologies are used. - Perform demonstration and evaluation of symbiotic design technologies through applications to sub-systems and systems of interest to the DoD. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects continued development and implementation of symbiotic design techniques and additional efforts related to demonstration and evaluation on sub-systems and systems of interest to DoD.			
Title: Knowledge-directed Artificial Intelligence Reasoning Over Schemas (KAIROS)	13.000	22.000	27.334
Description: The Knowledge-directed Artificial Intelligence (AI) Reasoning Over Schemas (KAIROS) program is developing AI and machine learning technologies to aid a human operator in understanding complex sequences of events in the world. For the purposes of KAIROS, an event is an occurrence that results in an observable and recognizable change in either the physical world or human activity. Events of particular interest to KAIROS are those that create changes that have significant impact on national or homeland security. The KAIROS program will develop automated systems that codify existing event-representation schemas and, when needed, create and codify new schemas to bring structure to complex event sequences and present these structured representations to operators. Given multi-media inputs, operators will use KAIROS technologies to identify subsidiary event elements, determine their temporal order, recognize complex event sequences, and link disparate events. KAIROS technologies aim to enable analysts and warfighters to understand unfolding events rapidly and accurately. ***FY 2022 Plans:*** - Develop capability for machine learning of the similarities and differences in the structural features of various complex event schemas. - Develop the means to curate the schema library and methods for identifying intermediate levels in the structure of the library. - Develop a user interface to probe input sources for missing information and to provide interactive feedback.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Collaborate with transition partners to evaluate systems on complex real-world event sequences and identify necessary adjustments. ***FY 2023 Plans:*** - Develop means to interpolate events of interest not reported in multiple sources that occur within complex sequences of events. - Develop means to predict future events from a sequence of complex events that is presently unfolding. - Evaluate the detection and prediction capabilities with DoD and IC users on problems related to stabilization in regional conflicts. - Optimize the system in response to operational partner assessments on complex real-world event sequences and transition the technology. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects continued development of techniques for learning complex event schemas and event discovery and prediction, and increased work to assess techniques on operational DoD and IC data.			
Title: Automated Rapid Certification Of Software (ARCOS)	27.000	25.000	24.400
Description: The Automated Rapid Certification Of Software (ARCOS) program is developing technologies that automate the capture and evaluation of software assurance evidence to enable certifiers to assess system risks earlier in the process and to commit to engineering decisions more rapidly and safely. Current software certification practices do not scale with the extent, complexity, and interconnection of software being developed by the DoD, so certification is becoming a bottleneck to new system deployment. ARCOS technologies address DoD software system certification time and cost. ARCOS technology will automatically and interactively generate strong assurance arguments that incorporate supporting evidence for certification criteria. ARCOS will also develop techniques to compose assurance arguments for pre-evaluated components into consolidated assurance arguments for new systems incorporating those components. ***FY 2022 Plans:*** - Develop approaches to augment assurance evidence for legacy software to provide stronger fitness arguments. - Demonstrate automatically calculated confidence measures for assurance case arguments that are objectively meaningful. - Demonstrate the composability of automatically generated assurance case arguments to support incremental evaluations. - Reduce the computation time necessary to automatically generate assurance case arguments for complex military systems. ***FY 2023 Plans:*** - Expand assurance case generation to address assurance criteria in multiple domains such as safety and security. - Develop a mechanism to track the provenance of assurance evidence used in assurance case arguments. - Demonstrate an approach to assurance-driven software development that generates evidence targeted for the high confidence software assurance required for military systems.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Demonstrate automated generation of assurance arguments for a representative complex military system. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Learning Introspective Control (LINC)*	-	12.500	19.000
Description: *Formerly Control System Introspection The Learning Introspective Control (LINC) program will develop machine introspection and learning technologies to characterize a modified or damaged military platform from its behavior, and update the control law to maintain stability and control. The current approach to handling platform modification or damage places the burden of recovery and control on the operator, whether the operator is human or an autonomous controller. In contrast, a platform equipped with LINC technology will continually compare the real-time behavior of the platform as measured by on-board sensors with a learned model, determine if the current observed behavior of the platform differs from that model in ways that might compromise stability and control, and implement an updated control law when required. The LINC capability would aid operators in maintaining effective control of military platforms that suffer damage in battle or have been modified in the field to address emergent requirements identified during operations. ***FY 2022 Plans:*** - Develop machine introspection and learning approaches for estimating the transfer function and related control-theoretic models in real time using data from the multiple sensors organic to the platform. - Develop machine-learning based algorithms to enable the automated adaptation of a physical model representative of a system to enable it to reconstitute effective control after battle damage or in-the-field modification. - Collaborate with Service transition partners to identify high-priority military cyber-physical systems and use cases for initial experimentation. ***FY 2023 Plans:*** - Design and implement a testbed for assessing integrated machine introspection and learning approaches for operator-assisted recovery and control of military platforms that suffer damage in battle or are modified in the field. - Improve the computational efficiency of control reconstitution algorithms and expand their applicability to more complex DoD systems. - Develop a computational platform to support experiments involving cyber-physical systems and high-priority use cases in collaboration with Service transition partners. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase reflects ramping up the development of learning introspective control techniques and initiation of efforts to implement the techniques in a demonstration platform.			
Title: Counter Adversarial Artificial Intelligence ***Description:*** The Counter Adversarial Artificial Intelligence program aims to enhance the capability to detect, deflect, and diminish the effects of adversarial attacks on AI-based systems. Defense systems increasingly incorporate artificial intelligence (AI) capabilities such as machine learning and automated reasoning. These AI-enabled systems are typically engineered and optimized for environments where adversary systems are either static or strictly limited in terms of adaptive behaviors. Engagements between sophisticated AI-enabled systems are likely to become increasingly common going forward. Maintaining AI-superiority for the U.S. will require systems with higher levels of capability. Specific capabilities to be developed include recognizing when an adversary system is AI-enabled, identifying and modeling adversary AI capabilities based on empirical data, and creating counter-AI strategies including techniques to render adversary AI capabilities ineffective and/or deleterious. ***FY 2022 Plans:*** - Model the range of potential adversarial AI behaviors, including the nature of vulnerabilities in machine learning (ML) components and symbolic AI components. - Conceptualize AI systems with capabilities to detect, deflect, and diminish the effects of adversarial attacks. - Formulate approaches for recognizing when an adversary system is AI-enabled, identify and model adversary AI capabilities based on empirical data, and counter adversary AI strategies. ***FY 2023 Plans:*** - Develop and demonstrate the capability to model and learn adversarial AI behaviors and formulate approaches for using this capability to detect, deflect, and diminish the effects of adversarial attacks. - Develop techniques for establishing dimensionality reduction properties for AI-enabled systems and use these properties to constrain the extent of analysis including the number of test cases. - Develop cross-validation-based approaches for mitigating the vulnerabilities in ML-based and symbolic AI components and demonstrate the capability to render adversarial AI attacks ineffective for high-priority military use cases. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects ramping up of development of counter adversarial AI techniques and initial demonstrations of techniques on high-priority military use cases.	-	14.500	22.000
Title: Assured Autonomy ***Description:*** The Assured Autonomy program is developing rigorous design and analysis technologies for continual assurance of learning-enabled autonomous systems to enhance system safety in uncertain environments. Currently, the state of the art for test,	15.000	13.000	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
evaluation, verification, and validation is only applicable to non-learning systems operating in well-characterized environments. As a result, autonomous systems enabled by machine learning (e.g., deep neural nets for perception, reinforcement learning for control policies, and online model learning) lack rigorous safety assurance. Assured Autonomy is developing new techniques for modeling and system design, formal verification, simulation-based testing, and safety-assured learning to provide continual assurance of learning-enabled autonomous systems. The technologies being developed in Assured Autonomy will enable the DoD to more rapidly and efficiently deploy learning-enabled autonomous systems that can be trusted to operate safely in uncertain environments. ***FY 2022 Plans:*** - Evaluate the impact of safety-constraints incorporated in online learning algorithms on the performance of autonomous systems operating in unknown and unstructured environments. - Develop and implement improvements to formal verification tools and monitoring techniques. - Demonstrate technologies on assurance challenge problems for several learning-enabled autonomous platforms of interest to the DoD. ***FY 2023 Plans:*** - Develop integrated toolchains for end-to-end development and assurance of learning-enabled systems. - Demonstrate integrated tools on multiple autonomous systems of interest to DoD. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the shift from development of techniques and tools to demonstrations on several learning-enabled autonomous platforms.			
Title: Active Interpretation of Disparate Alternatives (AIDA)	17.500	16.950	9.300
Description: The Active Interpretation of Disparate Alternatives (AIDA) program is developing a multi-hypothesis semantic engine that generates alternative interpretations of events, situations, and trends from a variety of unstructured sources where there are noisy, conflicting, and potentially deceptive data. At present, information from each medium is often analyzed independently, without the context provided by information from other media, with only informal comparison among competing hypotheses. The consequence of this can be inadequate interpretations, because alternatives are eliminated due to lack of evidence even in the absence of contradictory evidence. AIDA seeks to develop and demonstrate technology to automatically map information derived from diverse media into a common semantic representation, aggregate information, resolve ambiguities, discover conflicting information, and generate and explore multiple interpretations of events, situations, and trends. AIDA aims to provide decision makers a capability to understand alternative explanations for available information and to make contingency plans accordingly. ***FY 2022 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Develop the means to change statistical priors for new sources to reflect known biases and reliability, and thereby enable more accurate computation of coherence measures. - Enhance interface capabilities to facilitate exploration of user-generated conjectures and other models of human-computer interaction. - Collaborate with transition partners to conduct experiments to evaluate information extraction and hypothesis generation performance on operational data. ***FY 2023 Plans:*** - Enhance the techniques for detecting important changes in otherwise similar documents to achieve a level of precision and recall necessary to enable discovery and analysis of different hypotheses. - Collaborate with transition partners to establish the utility of the technology and tailor the platform for transition partner applications. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the shift from development of techniques for generating multiple alternative interpretations from multimedia data to evaluations of techniques on real-world data and optimization of the platform for transition partner applications.			
Title: Automating Scientific Knowledge Extraction and Modeling (ASKEM)	-	-	16.200
Description: The Automating Scientific Knowledge Extraction and Modeling (ASKEM) program will develop technologies and tools for the agile creation, sustainment, and enhancement of complex models and simulators to enable knowledge extraction and data-informed decision making in diverse scientific domains and military missions. Current modeling and simulation pipelines do not maintain the relevant inputs, assumptions, and modeling choices made during development, while rapidly changing knowledge, semantically-opaque models, and black-box simulators make pipelined development nearly impossible. ASKEM will enable a new paradigm for scientific modeling analogous to the transition in software development from the lengthy waterfall model to agile, continuous DevOps. ASKEM will produce modeling automation tools that 1) extract model components from documents and code while abstracting away from implementation details like math framework, language, and platform; 2) compose distinct model and simulator components; and 3) integrate all elements and processes in an extensible workbench that addresses the entire modeling and simulation lifecycle. ASKEM tools will enable experts to maintain, reuse, and adapt large collections of heterogeneous data, knowledge and models with traceability across knowledge sources, model assumptions, and model fitness and thereby bring agile, pipelined development to modeling and simulation. ASKEM technologies will be applied to multiple use cases to drive scalability and generality. ***FY 2023 Plans:*** - Develop formal representations and techniques for machine-assisted modeling that support automated composition and decomposition for model creation, sustainment, and customization.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Develop tools for machine-assisted simulator design and construction, enabling the rapid composition of models, frameworks, and solvers that are problem appropriate. - Develop tools for continuous machine-assisted validation of models, including construction of fitness-for-purpose simulators to accompany prognostic measures. - Initiate development of an extensible workbench that spans the entire modeling and simulation lifecycle in which the technologies can be evaluated against diverse use cases in collaboration with transition sponsors. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Artificial Intelligence Reliability and Traceability (AIRT)	-	6.000	-
Description: The Artificial Intelligence Reliability and Traceability (AIRT) program will develop design-time and run-time technologies to ensure the correct functioning of AI-enabled systems. As AI deployment scales up, it becomes more important for machine learning (ML) systems and their training data to be explainable, which means providing rationale for classifications, characterizing confidence level of the classifications, and, as a consequence, conveying an understanding of how the system will behave with similar inputs. Explainability, however, is not sufficient to ensure that ML systems meet reliability requirements and are free of bias, in the sense that the ML operates consistently with domain-focused predictive models, nor that they are traceable, in the sense that there are mappings between the models and the ML behaviors. AIRT will develop the test, evaluation, verification, and validation (TEVV) technologies that system developers need to ensure that AI-enabled systems will correctly perform their intended functions. The AIRT TEVV technologies will address the challenge of how to specify AI-related behaviors and then how to verify the specified behaviors using both analytic formal approaches, which emphasize mathematical modeling and reasoning, and traditional statistical-sampling based approaches. AIRT will also develop design principles for machine learning and related systems that enhance reliability and traceability without appreciable compromise to reasoning capability. Additionally, AIRT will develop traceability approaches that model the learning behavior of an AI component to enable developers, testers, and operators to gain detailed knowledge of how the AI system reached a computational state. The AIRT program aims to make the design and operation of AI systems more scientific and safe. ***FY 2022 Plans:*** - Formulate approaches for TEVV of AI-enabled systems and associated data to increase confidence in correct performance of intended functions. - Explore TEVV approaches that include means to specify intended AI-related behaviors and that combine analytic formal approaches, which emphasize mathematical modeling and reasoning, with traditional statistical-sampling based approaches.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Introduce traceability approaches akin to check-pointing and other roll-back techniques that can enhance knowledge of how an AI system reached a computational state. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Engineering Artificial Intelligence Systems Implementations (EAISI) ***Description:*** The Engineering Artificial Intelligence Systems Implementations (EAISI) program is creating technologies and tools to support the development of viable and trusted systems that include AI and machine learning (ML) capabilities. Modern AI-dependent systems may include multiple AI components, drawing on a diverse set of AI-related techniques, ranging from ML to knowledge representation, search, planning, game theory, and optimization. Current methods for development of such systems remains primarily based on trial-and-error designs, with limited abstractions, architectures, and patterns. These developments can be costly, risky, and demanding of very high levels of expertise. To address this, EAISI will develop abstractions, patterns, architectures, assurance techniques, and iterative processes that facilitate the analysis and synthesis of complex systems that must rely on AI-based components and associated training data. One of the more difficult engineering challenges with AI is evaluation and assurance, since AI-based systems tend to resist traditional approaches to testing, inspection, and analysis. It is not possible to fully test an AI-based system for every situation it will ever encounter, so new techniques are needed for verifying and validating AI-based systems. EAISI aims to create software and systems engineering techniques, tools, and practices to facilitate the development of AI-based systems that are capable, trustworthy, affordable, and timely. ***FY 2022 Plans:*** - Formulate rigorous approaches for managing training data for AI-based systems, including provenance, security, and quality, to facilitate the engineering of AI-based systems that are capable, trustworthy, affordable, and timely. - Devise approaches for testing, analyzing, and evaluating AI-based systems as means for gaining confidence in and rigorously validating those systems. - Devise a framework for integrating prototype tools in an AI systems engineering development environment for use by developers and evaluators who are not experts in AI. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	7.300	11.800	-
Title: Explainable Artificial Intelligence (XAI) ***Description:*** The Explainable Artificial Intelligence (XAI) program is developing a new generation of machine learning techniques that are able to explain their rationale, characterize their strengths and weaknesses, and convey an understanding of how they will behave in the future. AI is a critical enabler for U.S. military systems that will perform increasingly complex and sensitive	9.165	8.324	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
missions. However, in order for developers, users, and senior leaders to feel confident enough to deploy and use AI-enabled systems, these systems must be able to explain their rationale, and their recommendations, decisions, and actions must be delivered in a way that military users can understand and trust. Today, most machine learning systems provide no explanations, or provide explanations that are at the wrong level of abstraction, not meaningful to a human user, or inconsistent with the full range of behaviors of the AI system. XAI is developing the tools necessary to build explainable AI systems, specifically with: (1) new machine learning techniques that produce human-interpretable models and (2) user interfaces that generate explanations from those models that are meaningful to end-users, using natural language, saliency maps, and other representations. XAI implementations will be developed and demonstrated in next-generation data analytics and autonomous systems. ***FY 2022 Plans:*** - Refine machine learning explanation systems for human-machine teaming prototypes in coordination with DoD partners. - Provide toolkit for explainable AI to DoD and IC partners targeting relevant use cases. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Accomplishments/Planned Programs Subtotals	151.005	193.274	193.234

	FY 2021	FY 2022
Congressional Add: AI Cyber Data Analytics (AI) - Congressional Add	-	10.000
FY 2022 Plans: Develop scalable machine learning technologies capable of learning from large training sets with orders of magnitude less computation.		
Congressional Adds Subtotals	-	10.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602383E / *BIOLOGICAL WARFARE DEFENSE*

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	-	26.082	31.421	23.059	-	23.059	10.536	11.035	11.852	11.852	-	-
BW-01: *BIOLOGICAL WARFARE DEFENSE*	-	26.082	31.421	23.059	-	23.059	10.536	11.035	11.852	11.852	-	-

A. Mission Description and Budget Item Justification

The Biological Warfare Defense project is budgeted in the Applied Research Budget Activity because its focus is on the underlying technologies associated with the detection, prevention, treatment and remediation of biological, chemical, and radionuclide threats.

Efforts to counter existing and emerging biological, chemical and radiological threats include: countermeasures to stop the pathophysiologic processes that occur as a consequence of an attack; collection of environmental trace constituents to support chemical mapping, tactical and strategic biological, chemical, and radiological sensors; and integrated defense systems.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	26.950	31.421	0.000	-	0.000
Current President's Budget	26.082	31.421	23.059	-	23.059
Total Adjustments	-0.868	0.000	23.059	-	23.059
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-0.868	0.000			
• Adjustments to Budget Year	-	-	23.059	-	23.059

Change Summary Explanation

FY 2021: Decrease reflects SBIR/STTR transfer.
FY 2022: NA
FY 2023: FY 2023 funding increase reflects the fact that the FY 2022 President's Budget request did not include out-year funding.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Defense Against Mass Terror Threats	26.082	31.421	23.059

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602383E / *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The objective of the Defense Against Mass Terror Threats program is to identify and develop technologies that have the potential to significantly improve the United States' ability to reduce the risk of mass casualties in the wake of a Weapons of Mass Terror (WMT) attack. Challenges in reducing U.S. vulnerability to these attacks include developing new sensors and systems that afford early warning and opportunities to interdict these threats before they can be employed in urban areas and other population centers. A major goal of this program is to develop new sensors and sensing networks that can economically and reliably provide these wide-area monitoring capabilities for WMT threat signatures. ***FY 2022 Plans:*** - Continue spiral development of chemical and biological sensors, with emphasis on algorithm development, to include follow-on independent government testing of performance and suitability. - Conduct follow-on operational demonstrations of new and augmented, commercial-off-the-shelf chemical and biological sensor systems with local and Federal Government stakeholders. - Expand on utility assessment of worn physiological sensors building on developments associated with infectious disease detection. - Continue spiral development of a network backbone and operating system supporting sensor, contextual and transactional data ingestion with a focus on streaming data from open-source and stakeholder-provided sources. - Work with Federal Government partners to develop and mature methods for template generation supporting various law enforcement investigative processes. - Mature end-to-end beta build of the network, including data model, pipeline and analytics engine capable of ingestion and automated analytics of heterogeneous sensor data, with contextual and law enforcement transactional data. - Develop transition strategies for sensor and network technologies with local municipalities and Federal Government partners such as the Department of Homeland Security (DHS), Countering Weapons of Mass Destruction (CWMD) Office, Immigration and Customs Enforcement (ICE), Port Authority of New York and New Jersey, and Indianapolis Metropolitan Police Department (IMPD). - Identify limits of continuous sensing for the detection of SARS-CoV-2 viruses in the environment. ***FY 2023 Plans:*** - Complete spiral development of chemical and biological sensors validated in independent government testing. - Conclude utility assessment of worn physiological sensors using developments associated with infectious disease detection and reporting, coupled with integrated algorithms. - Finalize suite of augmented, commercial-off-the-shelf chemical and biological sensors that will compose a system including fully scaled, integrated sensors and operationalized algorithms. - Complete spiral development of a network backbone and operating system supporting sensor, contextual and transactional data ingestion with a focus operating within stakeholder system environments.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602383E / *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Mature end-to-end beta build of the network, including data model, pipeline, and analytics engine capable of ingestion and automated analytics of heterogeneous sensor data, with contextual and law enforcement transactional data focusing on incorporating law enforcement feedback. - Present system concept of operations to local municipality and Federal Government partners to outline how developed capabilities can support relevant interdiction and response operations. - Demonstrate system in large-scale field trials (>10 square kilometers) with objective metrics or better. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease is due to a shift from major development activities to final operational demonstrations prior to transition.			
Accomplishments/Planned Programs Subtotals	26.082	31.421	23.059

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL 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	-	230.211	207.515	221.883	-	221.883	262.105	324.422	307.681	299.931	-	-
TT-03: *NAVAL WARFARE TECHNOLOGY*	-	6.868	11.059	23.924	-	23.924	12.959	17.059	16.484	23.234	-	-
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	-	86.864	54.060	67.157	-	67.157	80.305	98.603	100.147	93.897	-	-
TT-07: *AERONAUTICS AND SPACE TECHNOLOGY*	-	51.129	44.507	33.300	-	33.300	30.100	30.500	19.250	8.000	-	-
TT-13: *INFORMATION ANALYTICS TECHNOLOGY*	-	85.350	97.889	97.502	-	97.502	138.741	178.260	171.800	174.800	-	-

A. Mission Description and Budget Item Justification

The Tactical Technology Program Element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology Program Element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Aeronautics and Space Technology and Information Analytics Technology.

The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. Enabling and novel technologies include concepts for expanding the envelope of operational naval capabilities to include the entire sea column such as improved situational awareness over large maritime environments, ship self-defense techniques, novel underwater propulsion modalities, high speed underwater vessels, improved techniques for underwater object detection and discrimination, long endurance unmanned surface vehicles, methods and techniques for servicing assets throughout the sea column, and high bandwidth communications. This project will also examine methods and architectures for distributing maritime operations to enable a more agile, survivable, and cost-effective fleet.

The Advanced Land Systems Technology project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations, including competing in undergoverned spaces. Programs in this project will break the relative symmetry of land combat to give U.S. forces a decided advantage in the current and future ground battlefield. The emphasis is on developing affordable technologies that reduce reliance on consolidated forward-operating bases and required lines of communication, and provide small units and individual warfighters with hyper-mobility and hyper-lethality. This project will develop methods and technologies to expand the maneuver trade space to include the vertical dimension, including subterranean environments, as well as undergoverned spaces. It will leverage advances in artificial intelligence to enable integrated manned-unmanned operations and decrease warfighter exposure through the use of autonomous agents.

Aeronautics and Space Technology efforts will address high payoff opportunities that dramatically reduce costs associated with advanced aeronautical and space systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. This includes advanced technology studies of revolutionary propulsion, vehicle, and launch concepts, sophisticated fabrication methods, and examination of novel materials and enabling technologies for

aeronautics and space system applications. Studies that also fundamentally change the calculus of battle including consideration of a mix of assets, platforms that are potentially disposable or with limited lifespans, and autonomous integration of space and air platforms in the tactical battlespace are included as well.

The Information Analytics Technology project develops technology for analyzing data and information arising from: 1) intelligence networks; 2) open sources, social and broadcast media, and other external sources; 3) sensors and signal/image processors; and 4) collection platforms and weapon systems. Technical challenges include processing huge volumes of diverse, incomplete, and uncertain data in tactically-relevant timeframes, and countering the information operations of sophisticated adversaries who seek to deceive, degrade, deny, and disrupt the U.S. information enterprise. Benefits sought include a deeper understanding of the evolving operational environment tailored to the needs of commanders at every echelon; an enhanced capability to plan, monitor, and control diverse military operations ranging from stabilization and information operations to combat engagements; and increased efficiency of core military functions such as national and homeland security, warfighter health and readiness, and defense support of law enforcement and civil authorities.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	237.271	202.515	0.000	-	0.000
Current President's Budget	230.211	207.515	221.883	-	221.883
Total Adjustments	-7.060	5.000	221.883	-	221.883
• Congressional General Reductions	0.000	-10.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	15.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.580	0.000			
• SBIR/STTR Transfer	-7.640	0.000			
• Adjustments to Budget Year	-	-	221.883	-	221.883

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*		
Congressional Add: *Counter Directed Energy Laser Eye Protection Research - Congressional Add*	4.000	-
Congressional Add Subtotals for Project: TT-04	4.000	-
Project: TT-13: *INFORMATION ANALYTICS TECHNOLOGY*		
Congressional Add: *AI Cyber Data Analytics (Data) - Congressional Add*	-	15.000
Congressional Add Subtotals for Project: TT-13	-	15.000
Congressional Add Totals for all Projects	4.000	15.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*

Change Summary Explanation

FY 2021: Decrease reflects SBIR/STTR transfer offset by reprogrammings.

FY 2022: Increase reflects Congressional Add for AI, Cyber, Data Analytics offset by Congressional reduction.

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

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*	Project (Number/Name) TT-03 / *NAVAL WARFARE 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
TT-03: *NAVAL WARFARE TECHNOLOGY*	-	6.868	11.059	23.924	-	23.924	12.959	17.059	16.484	23.234	-	-

A. Mission Description and Budget Item Justification

The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. Enabling and novel technologies include concepts for expanding the envelope of operational naval capabilities to include the entire sea column such as improved situational awareness over large maritime environments, ship self-defense techniques, novel underwater propulsion modalities, high speed underwater vessels, improved techniques for underwater object detection and discrimination, long endurance unmanned surface vehicles, methods and techniques for servicing assets throughout the sea column, and high bandwidth communications. This project will also examine methods and architectures for distributing maritime operations to enable a more agile, survivable, and cost-effective fleet.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Multi-Azimuth Defense Fast Intercept Round Engagement System (MAD-FIRES)	3.512	7.157	18.639

Description: The Multi-Azimuth Defense Fast Intercept Round Engagement System (MAD-FIRES) program will develop a point defense system against today's most stressing threats by developing a highly maneuverable, medium caliber, guided projectile, fire sequencing and control system capable of neutralizing large threat raids of high speed, highly maneuverable targets. Leveraging recent advancements in gun hardening, miniaturization of guided munition components, and long-range sensors, MAD-FIRES advances fire control technologies, medium caliber gun technologies, and guided projectile technologies enabling the multiple, simultaneous target, kinetic engagement mission at greatly reduced costs. MAD-FIRES will achieve lethality overmatch through accuracy rather than size, thus expanding the role of smaller combat platforms into missions where they have been traditionally outgunned. MAD-FIRES, sized as a medium caliber system, enhances flexibility for installment as a new ship self-defense system. This phase of the project will mature and demonstrate key projectile technologies and subsystem elements. The final phase of system integration and supersonic testing is funded in PE 0603766E, Project NET-02.

FY 2022 Plans:
- Verify function and survival of the updated projectile after gun firing.
- Measure projectile maximum maneuver performance.
- Demonstrate closed-loop guidance of the projectile in flight.

FY 2023 Plans:
- Commence subsystems development, integration and testing.
- Mature critical technologies to enable future surrogate threat engagement demonstrations.
- Update Modeling, Simulation and Analysis (MS&A) toolset and perform gun-fired testing to validate MS&A tools.

FY 2022 to FY 2023 Increase/Decrease Statement:

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-03 / *NAVAL WARFARE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase reflects completing the current development phase with demonstrations of projectile technologies and subsystem elements.			
Title: Maritime Defense	3.356	3.902	5.285
Description: The Maritime Defense program will explore novel technologies and concepts of operations to mature capabilities to extend freedom of access, operations, and homeland defense in all parts of the maritime domain, including waterways, arctic areas, and the seabed. The program will investigate and mature technologies necessary for unmanned underwater vehicle (UUV) and unmanned surface vessel (USV) concepts for defense against large volumes of low-cost expendable platforms, including compressing the detect-to-engage sequence by exploiting localized networked sensors to rapidly detect, identify, and neutralize threats. Enabling technologies for advanced undersea systems, including a revolutionary propulsion concept, and novel approaches for maritime platform self-defense will be investigated. Novel technologies and concepts required for arctic and seabed operations, such as distributed sensing, navigation, and communications architectures, as well as including new technologies to enable long duration maritime platforms, will also be investigated. Finally, future concepts, approaches, and techniques will be identified to enable contested environment operations utilizing unmanned maritime platforms. ***FY 2022 Plans:*** - Mature conceptual design and conduct risk reduction activities for advanced underwater payloads and sensors. - Refine conceptual design in the development of advanced payloads and autonomy. - Conduct cost analysis and readiness level assessments for transition opportunities to follow-on research and development. ***FY 2023 Plans:*** - Initiate studies of novel underwater sensor systems and extended range maritime platforms. - Assess autonomous maritime platform integration with advanced payload capabilities. - Assess novel technologies and concepts for arctic operations. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects broadening investigation utilizing unmanned maritime platforms for contested environments.			
Accomplishments/Planned Programs Subtotals	6.868	11.059	23.924

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*	Project (Number/Name) TT-04 / *ADVANCED LAND 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
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	-	86.864	54.060	67.157	-	67.157	80.305	98.603	100.147	93.897	-	-

A. Mission Description and Budget Item Justification

The Advanced Land Systems Technology project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations, including competing in undergoverned spaces. Programs in this project will break the relative symmetry of land combat to give U.S. forces a decided advantage in the current and future ground battlefield. The emphasis is on developing affordable technologies that reduce reliance on consolidated forward-operating bases and required lines of communication, and provide small units and individual warfighters with hyper-mobility and hyper-lethality. This project will develop methods and technologies to expand the maneuver trade space to include the vertical dimension, including subterranean environments, as well as undergoverned spaces. It will leverage advances in artificial intelligence to enable integrated manned-unmanned operations and decrease warfighter exposure through the use of autonomous agents.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Robotic Autonomy in Complex Environments with Resiliency (RACER)	20.941	31.600	45.924
Description: Multi-domain operations (MDO) environments present complex and challenging environments to ground combat platforms. Ground combat platforms must operate in a more distributed manner in these environments to gain a sustained tactical advantage and enhance Warfighter survivability. The Army intends to deploy autonomous robotic combat vehicles and optionally manned fighting vehicles to accomplish this objective. In order to meet the demands of an MDO environment, significant advances in perception, planning, and control algorithms are required to autonomously maneuver faster and more resiliently in complex and novel off-road environments. Maneuver environments are characterized by three-dimensional surfaces of highly compliant soils and vegetation, hundreds of positive and negative obstacle classes, no defined road networks or driving rules, and where use of terrain for survivability is critical. In order to achieve operationally relevant speeds and resilience to novel situations on the future battlefield, while simultaneously reducing the Soldier cognitive and communications burden and increasing battle space awareness, Robotic Autonomy in Complex Environments with Resiliency (RACER) will demonstrate game-changing autonomous ground combat vehicle mobility using a combination of simulation and advanced platforms. RACER will deliver autonomy algorithms using the latest in Artificial Intelligence (AI) and machine-learning techniques, a code repository, an off-road simulation environment tailored for military off-road autonomy development, tactical route planning methods and field-demonstrated off-road autonomous capabilities. The culmination of the RACER program will be to demonstrate fully autonomous maneuver on a military Unmanned Ground Vehicle (UGV) in a variety of militarily relevant environments.			
FY 2022 Plans: - Initiate Government-hosted field experiments of varying terrain and obstacle complexity. - Initiate large-scale demonstration platform (combat vehicle scale) preparations.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-04 / *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Demonstrate initial capabilities of off-road autonomy simulation technologies. - Determine off-road speeds and interventions comparable to best human driver capability. ***FY 2023 Plans:*** - Continue Government-hosted field experiments in increasingly complex terrain and obstacle classes. - Initiate development of tactically relevant routes for small-scale demonstration platforms using initial tactics versus an opposing force. - Deliver a simulation environment compared against real-world system performance and environments. - Deliver autonomy algorithm modules demonstrated in the real-world and compared against a simulation environment. - Begin testing on large-scale demonstration platform (combat vehicle scale) in increasingly complex and large-scale demonstrations. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects the continuation of field demonstrations and initiation of large-scale demonstration platform (combat vehicle scale) commissioning.			
Title: Competing in Undergoverned Spaces	-	10.460	15.733
Description: A vast majority of U.S. technology is focused on gaining competitive advantage against near peer adversaries in kinetic engagements where there are known rules and players, concrete timelines and clear winners and losers. While these finite games are important, many critical engagements are closer to infinite contests--dynamic, diffuse high dimensionality interactions that play out over long periods with an ultimate goal of resetting the regional power and influence equilibrium. Competing in these contests is critical for successful stabilization and Humanitarian Assistance Disaster Relief (HADR) missions, as well as operations in undergoverned spaces. Some undergoverned spaces are geographic, where local governance is sufficiently weak such that internal or external parties can compete for influence over the local population. Some contested undergoverned spaces are more conceptual yet still very real, defined by virtual or physical domains that lack or regularly violate ethical, legal, social and institutional order such as supply chains or the cyber-domain. The Competing in Undergoverned Spaces will develop technologies that are focused on successfully competing in infinite contests by developing tools for situational awareness and interpretation of signals, constant acting, assessing and adapting (i.e., iterative Hypothesis A/B testing) and new ways of viewing experimentation from a foundation of asynchronous observations and actions. Specific areas of interest include information, influence or economic tools that rapidly adapt to the environment to yield specific effects that can be sensed. This includes developing new options to engage friendly/non-friendly local populations while minimizing the social impact of stabilization. Other areas of interest include sensing tools designed to update pre-existing models to support decision making, and decision tools designed to adapt to changing population or adversary actions. ***FY 2022 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-04 / *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Initiate efforts to develop techniques for measuring and characterizing changes to structure and operation of an exemplar global system (e.g., food) at multiple time scales. - Identify potential approaches for bridging the gap between static risk analysis and real time monitoring for an exemplar global system (e.g., food). - Explore approaches to link diverse spectroscopy techniques to quantifiable local activity (e.g., economic, social). - Initiate the development of models to anticipate community dynamics through studies of how terrain, social structure, environment, etc. shape activity. - Begin the development of active sensing tools that reveal functional properties of local economic, political, or physical systems. ***FY 2023 Plans:*** - Test links between diverse spectroscopy techniques and quantifiable local activity (e.g., economic, social). - Continue development of models to anticipate community dynamics through studies of how terrain, social structure, environment, etc. shape activity. - Continue the development of active sensing tools that reveal functional properties of local economic, political, or physical systems. - Devise approaches to experimentation and assessment in high-dimensionality, subkinetic contests. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase is due to a shift from initial system design to development and demonstration.			
Title: Advanced Ground Technologies Concepts	-	-	5.500
Description: The Advanced Ground Technologies Concepts program aims to surmount key challenges associated with redefining access and delivery of effects to every aspect of the ground domain by using targeted investments that explore the feasibility of novel technical solutions, force capabilities and new concepts of operations. In particular, program investments encompass technologies that promise breakthroughs in enabling actionable situational awareness across diverse environments, Artificial Intelligence (AI) enabled autonomy for large scale integration of manned-unmanned ground force operations; intelligent ground mobility systems; advanced military robotic systems for urban operations; technologies expanding the effective ranges of surface-to-surface precision fires and technologies that expand the combined arms maneuver trade space to include the vertical dimension, interiors of buildings, and exploiting natural and man-made subterranean environments. ***FY 2023 Plans:*** - Mature conceptual design for technologies that enhance detection and tracking of large land targets in denied areas. - Mature framework for enhancing manned-unmanned teaming (MUM-T) operations and develop demonstration plans to field the framework.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-04 / *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Mature approaches for testing tactical autonomy in urban environments and develop demonstration framework. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Subterranean (SubT) Challenge ***Description:*** The DARPA Subterranean (SubT) Challenge is developing novel integrated solutions capable of mapping, navigating, and searching complex and dynamic terrains (tunnel systems, urban underground and cave networks); sensors and computation for perception in austere conditions; distributed information sharing in degraded communications environments; and collaborative autonomy enabling extended operations with minimal human intervention. The core objective of the SubT Challenge is to discover the solution(s) which best outperforms current approaches for manually and laboriously mapping and searching subterranean environments. Newly developed capabilities will span across four technology focus areas in autonomy, perception, networking, and mobility technologies. The program will increase the diversity, versatility, and robustness of relevant system technologies, capable of addressing the multi-faceted needs of a wide range of environments. Innovations are being explored in the context of a public-facing, broadly inclusive DARPA Challenge. ***FY 2022 Plans:*** - Facilitate deep tech commercialization and transfer opportunities. - Complete technology assessments, reference data collection, and prize award execution from the Final Event. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of program.	21.800	4.000	-
Title: Urban Reconnaissance through Supervised Autonomy (URSA) ***Description:*** The Urban Reconnaissance through Supervised Autonomy (URSA) program is developing and demonstrating new autonomous agents and techniques that support a Blue Force Commander in managing the complexity and ambiguity of urban spaces by rapidly identifying and discriminating among potential threats during missions ranging from minutes to hours. The program uses perception-enabled autonomous vehicles to manage complexity and interactions with populations to drive down the ambiguity between peaceful civilians and threats. The program will create a system of autonomous ground and air platforms operating in conjunction with U.S. ground forces that monitor an area overtly to detect hostile forces and establish Positive Identification (PID) before any U.S. troops come into contact. Military units follow strict rules of engagement (ROEs) that prescribe an escalation of force appropriate with the level of hostilities and confidence that an individual is engaged in nefarious behavior. This program will establish a Legal, Moral, Ethical (LME) working group comprising multiple individuals (technologists, military, university professors, ethicists, legal experts) to develop an understanding of how escalation and/or de-escalation of force can and should be appropriately applied in the context of supervised autonomous systems. URSA is exploring scenarios and	19.000	8.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-04 / *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
probing behaviors to enable identifying innocent civilians and individuals who pose a threat to U.S. Forces, allies, or non-combat civilians. This mission requires the integration and maturation of novel sensors, and unmanned ground and air vehicles which leverage current techniques in perspective and reactive autonomy to navigate cluttered urban environments. URSA is developing new search and engagement behaviors to disambiguate human actions and serve as evidence that a potential target is a threat. It is implementing new dimensions of evidence such as the human reactions to these engagements to improve confidence in its decisions, and building a novel framework for escalating and de-escalating nonlethal force. ***FY 2022 Plans:*** - Evaluate system performance with incremental field demonstrations in increasingly complex and varying urban environments. - Conduct the final system end-to-end performance evaluation in a live environment. - Conduct feasibility demonstration that will validate validity of the system in a live event. - Explore transition activities with Marine Corps Systems Command to assess potential application to emerging programs. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of program with live capstone field demonstration.			
Title: Proportional Weapons ***Description:*** The Proportional Weapons program pursued a real-time capability to analyze and apply proportional effects for families of weapons that suppress or breach any external structure to neutralize threats, clear spaces at range, keep them intact, and minimize collateral damage. Novel approaches that are effective from the air or ground against several scales of threats while not being catastrophically destructive were needed. Current approaches to identifying, engaging, and assessing effects against evasive ground targets require significant human oversight combined with human semantic reasoning tied to rules of execution, resulting in slow and methodical engagements. Proportional Weapons studied systems that provided extended range and tunable effects. Proposed technical approaches are scalable for application to dismounted warfighters, vehicle-borne (air and ground) systems, or as human-in-the-loop payloads for future autonomous platforms.	2.000	-	-
Title: Mobile Force Protection (MFP) ***Description:*** The goal of the Mobile Force Protection (MFP) was to develop and demonstrate an integrated system capable of defeating a raid of self-guided small unmanned aircraft systems (sUAS) attacking a high value convoy on the move. By focusing on protecting mobile assets, the program emphasized low footprint solutions, in terms of size, weight, power (SWaP), and manning, which benefited other counter-UAS missions and resulted in more affordable systems. Defending in a variety of operating environments against these sUAS threats and associated concept of operations required several breakthroughs in affordable technology to sense, decide and act on a compressed timeline while mitigating collateral damage. The program developed solutions applicable to the defense of mobile ground and naval forces that can also potentially defeat more	4.320	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-04 / *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
conventional threats. The solutions are scalable and modular such that they can be deployed in multiple defense applications and do not become obsolete with evolving threat capability.			
Title: Underminer ***Description:*** The Underminer effort, an outgrowth of the Subterranean Challenge program, explored the development and integration of technologies that drill/bore and build the underground environment for tactical operations. Underminer explored creation and utilization of tunneling, drilling, and boring capabilities for systems at multiple scales. The program also examined multiple concepts of operation and considered creation and use of both temporary tunnels as well as rapid creation of tunnel networks.	8.763	-	-
Title: Squad X ***Description:*** The U.S. military achieves overmatch against its adversaries in certain regimes; however, this level of overmatch is not realized at the squad to individual dismounted warfighter level. The goal of the Squad X program was to leverage advances in real-time situational awareness and mission command; organic three-dimensional dismount mobility; extended range tracking, targeting, and response; and unmanned mobility and perception in order to create a squad with substantial combat overmatch. The concept of overmatch at the squad level included increased human stand-off, a smaller force density, and adaptive sensing to allow for responses at multiple scales. Squad X explored advanced wearable force protection, advanced organic squad level direct and indirect trajectory precision weaponry, and non-kinetic precision capabilities. The end result of the Squad X program was an individual dismount unit outfitted with sensors, weaponry, and supporting technology to achieve unit level overmatch as well as the overall integration of unmanned assets alongside the dismounts to create an advanced, dismounted small unit.	6.040	-	-
Accomplishments/Planned Programs Subtotals	82.864	54.060	67.157

	FY 2021	FY 2022
Congressional Add: Counter Directed Energy Laser Eye Protection Research - Congressional Add	4.000	-
FY 2021 Accomplishments: - Develop large-area coatings for counter laser eye protection by hardening windows to repel laser energy while providing high visible transmission and color neutrality.		
Congressional Adds Subtotals	4.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-04 / *ADVANCED LAND SYSTEMS TECHNOLOGY*

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*	Project (Number/Name) TT-07 / *AERONAUTICS AND SPACE 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
TT-07: *AERONAUTICS AND SPACE TECHNOLOGY*	-	51.129	44.507	33.300	-	33.300	30.100	30.500	19.250	8.000	-	-

A. Mission Description and Budget Item Justification

Aeronautics and Space Technology efforts will address high payoff opportunities that dramatically reduce costs associated with advanced aeronautical and space systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. This includes advanced technology studies of revolutionary propulsion, vehicle, and launch concepts, sophisticated fabrication methods, and examination of novel materials and enabling technologies for aeronautics and space system applications. Studies that also fundamentally change the calculus of battle including consideration of a mix of assets, platforms that are potentially disposable or with limited lifespans, and autonomous integration of space and air platforms in the tactical battlespace are included as well.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Advanced Aeronautics and Space Technologies*	3.000	3.500	9.500

Description: *Formerly Advanced Aeronautics Technologies

The Advanced Aeronautics and Space Technologies program examines and evaluates aeronautical and space technologies and concepts through applied research. These may include feasibility studies of novel or emergent materials, sensors and tactics for air and space platforms, launch vehicles, satellites, as well as manufacturing and implementation approaches. The areas of interest range from propulsion and power, guidance and control, concepts to enable novel air platforms, to innovative technologies and platform concepts to enable new missions and resilient operations for space systems, from low earth orbit to cislunar space. Aeronautics interest areas include hybrid electric/combustion propulsion concepts, small-scale air mobility solutions, and networking of both piloted and unpiloted air vehicles. Space interest areas include advanced or novel power and propulsion systems, novel sensors, advanced lightweight structures, advanced miniature radio frequency (RF) technology, navigation technologies, avionics, structures, and advanced communications. These studies may lead to the development of new programs, components or subsystems to enhance future aerospace platforms, or improvement of existing systems.

FY 2022 Plans:
- Continue conceptual design studies and demonstrate emerging technologies.
- Perform modeling and simulation that support future concepts and novel architectures.
- Identify and demonstrate feasible technologies for air platform defense.
- Examine concepts for advanced space technologies and perform laboratory demonstrations.

FY 2023 Plans:
- Refine conceptual design studies and test emerging technologies.

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-07 / *AERONAUTICS AND SPACE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Extend and develop modeling and simulation that support future concepts and novel architectures. - Integrate feasible and practical technologies into systems level demonstration vehicles. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects expansion of research into technologies and concepts for space systems ranging from low earth orbit to cislunar space.			
Title: Oversight ***Description:*** Oversight will develop and demonstrate a suite of autonomy technologies to provide constant custody of targets as a service for tactical operations in contested environments. Existing and emerging space systems will be evaluated. Proliferated Low Earth Orbit (p-LEO) satellite constellations and payloads will be leveraged due to their high-bandwidth, processing-on-the-edge capabilities in support of tactical, efficient, integrated missions at scale. Oversight will develop autonomous technology to enable advanced collaboration among constellations of satellites for target custody in contested environments where the numbers of targets is far greater than the number of satellites and sensors over the operating area. The Oversight program will culminate with a demonstration using existing on-orbit p-LEO assets combined with live, virtual and constructive terrestrial assets. ***FY 2023 Plans:*** - Perform systems engineering for a conceptual design. - Conduct analysis necessary to derive system requirements for track custody, resource management and infrastructure support. - Conduct assessment of government-owned applications and services that could be leveraged for system development. - Establish a government-owned modeling and simulation framework for evaluating performer algorithms. - Develop a software development kit and interface documents for incorporating software into the modeling and simulation framework. - Conduct trade studies and develop necessary algorithms for software applications and services. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.	-	-	23.800
Title: Control of Revolutionary Aircraft with Novel Effectors (CRANE) ***Description:*** The Control of Revolutionary Aircraft with Novel Effectors (CRANE) program is demonstrating revolutionary improvements in aircraft controls technology. The program will design, build, and flight test an aircraft able to fly and maneuver at altitude relying on state-of-the-art Active Flow Control (AFC) technology. AFC is a broad term that encompasses a range of technology approaches; it includes a number of control mechanisms which alter the aerodynamic flow field thru ejection or suction of fluid via an orifice on a lifting body. An emphasis of the program is assessing AFC component technologies, risk reduction and experimentation, integrated testing, fabrication and demonstration of a relevant scale novel and innovative aircraft. Technologies,	23.614	28.507	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-07 / *AERONAUTICS AND SPACE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
design tools and models developed and demonstrated under this program will be made available to all Services as well as the civilian aerospace sector for application to future air systems development. Beginning in FY 2023, this program is funded in PE 0603286E, Project AIR-01. ***FY 2022 Plans:*** - Complete development of conceptual design tools for AFC enabled aircraft. - Complete analysis and test activities resulting in preliminary design review. - Initiate detailed design, flight software and control law development. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the program shift to PE 0603286E, Project AIR-01 as the programs enters into final detailed design and fabrication of the demonstration aircraft.			
Title: Gremlins ***Description:*** The Gremlins program is developing platform technologies that enable a new class of distributed warfare. The Gremlins concept envisions small air-launched unmanned systems that can be responsively dispatched in volley quantity from existing air platforms, fly into contested airspace, conduct a moderate duration mission, and be ultimately air recovered. Key enabling technologies for the concept include smaller developmental payloads that benefit from multiple collaborating host platforms. The Gremlins program will conduct risk reduction and development of the host platform launch and recovery capability and develop and demonstrate a recoverable Unmanned Air Vehicle (UAV) platform concept. Enabling platform technologies will include precision relative navigation, advanced computational modeling, small form factor payloads, compact propulsion systems, and highspeed digital flight control. The program will leverage these technologies, perform analytic trade studies, conduct incremental development, and ultimately demonstrate the potential for an integrated air-launched Gremlins unmanned platform capable of conducting distributed air operations. ***FY 2022 Plans:*** - Conduct flight test demonstrating full recovery capability of a Gremlins Air Vehicle. - Conduct flight analysis and reporting of airborne launch and recovery. - Perform design work for Intelligence Surveillance and Reconnaissance (ISR) payload integration. - Begin autonomy architecture integration into Gremlins system. - Conduct preliminary flight test demonstrating autonomy capability. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	11.515	12.500	-
Title: OFFensive Swarm-Enabled Tactics (OFFSET)	8.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-07 / *AERONAUTICS AND SPACE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The OFFensive Swarm-Enabled Tactics (OFFSET) program designed, developed, and demonstrated a swarm system architecture to advance the innovation, interaction, and integration of novel swarm tactics. The program examined enabling technologies for collaborative autonomy for large teams of unmanned systems, including unmanned ground and air capabilities through the use of both virtual, game-based and physical, live-fly testbeds. Key research thrusts included the development of advanced swarm tactics-centered autonomy and development of human-swarm teaming interface technologies. These combined enhancements facilitated insights and enabled employment of these collective systems to address current needs and defeat future threats. The program considered technologies supporting U.S. ground and air operations, extensible to other operating environments, requiring organic and/or tactical swarm capabilities, and leveraged low-cost, rapidly deploy-able, autonomous system technologies.			
Title: CounterSwarmAI ***Description:*** The objective of the CounterSwarmAI program was to develop systems for anticipating and defeating autonomous systems threats of the future. These adversary systems will likely employ advanced artificial intelligence (AI) and machine learning techniques which will inevitably lead to increased complexity and unpredictability of these advanced threats. CounterSwarmAI envisioned the development of disruptive technologies across the engagement kill chain, themselves AI-empowered, to directly combat these challenges. CounterSwarmAI decision software would directly interface with future and legacy defensive systems (kinetic and non-kinetic) to rapidly assess, optimally exploit, and efficiently defeat enemy autonomous systems threats. Innovative solutions would enable (a) autonomous systems which provide understanding and vulnerability exploitation through machine learning, (b) an integrated AI-equipped open architecture for multi-faceted swarm defense, and (c) integration and experimentation with live surrogate swarm threats against current fielded defensive systems.	5.000	-	-
Accomplishments/Planned Programs Subtotals	51.129	44.507	33.300

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*	Project (Number/Name) TT-13 / *INFORMATION ANALYTICS 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
TT-13: *INFORMATION ANALYTICS TECHNOLOGY*	-	85.350	97.889	97.502	-	97.502	138.741	178.260	171.800	174.800	-	-

A. Mission Description and Budget Item Justification

The Information Analytics Technology project develops technology for analyzing data and information arising from: 1) intelligence networks; 2) open sources, social and broadcast media, and other external sources; 3) sensors and signal/image processors; and 4) collection platforms and weapon systems. Technical challenges include processing huge volumes of diverse, incomplete, and uncertain data in tactically-relevant timeframes, and countering the information operations of sophisticated adversaries who seek to deceive, degrade, deny, and disrupt the U.S. information enterprise. Benefits sought include a deeper understanding of the evolving operational environment tailored to the needs of commanders at every echelon; an enhanced capability to plan, monitor, and control diverse military operations ranging from stabilization and information operations to combat engagements; and increased efficiency of core military functions such as national and homeland security, warfighter health and readiness, and defense support of law enforcement and civil authorities.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Semantic Forensics (SemaFor)	19.700	21.921	29.839
Description: The Semantic Forensics (SemaFor) program is developing technologies to defend against the falsification of multimedia and disinformation campaigns. Statistical detection techniques have been successful, but media generation and manipulation technologies applicable to imagery, voice, video, text, and other modalities are advancing rapidly. Purely statistical detection methods are now insufficient to detect these manipulations, especially when multiple modalities are involved. Existing media generation and manipulation algorithms are data driven and are prone to making semantic errors that provide defenders an opportunity for asymmetric advantage. SemaFor is developing semantic and statistical analysis algorithms that determine if media is generated or manipulated, attribution algorithms that infer if media originates from a particular organization or individual, and characterization algorithms that reason about whether media was falsified (generated or manipulated) for malicious purposes. SemaFor aims to create technologies to identify, deter, and understand adversary media falsification.			
FY 2022 Plans: - Implement algorithmic approaches for analyzing and reasoning about inconsistencies across multiple media instances, detecting falsification, and explaining the reasoning for detections. - Develop machine learning and other artificial intelligence techniques to attribute falsified media to particular adversarial elements and to characterize the intent of falsified media as benign or malicious. - Extend evaluations to social media and news feeds requiring multimodal reasoning and incorporate datasets informed by DoD and IC transition partners into challenge problems and evaluations.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-13 / *INFORMATION ANALYTICS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Collaborate with DoD and IC partners to assess adversarial threat scenarios and to identify areas for additional research effort. ***FY 2023 Plans:*** - Implement more advanced forms of machine learning and artificial intelligence in media falsification detection, attribution, and characterization techniques for emerging complex adversarial falsified media. - Extend datasets and evaluation efforts to include disinformation in technical documents, media collections, and diverse social media feeds. - Refine application programming interfaces to include multiple sources, and provide multimodal (image, video, audio or text) system enhancements based on input from DoD and IC transition partners and other stakeholders. - Begin development of software prototype to address adversarial threat scenarios and to facilitate a deeper understanding of the intent of falsified media. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase is due to ramping up of development of semantic techniques for reasoning about inconsistencies in potentially falsified multimedia, and expansion of prototyping and evaluation work.			
Title: Influence Campaign Awareness and Sensemaking (INCAS)	6.000	13.500	23.000
Description: The Influence Campaign Awareness and Sensemaking (INCAS) program is developing analyst-guided techniques, tools, and platforms for the DoD to detect and understand geopolitical influence campaigns in a rigorous, quantitative manner. Increasingly, competitors and adversaries are using influence operations to project soft power. Competitor and adversary influence campaigns can be overt in the form of anti-U.S. messaging, or they can be disguised in the form of complex narratives that seek to advance agendas harmful to U.S. interests. The U.S. Government and DoD need the capability to rapidly detect and understand competitor and adversary messaging campaigns and narratives within the context of the populations and groups for whom they are intended. To accomplish this, the program will develop and operationalize natural language processing, social network analysis, psychographics, and behavioral science-based technologies, and integrate these into a unified influence campaign modeling framework and sensemaking platform. INCAS aims to produce a suite of automated digital tools to enable analysts to better understand how information is being used by competitors and adversaries, and to quantitatively assess in real time and at scale the effects of influence campaigns across time and over multiple platforms. ***FY 2022 Plans:*** - Develop tools for extraction of influence indicators and demographic and psychographic target population attributes from social and other media messaging at scale. - Develop tools for dynamically segmenting target population based on response, incorporating parameters such as volume and emotion. - Develop testbed infrastructure and data provisioning ingest pipeline components for performance evaluations.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-13 / *INFORMATION ANALYTICS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Develop user interfaces for campaign modeling and conduct usability assessment in collaboration with military subject matter experts. ***FY 2023 Plans:*** - Extend tools for extraction of additional influence indicators and demographic and psychographic target population attributes from social and other media messaging at scale. - Formulate analytic techniques to identify adversary information operations playbooks, quantify the effectiveness of countermeasures and response strategies, and detect extremist radicalization and other threats from online data. - Develop tools that correlate influence indicators in messaging with population attributes to explain and anticipate responses, and analytics for assessing the threat, similarity, and confidence of campaign models. - Implement techniques in the testbed infrastructure and deploy technology to support experimentation by operational stakeholders. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects continuation of work to develop and implement techniques in a modeling framework and sensemaking platform and initiation of efforts to evaluate the technology in collaboration with military stakeholders.			
Title: Adapting Cross-domain Kill-Webs (ACK)	14.400	11.700	8.000
Description: The Adapting Cross-domain Kill-Webs (ACK) program is assisting military decision makers with rapidly identifying and selecting options for tasking and re-tasking assets within and across organizational boundaries. Based on technologies developed in the Resilient Synchronized Planning and Assessment for the Contest Environment (RSPACE) program (previously budgeted in PE 0603766E, Project NET-01), ACK will assist users with selecting sensors, effectors, and support elements across military domains (space, air, land, surface, subsurface, and cyber) to form and adapt kill chains to deliver desired effects on targets. Today's Command and Control (C2) organizations and processes cannot support multi-domain warfighting concepts, especially during joint operations. ACK will address this challenge by utilizing a decentralized approach to allocating resources to tasks and assigning mission orders to assets, motivated by ideas developed in online commerce, sourcing, and supply chain management, such as bid requests and offers. The impact of ACK will be to accelerate asset re-allocation and assignment decision timelines to be on the order of minutes, and the output of ACK will be automated tools and decision aids to support the selection of the elements of a kill-chain and assignment of roles and responsibilities to each of the elements. Technology developed under this program will be transitioned to the Services. ***FY 2022 Plans:*** - Execute evaluation scenario to exercise algorithm cross-domain reasoning capabilities. - Evaluate cross-domain solution recommendations and user interface presentation. ***FY 2023 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Conduct evaluation capstone event. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from dynamic evaluation in testbed to final capstone demonstration with Services.			
Title: Data-Driven Discovery of Models (D3M) ***Description:*** The Data-Driven Discovery of Models (D3M) program is developing automated model discovery techniques and tools that enable non-expert users to create empirical models of real, complex processes and phenomena. The ability to understand the battlespace is driven increasingly by expert analysis of sensor and open source data. The DoD and IC communities are fundamentally limited by a shortage of domain-focused subject matter expert data scientists to construct empirical models that predict behaviors and anticipate contingencies during tactical and strategic planning. D3M is addressing this need by creating technologies that automate the construction of complex empirical models. D3M technologies include a library of data modeling primitives that are automatically selectable, automated approaches for composition of complex models from modeling primitives, and intuitive mechanisms for human-model interaction that enable curation of models by non-experts. D3M is focused on the types of empirical modeling problems commonly encountered by the DoD and IC. ***FY 2022 Plans:*** - Enhance automated machine learning tools for domain experts, analysts, and data scientists with causal explanations in support of critical domains, such as supply chain risk modeling. - Refine software modeling tools and systems in response to inputs from operational users. ***FY 2023 Plans:*** - Harden and transition software tools to DoD partners. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease is the result of development work ramping down and the focus shifting to hardening of modeling tools for transition.	10.650	7.200	5.063
Title: Computational Cultural Understanding (CCU)* ***Description:*** *Formerly Culturally-aware IO Defense (CLAID) The Computational Cultural Understanding (CCU) program is creating cross-cultural language understanding technologies to improve a DoD operator's situational awareness and interactional effectiveness. CCU natural language processing technologies will recognize, adapt to, and recommend how to operate within the emotional, social, and cultural norms that differ across societies, languages, and group affinities. To support diverse and emergent use cases, CCU technologies will be engineered to require minimal-to-no training data in a local culture, while maximizing operator success during negotiations and other interactions	-	12.000	21.100

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-13 / *INFORMATION ANALYTICS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
in the field. CCU will create new component technologies for the discovery of sociocultural norms, cross-cultural emotion recognition, and communicative change detection. The program will incorporate these component technologies into a prototype platform to assist military users with cross-cultural dialogue. ***FY 2022 Plans:*** - Initiate development of novel techniques for sociocultural analysis, including the analysis of norms, emotions, and important changes in communication, and of multimodal datasets demonstrating sociocultural norms, emotions, and shifts in these behaviors. - Initiate development of component technologies for automated dialogue assistance during cross-cultural interaction, including detection of sociocultural context, identification of the need for assistance, and dialogue remediation, for a culture-language pair. - Develop techniques to enable self-directed learning of concepts of increasing complexity, and capabilities for human-machine dialogue to simulate human-like instructional experiences. - Formulate a modeling capability for group affinities present in a local population that enables rapid detection and characterization of targeted mis/disinformation attacks and adversary influence operations. ***FY 2023 Plans:*** - Develop means to analyze interactions between sociocultural norms and emotional feedback, and extend development to a second culture-language pair. - Evaluate technologies for sociocultural analysis and cross-cultural dialogue assistance within negotiation scenarios of interest, such as discovery of local perspectives on an issue, gathering of logistical information, or requesting access to resources. - Develop means to understand indefinite or relative concepts such as distance, size, or weight, and integrate concept acquisition framework to automated systems. - Develop an initial integration testbed and evaluate cross-cultural language understanding and situational awareness technologies. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects ramping up of development and implementation of technologies for cross-cultural language understanding and situational awareness.			
Title: Resilient Supply-and-Demand Networks (RSDN) ***Description:*** Resilient Supply-and-Demand Networks (RSDN) seeks to develop supply-chain risk management analytics to detect systemic vulnerabilities and improve resilience in supply and demand networks. At present, the federation of supply-chain information into confidential silos obscures a system-wide view, inhibiting comprehensive risk-focused analysis of supply and demand networks. RSDN will develop techniques for modeling both the broad level of the supply-chain network and the detailed level of individual procurement agreements. Network analytics and visualizations will be created to reveal emerging	-	-	10.500

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
fragilities and enable deep situational awareness of systemic vulnerabilities and potential disruptions. Blind spots due to hidden interdependencies can lead to fragility in supply chains. To address this problem, a stress-testing framework will be developed that enables repeatable scenario analysis of strategic vulnerabilities in supply and demand networks, automated analysis and discovery of patterns of risk, and evaluation of alternative risk mitigation strategies. ***FY 2023 Plans:*** - Develop semantically rich representations of contractual relationships as the basis for visualizing supply and demand networks as graphs. - Develop an initial library of vulnerability analytics and visualizations to expose and understand strategic risks in supply and demand networks. - Begin development of a stress-testing framework to illuminate the propagation of shocks through a supply and demand network based on realistic scenarios. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Modeling Adversarial Activity (MAA) ***Description:*** The Modeling Adversarial Activity (MAA) program is developing technologies for generating high-confidence indications and warnings for weapons of mass terror (WMT) activities. WMT pathways consist of networks or links among individuals, groups, organizations, and other entities that act to promote or enable the development, procurement, possession, transportation, or proliferation of WMTs and related capabilities. Monitoring and controlling WMT pathways is essential to denying access to WMT technology, knowledge, materials, expertise, and weapons. MAA will create template graph models reflecting prototypical WMT pathways, develop methods for creating merged activity graphs by aligning entities across multiple intelligence modalities, develop algorithms to match large-scale empirical activity graphs with pathway models, and create synthetic data sets at scale to support development and testing of WMT activity detection techniques. MAA technology development is being coordinated with operational partners. ***FY 2022 Plans:*** - Harden graph analysis techniques and transition software capabilities to operational partners. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	10.729	6.100	-
Title: Causal Exploration of Complex Operational Environments ***Description:*** The Causal Exploration of Complex Operational Environments program is developing advanced modeling, analysis, simulation, and visualization tools to enable command staffs to rapidly and effectively design, plan, and manage missions in	13.400	5.468	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
complex operational environments. The U.S. military increasingly operates in remote and unstable parts of the world where mission success depends heavily on cooperation with a wide variety of stakeholder groups on civil, economic, and military matters. These groups typically include host nation government organizations, local civilian groups, and non-governmental organizations, each of which has priorities, sensitivities, and concerns that may differ significantly. Current mission design and planning technologies do not adequately model the range of options or the inherent uncertainties. This program is developing tools to create causal, computational models that represent the most significant relationships, dynamics, interactions, and uncertainties of the operational environment including political, military, economic, and social factors. These tools will enable command staffs to design and quantitatively assess potential courses of action in complex operational environments. ***FY 2022 Plans:*** - Harden the system and transition to operational users. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Warfighter Analytics using Smartphones for Health (WASH) ***Description:*** The Warfighter Analytics using Smartphones for Health (WASH) program is developing analytic techniques for continuous and real-time assessment of warfighter activities based on the multiple sensor data streams generated by modern smartphones. Smartphone sensors provide a rich source of information that can be used to identify a user's activities and environment and also provide a proximity detection capability. WASH will create a scalable proximity detection capability that addresses strong privacy considerations. ***FY 2022 Plans:*** - Evaluate algorithms to associate a user's activity and environment and label those activities accordingly. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	10.471	5.000	-
Accomplishments/Planned Programs Subtotals	85.350	82.889	97.502

	FY 2021	FY 2022
Congressional Add: AI Cyber Data Analytics (Data) - Congressional Add ***FY 2022 Plans:*** - Develop neurosymbolic autonomy solutions focused on reinforcement learning, planning, and transfer learning capabilities with improved performance and trustworthiness.	-	15.000
Congressional Adds Subtotals	-	15.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-13 / *INFORMATION ANALYTICS TECHNOLOGY*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL 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	-	238.215	308.024	352.976	-	352.976	339.904	342.618	341.522	357.240	-	-
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	94.338	133.326	157.652	-	157.652	165.957	166.999	177.075	176.175	-	-
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	143.877	174.698	195.324	-	195.324	173.947	175.619	164.447	181.065	-	-

A. Mission Description and Budget Item Justification

The Materials and Biological Technology Program Element is budgeted in the Applied Research Budget Activity because its objective is to develop materials and biological technologies that make possible a wide range of new military capabilities. This Program Element also supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA funded technologies take root in the U.S. and provide new capabilities for national defense.

The major goal of the Materials Processing Technology project is to develop novel materials, fabrication and processing techniques, models, devices and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of technology areas including manufacturing, electronics, sensors, optics, and complex and autonomous systems.

The Biologically Based Materials and Devices project will leverage the growing application space of the biological sciences for the development of new DoD capabilities in materials development, threat detection, and warfighter performance. Contained in this project are thrusts that apply biology's unique synthesis capabilities to source DoD-relevant materials and overcome current limitations in accessing, scaling, and distributing critical microbes and resources to achieve overmatch. Programs in this project enable in situ and stand-off detection and mitigation of biological, chemical, traditional, and emerging threats against the warfighter, the food supply, DoD infrastructure, and other targets. This Project also includes efforts to develop novel biological technologies for maintaining the performance of warfighters and warfighting platforms in increasingly challenging environments. This Project supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA-funded technologies take root in the U.S. and provide new capabilities for national defense.

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	245.107	317.024	0.000	-	0.000
Current President's Budget	238.215	308.024	352.976	-	352.976
Total Adjustments	-6.892	-9.000	352.976	-	352.976
• Congressional General Reductions	0.000	-9.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	1.000	0.000			
• SBIR/STTR Transfer	-7.892	0.000			
• Adjustments to Budget Year	-	-	352.976	-	352.976

Change Summary Explanation

FY 2021: Decrease reflects SBIR/STTR transfer offset by reprogrammings.

FY 2022: Decrease reflects a reduction for Unjustified Increase.

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

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	Project (Number/Name) MBT-01 / *MATERIALS PROCESSING 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
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	94.338	133.326	157.652	-	157.652	165.957	166.999	177.075	176.175	-	-

A. Mission Description and Budget Item Justification

The major goal of the Materials Processing Technology project is to develop novel materials, fabrication and processing techniques, models, devices and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of technology areas including manufacturing, electronics, sensors, optics, and complex and autonomous systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Materials for Extreme Environments	36.140	55.094	57.144

Description: The Materials for Extreme Environments thrust is exploring new materials, innovative architectures, and development processes that will significantly enhance the performance and persistence of DoD platforms operating in extremely harsh environments. Materials with superior strength, functionality, and resiliency are critical for enabling DoD platforms, weapons and other components to operate and persist under conditions including, but not limited to, extremely high or low temperatures, turbulence, ionizing radiation, and/or corrosive environments. Recent developments in materials such as high entropy alloys and infiltrated carbon fiber composites hold promise for achieving material solutions for improved survivability in a wide range of harsh environment conditions. Similarly, advancements in material design, processing and manufacturing are enabling novel material architectures that can further enhance performance and resilience in structures such as leading edges, windows and apertures, propulsion systems, and space structures. Exemplar areas of research within the Materials for Extreme Environments thrust include the following: 1) high temperature materials for hypersonic platforms; 2) high temperature window and aperture materials; 3) radiation and/or electromagnetic pulse (EMP) hardened electronics for space platforms; and 4) coatings for platform survivability in corrosive environments.

FY 2022 Plans:

- Validate component level models for scaled cooled leading edge structures under high aerothermal conditions.
- Manufacture scaled architected leading edge structures with integrated cooling and demonstrate under flight relevant transient and sustained aerothermal conditions; high gravity maneuvers; and mechanical loading.
- Commission novel laboratory-scale electron transpiration cooling measurement tool.
- Develop new test capabilities for testing infrared and radio frequency performance under high temperature oxidative conditions.
- Model novel sensing capabilities suitable for hypersonic platforms under high temperature conditions.
- Identify new designs and stabilization techniques for ultra-low mass density structures suitable for on-orbit applications such as solar arrays, antennas and optical surfaces.
- Identify new on-orbit capabilities and missions enabled by larger stable structures.

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Perform laboratory demonstration of critical materials manufacturing steps to enable ultra-low mass density structures. - Develop system-level models that couple vehicle geometry, materials response and vehicle trajectory to project performance enhancements. ***FY 2023 Plans:*** - Conduct integration studies for scaled cooled leading edge components to facilitate technology transition. - Validate manufacturing models for scaled architected leading edge structures with integrated cooling suitable for high heat flux conditions. - Demonstrate enhanced heat flux performance from increased scale leading edge components under oxidative conditions. - Demonstrate initial proof of concept of novel sensing capabilities suitable for hypersonic platforms under high temperature conditions with selected materials. - Develop and validate manufacturing models for scaled infrared and radio frequency materials suitable for high heat flux oxidative conditions to support transition. - Develop and validate new test capabilities for testing infrared and radio frequency performance under high temperature oxidative conditions. - Develop system-level models that project improved seeking capability. - Develop and populate government use software repository and materials database to exercise system-level models to predict system performance. - Determine achievable properties of materials manufactured using processing methods applicable to lunar surface processes. - Validate material build rate for manufacturing processes based on lunar sourced materials. - Demonstrate exemplar components for solar array structures using lunar surface derived materials. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase is due to minor program repricing.			
Title: Functional Materials and Devices	20.500	44.204	66.415
Description: The Functional Materials and Devices thrust is developing advanced materials, components and systems to improve device performance for DoD sensing, imaging and communication applications. One focus of this thrust involves development of advanced transductional materials that convert one form of energy to another for DoD-relevant applications in areas such as thermoelectrics. While promising transduction materials are known for a variety of applications, integration into devices has not been realized. Another focus area is the development of physics-based models that predict material behavior when illuminated by high peak power electromagnetic interference. A third focus area involves development of new multi-functional materials and device designs that will radically decrease the size, weight and power requirements of electron, neutron, and gamma sources for high-resolution neutron, gamma and x-ray imaging. Such devices should enable fieldable detection units for non-destructive evaluation of parts, detection of explosives and other DoD-relevant targets.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: - Complete initial prototype for compact gamma ray sources that feature high intensity, tunability, and narrow bandwidth. - Conduct initial demonstrations of prototypes for compact gamma ray sources that are capable of meeting base phase performance goals for intensity and bandwidth. - Design novel techniques to extract three-dimensional information from infrared data. - Perform spectral analysis of passive thermal emissions to mathematically determine object structures. - Perform co-optimization of planar optics and materials for transduction to identify paths towards low torque night vision systems with a wide field-of-view. - Initiate research studies exploring passive and active obscurant particulates that provide asymmetric visibility. - Complete the defining of system requirements for a compact ruggedized linear accelerator.			
FY 2023 Plans: - Use optimized designs of planar optics and planar image intensifiers to develop a prototype device. - Complete testing of compact, ruggedized, electron accelerator components and validate performance consistent with overall system goals. - Finalize system design for a compact and ruggedized electron accelerator system based on demonstrated components. - Finalize components and begin system integration of a compact, high-intensity, narrow-bandwidth, and tunable gamma ray source prototype. - Finalize system demonstration that illustrates the unique capabilities of a compact, high-intensity, narrow-bandwidth, and tunable gamma ray source. - Define system requirements for compact and directional particle sources. - Create adaptive algorithms to predict parameters of sensors for high-speed driving. - Demonstrate stationary three-dimensional vision and mobile three-dimensional vision techniques for driving at speeds up to 25 mph. - Design architecture for beyond state of the art non-volatile memory density, speed, and efficiency using topological magnetic bits. - Establish concept of operations for compute in memory using topological magnetic bits. - Simulate asymmetric capabilities of novel obscurants with optical sensors and demonstrate potential to enable asymmetry on the battlefield. - Develop new methods for on-demand manipulation of obscurants, potentially creating an actively tunable asymmetric advantage.			
FY 2022 to FY 2023 Increase/Decrease Statement:			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase is due to the transition from integrated system design to demonstration.			
Title: Chemical Processing for Force Protection	17.000	17.028	17.093
Description: Research in the Chemical Processing for Force Protection thrust is focused on the development of new chemical approaches and technologies across a broad spectrum of DoD needs. One area involves development of innovative approaches for scalable small molecule synthesis coupled with predictive tools for route design, possibly offering a new strategy to discover how to make new molecules such as pharmaceuticals and explosives. Another focus leverages advances in automation to develop safe, reproducible experimental approaches for systematic development of energetic materials. In addition, investments in this thrust will advance chemical characterization, information management and analysis, and automation. ***FY 2022 Plans:*** - Demonstrate semi-automated, reproducible experimental systems that integrate more than three explosive ingredients at scales over 10 grams per formulation with on-board sensitivity tests. - Extend semi-automated experimental systems to handle materials for propellant development, with automated integration of more than six propellant ingredients at scales over 25 grams per formulation. - Demonstrate accurate and safe determination of explosive and propellant metrics using gram-scale quantities. ***FY 2023 Plans:*** - Initiate plans for integrating the semi-automated energetics formulation platform with onboard advanced metrology to enable small-scale tests. - Assess current energetics performance requirements with respect to formulation platform capabilities to determine initial energetics discovery and system validation targets. - Initiate propellant and explosive demonstrations on an integrated, semi-automated formulation platform. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase is due to minor program repricing.			
Title: Reconfigurable Systems	3.000	8.000	17.000
Description: In the Reconfigurable Systems thrust, new approaches are being developed to enable more rapid and robust adaptation of defense systems and systems-of-systems to changing mission requirements and unpredictable environments. This includes development of capabilities across sensing, perception, planning and control for autonomous, high-speed operation in cluttered environments without Global Positioning System (GPS) information. This also includes development of capabilities to manipulate and control adversary sensory perception and/or situational awareness. Additional work in this thrust focuses on how sensing systems and military systems-of-systems are designed for real-time resilient response to dynamic, unexpected signals and contingencies. Research is developing a more unified view of system behavior that allows better understanding and			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
exploitation of complex interactions among components, including development of formal mathematical approaches to complex adaptive system composition and design. These capabilities will impact autonomous systems and systems-of-systems, including those that involve humans, in a variety of DoD-relevant contexts. ***FY 2022 Plans:*** - Initiate development of high-performance portable optical clock with picosecond timing precision. - Initiate design for a transportable optical clock with month-long nanosecond holdover. ***FY 2023 Plans:*** - Identify fundamental limits and associated disruptive breakthrough opportunities for electrically small transmitting and receiving antennas, and their associated non-traditional sub-circuits. - Continue development of high-performance portable optical clock with picosecond timing precision. - Continue development of transportable optical clock with month-long nanosecond holdover. - Begin engineering design of low size, weight, and power portable and transportable clocks. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase is due to the transition from initial component demonstration to integrated system demonstration.			
Title: Multi-Scale Modeling ***Description:*** The Multi-Scale Modeling thrust is developing advanced, multi-physics models that can predict the effect of disturbances and/or perturbations in the space environment in order to inform operational decisions based on current space environment conditions. Current space environment models are limited to predicting long term climatic averages or regularly occurring phenomena and do not fully account for coupling effects where perturbations in one region of the space environment may produce disturbances in another region. Approaches for addressing these limitations under the Multi-Scale Modeling thrust include the following: (1) development of observation driven/first-principles theory of magnetosphere-ionosphere-thermosphere coupling; (2) creation of an extensible assimilation framework for unifying space environment monitoring systems and data; and (3) non-traditional space environment measurement approaches. These developments will ensure the accuracy and spatiotemporal resolution of space weather models and is sufficient to enable prediction of operationally relevant perturbations and disturbances in the space environment. ***FY 2022 Plans:*** - Demonstrate and field test an integrated space environment forecasting capability to predict perturbation and disturbances within scale lengths as small as one hundred kilometers, every hour, within a seventy-two-hour window, and over an area representative of an operation area of responsibility. ***FY 2022 to FY 2023 Increase/Decrease Statement:***	13.198	9.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 decrease is due to program completion.			
Title: Accelerating Discovery and Innovation ***Description:*** The Accelerating Discovery and Innovation thrust developed new approaches, tools and technologies to speed the pace of scientific discoveries and technological innovations from idea generation and fundamental research through integration of technologies into fieldable products and systems in production. The path from idea generation to a discovery is a lengthy, complex process involving many unpredictable steps, cycles and stages across fundamental and applied research and development. Research in this thrust focused on developing and implementing strategies to address many of the challenges and bottlenecks inherent along this path and to speed the rate at which an idea can be advanced into a concrete capability. Specific approaches included advanced multiplayer gaming technologies to catalyze development of new technology concepts, development of tools for data collection and visualization to accelerate fundamental and applied research, and strategies to understand how seemingly benign commercially available technologies may be converted or combined into threats to military operations, equipment or personnel.	4.500	-	-
Accomplishments/Planned Programs Subtotals	94.338	133.326	157.652

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	Project (Number/Name) MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*	

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
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	143.877	174.698	195.324	-	195.324	173.947	175.619	164.447	181.065	-	-

A. Mission Description and Budget Item Justification

The Biologically Based Materials and Devices project will leverage the growing application space of the biological sciences for the development of new DoD capabilities in materials development, threat detection, and warfighter performance. Contained in this project are thrusts that apply biology's unique synthesis capabilities to source DoD-relevant materials and overcome current limitations in accessing, scaling, and distributing critical microbes and resources to achieve overmatch. Programs in this project enable in situ and stand-off detection and mitigation of biological, chemical, traditional, and emerging threats against the warfighter, the food supply, DoD infrastructure, and other targets. This Project also includes efforts to develop novel biological technologies for maintaining the performance of warfighters and warfighting platforms in increasingly challenging environments. This Project supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA-funded technologies take root in the U.S. and provide new capabilities for national defense.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Persistent Terrestrial Living Sensors	15.195	17.172	15.140
Description: The Persistent Terrestrial Living Sensors program is developing engineered biological sensor platforms capable of detecting land-based threats (e.g., chemicals, radiation, explosives, biologics) and relaying unique signals to existing DoD ground, air, and space assets. Unlike conventional methods that monitor threats and are limited by sensor energy needs, these biological sensors are effectively energy independent, increasing the potential for wide distribution and environmental robustness. Resulting platforms will enable a variety of remote, persistent monitoring and reporting capabilities to address threat scenarios relevant for national security, including passively detecting neurotoxic chemicals and biological pathogens in outdoor environments. These sensors will provide a flexible suite to complement conventional sensor systems within the DoD.			
FY 2022 Plans: - Confirm plant sensor reporting phenotypes are detectable from stand-off post stimulus exposure. - Perform phenotyping of plant sensors under defined, simulated biosecurity threat scenario. - Quantify plant sensor functionality by applying trace stimuli and evaluating response for high sensor sensitivity and specificity. - Evaluate altered plant physiological properties based on understanding of molecular mechanisms. - Demonstrate protein production and analyze system for potential unexpected effects.			
FY 2023 Plans: - Optimize plant sensor to function consistently in enclosed environment simulating ecological stress conditions. - Perform technical integration of different molecular mechanisms of protein production in mature plants for optimized phenotype.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Mitigate undesired effects based on system analysis and redesign for preferred protein production outcomes. - Investigate approaches to apply plant-based genetic technologies to impart environmental resilience to unstable ecological systems. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of proof of concept testing and shift toward optimization activities to produce a final integrated plant sensor.			
Title: Preemptive Expression of Protective Alleles and Response Elements (PREPARE)	16.261	14.585	9.241
Description: The Preemptive Expression of Protective Alleles and Response Elements (PREPARE) program is creating a transient, near immediate prophylaxis and treatment to protect military personnel and civilians against public health and national security threats. Currently, protection against Chemical, Biological, Radiological, and Nuclear (CBRN) threats relies on physical barrier technology. This program includes research to develop novel transient and reversible gene modulator therapies to bolster intrinsic host defenses. Work within this program will provide novel solutions that extend beyond the DoD's capabilities to respond to re-emerging, newly emerging, or engineered threats. ***FY 2022 Plans:*** - Refine formulations to deliver programmable gene modulators to appropriate cells and tissues with high specificity and for threat-relevant periods of time. - Refine specificity to targets, duration, and magnitude of programmable gene modulator activity in vivo. - Perform capability demonstration of programmable gene modulator platform to assess protection against a chemical, biological, or radiological threat in large animal models. - Begin collecting data for a pre-Investigational New Drug (IND) package for submission to the FDA. ***FY 2023 Plans:*** - Finalize formulations to deliver programmable gene modulators to appropriate cells and tissues with high specificity for relevant threat exposure durations. - Finalize gene targets, duration, and magnitude of programmable gene modulator activity in vivo. - Perform capability demonstration of programmable gene modulator platform to assess protection against a biological or radiological threats in second large animal model. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of large-scale screening studies and an increased focus on specific pre-clinical studies.			
Title: Persistent Aquatic Living Sensors	25.082	26.541	20.004

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The Persistent Aquatic Living Sensors program is developing novel capabilities to sense and surveil submersibles (e.g., submarines, unmanned underwater vehicles) and divers in littoral waters using living organisms present in the environment. This effort focuses on characterizing marine biological behavior in response to targets of interest and developing the hardware, software, and algorithms that will translate organism behavior into DoD actionable information. By harnessing the unique capabilities of biology, including adaptation, response, and replication, work in this program will enable persistent dominance in contested waters. Results from this research will enhance security for maritime activities and provide DoD naval operations with new sensing paradigms to complement current sensor technologies used in traditionally challenging regions across the world. ***FY 2022 Plans:*** - Demonstrate improvements in approaches to evoke and characterize biological responses in marine organisms. - Test the accuracy of biological systems at various distances in multiple environments. - Refine system improvements and validate performance in the presence of noise and surface vessel traffic. - Demonstrate the ability of second-generation prototype to detect, process, characterize and alert the presence of manned or unmanned underwater vehicles in near shore or open water environments. ***FY 2023 Plans:*** - Demonstrate ability of underwater systems to achieve objectives in surrogate operational environment against real-world targets. - Complete transition of approaches to evoke and characterize biological responses in marine organisms under real-world conditions. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects initial completion of initial technology development efforts to conduct final demonstration activities.			
Title: Expanding Human Resiliency	12.862	17.773	16.890
Description: The Expanding Human Resiliency program aims to maximize warfighter resiliency by leveraging the signals of the human microbiome to improve physiology. This program will develop new technologies to control and manipulate the microbiome (e.g., to reduce attraction and feeding of disease vectors such as mosquitoes). Current state-of-the-art approaches are focused on metagenomics to inventory and categorize the microbes in a given sample. In order to have more precise and on-demand control of microbiomes, technologies will be developed to elucidate the complex interactions between the microorganisms and their host as well as the interactions between consortia of adapted and evolved microorganisms. Advances in this area will both develop novel technologies to interrogate complex microbial communities in human systems and discover ways to beneficially harness microbiomes to expand warfighter resiliency. ***FY 2022 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Test integration and stability of altered microbial strains in animal models. - Investigate methods to deliver interventions to skin to alter chemical production by the microbiome. - Down select and refine targets for chemical production by microbiomes. - Validate alterations to chemical production to reduce attraction and feeding of mosquitoes or other disease vectors within in vitro model communities. - Refine and validate physical and computational models of microbiomes based on empirical data. ***FY 2023 Plans:*** - Develop human skin microbiome-based formulation that reduces mosquito attraction and feeding, and test it in animal models. - Expand the number of distinct human skin microbiome-based models to enable testing of mosquito attraction and feeding, and utilize these models for animal model testing. - Conduct independent verification and validation (IV&V) testing of performance of human skin microbiome-based formulations using in vivo models. - Test ability of human skin microbiome-based formulations to reduce attraction and feeding by additional genera of insect vectors. - Evaluate that methods used to alter the skin microbiome are safe for human use. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Restoring Cognitive Capability	11.178	11.423	10.860
Description: The Restoring Cognitive Capability program is developing novel drugs to provide rapid therapy for neuropsychiatric disorders experienced by warfighters and veterans. Active duty military personnel face increased risk of acute and chronic neuropsychiatric dysfunction, limiting day-to-day function and return to duty. Current therapeutic approaches for many neuropsychiatric disorders (e.g., Post Traumatic Stress Disorder [PTSD], mood disorders, and substance abuse) rely on individual management with integrated psychiatric therapy and medication. However, most interventions approved for use in these conditions lack long-term efficacy, involve a logistical burden of treatment and/or carry a risk of serious adverse side effects. Novel drugs developed under this program will be designed to functionally interact with neuronal receptor subtypes known to play a role in these neuropsychiatric conditions, with the aim of enabling fast-acting and effective alleviation of neuropsychiatric dysfunction with single or minimal doses. Additional studies in this area seek to develop a mechanistic understanding of brain injury (UBI) resulting from blast, ultrasound, electromagnetic waves, or other directed-energy sources. ***FY 2022 Plans:*** - Evaluate in vitro signaling effects of novel drug-like molecules. - Develop and validate biosensors for assessment of drug uptake and distribution in vivo.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Test novel molecules for therapeutic actions and side effects in vivo. - Document the initial biological events that take place after brain injury. ***FY 2023 Plans:*** - Evaluate novel drugs that exhibit specific signaling effects in vitro compared to existing drugs. - Use atomic-level structures and simulations of novel drugs bound to receptors, in combination with specific signaling effects, to optimize novel drug-like molecules for therapeutic effects. - Demonstrate therapeutic action of novel drugs with reduced side effects in vivo compared to existing therapeutic drugs. - Expand molecule library for novel drug discovery. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Food and Feedstocks on Demand	12.415	17.642	17.895
Description: The Food and Feedstocks on Demand program is developing biological technologies to support the DoD need to strengthen local resource security for the warfighter. Currently, operators in the field are burdened with transport and disposal of single-use materials. This program is using these burdensome materials as inputs and re-form the molecules for nutrition or other strategic applications. Research in this program will provide a versatile system that delivers food, water, and petroleum/oils/lubricants (POLs) so that warfighters can independently produce material support to extend mission duration and/or expand operational flexibility in resource-limited environments. ***FY 2022 Plans:*** - Breakdown plastic waste material into a biodegradable, detoxified environmentally compatible formulation. - Scale purification techniques to obtain desired products free from contaminants. - Optimize the process for product generation from increasingly complex plastic waste mixtures. - Demonstrate the capability to convert waste into usable materials in 24 hours. ***FY 2023 Plans:*** - Demonstrate breakdown techniques with realistic military waste mixtures and conditions relevant to a military operational scenario. - Deconstruct the majority of starting waste material into a biodegradable and nontoxic form. - Evaluate purification and extraction techniques conducive to novel breakdown and conversion processes for technical integration of the system. - Demonstrate scale up by converting a sufficient quantity of waste to a valuable product. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase reflects minor program repricing.			
Title: Gene Editor Enabled Diagnostics & Biosurveillance	13.550	18.923	18.931
Description: The Gene Editor Enabled Diagnostics & Biosurveillance program is developing fieldable, low-cost, programmable and reconfigurable diagnostic capabilities for rapid, specific, sensitive, and multiplexed detection of biological threats in military and public health scenarios. This program will investigate the design rules for diagnostic and biosurveillance targets to achieve broad-spectrum detection with high confidence diagnostic results. These design rules will inform advanced computational and machine learning approaches to scan genome data and algorithmically design probes and guides for optimal assay results. Additional work will develop assay architectures, reagents, and detection platforms to enable field-forward diagnostics at the point-of-care with the same sensitivity, and reliability tests conducted in hospital/central laboratories. ***FY 2022 Plans:*** - Establish computational tools to create diagnostic assays for a target biological signature. - Demonstrate assay utility for detection of targets in relevant clinical or environmental samples. - Develop prototype handheld devices for point-of-care and demonstrate detection of targets. - Develop prototype benchtop modules for highly multiplexed diagnostic assays and demonstrate detection of targets. ***FY 2023 Plans:*** - Refine computational tools to create novel diagnostic assays for a target biological signature. - Validate assay for detection of targets in relevant clinical or environmental samples. - Refine prototype handheld devices for point-of-care and detection of multiple targets simultaneously. - Integrate prototype benchtop modules into a functional prototype device for multiplexed diagnostic assays and demonstrate detection performance of targets. - Begin to determine disease severity through integration of host biomarker detection. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.			
Title: Unburdening the Warfighter from Chemical/Biological (CB) Defense	9.040	17.198	18.058
Description: The Unburdening the Warfighter from Chemical/Biological (CB) Defense program aims to increase warfighter survivability by developing improved personal protective equipment (PPE) and medical countermeasure (MCM) technologies to protect against CB threats. Current methods of CB protection require significant logistical burdens, including suits that are bulky and hot, which limit operational effectiveness. These burdens increase if an increased level of protection is required. The Unburdening the Warfighter from CB Defense program will investigate and design novel biological and material approaches that provide rapid protection against multiple CB agents for the warfighter. This research will innovate PPE through the discovery of			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
compounds and lightweight, durable systems designed to capture, neutralize, or repel CB agents. This novel approach will provide almost immediate and lasting protection even in austere operational settings. ***FY 2022 Plans:*** - Develop formulations and delivery methods required to provide the warfighter with biological systems capable of mitigating threats. - Begin testing the ability of the system components to protect against exposure to CB threats using special coatings, enzymes and biological approaches. - Validate system component safety in a simulated environment. ***FY 2023 Plans:*** - Test the ability of system components to protect from CB exposure by using clinically relevant experimental models. - Test the ability to rapidly reconfigure platform technologies in response to a novel threat, and protect clinically relevant models exposed to the novel CB threat using they system component of special coatings, enzymes and biological approaches. - Initiate demonstrations of material system components for weather and wear resistance and near-zero thermal burden. - Continue safety studies to ensure host compatibility for technologies, formulations, and delivery methods commensurate with FDA requirements. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.			
Title: Atmospheric Water Extraction (AWE)	9.500	13.887	13.952
Description: The Atmospheric Water Extraction (AWE) program aims to enable water harvesting directly from the atmosphere by leveraging new materials and advanced engineering and manufacturing techniques to alleviate the logistical and tactical burden of the water supply chain. Currently, the DoD relies on purification of existing water sources and/or distribution of bottled or treated water to provide the warfighter with sufficient daily hydration. State-of-the-art water-from-air generation systems are not suitable for military applications because the systems do not operate in a range of atmospheric conditions needed by our soldiers, from arid conditions (<40% relative humidity) to extremely humid, and are too energy-intensive (<7 gallons of water output per gallon of fuel). This program will deliver systems with extraordinarily low size, weight, and power (SWaP) characteristics to provide potable water to individual warfighters, and expeditionary units. Technologies developed under this program will provide strategic and tactical advantages aligned with the DoD's vision of future combat operations carried out by distributed and self-sustaining forces. ***FY 2022 Plans:*** - Optimize and refine water capture and release with developed sorbent materials. - Integrate sorbent materials with components of modeled water extraction device.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Test and evaluate fabricated components of modeled water extraction device. - Demonstrate initial prototype water extraction device under program test conditions. ***FY 2023 Plans:*** - Optimize sorbent material integration with water extraction device components. - Optimize and refine sorbent material candidates for final water extraction device prototype. - Begin production of final sorbent materials at scale. - Begin optimization of components and integrated system for final water extraction device prototype. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.			
Title: Bio-Inspired Coastal Defense	-	10.990	12.002
Description: Building upon technologies discovered in the Persistent Aquatic Living Sensors (PALS) program, the Bio-Inspired Coastal Defense program will develop self-sustaining, hybrid man-made and biological reef structures to fortify and defend DoD bases in low-lying coastal regions. Military assets in these coastal regions are vulnerable to storm surges, wave action, and sea-level rise that cause erosion, degrade infrastructure, and impede operations. Innovative coastal defense will require major technological advances in (1) design, construction, and placement of manufactured reef primers, (2) accelerated recruitment and/or growth of reef species, and (3) sustained, zero-cost natural maintenance and improvement (e.g., increased durability after challenge) of the defensive reef. The primary benefit of such structures is to attenuate wave height during storm events for both established and under construction coastal facilities. ***FY 2022 Plans:*** - Model and design scaled structural components to achieve target wave energy attenuation in wave tank simulations. - Initiate tests to determine the efficacy of reef-building approaches under laboratory conditions. - Begin experiments to promote improved temperature tolerance for reef-building organisms. - Investigate novel approaches to combat DoD infrastructure degradation. ***FY 2023 Plans:*** - Characterize ecosystem organisms for reef-building systems in laboratory conditions. - Fabricate structures and perform wave tank and flume testing to retire reef platform structural development risk. - Perform temperature tolerance, growth and disease resistance tests in the laboratory. - Initiate field tests. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase reflects minor program repricing.			
Title: Environmental Microbes as a Bioengineering Resource (EMBER) ***Description:*** The Environmental Microbes as a Bioengineering Resource (EMBER) program aims to develop novel, bio-based technologies to overcome key challenges facing domestic supply of Rare Earth Elements (REEs) critical to the U.S. and Department of Defense (DoD). This program will leverage the diversity, specificity, and customizability of environmental microbiology to enable new domestic biomining methods for the separation, purification, and conversion of REEs into manufacturing-ready forms. Advances in this area will deliver capabilities to assure access to DoD-critical materials domestically or in operational settings. ***FY 2022 Plans:*** - Identify novel organisms, gene pathways, and microbial chemistries required for separation and purification of REEs. - Begin development of synthetic biology tools to engineer organisms (or biomolecules), or adapt current chassis, to extract REEs. - Initiate studies of microbes that operate in high temperature, acidic, and alkaline conditions. - Initiate studies on the microbial extraction of specific REEs from simulated source materials at relevant concentrations. ***FY 2023 Plans:*** - Develop and test genetically engineered microbes that can tolerate above-normal levels of REE concentrations, acidic or basic conditions and/or temperatures. - Develop and test biological components capable of specifically binding individual REEs from simulated REE source materials. - Demonstrate the ability to biologically alter the chemical form of one of more individual REEs into a form suitable for manufacturing. - Develop an assay to detect REEs associated with cells or biomolecules with high sensitivity. - Compile data for a conceptual techno-economic analysis that illustrates the potential benefits of using the proposed biomining approach. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.	-	8.564	9.200
Title: Materiel Protection through Biologics ***Description:*** Military infrastructure and systems are expected to function years beyond their original intended lifetime but are subject to degradation by environmental factors. For instance, the formation of biofilms is ubiquitous, corroding and biofouling many military systems, such as aircraft, fuel tanks, ships, medical devices, and filtration systems for water and air. These microbial communities routinely endanger warfighter health and strip years of service from critical defense assets, ultimately costing the	-	-	12.188

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
DoD billions of dollars annually. Building upon technologies investigated under the Bio-Inspired Coastal Defense program, the Materiel Protection through Biologics thrust will develop biological approaches to sustain military infrastructure and systems by developing or repurposing dynamic microbial-based biofilm communities to exhibit beneficial functions such as reducing drag or corrosion. These microbial-based interventions will protect and sustain equipment and infrastructure to reduce cost and increase the service lifetime. ***FY 2023 Plans:*** - Initiate model development to predict biofilm assembly in static conditions. - Generate testbeds that replicate specific disturbances experienced by materiel in the field and track biofilm growth. - Initiate development of a design-build-test cycle that tracks microbial community development nondestructively. - Investigate biomolecular approaches to sense and repair deficits in reinforced concrete. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Bioremediation of Battlefields ***Description:*** The Bioremediation of Battlefields effort will address the DoD need to stabilize and remediate sites impacted by prior military activities, including contaminated combat zones, defense installations, and test ranges. This will ensure the safety of service members and local communities, and minimize the environmental impact of warfare by developing biological tools that remediate soil and groundwater contamination. This program will eliminate contaminants, and thus restore habitability, by identifying and optimizing organisms, such as microbes, fungi, and plants, that can detect toxic compounds, mitigate their impact, and report on the state of remediation. To accomplish these goals, research will be accelerated by leveraging the complex processes of biological organisms and communities. Bioremediation of Battlefields will reduce the long-term impacts of military activities and improve the overall environmental health and land use potential for contaminated sites. ***FY 2023 Plans:*** - Begin collection and characterization of microbial communities in contaminated environmental samples. - Begin high-speed screening of contaminated environmental samples for organisms that can extract, sequester, or degrade contaminants resulting from military activities. - Initiate model development to understand the spatiotemporal trajectory of a biological community or consortia in the presence of contaminants. - Begin analysis of mechanisms that enable biological indications of contaminant presence or organism activity. ***FY 2022 to FY 2023 Increase/Decrease Statement:***	-	-	9.150

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase reflects program initiation.			
Title: Biotechnology for Challenging Environments	-	-	11.813
Description: The Biotechnology for Challenging Environments program will develop novel biological solutions to enable warfighter operations in remote and extreme environmental conditions. As the DoD expands operations into previously inaccessible domains, new and unique logistical constraints imposed by extreme conditions and resource scarcity threaten force readiness. This program will develop technologies to enable new capabilities that harness microbes, biopolymers, and/or other bioprocesses to protect warfighters and maintain performance of warfighting platforms, such as electronics and infrastructure, from challenging environments. Technology advances developed in this effort will enable extended mission duration, resilient warfighting platforms, and enhanced operational capabilities for emerging domains. ***FY 2023 Plans:*** - Initiate identification and characterization of novel extremophiles and bio-inspired materials that correspond to adaptations to extreme environments. - Initiate design and engineer of microbes and other biological or bio-inspired components to produce novel materials for capabilities in extreme environments. - Initiate performance characterization of biological strains for specific endogenous functions outside of traditional laboratory settings. - Develop approaches for biologically driven low-power/self-powered remote electronics that can assess damage for self-repair in harsh environments. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Genome Protection Technologies	10.296	-	-
Description: The Genome Protection Technologies program developed a biodefense capability to control, counter, and reverse the effects of accidental or malicious misuse of gene editing technologies. This research investigated new approaches for tunable controls to enable the safe and predictable use of synthetic genes and pathways. Additional work developed measures to prevent or limit unintended genome editing or engineering and developed new tools to recall or reverse engineered changes. Advances within this program ensure that the U.S. remains at the vanguard of this widespread, advancing field that poses potential national security threats due to the large-scale democratization of gene editing technologies.			
Title: Defend Against Crop System Attack	8.498	-	-
Description: The Defend Against Crop System Attack program developed a platform technology aimed at increasing the speed of DoD response to state or non-state actor release of biological threats directed at our crop systems. Conventional methods			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
to defend against these threats are generally slow and ineffective. This program leveraged recent advances in molecular and synthetic biology to enable rapid delivery of gene therapies to plants for large-scale trait modification, improving resilience against adversary attack or emerging natural threats. Research within this program demonstrated an agnostic, scalable capability for protecting entire crop systems from emerging threats posed to food security by U.S. adversaries.			
Accomplishments/Planned Programs Subtotals	143.877	174.698	195.324

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS 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	-	307.791	393.384	557.745	-	557.745	571.062	565.566	587.146	586.896	-	-
ELT-01: *ELECTRONIC TECHNOLOGY*	-	113.633	160.891	136.744	-	136.744	143.985	142.356	139.622	146.872	-	-
ELT-02: *BEYOND SCALING TECHNOLOGY*	-	194.158	232.493	421.001	-	421.001	427.077	423.210	447.524	440.024	-	-

A. Mission Description and Budget Item Justification

The Electronics Technology Program Element is budgeted in the Applied Research Budget Activity because its objective is to develop electronics that make a wide range of military applications possible. The Electronics Technology Project focuses on turning basic advancements into the underpinning technologies required to address critical national security issues and to enable an information-driven warfighter. This Program Element also supports innovation and robust transition planning in the technology cycle by working with entrepreneurs to increase the likelihood that DARPA funded technologies take root in the U.S. and provide new capabilities for national defense.

Advances in microelectronic device technologies continue to significantly benefit improved weapons effectiveness, intelligence capabilities, and information superiority. The Electronic Technology project supports continued advancement in microelectronics, including electronic and optoelectronic devices, Microelectromechanical Systems (MEMS), semiconductor device design and fabrication, and new materials and material structures. Areas of particular emphasis of this work include reducing the barriers to designing and fabricating custom electronics and exploiting improved manufacturing techniques to provide low-cost, high-performance sensors. Programs in this project will also greatly improve the size, weight, power, and performance characteristics of electronic systems; support positioning, navigation, and timing in GPS-denied environments; and develop sensors more sensitive and robust than today's standards. This project has six major focus areas: Electronics, Photonics, Microelectromechanical Systems, Architectures, Algorithms, and other Electronic Technology research.

The Beyond Scaling Technology project recognizes that, within the next decade, the continuous pace of improvements in electronics performance will face the fundamental limits of silicon technology. This project pursues electronics performance advancements that exploit new concepts in circuit specialization by the optimization of materials, devices, architectures, and designs to achieve specific circuit function at high performance. Because electronics advancements must simultaneously make progress in performance and secure the foundation on which our digital infrastructure relies, this envisioned electronics specialization will require incorporation of security safeguards. Accordingly, programs within the Beyond Scaling project will reduce barriers to making specialized circuits in today's silicon hardware and significantly increase the ease with which DoD can design, deliver, and eventually upgrade critical, customized electronics. Programs also explore alternatives to traditional circuit architectures, for instance by exploiting vertical circuit integration to optimize electronic devices and by incorporating novel materials and new techniques for securing DoD and commercial data and hardware.

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	322.693	357.384	0.000	-	0.000
Current President's Budget	307.791	393.384	557.745	-	557.745
Total Adjustments	-14.902	36.000	557.745	-	557.745
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	36.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-4.512	0.000			
• SBIR/STTR Transfer	-10.390	0.000			
• Adjustments to Budget Year	-	-	557.745	-	557.745

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: ELT-02: *BEYOND SCALING TECHNOLOGY*		
Congressional Add: *ERI 2.0 - Congressional Add*	-	36.000
Congressional Add Subtotals for Project: ELT-02	-	36.000
Congressional Add Totals for all Projects	-	36.000

Change Summary Explanation

FY 2021: Decrease reflects reprogrammings and SBIR/STTR transfer.

FY 2022: Increase reflects a Congressional add for ERI 2.0.

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

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602716E / *ELECTRONICS TECHNOLOGY*	Project (Number/Name) ELT-01 / *ELECTRONIC 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
ELT-01: *ELECTRONIC TECHNOLOGY*	-	113.633	160.891	136.744	-	136.744	143.985	142.356	139.622	146.872	-	-

A. Mission Description and Budget Item Justification

Advances in microelectronic device technologies continue to significantly benefit improved weapons effectiveness, intelligence capabilities, and information superiority. The Electronic Technology project supports continued advancement in microelectronics, including electronic and optoelectronic devices, Microelectromechanical Systems (MEMS), semiconductor device design and fabrication, and new materials and material structures. Areas of particular emphasis of this work include reducing the barriers to designing and fabricating custom electronics and exploiting improved manufacturing techniques to provide low-cost, high-performance sensors. Programs in this project will also greatly improve the size, weight, power, and performance characteristics of electronic systems; support positioning, navigation, and timing in GPS-denied environments; and develop sensors more sensitive and robust than today's standards. This project has six major focus areas: Electronics, Photonics, Microelectromechanical Systems, Architectures, Algorithms, and other Electronic Technology research.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Focal Arrays for Curved Infrared Imagers (FOCII)	19.000	21.750	12.139

Description: The Focal Arrays for Curved Infrared Imagers (FOCII) program is developing curved focal plane arrays for broadband infrared (IR) imagers to enhance battlefield detection and discrimination while maintaining situational awareness. FOCII will leverage curving strategies for state-of-the-art focal plane arrays combined with advances in designing and manufacturing stress relief features to demonstrate hardware that simultaneously provides maximum resolution and illumination. This program will develop novel designs for IR imagers that enable minimal size, weight and cost for size-constrained applications. This will enable new applications in passive seeker technology for missiles, overhead persistent infrared imaging, 360-degree situational awareness, infrared search and track, and long-range targeting.

FY 2022 Plans:
- Measure operability of large area focal arrays curved to program specified objective radius.
- Design and fabricate readout integrated circuits for structured focal arrays.
- Measure initial effects of thermal cycling and baking.

FY 2023 Plans:
- Demonstrate large area focal array curved to final program specified objective radius.
- Complete preliminary camera design with curved structured focal array.
- Measure curved focal array performance on laboratory scale test equipment.

FY 2022 to FY 2023 Increase/Decrease Statement:

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-01 / *ELECTRONIC TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 decrease reflects the shift from design and fabrication to demonstration and testing.			
Title: Wideband Adaptive RF Protection (WARP)	19.845	20.141	17.000
Description: The Wideband Adaptive RF Protection (WARP) program is developing radio frequency (RF) front-end technology that can protect wideband digital radios against external electromagnetic threats and self-interference through tunable filtering, limiting, and/or signal cancellation. The ability to create tunable and reconfigurable band pass and band stop filters in the range of 2 gigahertz (GHz) to 8 GHz will be important for implementing transmit/receive modules in next-generation multi-function arrays. Another important area of interference mitigation is self-interference. WARP is developing the signal cancellation technology that will listen to the transmitted interfering signal and subtract it from the input of the receiver so faint signals near the noise floor can still be detected. Program research will provide feedback mechanisms that intelligently correct these problems. Whether for self-induced interference or external interference jamming, WARP is developing intelligent filtering and self-interference cancellation technologies to protect wideband DoD receivers. ***FY 2022 Plans:*** - Demonstrate a center frequency and bandwidth tuning range of band pass and band stop filters that aligns with the need to protect wideband digital receivers. - Demonstrate analog signal cancellers that mitigate transmitter self-leakage into a wideband receiver and while achieving relevant bandwidth and delay spread. - Evaluate scalability of candidate approaches for wideband adaptive filtering and signal cancellation architectures to achieve desired RF protection. ***FY 2023 Plans:*** - Demonstrate wideband adaptive filters that implement embedded interference sensing and closed-loop adaptive tuning. - Demonstrate analog signal cancellers that implement embedded leakage channel sensing and closed-loop adaptive tuning. - Prepare demonstration of the RF protection technology that is well-aligned to transition partners within the government. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the transition from initial component demonstration to component scaling.			
Title: Quantum Imaging of Vector Electromagnetic Radiation (QuIVER)	20.000	21.000	15.000
Description: The Quantum Imaging of Vector Electromagnetic Radiation (QuIVER) program is developing full-tensor magnetic field sensors and will demonstrate them in DoD-relevant applications and concept of operations. In addition to being diagnostically relevant, such sensitive magnetometers could enable future human-machine/brain-machine interfaces. The DoD and industry also use magnetometers for magnetic anomaly detection, which may allow for the discovery of mineral/oil deposits, discovery of old wellheads, or the detection of improvised explosive devices. In addition, magnetometers offer the possibility of magnetic			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-01 / *ELECTRONIC TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
navigation, which may operate in GPS-denied environments. Recent advancements have resulted in the potential to develop highly-sensitive vector magnetometers, which would enable the consequent development of sensitive full-tensor gradient sensors. Such tensors offer more degrees of freedom than their scalar or vector counterparts and potentially provide additional information about the source of the magnetic field. ***FY 2022 Plans:*** - Demonstrate sensitivity and functionality of tensor magnetometer. - Design portable tensor magnetometer system for field testing. - Initiate construction of tensor magnetometer system for field testing. ***FY 2023 Plans:*** - Validate sensitivity and functionality of tensor magnetometer. - Complete construction of tensor magnetometer system for field testing. - Field test tensor magnetometer system. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the completion of system construction and transition to testing.			
Title: Fast Event-based Neuromorphic Camera and Electronics (FENCE)	16.000	24.000	20.000
Description: The Fast Event-based Neuromorphic Camera and Electronics (FENCE) program will develop and demonstrate a low latency, low power event-based infrared (IR) camera to enable intelligent sensors for tactical DoD applications. Event-based imagers are an emerging class of sensors with major demonstrated advantages relative to traditional cameras. State-of-the-art visible event-based cameras have been shown to produce over two orders of magnitude less data in optimal conditions relative to traditional framing cameras because they transmit data only from pixels that have changed. This leads directly to two orders of magnitude lower data latency and a commensurate reduction in power consumption. Despite their inherent advantages, existing event-based cameras are not compatible with DoD applications because DoD applications regularly face conditions that are not naturally sparse, where issues such as clutter and noise would cause a large percentage of the event-based pixels to change simultaneously. When this happens, today's event-based cameras do not perform significantly better than traditional cameras. FENCE will develop an infrared event-based imager consistent with military requirements. FENCE will develop a four-megapixel asynchronous read-out integrated circuit (ROIC), co-designed with a 3D integrated processor that will intelligently remove noise and clutter to maintain low power and latency operation even when faced with all of the pixels firing simultaneously. If successful, this new class of sensors enabled by FENCE will be capable of responding to fast moving targets and discriminating dim targets in noisy conditions. ***FY 2022 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Conduct ROIC preliminary design review. - Simulate timing accuracy and power of the ROIC. - Conduct processor layer preliminary design review. - Perform initial analysis of relevant system parameters including power and latency. ***FY 2023 Plans:*** - Measure ROIC power and timing fidelity. - Conduct critical design review of processor layer. - Fabricate processor layer in advanced node silicon. - Measure processing layer power consumption. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the shift from ROIC design and simulations to processing layer design and fabrication.			
Title: Quantum Apertures (QA)	15.000	19.000	16.000
Description: The Quantum Apertures (QA) program will develop novel radio receiver and aperture systems using quantum sensors as the receiving elements. These receiver systems will be portable, programmable over a very large frequency range, and more sensitive than classical systems at similar size and temperature. This will be achieved by exploiting quantum-based receiving elements composed of atomic vapor cells in highly-excited "Rydberg" states that have programmable sensitivity over a large range of frequencies and amplitudes. The program will require quantum engineering and traditional electro-mechanical systems engineering to overcome technical and application challenges that impede rapid adoption of a quantum aperture receiver by the defense industrial base. The receiver system's enhanced capabilities will be leveraged in this program to develop novel waveforms while also being compatible with constraints imposed by real-world defense applications. The final receiver system will comprise a phase-sensitive array of quantum receiving elements, lasers to program the sensor and read out radio signals, and processing electronics. ***FY 2022 Plans:*** - Demonstrate quantum aperture sensor sensitivity and frequency tunability. - Complete government-owned model of quantum aperture receiver for complex signal inputs. - Complete DoD-relevant application studies that use a single-element or phased array quantum aperture receiver system. ***FY 2023 Plans:*** - Develop architecture for quantum aperture sensors in multiple-element arrays. - Demonstrate reception of novel waveforms by quantum aperture.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-01 / *ELECTRONIC TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Design system to use a single quantum aperture sensor in a DoD-relevant application. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the shift from development of multiple models and application studies to development of a specific architectures and system designs.			
Title: Waveform Agile Radio-frequency Directed Energy (WARDEN)	6.000	20.000	23.000
Description: The Waveform Agile Radio-frequency Directed Energy (WARDEN) program aims to extend the range and lethality of high-power microwave (HPM) systems by introducing flexible waveform techniques that use combinations of frequency, amplitude, and pulse-width modulations to significantly improve electromagnetic coupling into complex target enclosures and increase the probability of disruption or damage to internal electronic components and circuits. Applications for HPM systems include counter-unmanned aerial systems (C-UAS), vehicle and vessel disruption, electronic strike, and guided missile defense. Current HPM systems use oscillators to produce electromagnetic radiation. These systems are inherently narrowband and lack the frequency agility to support waveforms to maximize electromagnetic coupling and to optimally exploit electronic system vulnerabilities. Lacking the capability to use optimized waveforms, HPM oscillators have been pushed close to the physical limits of peak power generation. To develop a more efficient, lower power, waveform agile approach, the WARDEN program will develop and demonstrate the first broadband HPM amplifier; create new theory and simulation tools to predict electromagnetic coupling into complex enclosures and the effects on electronics; and develop novel agile waveform techniques capable of reducing the susceptibility threshold of targeted electronics systems to HPM attack. ***FY 2022 Plans:*** - Develop broadband amplifier designs and verify them through 3D simulation. - Develop time-domain electromagnetic coupling theory and demonstrate early concept computational models. - Develop initial electronic effects models and demonstrate agile waveforms optimized for effects on basic electronics. ***FY 2023 Plans:*** - Finalize broadband amplifier designs and initiate fabrication, procurement, and laboratory preparation. - Develop initial hybrid electromagnetic coupling tools that combine deterministic, reduced-model, and statistical approaches. - Develop predictive models and agile waveform techniques to produce disruptive effects on integrated electronics. - Validate electromagnetic coupling tools, predictive models, and agile waveform techniques through comparison with experimental measurements. - Develop high current electron gun and high power, broadband amplifier designs and verify them through 3D simulation. ***FY 2022 to FY 2023 Increase/Decrease Statement:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 increase reflects the transition from initial development to initiation of fabrication.			
Title: Generating RF with Photonics for low Noise (GRYPHON)	-	17.000	21.000
Description: The Generating RF with Photonics for low Noise (GRYPHON) program will develop compact sources of microwaves and millimeter waves with extremely low phase noise. Compact signal sources used today, such as crystal oscillators, are too noisy to support advanced military radar and communications functions. Conversely, best-in-class oscillators which use optical techniques to synthesize extremely pure microwaves are too large and expensive to deploy on the airborne systems, munitions, and other size-constrained platforms where the DoD requires high-performance capabilities. The GRYPHON program will draw on recent advances in miniature optical components to replicate best-in-class optical frequency synthesis techniques in microchip form factors. ***FY 2022 Plans:*** - Develop optical synthesis theoretical models. - Design and fabricate chip-scale optical components. - Perform initial demonstration of chip-scale component functionality. ***FY 2023 Plans:*** - Perform benchtop-level integration of components. - Setup characterization equipment and frequency references for phase noise measurements. - Demonstrate microwave generation at a fixed frequency. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects the shift from the initial chip-scale demonstration to integration of components testing and characterization.			
Title: Compact High Intensity Radiating Photonics (CHIRP)	-	12.000	12.605
Description: The Compact High Intensity Radiating Photonics (CHIRP) program will develop compact, ultra-fast, high-power lasers. Current high-power lasers are capable of providing the high optical intensities required to achieve directed energy effects, but the size of these lasers limits their ability to be used on or against highly mobile platforms. CHIRP will decrease the size, weight and power (SWaP) of ultra-fast laser sources by employing emerging integrated photonics and amplification techniques. Additionally, CHIRP will develop high-performance components and package these elements employing innovative thermal management strategies. ***FY 2022 Plans:*** - Analyze designs for high peak-power laser systems with reduced SWaP.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Initiate development of high efficiency ultra-fast laser components. ***FY 2023 Plans:*** - Begin development of materials for high performance at high optical intensities. - Perform initial thermal management analysis for compact, high peak-power laser systems. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.			
Title: Atomic Magnetometry for Biological Imaging In Earth's Native Terrain (AMBIIENT) ***Description:*** The Atomic Magnetometry for Biological Imaging In Earth's Native Terrain (AMBIIENT) program is developing novel magnetic sensors capable of providing high-sensitivity signal measurements in the presence of ambient magnetic fields. The AMBIIENT program will exploit novel physical architectures that are resistant to the impact of common noise sources. The AMBIIENT sensor itself must be able to detect the gradient of a local magnetic field while subtracting the much larger ambient signal. This capability would enable low-cost, portable, high-sensitivity measurements for in-the-field applications. In addition to medical research and clinical diagnosis, AMBIIENT sensors promise to enable diverse sensing applications including magnetic gradient navigation, anomaly detection, perimeter monitoring, and ultra-low frequency communications. ***FY 2022 Plans:*** - Demonstrate medical effectiveness of the AMBIIENT array using simulated neural signals. - Test AMBIIENT sensor sensitivity and dynamic range in government owned and operated facility. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	4.788	6.000	-
Title: Modular Optical Aperture Building Blocks (MOABB) ***Description:*** The Modular Optical Aperture Building Blocks (MOABB) program greatly improved the cost, size, weight, and performance of free-space optical systems. Specifically, MOABB constructed millimeter-scale optical building blocks that can be coherently arrayed to form larger, higher power devices. MOABB developed scalable optical phased arrays that can steer light waves without the use of mechanical components. These advances allow for a 100-fold reduction in size and weight and a 1,000-fold increase in the steering rate of optical systems.	4.000	-	-
Title: Dynamic Range-enhanced Electronics and Materials (DREaM) ***Description:*** The Dynamic Range-enhanced Electronics and Materials (DREaM) program developed intrinsically linear (ideal) radio frequency (RF) transistors with improved power efficiency and extremely high dynamic range. Linearity, power efficiency, and dynamic range are fundamental characteristics that allow RF systems to reliably transmit clear signals. Improving these	9.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
characteristics is essential to operating in a crowded electromagnetic spectrum environment and to enabling next-generation communication, sensing, and electronic warfare systems. Traditional RF transistor designs typically require a trade-off between linearity and output power, and poor linearity results in undesired interference. DREAM overcame this tradeoff by employing new transistor materials, architectures, and designs. The resulting DREAM-enabled technologies will allow future RF electronics to increase their operating range while consuming less system power, without adding interference to the already-congested electromagnetic spectrum.			
Accomplishments/Planned Programs Subtotals	113.633	160.891	136.744

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
ELT-02: *BEYOND SCALING TECHNOLOGY*	-	194.158	232.493	421.001	-	421.001	427.077	423.210	447.524	440.024	-	-

A. Mission Description and Budget Item Justification

The Beyond Scaling Technology project recognizes that, within the next decade, the continuous pace of improvements in electronics performance will face the fundamental limits of silicon technology. This project pursues electronics performance advancements that exploit new concepts in circuit specialization and three-dimensional heterogeneous integration (3DHI) by the optimization of materials, devices, architectures, and designs to achieve specific circuit function at high performance. Because electronics advancements must simultaneously make progress in performance and secure the foundation on which our -microelectronics infrastructure relies, this envisioned specialization will require incorporation of security safeguards and advancing manufacturing tools and process automation. Accordingly, programs within the Beyond Scaling project will reduce barriers to making specialized circuits in today's silicon hardware and 3DHI by improving producibility. This will significantly increase the ease with which DoD can design, deliver, and eventually upgrade critical, customized microelectronics, particularly for operation in extreme environments. Programs also explore alternatives to traditional circuit architectures, for instance by exploiting 3DHI to optimize electronic devices and by incorporating novel materials and new techniques for securing DoD and commercial data and hardware.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Digital RF Battlespace Emulator (DRBE)	24.000	23.000	22.000
Description: The Digital RF Battlespace Emulator (DRBE) program is developing a large-scale, interactive, emulated radio frequency (RF) environment, providing the DoD with the capability to cost-effectively evaluate adaptive, intelligent, and spatially distributed next-generation RF systems. DRBE is leveraging advances in massively multi-core computing hardware and high-bandwidth digital cross-connects to emulate realistic RF environments accounting for RF platform movement, signal propagation effects and delays, signal interference, and interactions between RF systems. An electronics architecture supporting the power and latency requirements demanded by these emulation environments does not currently exist. DRBE is pursuing three technical thrust areas: architecture, massively multi-core computing, and scenario modeling. The resulting test environment will allow plug-and-play connections for hundreds of RF systems in a battlespace test. Multi-system exercises will then be quickly executed through many different combat scenarios and variations. DRBE is serving to develop concept of operations (CONOPS), inform battle plans, and fine-tune the performance of both individual and large groups of RF systems.			
FY 2022 Plans: - Complete DRBE real-time High Performance Computer (HPC) design to the level of a Preliminary Design Review. - Complete DRBE system design to the level of a Critical Design Review. - Design, fabricate, and test computational accelerator chips.			
FY 2023 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Complete DRBE real-time HPC design to the level of Critical Design Review. - Validate DRBE system design following the Critical Design Review. - Demonstrate real-time RF emulation on computational accelerator chip. - Establish agreement to transition DRBE to DoD laboratory. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Low Temperature Logic Technology (LTLT) ***Description:*** The Low Temperature Logic Technology (LTLT) program will exploit the unique device and material performance characteristics of state-of-the-art silicon transistors at cryogenic temperatures. Current silicon transistors are performance and power limited when operating at room temperature or higher. This program removes these limitations through modifying the design of existing silicon transistors to optimize their performance at cryogenic temperatures. These devices will be compatible with current complementary metal-oxide-semiconductor (CMOS) fabrication process flows and will offer significant increases in performance and power efficiency over room temperature devices. Basic research for this program is funded within PE 0601101E, Project ES-02. ***FY 2022 Plans:*** - Perform initial design of transistor, memory, and interconnect technologies that are optimized for low temperature operation. - Initiate plans to modify the fabrication flow for state-of-the-art silicon technology for transistors with optimized cryogenic performance. ***FY 2023 Plans:*** - Complete design of transistor, memory, and interconnect technologies that are optimized for low temperature operation. - Develop high speed, low power switching devices and experimentally demonstrate their performance at low temperature. - Demonstrate a low power and high-performance memory unit at low temperature. - Continue improving low-temperature device characteristics to enhance performance. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects transition from design to component fabrication and testing.	-	15.000	22.000
Title: Automatic Implementation of Secure Silicon (AISS) ***Description:*** The Automatic Implementation of Secure Silicon (AISS) program is enabling a design tool and Intellectual Property (IP) ecosystem where security is pervasive and can be incorporated naturally into chip design with minimal effort and expense. The program will enable rapid evaluation of architectural alternatives in platform integration where security can be optimized relative to the conventional design economic measure of power, area, and speed. The program will advance multi-level	18.000	18.000	21.700

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
provenance and integrity validation techniques for design through improvement of current methods or invention of novel technical approaches, and will demonstrate new capabilities in the context of reduced instruction set computing (RISC) architectures or computer processors. AISS will protect advanced chips from known attack strategies by incorporating security into a highly automated system aimed at reducing design time while maximizing exploration of architectural alternatives. As a result, DoD applications will benefit from more secure chips becoming pervasive whether procured commercially or designed specifically for defense systems. ***FY 2022 Plans:*** - Demonstrate automatic generation of the on-chip Security Engine, adjustable to different cost points and defense intensities. - Demonstrate rapid power and security estimation models executed on the auto-integrated proof-of-concept (PoC) systems and accurately grade their relative attack resistivity. - Finalize design and demonstrate that the two selected PoC designs can be built semi-automatically using AISS IP. ***FY 2023 Plans:*** - Develop additional static components including balanced and noisy cryptography cores, boot and activity odometers. - Add features to support bus monitoring and uploading of security policies. - Develop a threat analysis prototype and a library of heuristics. - Demonstrate optimized generation of two selected PoC designs can be built semi-automatically using AISS IP. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects a shift from modeling and design to prototype development and testing.			
Title: Lasers for Universal Microscale Optical Systems (LUMOS)	21.000	23.000	18.000
Description: The Lasers for Universal Microscale Optical Systems (LUMOS) program is integrating high-performance light sources into silicon integrated photonics enabling compact, rugged, high-performance systems for positioning, navigation, communications, 3D imaging, and quantum technologies. Silicon photonics today enables microscale integration of complex optical systems, but the platform's lack of optical gain precludes the creation of lasers and amplifiers through foundry processes. LUMOS will deliver the missing capability to provide compact optical sources at wavelengths from the visible to the infrared, and will create a universal manufacturing platform that builds upon the current photonics ecosystem. To drive innovation and maintain DoD access to leading-edge deployable photonic solutions, LUMOS will establish a technology pathway connecting government, academic, commercial, and defense users of integrated photonics, and will provide multi-project wafer runs through an open-access foundry. ***FY 2022 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Develop heterogeneous integration technology for optical gain and nonlinear photonics components in a complementary metal-oxide semiconductor (CMOS) compatible photonics process. - Create initial process design rules and design methodologies to enable early foundry users to fabricate integrated photonics circuits leveraging novel gain mediums and nonlinear photonic components. - Demonstrate active platform components, including modulators and detectors, with high performance. ***FY 2023 Plans:*** - Optimize high-performance lasers and optical amplifiers while providing designers access through first active foundry runs. - Begin layout and characterization of advanced lasers, and testing of essential demonstration components. - Scale optical power and component bandwidth for integrated microwave-compatible platform. - Demonstrate narrow linewidth lasers at design wavelengths on integrated visible platform. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects transition from fabrication and initial demonstration to optimization and component characterization.			
Title: COmpact Front-end Filters at the ElEment-level (COFFEE) ***Description:*** The COmpact Front-end Filters at the ElEment-level (COFFEE) program will develop and demonstrate compact, high frequency radio frequency (RF) filter technology without compromising performance, specifically low insertion loss and high power handling. The new filtering technology will enable interference rejection capability, efficient spectral management, and coexistence with commercial 5G applications. It is projected that COFFEE filter technology will enhance the resilience of military microwave and mm-wave radar and communication systems for DoD spectral dominance into the future. For commercial applications, COFFEE will result in more efficient use of mm-wave frequency allocations for 5G networks. The COFFEE program was originally funded within PE 0602716E, ELT-01. ***FY 2022 Plans:*** - Design new high frequency resonator technologies that are significantly smaller than current state-of-the-art electromagnetic resonators. - Demonstrate, through modeling and simulation, the feasibility of high-performance filters using resonators developed in the program. - Initiate fabrication of high frequency resonators. ***FY 2023 Plans:*** - Verify and validate performance of new high frequency resonators in the laboratory. - Demonstrate new high frequency resonators and evaluate performance against program technical metrics.	-	12.000	17.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Integrate new high frequency resonators into new high-performance filters. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects the program moving from design to component demonstration and integration.			
Title: ELectronics for G-band ARrays (ELGAR) ***Description:*** The ELectronics for G-band ARrays (ELGAR) program, building upon technologies developed in the LUMOS program (budgeted within this PE and Project) will develop the integration technologies needed to create compact, high-performance G-band array front-end electronics to enable phased array antenna systems for DoD communications and sensing. ELGAR will address the key technical challenges that prevent III-V electronics from realizing high-performance G-band arrays, namely, 1) achieving efficient, compact G-band III-V monolithic microwave/millimeter wave integrated circuit power amplifiers (MMIC PAs) with high output power density, and 2) achieving low loss off-chip interconnects between adjacent G-band array components. In particular, ELGAR will develop III-V compatible, silicon like fabrication and integration approaches to enable compact, high power density, high efficiency G-band MMICs and arrays. The technologies developed will support transitions including enabling emerging satellite communication and sensing missions to provide enhanced situational awareness. ***FY 2022 Plans:*** - Initiate development of III-V semiconductor compatible silicon-like multilayer interconnects and integration processes. - Design and fabricate 1) compact, low loss passive component test structures, 2) compact, multi-finger III-V transistor test structures whose power and efficiency are not degraded by the silicon-like interconnects, and 3) high aspect ratio, solid filled III-V through substrate via (TSV) test structures. ***FY 2023 Plans:*** - Continue to compact and reduce the loss of the III-V semiconductor compatible silicon-like multilayer interconnects, integration processes, and test structures. - Design, fabricate, and characterize compact G-band III-V MMIC PAs that use the silicon-like multilayer interconnects. - Design, fabricate, and characterize low loss, array-level interconnects for integration of G-band PAs with other array components. - Perform design of III-V circuits and transmitters with spectrally pure output. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects the program moving from initial design to fabrication and characterization of components.	-	7.000	16.000
Title: Data Privacy for Virtual Environments (DPRIVE) ***Description:*** The Data Privacy in Virtual Environments (DPRIVE) program will enable homomorphic encryption for data privacy at the user and application level through the development of new hardware accelerators to achieve acceptable computational	10.000	16.000	15.960

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
times. The program plans to provide strong privacy protections at the tactical edge with no more than one order of magnitude penalty in computation time, and to enable very strong privacy at the enterprise level with no more than three orders of magnitude penalty over unencrypted processing. DPRIVE will build hardware to accelerate the computation of homomorphic encryption, which enables mathematical operations to execute on encrypted data such that the data is never unencrypted. The program will enable the development and deployment of these hardware accelerators to edge computing devices where power and time are a premium, as well as to enterprise computing facilities where the amount and sensitivity of the data requires increased protection. ***FY 2022 Plans:*** - Design an accelerator that is ready for fabrication. - Emulate integrated accelerator design for relevant workloads. - Verify accelerator design through appropriate testing. ***FY 2023 Plans:*** - Fabricate DPRIVE accelerator design in advanced node complementary metal oxide semiconductor (CMOS). - Execute and demonstrate mission workloads with full design simulations. - Complete full DPRIVE accelerator software integration. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY2023 decrease reflects minor program repricing.			
Title: Quantum Inspired Classical Computing (QuICC)	-	10.000	14.000
Description: The Quantum Inspired Classical Computing (QuICC) program will implement quantum-inspired algorithms using classical dynamic systems in novel computing architectures for the efficient solving of complex optimization problems. Currently, too much computational energy is required to solve mission-scale optimization problems leading to sub-optimal solutions and excessive computation times. This program will create frameworks for analyzing the computational advantage provided by quantum-inspired algorithms and perform the hardware and algorithm co-design needed to reduce the required energy to optimally solve mission-scale problems. ***FY 2022 Plans:*** - Initiate development of quantum-inspired algorithms on classical hardware for scalable optimization problems. - Perform initial hardware and algorithm co-design analysis for representative mission-scale optimization problems. ***FY 2023 Plans:*** - Initiate development of analog subsystems for quantum-inspired solvers. - Perform initial hardware performance model development. - Demonstrate co-design framework for digital resource estimation.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Develop systematic methodologies for predictive benchmarks. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects the move from initial algorithm and hardware design to subsystem development and design.			
Title: Guaranteed Architectures for Physical Security (GAPS) ***Description:*** The Guaranteed Architectures for Physical Security (GAPS) program is developing hardware security and software architectures with provable security interfaces. These interfaces will physically isolate high-risk transactions during both system design and system build, and will ensure that such protections are enforced at run-time. GAPS will reduce the inherent complexity through the development of hardware and software that is open, extendible, and compatible with size, weight, and power constrained environments to enable security across DoD and commercial systems. The program will substantially lower the barrier to safely enabling high-risk transactions, thus allowing for fast computer-to-computer transactions, physical spatial isolation reducing the need for unreliable software partitioning solutions, and more complex missions without putting sensitive data at risk. Basic research for this program is funded within PE 0601101E, Project ES-02. ***FY 2022 Plans:*** - Implement interconnect architectures and board support packages (BSPs) for a single common embedded bus while increasing the number of protocol layers. - Demonstrate a reduction in transaction overhead on embedded busses when implementing GAPS extensions for multilevel security. - Permit at least one gigabit per second sustained throughput across multiple security level architectures. - Integrate GAPS isolation techniques to a research application associated with an ongoing DoD platform. ***FY 2023 Plans:*** - Implement interconnect architectures and BSPs for a single common embedded bus while increasing to three protocol layers or more. - Demonstrate further reduction in transaction overhead on embedded busses when implementing GAPS extensions for multilevel security. - Permit multiple gigabit per second sustained throughput across multiple security level architectures.	12.000	12.000	12.000
Title: Massive Cross Correlation (MAX) ***Description:*** *Previously part of Beyond Scaling - Architectures The Massive Cross Correlation (MAX) program aims to develop a scalable wideband correlator that can simultaneously achieve the state-of-the-art dynamic range of a digital correlator with the power efficiency enabled by analog electronics. Correlators	-	4.000	12.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
are the core signal processing component used in critical DoD applications such as spread spectrum communications, passive coherent location (PCL) and synthetic aperture radar. Current correlator implementations use FPGAs and general-purpose graphics processing units (GPGPUs) requiring thousands of watts of power and racks of supporting computer equipment for today's low frequency, low bandwidth applications, which creates challenges for their use in power-constrained platforms and in applications that require high frequency, high bandwidth solutions. The MAX program will leverage advances in analog signal processing and state-of-the-art fin field-effect transistor (FinFET) semiconductor processes to overcome these challenges. ***FY 2022 Plans:*** - Perform proof-of-concept design of scalable wideband correlator that combines benefits of digital correlator with efficiency of analog electronics. ***FY 2023 Plans:*** - Implement proof-of-concept designs showing program efficiency goals at program dynamic range requirements meeting initial bandwidth metrics. - Fabricate initial designs of scalable, wideband analog correlators. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program moving from initial concept design to design completion and the start of device fabrication.			
Title: Structured Array Hardware for Automatically Realized Applications (SAHARA)*	-	3.500	7.500
Description: *Previously part of Beyond Scaling - Design The Structured Array Hardware for Automatically Realized Applications (SAHARA) program is developing technology for the secure development of custom chips for defense systems. Current DoD systems often employ field-programmable gate array (FPGAs), whose flexibility advantages are offset by lower performance. Structured application specific integrated circuits (ASICs) deliver significantly higher performance and lower power consumption, which makes them an efficient and effective alternative to FPGAs for defense electronic systems. Manually converting FPGAs to structured ASICs, however, is a complex, lengthy, and costly process. SAHARA is developing automated technologies to reduce design time, optimize performance, and minimize the power dissipated by the secure, structured ASIC. ***FY 2022 Plans:*** - Perform initial design of secure, structured ASICs. ***FY 2023 Plans:*** - Finalize design of secure, structured ASICs.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Analyze transition impact of secure, structured ASICs for DoD applications. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects the shift from initial to final design of secure, structured ASICs.			
Title: Ferroelectric Computing (FC) ***Description:*** The Ferroelectric Computing (FC) program will develop advanced, complementary metal oxide semiconductor (CMOS)-compatible ferroelectric transistor, compute-in-memory element, and memory compute array technologies for critical data-intensive DoD applications such as radar processing, signal intercept and identification, and image processing. Current compute-in-memory devices are not compatible with advanced CMOS and are too large be scaled to the performance and efficiency levels necessary to support these applications. This program will address this shortfall by developing CMOS-compatible ferroelectric transistor technology for next-generation power-efficient, dense, and scalable compute-in-memory accelerators. Basic research for this program is funded within PE 0601101E, Project ES-02. ***FY 2022 Plans:*** - Perform initial designs of novel ferroelectric transistors that are fast, dense, and energy efficient. - Initiate plans to integrate novel ferroelectric transistors into state-of-the-art silicon technology. ***FY 2023 Plans:*** - Demonstrate an initial compact compute-in-memory element using ferroelectric transistors. - Initiate strategy for connecting memory compute elements into memory compute arrays for computing in memory. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects transition from initial designs to proof-of-concept demonstration.	-	3.000	7.341
Title: Technologies for Rapid Assembly of Microsystems (TRAM) ***Description:*** The Technologies for Rapid Assembly of Microsystems (TRAM) program will develop technology to assemble heterogeneous electronics modules with high performance that can be readily inserted into DoD modules, arrays, and systems. Current low-volume assembly of heterogeneous electronics is time-intensive, expensive, and offers varying levels of performance and state-of-the-art packaging capability that is increasingly dominated by foreign industry and driven by commercial needs and volumes. Low-volume, domestic assembly of high-performance electronics is needed to preserve capability and security of DoD systems. In order to enable new electronics capabilities that can be readily transitioned into prototypes and systems, TRAM will develop technologies for desktop assembly and packaging of different electronics technologies to rapidly move them from design to systems. ***FY 2023 Plans:***	-	-	12.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-02 / *BEYOND SCALING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Analyze candidate technologies for heterogeneous desktop assembly. - Establish candidate circuits and modules with two or more electronics technologies. - Create initial process design rules and design methodologies for the heterogenous desktop assembly capability. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Reconfigurable, Actionable, Passive Technologies for Operational Remote Sensing (RAPTORS) ***Description:*** The Reconfigurable, Actionable, Passive Technologies for Operational Remote Sensing (RAPTORS) program will enable a passive, all-optical kill chain capable of finding both stationary and moving targets with a single sensor. Sensor format can be selected based on platform requirements. RAPTORS will achieve this by combining tileable focal plane arrays (FPAs) that have adaptable spatial resolution with agile filters to adapt the spectral content of the infrared radiation impinging upon the detector. Using a custom read-out integrated circuit (ROIC), the FPA will intelligently balance resolution and number of spectral filters to optimize the information content transmitted off of the chip to enable real-time actionable decisions. This system will enable search and track and improved probability of detection and identification for hard targets, e.g., camouflaged, concealed, and deceptive (CCD) targets, at tactical speeds within the constraints of the cryocooler power limit. If successful, this capability has applications across ground-, air- and space-based platforms. ***FY 2023 Plans:*** - Conduct advanced design review for custom ROIC. - Demonstrate single-pixel filters demonstrating speed and transmission. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.	-	-	9.500
Title: Robust Electronics for Radiative Environments (RE2) ***Description:*** The Robust Electronics for Radiative Environments (RE2) program will develop advanced radiation-hardened (rad-hard) and radiation-tolerant electronics, including processors and memory technologies, to meet the demands of emerging missions. Current rad-hard and rad-tolerant electronics are many generations behind state-of-the-art commercial electronics and cannot meet the needs of future systems. In order to address these needs, RE2 will work to deliver high-performance electronics for space and strategic systems while maintaining the security of these electronics throughout the supply chain. ***FY 2023 Plans:*** - Perform trade study on modifying advanced node complementary metal oxide semiconductor (CMOS) fabrication for rad-hard and rad-tolerant processors and memory.	-	-	9.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-02 / *BEYOND SCALING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Initiate design of candidate rad-hard and rad-tolerant processor and memory architectures. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Next Generation Microelectronics - Advanced Manufacturing Tools ***Description:*** Next Generation Microelectronics - Advanced Manufacturing Tools addresses the development of new manufacturing tools for the design, fabrication, packaging, assembly, testing, and digital emulation of the next generation of advanced microsystems. Specifically, these advanced microsystems include three-dimensional heterogeneous integration (3DHI) and designs targeted for use in extreme environments such as high voltage, high current, high temperature, low temperature, and radiation exposure. New tools to improve manufacturing and testing will be designed, built, and characterized. These tools will enable cost-effective on-shoring of automated processes for packaging, assembly, and testing of advanced microsystems. The software and hardware tools addressed in this program will advance integration techniques beyond current commercial capabilities to support national security needs. Design, verification, and security for 3DHI will be supported by coordinated investments that couple manufacturing and electronic design automation. Basic research related to this effort is funded within PE 0601101E, Project ES-02. ***FY 2023 Plans:*** - Establish tools for design, simulation, testing, and cost-optimization of 3DHI components and packages. - Develop specialized tools for design, simulation, and testing of thermally and radiation hardened components and microsystems. - Initiate developing multi-domain models for virtual prototyping of 3DHI components and packages. - Create methodologies for design optimization for multi-chip, multi-technology packaging and assembly techniques consistent with high density interconnects. - Identify advancements required to automate packaging tools and metrology for volume 3DHI manufacturing. - Increase fidelity and accuracy of techniques for digital twin emulation to decrease prototyping cycle-time that includes system analysis. - Determine an equivalent to a front opening unified pod to facilitate automating die and chiplet handling during the assembly and packaging process. - Demonstrate first version of tools for power and thermal management of high-voltage and high-current microsystems. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.	-	-	90.000
Title: Next Generation Microelectronics - Advanced Manufacturing Approaches for three-dimensional heterogeneous integration (3DHI)	-	-	60.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-02 / *BEYOND SCALING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: Next Generation Microelectronics - Advanced Manufacturing Approaches for three-dimensional heterogeneous integration (3DHI) addresses the unique manufacturing requirements for 3DHI microsystems, including design, fabrication, packaging, assembly, testing, and digital emulation. These new manufacturing methods will feature increasing circuit-scale interconnect densities for integration, and enhancing the security and interoperability of these complex designs. New multi-chip, multi-technology assembly and packaging will advance beyond silicon-centric integration to include integration of radio frequency (RF), photonics, novel memory, and compound semiconductors. In order to enable this diversity of materials and functions, integration technologies will be enabled by improving thermal management, improving inter-chip power delivery, and improving the modeling and simulation of these new systems on chip. Basic research related to this effort is funded within PE 0601101E, Project ES-02. ***FY 2023 Plans:*** - Initiate developing multi-chip, multi-technology assembly and packaging techniques consistent with high density interconnects (less than or equal to one-micron pitch). - Identify techniques to improve co-planarity for die-to-die, wafer-to-wafer, and die-to-wafer high density interconnects. - Launch development of integration techniques consistent with high-volume automation and inspection. - Expand automated integration techniques to enable low-volume manufacturing. - Implement manufacturing, assembly, and packaging techniques for high-density integration of photonics and electronics. - Increase integration density of silicon digital microelectronic components with compound semiconductor RF microelectronic components through maturation of manufacturing, assembly, and packaging techniques. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Next Generation Microelectronics - Advanced Manufacturing for Extreme Environment Electronics	-	-	30.000
Description: Next Generation Microelectronics - Advanced Manufacturing for Extreme Environment Electronics addresses the design, fabrication, packaging, assembly, testing, and digital emulation of the next generation of microsystems targeted for use in extreme environments: high voltage, high current, high temperature, low temperature, and radiation exposure. New manufacturing methods along with new testing and evaluation methods will be created, with an emphasis on developing techniques to enable in-situ measurements of these microsystems while operating in the extreme environments. These new manufacturing methods will also focus on a higher degree of automation in the packaging, assembly, and testing processes. This effort will also develop techniques to significantly improve thermal management, inter-chip power delivery, package integrity, and the modeling and simulation of these unique microsystems. Basic research related to this effort is funded within PE 0601101E, Project ES-02. ***FY 2023 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-02 / *BEYOND SCALING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Initiate developing multi-chip, multi-technology assembly and packaging techniques for thermally-hardened and radiation-hardened microsystems. - Define device design and thermal management techniques for very high operating temperatures. - Initiate developing techniques for power management and thermal management of high-voltage and high-current microsystems. - Create extremely low-loss passive materials for efficient power distribution in high-voltage and high-current microsystems. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Next Generation Microelectronics Prototyping Designs ***Description:*** Next Generation Microelectronics Prototyping Designs supports the development of novel three-dimensional heterogeneous integration (3DHI) capable of being prototyped using the National Network for Next-generation Microelectronics Manufacture (N3M2). The N3M2 will include public-private partnerships that provide the ability to manufacture prototypes of next-generation 3DHI microsystems, including fabrication, packaging, assembly, and testing. The design challenges provide the opportunity to explore approaches that will improve and accelerate the adoption of 3DHI standardized chip-to-chip interfaces and package optimization. Leading-edge chip designs will be fabricated, and subsequently integrated into 3DHI designs in multi-project demonstration runs. Research related to this effort is funded within PE 0603739E, Project MT-16. ***FY 2023 Plans:*** - Identify and initiate challenge problems for 3DHI microsystems and establish appropriate metrics. - Determine goals for design challenges for standardized chip-to-chip integration practices. - Establish a fabrication run for leading edge chips to develop components for novel 3DHI prototype designs. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.	-	-	25.000
Title: Beyond Scaling - Materials ***Description:*** The Beyond Scaling - Materials program is demonstrating the integration of novel materials into next-generation logic and memory components. This program is pursuing potential enhancements in electronics that do not rely on Moore's Law, i.e. silicon transistor scaling, including research into new materials and the implications of those materials at the device, algorithm, and packaging levels. Research areas include heterogeneous integration of multiple materials, "sticky logic" and novel transistor devices that combine elements of computation and memory, and three-dimensional vertical circuit integration to demonstrate dramatic performance improvements using older silicon technologies. Further research supports innovation in the technology cycle by working with entrepreneurs focused on DoD-relevant businesses. Basic research for this program is funded within PE 0601101E, Project ES-02.	26.451	16.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: - Analyze the manufacturability of a large-scale fully integrated 3D monolithic system-on-chip, and share analysis with DoD and commercial end users. - Demonstrate broadband, low noise mixed-mode integrated circuits with enhanced transistors in a commercial foundry. - Integrate advanced transistor processing technology and models in a commercial foundry. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Beyond Scaling - Architectures ***Description:*** The Beyond Scaling - Architectures program is demonstrating a new DoD capability to create and utilize specialized hardware by enabling the writing of a common code base on top of customized hardware. The program is exploring technologies and techniques such as new domain-specific circuit architectures, co-design of electronics hardware and software, intelligent edge sensors, hardware security architectures, and tight integration of chip-scale processing blocks and artificial intelligence-enabled processing controllers. Further research will enable significant improvements in programming productivity for massively parallel heterogeneous processing systems (e.g., data centers). Basic research for this program is funded within PE 0601101E, Project ES-02. ***FY 2022 Plans:*** - Prototype reconfigurable software-defined hardware and associated software. - Demonstrate a system-on-chip executing five simultaneous applications utilizing multiple heterogeneous processing elements. - Demonstrate a prototype test bench that can detect anomalous system behavior due to hardware Trojans in complex systems. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	31.707	18.000	-
Title: Beyond Scaling - Design ***Description:*** The Beyond Scaling - Design program is developing and demonstrating the tools required for rapidly designing and deploying specialized circuits. Research efforts are exploring technologies and techniques for rapid, specialized design such as intelligent design tools, automated physical layout generation, and open-source circuit design. The goal of this program is to reduce the barrier to entry for complex system-on-chip (SoC) designs and to provide a pathway for the rapid upgrade of electronics. Advances under this program demonstrate a new DoD capability to create specialized hardware and provide electronics improvements that do not depend on continued, rapid silicon transistor scaling. Basic research for this program is funded within PE 0601101E, Project ES-02.	25.000	11.993	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-02 / *BEYOND SCALING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: - Optimize algorithms and the physical design platform to demonstrate path to improvement of power, performance, and area for performance beyond existing state-of-the-art techniques. - Further develop open source tools to enhance interoperability and integration between tools and begin integration into a unified chip development infrastructure. - Fabricate and test initial system-on-chip design using open source Intellectual Property (IP) building blocks verified for correctness with open source simulation technologies. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: System Security Integrated Through Hardware and firmware (SSITH) ***Description:*** The System Security Integrated Through Hardware and firmware (SSITH) program seeks to secure DoD and commercial electronic systems against cybersecurity threats by developing novel hardware/firmware security architectures and hardware design methodologies. Current responses to cybersecurity attacks typically consist of developing and deploying software patches to address specific vulnerabilities in a software firewall without addressing potential vulnerabilities in the underlying hardware architecture. To address this challenge, SSITH is driving new research in electronics hardware security and exploiting current research in areas such as cryptographic-based computing and hardware verification. Implementation of these advanced ideas has been enabled by the extremely capable semiconductor technology driven by Moore's Law. The program also is investigating flexible hardware architectures that adapt to and limit the impact of new cybersecurity attacks. Finally, SSITH is mitigating the potential negative impact of new security protection architectures on system performance and power usage. Once developed, SSITH capabilities will be applicable to both commercial and military electronic systems. ***FY 2022 Plans:*** - Deliver a high-performance, secure SSITH application-specific integrated circuit (ASIC) for transition and demonstration purposes. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	9.000	4.000	-
Title: Hierarchical Identify Verify Exploit (HIVE) ***Description:*** The Hierarchical Identify Verify Exploit (HIVE) program pursued new hardware architectures and algorithms for improving the efficiency of graph and sparse data analytics. When developing operationally significant intelligence, human analysts today are forced to reduce the scope of the problems that they can address and the tempo of their analyses due to the limitations of currently deployed hardware. Because of these limitations, the amount of information gathered is quickly outstripping	10.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-02 / *BEYOND SCALING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
the human ability to review, process, fuse, and interpret data. To resolve this challenge, HIVE leveraged improvements in computational efficiency to augment the analyst's ability to integrate large streams of data. The program investigated advances in chip architecture and data analytics algorithms that can allow machines to infer meaning out of data based on the information needs of the warfighter. This program enabled the warfighter to understand far more of the battlespace in real time.			
Title: Common Heterogeneous integration and IP reuse Strategies (CHIPS) ***Description:*** The Common Heterogeneous integration and IP reuse Strategies (CHIPS) program developed the design tools and integration standards required to better leverage leading-edge commercial sector technologies in DoD systems. The program designed chiplets which can be reused across applications, manufacturers, and transistor types, allowing DoD to amortize IC design costs across programs, better align electronics design and fabrication with military performance goals, and expand beyond its traditional reliance on the proprietary capabilities of a few on-shore manufacturers.	7.000	-	-
Accomplishments/Planned Programs Subtotals	194.158	196.493	421.001

	FY 2021	FY 2022
Congressional Add: ERI 2.0 - Congressional Add	-	36.000
FY 2022 Plans: - Identify tools for software/hardware logic co-design to identify three-dimensional heterogeneous integration (3DHI) security vulnerabilities. - Evaluate status of additive manufacturing for 3DHI. - Characterize current state of automation in packaging tools, metrology, and test for 3DHI to identify capabilities required for fully automated 3DHI manufacturing. - Analyze techniques for digital twin emulation of microsystems and associated methods for validation of complete digital models. - Initiate developing multi-domain models for virtual prototyping of three-dimensional heterogeneous integration (3DHI) components and packages. - Initiate developing co-design techniques for optimizing a thermal floorplan and performance in microsystems. - Investigate new dielectric and magnetic materials integrated into high power and high temperature microsystems. - Identify methodologies to develop multi-physics, multi-scale design tools that incorporate on-chip generated electromagnetic interference effects in high-voltage and high-current microsystems.		
Congressional Adds Subtotals	-	36.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602716E / *ELECTRONICS TECHNOLOGY*	**Project (Number/Name)** ELT-02 / *BEYOND SCALING TECHNOLOGY*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603286E *I ADVANCED AEROSPACE SYSTEMS*

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	-	216.283	194.043	253.135	-	253.135	200.933	200.546	225.320	238.057	-	-
AIR-01: *ADVANCED AEROSPACE SYSTEMS*	-	216.283	194.043	253.135	-	253.135	200.933	200.546	225.320	238.057	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Advanced Aerospace Systems program element, budgeted in the Advanced Technology Development Budget Activity, is focused on exploiting high pay-off opportunities to provide revolutionary new system capabilities, as opposed to incremental or evolutionary advancements, in order to achieve undeterrable air presence at dramatically reduced costs. Rapid prototyping and experimentation of integrated system concepts, as well as enabling vehicle subsystems will be conducted. Programs will explore new architectural concepts that employ a mix of weapon technologies that achieve lethality through a combination of overwhelming performance and overwhelming numbers rather than through the use of singular and costly high value assets. Studies conducted under this program element include examination and evaluation of emerging aerospace threats, technologies, concepts, use of autonomy to minimize risk, and applications for missiles, munitions, and vehicle systems.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	223.478	174.043	0.000	-	0.000
Current President's Budget	216.283	194.043	253.135	-	253.135
Total Adjustments	-7.195	20.000	253.135	-	253.135
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	20.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	-7.195	0.000			
• Adjustments to Budget Year	-	-	253.135	-	253.135

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: AIR-01: *ADVANCED AEROSPACE SYSTEMS*		
Congressional Add: *Advanced Full Range Engine (AFRE) Congressional Add*	2.500	-
Congressional Add: *Hypersonic Risk Reduction (Hypersonic Air breathing Weapon Concept) - Congressional Add*	-	15.000
Congressional Add: *Hypersonic Risk Reduction (Tactical Boost Glide) - Congressional Add*	-	5.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603286E / *ADVANCED AEROSPACE SYSTEMS*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Congressional Add Subtotals for Project: AIR-01	2.500	20.000
Congressional Add Totals for all Projects	2.500	20.000

Change Summary Explanation

FY 2021: Decrease reflects SBIR/STTR transfer.
FY 2022: Increase reflects a Congressional add for Hypersonic risk reduction.
FY 2023: FY 2023 funding increase reflects the fact that the FY 2022 President's Budget request did not include out-year funding.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: LongShot	24.000	36.000	36.000
Description: The LongShot program is developing and flight demonstrating an air-launched Unmanned Aerial Vehicle (UAV) capable of engaging multiple adversary targets from standoff ranges using existing air-to-air missiles. LongShot will be deployed either externally from existing fighters or internally from existing bombers. This system will capitalize on a slower speed, fuel-efficient air vehicle for ingress, while retaining highly energetic air-to-air missiles for end-game target engagements, which provides several key benefits that increase weapon effectiveness. This program will address the stability and control challenges of launching air-to-air missiles from a relatively small UAV in an operational environment. Potential transition partners include the Navy and Air Force. ***FY 2022 Plans:*** - Complete preliminary design of the Demonstration System and conduct preliminary design review. - Complete Wind Tunnel Testing of the Demonstration Air Vehicle. - Conduct missile separation test. - Initiate System Integration Laboratory setup and testing. ***FY 2023 Plans:*** - Conduct risk reduction testing and requirements verification and validation events to mature the demonstration system design. - Complete critical design of the demonstration system and conduct critical design review. - Initiate demonstration system fabrication, integration, assembly, and test.			
Title: Series Hybrid Electric Propulsion AircRaft Demonstrator (SHEPARD)	16.770	23.000	22.000
Description: The Series Hybrid Electric Propulsion AircRaft Demonstrator (SHEPARD) program is designing and developing an efficient Hybrid Electric Propulsion (HEP) system and integrating it into a unique military aircraft application. The innovative aircraft design will include essential operational considerations and mission system components. The program employs a rapid development framework that capitalizes on maturing mission-enabling technologies to quickly meet emergent mission needs while			

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
overcoming significant system-level technical challenges. The result will be a flight-demonstrated system with a minimal viable mission capability that is developed quickly and at relatively low cost. ***FY 2022 Plans:*** - Conduct propulsion component testing. - Begin aircraft fabrication. - Conduct system integration lab testing. - Develop test plans and range coordination. ***FY 2023 Plans:*** - Complete aircraft fabrication. - Conduct a flight test series. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of aircraft fabrication.			
Title: Glide Breaker ***Description:*** Glide Breaker is developing and demonstrating a critical component technology to support a lightweight vehicle designed for precise engagement of hypersonic threats at very long range. Glide Breaker focuses on a single, critical, long-lead technology with applicability to a variety of interceptor concepts and designs. The development of the component technology will initiate with ground testing, followed by testing in a wind tunnel to develop a performance database to inform future designs and execution of a sounding rocket flight test to demonstrate the technology in a relevant hypersonic free flight environment. ***FY 2022 Plans:*** - Conduct ground demonstration of component technologies. - Initiate design of sounding rocket test article design for flight test of component technology. ***FY 2023 Plans:*** - Conduct wind tunnel testing of component to develop performance database in relevant aerothermal environment. - Complete preliminary design of flight test article. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects transition from demonstration of a component to prepare for integrated flight demonstration in a relevant aero-thermal environment.	7.000	7.000	18.250
Title: Advanced Aerospace System Concepts	3.000	3.000	3.200

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: Studies conducted under this program examine and evaluate emerging aerospace technologies and system concepts for applicability to military use. This includes the degree and scope of potential impact and improvements to military operations, mission utility, and warfighter capability. Studies are also conducted to analyze emerging aerospace threats along with possible methods and technologies to counter them. The feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate future prototype development programs or refocus ongoing work. Topics include: methods of defeating enemy anti-aircraft attacks; munition technologies to increase precision, range, endurance, and lethality of weapons for a variety of mission sets; novel launch systems; air vehicle control, power, propulsion, materials, and architectures; and payload and cargo handling systems. ***FY 2022 Plans:*** - Examine operational utility of novel aerospace system concepts. - Assess feasibility and practicality of developmental aerospace subsystems. - Perform modeling and simulation that support future concepts and novel architectures. ***FY 2023 Plans:*** - Assess ability of novel aerospace propulsion concepts to be integrated into feasible and practical weapons. - Refine concepts for integration of cross-domain air dominance solutions. - Integrate advanced aerospace systems concepts and technologies into realistic capability demonstrations. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects emphasis on studies related to advanced propulsion concepts leading to critical technologies enabling novel weapons delivery.			
Title: Liberty Lifter	-	-	31.000
Description: The Liberty Lifter program is designing and demonstrating a runway independent, large payload, survivable aircraft capable of extended on-water operations and flight both in and out of ground effect. Critical to an effective aircraft of this type is a robust sea plane capability to operate in high sea states as well as an innovative manufacturing approach that dramatically reduces vehicle acquisition costs. The vehicle is anticipated to be survivable against peer threats due to the combination of extremely low altitude operations and speeds significantly higher than ships. The ability to deploy amphibious cargo while on the water will minimize exposure time and enable a wide variety of mission capabilities in the maritime and air domains. The Liberty Lifter program is envisioned to transition a full-scale technology demonstrator to military service partners for continued testing and development activities. The Liberty Lifter program is building upon technologies developed in the Advanced Aeronautics and Space Technologies program budgeted in PE 0602702E, Project TT-07. ***FY 2023 Plans:***			

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Conduct design and analysis activities leading to a conceptual design. - Initiate preliminary design and analysis activities. - Conduct risk reduction activities. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Tactical Boost Glide	74.663	50.043	30.000
Description: The Tactical Boost Glide (TBG) program is a Joint DARPA / Air Force effort developing and demonstrating technologies to enable air-launched tactical range hypersonic boost glide systems, including flight demonstration of a vehicle that is traceable to an operationally relevant weapon that can be launched from current platforms. The program will also consider traceability, compatibility, and integration with the Navy Vertical Launch System (VLS). The metrics associated with this objective include total range, time of flight, payload, accuracy, and impact velocity. The program will address the system and technology issues required to enable development of a hypersonic boost glide system considering (1) vehicle concepts possessing the required aerodynamic and aero-thermal performance, controllability and robustness for a wide operational envelope, (2) the system attributes and subsystems required to be effective in relevant operational environments, and (3) approaches to reducing cost and improving affordability for both the demonstration system and future operational systems. TBG capabilities are planned for transition to the Air Force and the Navy. ***FY 2022 Plans:*** - Complete Engineering Review Board (ERB) activities for flight test 1 investigation. - Complete corrective-action design verification and qualification testing for return to flight. - Complete Assembly, Integration, and Test (AI&T) of second and third flight-test vehicle. - Conduct test readiness review (TRR) for second and third flights, conduct second flight test, and complete post-flight analysis. - Complete Navy variant weapon datalink (WDL) critical design. - Conduct Navy variant weapon datalink (WDL) lab verification test. - Complete Navy variant guidance electronic unit (GEU) critical design. - Conduct four Navy variant GEU captive flight tests and complete post-test analysis. - Complete materials arc-jet testing. - Complete second TBG performer's engineering component and system-level testing and design verification testing. - Complete second TBG performer's material and thermo-structural risk reduction testing, including structural model validation test, and full-scale hot structure test. ***FY 2023 Plans:***			

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Conduct third flight test and complete post-test analysis. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects move to final assembly integration and third test flight.			
Title: Control of Revolutionary Aircraft with Novel Effectors (CRANE) ***Description:*** The Control of Revolutionary Aircraft with Novel Effectors (CRANE) program is demonstrating revolutionary improvements in aircraft controls technology. The program will design, build, and flight test an aircraft able to fly and maneuver at altitude relying on state-of-the-art Active Flow Control (AFC) technology. AFC is a broad term that encompasses a range of technology approaches; it includes a number of control mechanisms which alter the aerodynamic flow field thru ejection or suction of fluid via an orifice on a lifting body. An emphasis of the program is on assessing AFC component technologies, risk reduction and experimentation, integrated testing, fabrication and demonstration of a relevant scale novel and innovative aircraft. Technologies, design tools and models developed and demonstrated under this program will be made available to all Services as well as the civilian aerospace sector for application to future air systems development. Prior to FY 2023, this program was funded in PE 0602702E, Project TT-07. ***FY 2023 Plans:*** - Complete detailed design, flight software, and control law development. - Conduct system critical design review. - Begin subsystems integration and begin fabrication of a demonstration aircraft. - Initiate airworthiness and ground/flight test approvals supporting testing of the X-Plane. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects maturation of program from PE 0602702E, Project TT-07, into detailed design and fabrication of the demonstration aircraft.	-	-	52.685
Title: Operational Fires ***Description:*** The Operational Fires (OpFires) program is developing and demonstrating a novel ground-launched system enabling advanced tactical weapons to penetrate modern enemy air defenses, and rapidly and precisely engage critical time-sensitive targets. This program will develop an advanced booster capable of delivering a variety of payloads at a variety of ranges. Additional considerations include the need for compatible mobile ground launch platforms enabling integration with existing ground forces and infrastructure, and specific system attributes required for rapid deployment and redeployment. The program will conduct an engineering flight test to demonstrate the critical technologies in a relevant environment. Those lessons will be captured in an integrated weapon system critical design review for a potential follow-on effort developing a full prototype. OpFires will leverage and integrate ongoing investments in hypersonics to achieve these objectives.	47.575	45.000	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: - Complete booster separation, missile control system, and design verification testing. - Complete flight test configuration assembly, integration, test plans and readiness review. - Complete flight test demonstrating canister egress engineering test. - Complete integrated weapon system Critical Design Review (CDR). ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Hypersonic Air-breathing Weapon Concept (HAWC) ***Description:*** The Hypersonic Air-breathing Weapon Concept (HAWC) program is a Joint DARPA / Air Force effort developing and demonstrating technologies for an effective and affordable air-launched hypersonic cruise missile. These technologies include advanced air vehicle configurations capable of efficient hypersonic flight, hydrocarbon scramjet-powered propulsion to enable sustained hypersonic cruise, thermal management approaches designed for high-temperature cruise, and affordable system designs and manufacturing approaches. Investments may lead into developments in aerodynamics, propulsion, and payload capacity, and algorithms that support maneuvering and target recognition. This is a joint program with the Air Force, and HAWC technologies are planned for transition to the Air Force after flight-testing is complete. ***FY 2022 Plans:*** - Complete flight tests. - Complete flight test data analysis and final program review. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects completion of flight tests and program completion.	30.880	10.000	-
Title: MoHAWC ***Description:*** The MoHAWC program builds off the demonstrator system design, technology advances and lessons learned under the Hypersonic Airbreathing Weapon Concept (HAWC) and supporting technology maturation programs. MoHAWC will develop, integrate, and demonstrate technologies to increase effectiveness and producibility of an air-launched hypersonic cruise missile. These technologies include advancing hydrocarbon scramjet-powered propulsion operation, shrinking navigation components, upgrading aircraft integration algorithms, and improving manufacturing approaches. Flight tests will expand the operational envelope. This program will collaborate with Navy and Air Force science and technologies efforts to meet future technology insertion dates for service programs of record ***FY 2023 Plans:***	-	-	60.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Incorporate HAWC lessons learned into the cruiser design. - Initiate procurement of long lead components for four flight test systems. - Complete subsystem technology risk reduction efforts. - Begin assembly, integration, and ground testing of cruisers. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects need to initiate a program to leverage, integrate, and demonstrate DARPA technologies into a hypersonic weapon.			
Title: Advanced Full Range Engine (AFRE) ***Description:*** The Advanced Full Range Engine (AFRE) program demonstrated turbine-based combined cycle (TBCC) technologies to establish the feasibility of a hypersonic reusable propulsion system. Specifically, AFRE demonstrated key components of the TBCC propulsion system at low speed where turbine propulsion is used, at high speed where a dual-mode ramjet (DMRJ) is used, and at turbine-to-DMRJ transition conditions. Large-scale components of this complex propulsion system were developed and demonstrated independently and experimentation focused on regimes where the propulsion system smoothly transitions from low-speed turbine only operation to high-speed DMRJ-only operation. AFRE will enable future airfield-based hypersonic systems to operate without special logistics considerations, resulting in transformational changes in long-range strike, high-speed Intelligence, Surveillance and Reconnaissance (ISR) and Two-Stage-To-Orbit (TSTO) operations. The anticipated transition partner for this effort is the Air Force.	9.895	-	-
Accomplishments/Planned Programs Subtotals	213.783	174.043	253.135

	FY 2021	FY 2022
Congressional Add: Advanced Full Range Engine (AFRE) Congressional Add ***FY 2021 Accomplishments:*** - Completed facility preparation, hardware installation, and ground test of full-scale combustor (DMRJ) at mode-transition conditions. - Initiated facility preparations and hardware installation for ground test of full-scale combustor (DMRJ) at mode-transition and high-Mach conditions.	2.500	-
Congressional Add: Hypersonic Risk Reduction (Hypersonic Air breathing Weapon Concept) - Congressional Add ***FY 2022 Plans:*** - Complete second and third flight tests. - Complete flight test data analysis and final program review.	-	15.000
Congressional Add: Hypersonic Risk Reduction (Tactical Boost Glide) - Congressional Add	-	5.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603286E *I ADVANCED AEROSPACE SYSTEMS*

	FY 2021	FY 2022
FY 2022 Plans: - Test range support for flight test 2. - Glider build up and initial system integration for flight test 3.		
Congressional Adds Subtotals	2.500	20.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603287E / *SPACE PROGRAMS 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	-	144.463	181.524	81.888	-	81.888	103.364	119.458	125.291	120.790	-	-
SPC-01: *SPACE PROGRAMS AND TECHNOLOGY*	-	144.463	181.524	81.888	-	81.888	103.364	119.458	125.291	120.790	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Space Programs and Technology program element is budgeted in the Advanced Technology Development budget activity because it addresses high payoff opportunities to dramatically reduce costs associated with advanced space systems and provides revolutionary new system capabilities for satisfying current and projected military missions.

A space force structure that is robust against attack represents a stabilizing deterrent against adversary attacks on space assets. This program element will examine concepts and architectures that move the U.S. away from a dependence on monolithic, ultra-capable, vulnerable, and unsustainably costly assets; replacing them with disaggregated assets that are agile, affordable, and easily replaced. Ready access to space requires the delivery of capabilities, replenishment of supplies into orbit, and rapid manufacturing of affordable space capabilities. In addition, developing space access and spacecraft servicing technologies will lead to reduced ownership costs of space systems and new opportunities for introducing technologies for the exploitation of space.

Systems development is also required to increase the interactivity and functionality of space systems, space-derived information, and services with terrestrial users. Studies under this program element include technologies and systems that will enable satellites and microsatellites to operate more effectively by increasing maneuverability, survivability, and situational awareness, and precision control of multi-payload systems. Studies will actively seek to take advantage of new commercial developments which may enable both rapid constitution/reconstitution of assets, and agility/functionality not previously available for military systems.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	151.439	101.524	0.000	-	0.000
Current President's Budget	144.463	181.524	81.888	-	81.888
Total Adjustments	-6.976	80.000	81.888	-	81.888
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	80.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-2.100	0.000			
• SBIR/STTR Transfer	-4.876	0.000			
• Adjustments to Budget Year	-	-	81.888	-	81.888

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: SPC-01: *SPACE PROGRAMS AND TECHNOLOGY*		
Congressional Add: *Hypersonic Risk Reduction (Blackjack) - Congressional Add*	-	55.000
Congressional Add: *Hypersonic Risk Reduction (Robotic Servicing of Geosynchronous Satellites) - Congressional Add*	-	25.000
Congressional Add Subtotals for Project: SPC-01	-	80.000
Congressional Add Totals for all Projects	-	80.000

Change Summary Explanation

FY 2021: Decrease reflects reprogrammings and SBIR/STTR transfer.
FY 2022: Increase reflects a Congressional add for Hypersonic risk reduction.
FY 2023: FY 2023 funding increase reflects the fact that the FY 2022 President's Budget request did not include out-year funding.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Demonstration Rocket for Agile Cislunar Operations (DRACO)	33.000	37.000	57.501

Description: Maintaining U.S. interests in cislunar space requires a leap-ahead propulsion technology. Current space propulsion includes electric (high efficiency but low thrust) and chemical (high thrust but low efficiency). The Demonstration Rocket for Agile Cislunar Operations (DRACO) program is developing and demonstrating a High-Assay Low-Enriched Uranium (HALEU) nuclear thermal propulsion (NTP) system on orbit by 2025. The NTP technology demonstrated by DRACO achieves thrust similar to chemical systems, but with 2-5 times the efficiency. The enhanced performance afforded by NTP will allow the U.S. to lead operations in the cislunar volume, a volume that is in danger of being defined by the adversary.

FY 2022 Plans:
- Conduct conceptual design of the demonstration system (DS) spacecraft.
- Conduct system requirements review for operational system (OS) and DS spacecraft concepts.
- Conduct subsystem requirements review for NTP demonstration reactor.
- Demonstrate designs of NTP fuel elements in representative test environments.
- Conduct baseline design review for NTP demonstration reactor.
- Conduct technology maturation plan for DS spacecraft concept.

FY 2023 Plans:
- Begin detailed design of the NTP demonstration reactor.
- Begin fabrication of long lead components for the NTP demonstration reactor.
- Begin fabrication of long lead components for the demonstration system NTP spacecraft.

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Conduct preliminary design of the NTP demonstration reactor. - Begin detailed design of the NTP demonstration reactor. - Conduct preliminary design review (PDR) for the demonstration system. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program focus shift from design to fabrication of long lead components for the NTP demonstration reactor and demonstration system NTP spacecraft.			
Title: Blackjack ***Description:*** The Blackjack program is developing space technologies demonstrating a proliferated smallsat constellation capability in Low Earth Orbit (LEO). Capabilities demonstrated will provide constant custody of very large numbers of concurrent targets; target identification, tracking, and characterization; tactical communications; architectural resilience via massive proliferation; and rapid on-orbit technology refresh and experimentation. Blackjack will leverage commercial industry plans to build constellations in LEO to provide global commercial broadband internet service. Key efforts include low size, weight, power, and cost (SWaP-C) multi-modality smallsat sensor payloads, algorithms for autonomous payload and architecture command and control, algorithms for satellite on-board processing and data fusion, and advanced manufacturing for military payload mass production. A Memorandum of Agreement (MOA) documents the partnership with U.S. Space Force and Air Force. The anticipated transition partners are the U.S. Space Force, Air Force and Space Development Agency. Blackjack will progress through design and build of 2 satellites with tactical communications and Intelligence, Surveillance, and Reconnaissance (ISR) payloads, and then build and launch 2 satellites with missile warning/defense payloads, then an additional 8 tactical communications/ISR satellites for the full Blackjack demonstration of a proliferated LEO constellation. ***FY 2022 Plans:*** - Conduct operations of laser communications demonstration satellites. - Complete assembly, integration, and testing of full demonstration satellites. - Launch full demonstration satellites to support autonomous constellation control. - Launch and conduct check-out and early operations of first two ISR/Radio Frequency (RF) satellites. ***FY 2023 Plans:*** - Launch and conduct check-out and early operations of first two Overhead Persistent InfraRed (OPIR) satellites. - Final Blackjack constellation demonstration payload and bus integration. - Launch and deploy full Blackjack constellation demonstration. ***FY 2022 to FY 2023 Increase/Decrease Statement:***	64.634	42.019	10.887

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 decrease reflects a shift from spacecraft assembly, integration, testing, and launch to on-orbit operations.			
Title: Robotic Servicing of Geosynchronous Satellites (RSGS)	43.329	19.005	10.000

Description: A large number of national security and commercial space systems operate at geosynchronous earth orbit (GEO), providing persistence and enabling ground station antennas to point in a fixed direction. Technologies for servicing of GEO spacecraft would involve a mix of highly automated and remotely operated (from Earth) robotic systems. The Robotic Servicing of Geosynchronous Satellites (RSGS) program will establish the capability to provide robotic services in GEO suitable for a variety of potential servicing tasks, in full collaboration and cooperation with existing satellite owners and national security space operators, and with sufficient propellant for several years of follow-on capability. Key RSGS challenges include robotic tool/end effector requirements, efficient orbital maneuvering of a servicing vehicle, robotic arm systems, automation of certain spacecraft operations, and development of the infrastructure for coordinated control between the servicer and client spacecraft operations teams. The transition agreement is with a commercial partner who will provide the satellite to carry the robotic payload and who will operate the robotic servicer. To support the development of a broadly accepted satellite servicing capability, DARPA is using the Consortium for Execution of Rendezvous and Servicing operations (CONFERS) approach to bring together experts from the private sector and Government to research, develop and publish nonbinding, consensus-based standards for safe operational approaches to on-orbit servicing.

FY 2022 Plans:
- Complete payload flight software qualification.
- Complete payload structures fabrication.
- Complete build and test of robotic arms.
- Complete integration of robotic payload.
- Start testing and space qualification of integrated robotic payload.
- Initiate partner training and detailed demonstration planning.
- Convene CONFERS fourth general assembly and Global Satellite Servicing Forum.
- Publication of CONFERS revised technical standards document inclusive of lessons learned from on-going commercial and government activity.

FY 2023 Plans:
- Complete testing and space qualification of integrated robotic payload.
- Deliver integrated and tested robotic payload for integration to spacecraft.
- Complete partner training and detailed demonstration planning.

FY 2022 to FY 2023 Increase/Decrease Statement:

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
The FY 2023 decrease reflects shift from completion of robotic payload fabrication, testing and space qualification to spacecraft integration.			
Title: Advanced Space Technology Concepts ***Description:*** Studies conducted under this program will examine and evaluate emerging technologies and concepts with the potential to provide substantial improvement in efficiency, effectiveness, and resilience of operations in space. This includes the degree and scope of potential impact and improvements to military operations, mission utility, and warfighter capability. Studies are also conducted to analyze emerging threats along with possible methods and technologies for countermeasures. The feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate future programs or refocus ongoing work. Topics of consideration include applying artificial intelligence to low earth orbit constellation operations to enable collaboration between space, air, maritime, and ground platforms in anti-access/area denial (A2/AD) theaters; robust architectures for precision navigation and timing; enabling operations in Cislunar space; and on-orbit software environments. ***FY 2022 Plans:*** - Initiate studies of new concepts and novel approaches for precision navigation and timing systems. - Examine the use of new technologies to enable operation in novel orbital domains. ***FY 2023 Plans:*** - Initiate studies of novel approaches for reconfigurable satellite systems and payloads.	3.500	3.500	3.500
Accomplishments/Planned Programs Subtotals	144.463	101.524	81.888

	FY 2021	FY 2022
Congressional Add: Hypersonic Risk Reduction (Blackjack) - Congressional Add ***FY 2022 Plans:*** - Build all ISR/RF & OPIR payloads, buses and Pit Bosses. - Complete assembly, integration, and testing of first two and initiate eight additional ISR/RF satellites to support autonomous constellation demonstration.	-	55.000
Congressional Add: Hypersonic Risk Reduction (Robotic Servicing of Geosynchronous Satellites) - Congressional Add ***FY 2022 Plans:*** - Complete flight software integration and test. - Integrate flight avionics, tools and robotic arms on spacecraft structure and test. - Conduct space qualification testing and deliver robotic payload components to commercial partner.	-	25.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603287E *I SPACE PROGRAMS AND TECHNOLOGY*

	FY 2021	FY 2022
- Initiate partner training and detailed demonstration planning.		
Congressional Adds Subtotals	-	80.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*

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	-	92.989	140.716	250.917	-	250.917	313.030	333.025	336.068	346.768	-	-
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	16.701	27.854	33.406	-	33.406	89.030	105.175	112.332	120.832	-	-
MT-16: *BEYOND SCALING ADVANCED TECHNOLOGIES*	-	76.288	112.862	217.511	-	217.511	224.000	227.850	223.736	225.936	-	-

A. Mission Description and Budget Item Justification

The Advanced Electronics Technologies Program Element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and processing technologies for the production of various electronics and microelectronic devices, sensor systems, integrated photonic-electronic components that have military applications and potential commercial utility. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements.

The Mixed Technology Integration project funds the advanced development and demonstration of selected basic and applied electronics research programs. Examples of technologies with funded development and demonstration activities include, but are not limited to: reducing the size, weight, and power (SWaP) of components for laser weapon systems that will protect airborne platforms from emerging surface-to-air missiles; integrated photonic-electronic components for positioning, navigation and timing in GPS-denied environments; flexible, software-defined cameras that enable real-time image analysis of complex scenes to provide more actionable information; and optical communications systems that rely on no moving parts enabling their use on SWaP-restricted platforms. Funding under this project is intended to advance transitioning novel technologies to use, providing advanced components compatible with mid-term and other future warfighting requirements.

The Beyond Scaling Advanced Technologies Project supports activities to enable and accelerate the transition of disruptive microelectronics advancement, including those developed under the Beyond Scaling Sciences (ES-02) and Beyond Scaling Technology (ELT-02) projects. Funding under this project will include developing new technologies and capabilities in commercial settings, establishing access to these new processes and to commercial state-of-the-art foundries, enabling prototyping, developing manufacturable processes for integrated photonics, advancing new architectures and integration technologies for advanced field programmable gate arrays (FPGAs), and innovating back end of line technologies for wide bandgap semiconductors.

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603739E *I ADVANCED ELECTRONICS TECHNOLOGIES*

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	95.864	116.716	0.000	-	0.000
Current President's Budget	92.989	140.716	250.917	-	250.917
Total Adjustments	-2.875	24.000	250.917	-	250.917
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	24.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.212	0.000			
• SBIR/STTR Transfer	-3.087	0.000			
• Adjustments to Budget Year	-	-	250.917	-	250.917

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: MT-16: *BEYOND SCALING ADVANCED TECHNOLOGIES*		
Congressional Add: *ERI 2.0 - Congressional Add*	-	24.000
Congressional Add Subtotals for Project: MT-16	-	24.000
Congressional Add Totals for all Projects	-	24.000

Change Summary Explanation

FY 2021: Decrease reflects SBIR/STTR transfer offset by reprogrammings.

FY 2022: Increase reflects a Congressional add for ERI 2.0.

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

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	Project (Number/Name) MT-15 / *MIXED TECHNOLOGY INTEGRATION*	

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
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	16.701	27.854	33.406	-	33.406	89.030	105.175	112.332	120.832	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Mixed Technology Integration project funds the advanced development and demonstration of selected basic and applied electronics research programs. Examples of technologies with funded development and demonstration activities include, but are not limited to: reducing the size, weight, and power (SWaP) of components for laser weapon systems that will protect airborne platforms from emerging surface-to-air missiles; integrated photonic-electronic components for positioning, navigation and timing in GPS-denied environments; flexible, software-defined cameras that enable real-time image analysis of complex scenes to provide more actionable information; and optical communications systems that rely on no moving parts enabling their use on SWaP-restricted platforms. Funding under this project is intended to advance transitioning novel technologies to use, providing advanced components compatible with mid-term and other future warfighting requirements.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Wideband Secured and Protected Emitter and Receiver (WiSPER)	8.701	21.854	21.000
Description: The Wideband Secured and Protected Emitter and Receiver (WiSPER) program aims to develop an ultra-broadband technology platform to demonstrate a robust, secure, and protected communication link. WiSPER technology provides high signal coding gain to deliver a secured and protected link with significantly enhanced capacity for next generation DoD communications. Current terrestrial tactical radios operate with limited bandwidth at prescribed low frequency bands, which are unable to support high capacity with multiple users and are vulnerable to interference and jamming. WiSPER technology addresses military needs for assured communications, throughput, security, and size, weight, and power limitations of future command, control, communications, computers, intelligence, surveillance and reconnaissance missions. The program will develop an ultra-broadband compact antenna, radio frequency front-end electronics, mixed-signal circuits, and waveform technologies. The WiSPER program will culminate with the integration and demonstration of a secured communication link. Technologies developed under the WiSPER program are planned for transition to the Services. ***FY 2022 Plans:*** - Optimize the secured radio transceiver design using modeling and simulation. - Integrate first-generation functional test prototype of the secured radio transceiver. - Test bench-top prototype secured radio transceiver in a laboratory environment, demonstrating spatial coding and first-generation featureless packet generation, transmission, and reception. ***FY 2023 Plans:*** - Design second-generation functional test prototype of the secured radio transceiver.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Begin implementation of second-generation functional test prototype secured radio transceiver doubling accessible bandwidth with increased dynamic range and diversity. - Optimize the second-generation secured radio transceiver design using modeling and simulation. - Integrate second-generation functional test prototype of the secured radio transceiver into a transportable unit. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Reconfigurable Imaging (ReImagine) ***Description:*** The Reconfigurable Imaging (ReImagine) program aims to create multi-functional readout integrated circuits (ROICs) that fundamentally change the way camera systems collect, process, and relay image information. This is accomplished by adding multifunctional flexibility in the ROIC. Today, most cameras are designed to capture high quality imagery at standard frame rates. These traditional camera architectures collect a single type of data across the full image frame. Specialty cameras can be used to capture different spatial, spectral, or temporal data but are rarely deployed because of the cost and complexity of adding imaging subsystems for niche measurements. Although these measurements typically are desired only for specific features or regions of interest (ROIs) in a scene, the cameras collect specialized data over the full image frame. The ReImagine architecture, conversely, would enable a single, real-time reconfigurable, software-defined camera system with the ability to collect different data in different ROIs. Depending on the need, a ReImagine imager would be able to selectively collect and simultaneously process data from a specific ROI, for example, at a higher resolution, at a higher frame rate, or with 3-D depth information. The system would interface with virtually any sensor and could therefore be used in any spectral band. By demonstrating more efficient data collection and computation across ROIs, ReImagine ROICs will enable real-time analysis of much more complex scenes and provide more actionable information than has ever been possible. Technologies from this program are intended for transition to the Air Force, Navy, and Army. ***FY 2022 Plans:*** - Fully demonstrate the updated ReImagine reconfigurable sensing system concept. - Engage with potential transition partners for relevant applications. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	6.000	6.000	-
Title: Modular Efficient Laser Technology (MELT) ***Description:*** The Modular Efficient Laser Technology (MELT) program will demonstrate the first compact, high-power laser tile as the key building block to enable the next generation of scalable high energy laser (HEL) sources for laser weapon systems (LWS). Today's LWS use fiber laser array HEL sources, complex optical benches, and beam directors. These systems are large	-	-	12.406

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
and heavy, contain large numbers of individual components, and require skilled labor to fabricate and integrate. This makes current LWS difficult and costly to manufacture, limiting their deployment and application. MELT will leverage recent advances in coherent beam combining and photonic integrated circuits (PICs) fabrication techniques to develop tiled arrays integrated with semiconductor-based optical systems, low-loss waveguides, optical interconnects, and application-specific integrated circuit (ASIC) into a compact laser tile that can be integrated with a supporting backplane to provide scalable HEL sources. This will provide the LWS developer a scalable HEL architecture that maintains excellent beam quality and allow LWS deployment on SWaP-constrained platforms. MELT will leverage a mature industrial base for semiconductor manufacturing, as well as recent advances in photonic integrated circuits, coherent beam combining algorithms, semiconductor cooling techniques, and optical lithography to achieve its program goals. Technologies from this program are intended for transition to Army, Air Force, and Navy. ***FY 2023 Plans:*** - Design semiconductor emitters with improved electrical-to-optical efficiency. - Demonstrate efficient beam combining with individual semiconductor emitters. - Develop algorithm and sensing architecture to control beam coherence. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Precise Robust Inertial Guidance for Munitions (PRIGM) ***Description:*** The Precise Robust Inertial Guidance for Munitions (PRIGM) program developed inertial sensor technologies for positioning, navigation, and timing (PNT) in GPS-denied environments. The program exploited advances in integrating photonic (light-manipulating) components into electronics and in employing microelectromechanical systems (MEMS) as high-performance inertial sensors for use in extreme environments. PRIGM focused on developing and transitioning a Navigation-Grade Inertial Measurement Unit (NGIMU), a state-of-the-art MEMS device, and advancing state-of-the-art MEMS gyros from Technology Readiness Level (TRL) 3 devices to a TRL 6 transition platform. Service laboratories were actively involved throughout program development and remain engaged to facilitate transition of NGIMU prototypes, which will be delivered at the program conclusion.	2.000	-	-
Accomplishments/Planned Programs Subtotals	16.701	27.854	33.406

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	Project (Number/Name) MT-16 / *BEYOND SCALING ADVANCED TECHNOLOGIES*	

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
MT-16: *BEYOND SCALING ADVANCED TECHNOLOGIES*	-	76.288	112.862	217.511	-	217.511	224.000	227.850	223.736	225.936	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Beyond Scaling Advanced Technologies Project supports activities to enable and accelerate the transition of disruptive microelectronics advancement, including those developed under the Beyond Scaling Sciences (ES-02) and Beyond Scaling Technology (ELT-02) projects. Funding under this project will include developing new technologies and capabilities in commercial settings, establishing access to these new processes and to commercial state-of-the-art foundries, enabling prototyping, developing manufacturable processes for three-dimensional heterogeneous integration (including integrated photonics), advancing new architectures and integration technologies for advanced field programmable gate arrays (FPGAs), and innovating back end of line technologies for wide bandgap semiconductors.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Programmable Logic for Applications In Defense (PLAID)	30.000	38.500	30.000

Description: The Programmable Logic for Applications In Defense (PLAID) program is developing a heterogeneous compute platform that can support processing of large data arrays. Current computing architectures are subject to scaling, bandwidth, and memory limitations, and the large size of today's chips limits the movement of data resulting in a fundamental trade-off between circuit size and data throughput. The PLAID program will break this paradigm with new architecture development and will achieve more than a 10X increase in on-chip bandwidth. In addition to the development of this new device, the PLAID program will expedite deployment into DoD systems by engaging the defense industrial base to map DoD-relevant radio frequency (RF) processing problems onto the new architecture. These RF problems may include element-level digital beamforming, multi-target tracking radar applications, and synthetic aperture radar processing. Once applications are mapped onto the new processor, the implementation will be programmed and tested with the intent that the use of the new device developed by commercial industry will directly transition into an asymmetric advantage for the DoD and will be used by the defense industrial base in emerging applications.

FY 2022 Plans:
- Demonstrate five-wafer stack with a complete reliability assessment.
- Freeze device definition in preparation for completion of physical design.
- Demonstrate full-chip model with fabric place and route using a commercial design environment.
- Engage with transition partners to identify relevant applications.
- Quantify DoD system application trade-offs with respect to how algorithms map into the device programming.

FY 2023 Plans:

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-16 / *BEYOND SCALING ADVANCED TECHNOLOGIES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Complete device verification and characterization for production quality. - Release completed designs for fabrication. - Demonstrate early functional tests in a commercial design environment. - Expand engagement with transition partners to include planning for memoranda of understanding and agreement. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from fabrication to final testing.			
Title: Technologies for Mixed-mode Ultra Scaled Integrated Circuits (T-MUSIC)	13.000	20.500	7.511
Description: The Technologies for Mixed-mode Ultra Scaled Integrated Circuits (T-MUSIC) program is developing an on-shore semiconductor foundry platform for very wide band radio frequency (RF) mixed-mode integrated circuit analog-to-digital converters for commercial and military systems. Mixed-mode circuits take analog and RF signals and transform them to digital data for processing in computing systems. As defense and commercial wireless applications move to higher frequencies in order to carry more data traffic, integrating the broadband mixed-mode circuitry with high speed digital processing logic onto one chip becomes imperative to avoid data transfer bottlenecks. T-MUSIC seeks to integrate high-speed, high-performance analog and digital electronics together in highly-scaled silicon complementary metal-oxide semiconductor (CMOS) foundries on-shore. Such processes will enable the high levels of integration and performance needed for DoD-relevant and commercial 5G/6G applications. A goal of the T-MUSIC program is to enable very wide bandwidth wireless operations beyond 100 gigahertz (GHz) with low noise and high dynamic range. In addition, T-MUSIC aims to develop next-generation terahertz (THz) mixed-mode devices based on the advanced digital CMOS fabrication platform. The T-MUSIC program will establish advanced on-shore foundry capabilities to establish a long-term domestic world-class RF mixed-mode system-on-chip technology for intended transition to DoD and commercial applications. ***FY 2022 Plans:*** - Demonstrate foundational mixed-mode analog and digital circuit building blocks at 400 GHz fabricated in domestic foundries. - Develop the processes and specifications for next-generation 600 GHz high speed mixed-mode device technologies. - Optimize and demonstrate advanced materials, scaled THz device structures, and integration processes based on program-developed domestic CMOS process platform. - Work with potential transition partners to identify applications of T-MUSIC technologies. ***FY 2023 Plans:*** - Demonstrate foundational mixed-mode analog and digital circuit building blocks at 600 GHz fabricated in domestic foundries. - Continue to optimize and demonstrate advanced materials, scaled THz device structures, and integration process based on program-developed domestic CMOS process platform.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-16 / *BEYOND SCALING ADVANCED TECHNOLOGIES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Work towards transition of T-MUSIC technologies for application in commercial and defense sectors. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the shift from demonstrating foundational mixed-mode analog/digital building blocks in domestic foundries to transition.			
Title: Photonics in the Package for Extreme Scalability (PIPES)	11.000	13.000	5.000
Description: The Photonics in the Package for Extreme Scalability (PIPES) program aims to develop optical signaling technologies for digital microelectronics. Distributed and parallel computing architectures are now pervasive across all size scales, from personal-scale multicore processing units to enterprise-scale high performance computing systems, and span application domains from consumer electronics to DoD systems. Increasingly, however, the benefits of parallelism are constrained not by the limits of computation at individual nodes but by the movement of data between nodes. PIPES will advance microelectronics capabilities by intimately integrating photonics with advanced integrated electronics to yield system connectivity with an unprecedented combination of high aggregate bandwidth, power efficiency, channel density, and link reach. Specifically, PIPES will develop photonic input/output (I/O) capability for application-specific integrated circuits and Field-Programmable Gate Arrays (FPGAs) that are widely used in advanced DoD sensors and radio frequency systems. The goal of the program is improving I/O bandwidth density, efficiency, and reach by more than 100X to enable disruptive DoD system parallelism and performance scaling. As PIPES technologies mature, they are anticipated to proliferate into central processing units, graphical processing units, and emerging tensor-flow processing units that will impact a wide range of dual-use applications including artificial intelligence, machine learning, large scale emulation, and high performance computing. Technologies from this program are intended for transition to larger scale commercial performers and the Services. ***FY 2022 Plans:*** - Mature FPGAs with optical interfaces for transition to commercial and DoD applications. - Develop domestic photonics interconnect capabilities to facilitate DoD access to key silicon photonics fabrication and packaging resources. - Engage with Service transition partners. ***FY 2023 Plans:*** - Deliver prototype units of leading FPGAs with integrated photonic interconnect for Government evaluation. - Continue to develop domestic photonic interconnect capabilities with emphasis on an accessible ecosystem for integration, assembly and packaging. - Mature next-generation photonic link capabilities with ten times better efficiency through novel low-loss optical designs and closer electronic-photonic integration.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-16 / *BEYOND SCALING ADVANCED TECHNOLOGIES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Continue to develop transition opportunities within the DoD. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the shift from integration and demonstration to commercialization.			
Title: Next Generation Microelectronics Prototyping - Public-Private Partnerships	-	-	175.000
Description: Next Generation Microelectronics Prototyping - Public-Private Partnerships plans, establishes, and supports public-private partnerships to manufacture next-generation microsystems using three-dimensional heterogeneous integration (3DHI), including design, fabrication, packaging, assembly, and testing. This capability, a National Network for Next Generation Microelectronics Manufacturing, will emphasize design innovations to sustain U.S. leadership in semiconductors and enhance the use of manufacturing automation in the design, assembly, and testing of 3DHI prototypes. The baseline capability will allow users from across the country to quickly and efficiently develop working prototypes based on early-stage R&D. This will enable a wide range of organizations and stakeholders to accelerate a domestic 3DHI ecosystem, similar to how foundry access enabled fabless design companies and their associated ecosystems to proliferate. This research service will feature a baseline fabrication capability for research prototypes via a stable 3DHI process design kit. Users of the research service will have the ability to join multi-project demonstrations runs or dedicated taxi runs. This national accelerator will remove a major impediment to the domestic development of next-generation three-dimensional microsystems and will extend research capabilities beyond those currently being developed worldwide. The research services will incorporate the ability to fabricate unique microsystem prototypes using a wide range of devices and materials, integrating the most advanced manufacturing and assembly technologies across silicon, compound semiconductors, photonics, MEMS, and other advanced microelectronics technologies. Applied research related to this effort is funded within PE 0602716E, Project ELT-02. ***FY 2023 Plans:*** - Determine the capabilities needed to support 3DHI prototyping, including electronic design automation, security, metrology, and advanced packaging toolsets. - Identify facilities with base capabilities suited to expanding to new 3DHI manufacturing techniques. - Create a development plan for automated assembly and advanced packaging toolsets. - Prepare a maturation plan for electronic design automation for custom assembly and advanced packaging. - Establish a National Network for Next Generation Microelectronics Manufacturing public-private partnership for developing pre-competitive technologies that enables the next generation of manufacturing and accelerates the transfer of innovation from research to prototyping, by enhancing the ability of users to access design, metrology, assembly and advanced packaging resources.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-16 / *BEYOND SCALING ADVANCED TECHNOLOGIES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Coordinate with interagency forums to implement the national strategy for microelectronics research and development including planning for the National Network for Next Generation Microelectronics Manufacturing public-private partnership goals to be coordinated with the other public-private partnerships under development within DoD and other agencies. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY2023 increase reflects program initiation.			
Title: Millimeter Wave Digital Arrays (MIDAS) ***Description:*** The Millimeter Wave Digital Arrays (MIDAS) program is developing a common millimeter wave phased array tile that is scalable to large arrays to provide wideband frequency agility from 18 gigahertz (GHz) to 50 GHz with element-level digital beamforming. Millimeter wave systems are used today to achieve physical security through the use of narrow antenna beams in a small form-factor for applications that include satellite communications and tactical line-of-sight communications such as in the F-22 and F-35. One of the challenges of using directional communications is establishing a link when both platforms are mobile. Element-level digital beamforming allows a platform to listen in all directions to facilitate discovering and linking with neighboring platforms. Digital beamforming also enables multiple beams so that one platform can communicate with several neighbors simultaneously, increasing network throughput and robustness against unexpected outages. To achieve these goals, MIDAS is developing a common digital phased array tile that can be used to build large arrays from this common block. MIDAS uses advanced complementary metal oxide semiconductor (CMOS) technology to develop the core transceiver elements at a size and power consumption compatible with current millimeter wave systems, and employs a combination of advanced packaging and high-performance compound semiconductors to build the power amplifiers and wideband apertures necessary to make a complete system. Technologies from this program are intended for transition through commercial industry to the Services. ***FY 2022 Plans:*** - Complete fabrication of millimeter wave 64-element digital phased arrays in advanced CMOS co-integrated with compound semiconductor power amplifiers and wideband apertures and begin array testing. - Begin scaling 64-element designs and create test plans for millimeter wave 256-element digital phased arrays. - Complete advancements in the fundamental technologies relevant to millimeter wave digital arrays in the areas of converters, filters, oscillators, and wideband apertures. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	14.555	10.862	-
Title: Beyond Scaling - Access ***Description:*** The Beyond Scaling - Access program demonstrates design and fabrication of advanced electronics, to include collaborations with leading industry players. Although the United States has led the development of advanced electronics and is	7.733	6.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-16 / *BEYOND SCALING ADVANCED TECHNOLOGIES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
home to three of the five leading-edge silicon foundries, recent investments by foreign competitors are threatening this leadership. Additionally, the fabrication cost of next-generation microelectronics has increased at an alarming rate. While the commercial sector is able to spread these costs over a large volume of products, the low volumes used by the DoD creates a cost barrier to meeting its future technology needs. The Beyond Scaling - Access program forges forward-looking collaborations among the commercial electronics community, defense industrial base, university researchers, and the DoD to address domestic and DoD-available microelectronics capabilities. Activities include establishing design capabilities for advanced digital logic in state-of-the-art foundries; enabling domestic production of millimeter wave circuits for 5G applications, military communication systems, and DoD radar sensors; initializing prototyping facilities and other activities to enhance the likelihood for domestic production and implementation of leading edge technologies; and exploring microelectronics development and manufacturing capabilities aligned to DoD-specific environments. ***FY 2022 Plans:*** - Demonstrate architectures for systems-on-chip with improved computing efficiency for DoD embedded processing needs. - Engage with Service transition partners on novel circuit and memory architectures. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Accomplishments/Planned Programs Subtotals	76.288	88.862	217.511

	FY 2021	FY 2022
Congressional Add: ERI 2.0 - Congressional Add	-	24.000
FY 2022 Plans: - Perform survey of potential user base, including defense, commercial and academic organizations, to assess three-dimensional heterogeneous integration (3DHI) capabilities that a public-private partnership should service. - Analyze projected commercial 3DHI packaging capabilities available in five years. - Determine baseline facility requirements needed to offer prototyping service of new 3DHI manufacturing techniques. - Define objectives for development plan for automated assembly and advanced packaging toolsets.		
Congressional Adds Subtotals	-	24.000

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-16 / *BEYOND SCALING ADVANCED TECHNOLOGIES*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*

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	-	220.184	251.794	305.050	-	305.050	286.745	285.565	251.452	252.002	-	-
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	-	89.818	122.057	162.803	-	162.803	186.360	236.295	225.202	235.502	-	-
CCC-06: *COMMAND, CONTROL AND COMMUNICATION SYSTEMS*	-	130.366	129.737	142.247	-	142.247	100.385	49.270	26.250	16.500	-	-

A. Mission Description and Budget Item Justification

The Command, Control and Communications Systems Program Element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

The success of military operations depends on timely, reliable, secure, and synchronized dissemination of command and control and relevant situational awareness information to every military echelon. While wired communications and networks are fairly well developed, providing assured high-bandwidth mobile wireless capabilities that match or exceed commercial wired infrastructure is needed to meet the demands of military users. The goal of the Information Integration Systems project is to develop and demonstrate technologies that will provide effective communications to U.S. forces. Approaches to this goal include developing technologies in these areas:

- High-Capacity Links technologies - enables greater back-haul capability.
- Advanced Networking technologies - supports resilience, adaptability, scalability, and composable systems to enable adaptive effects webs.
- Low Probability of Detection and Anti-Jam (LPD/AJ) technologies - provides assured communications in very high-threat environments.
- Novel Radio Frequency and Spectral Sensing (RF/SS) - supports efficient spectrum management in congested environments and detection of electromagnetic threats.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	221.724	251.794	0.000	-	0.000
Current President's Budget	220.184	251.794	305.050	-	305.050
Total Adjustments	-1.540	0.000	305.050	-	305.050
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	5.599	0.000			
• SBIR/STTR Transfer	-7.139	0.000			
• Adjustments to Budget Year	-	-	305.050	-	305.050

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603760E *I COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*

Change Summary Explanation

FY 2021: Decrease reflects SBIR/STTR transfer offset by reprogrammings.

FY 2022: N/A

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

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	Project (Number/Name) CCC-02 / *INFORMATION INTEGRATION SYSTEMS*	

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
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	-	89.818	122.057	162.803	-	162.803	186.360	236.295	225.202	235.502	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The success of military operations depends on timely, reliable, secure, and synchronized dissemination of command and control and relevant situational awareness information to every military echelon. While wired communications and networks are fairly well developed, providing assured high-bandwidth mobile wireless capabilities that match or exceed commercial wired infrastructure is needed to meet the demands of military users. The goal of the Information Integration Systems project is to develop and demonstrate technologies that will provide effective communications to U.S. forces. Approaches to this goal include developing technologies in these areas:

- High-Capacity Links technologies - enables greater back-haul capability.
- Advanced Networking technologies - supports resilience, adaptability, scalability, and composable systems to enable adaptive effects webs.
- Low Probability of Detection and Anti-Jam (LPD/AJ) technologies - provides assured communications in very high-threat environments.
- Novel Radio Frequency and Spectral Sensing (RF/SS) - supports efficient spectrum management in congested environments and detection of electromagnetic threats.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Space-Based Adaptive Communications Node (Space-BACN)	-	10.000	31.958
Description: The Space-Based Adaptive Communications Node (Space-BACN) program seeks to create a reconfigurable intersatellite optical communications terminal that has low size, weight, power, and cost (SWaP-C) and easily integrates onto small satellites, as well as a methodology for cross-constellation command and control (C2). Based on technologies developed in the Dynamic Network Adaptation for Mission Optimization (DyNAMO) program (budgeted in this PE/Project), Space-BACN will enable on-orbit communications and data relay between heterogeneous satellite constellations that operate on different optical intersatellite link (OISL) specifications. Today's government and commercial OISL-equipped satellites are unable to communicate with each other due to reliance on single-waveform terminals and a lack of standardization for waveform specifications. Space-BACN will overcome this challenge by developing a modular, reconfigurable optical terminal that is standard-agnostic and able to support most current and future OISL protocols. Space-BACN will also develop a C2 system that controls access and configures connectivity between constellations based on availability and mission requirements. Technology developed under this program will transition to the Services and the Space Development Agency (SDA).			
FY 2022 Plans: - Create initial design of reconfigurable communications terminal.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Model multiple government and commercial constellations in simulated environment. ***FY 2023 Plans:*** - Conduct bench top demonstration of reconfigurable, high-speed communications components. - Perform evaluation of optical aperture in presence of vibration and thermal fluctuations. - Develop design for low size, weight, power, and cost (SWaP-C) optical terminal based on bench top design. - Develop cyber hardening plan for communications terminal electronics, operating system, and command and control channel. - Specify interface requirements between communications terminal components. - Define initial application programming interfaces (APIs) and connectivity plan for different scenarios. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects the shift from initial design and modeling to development, testing, and integration.			
Title: Mission Integrated Network Control (MINC)	-	16.000	29.022
Description: The goal of the Mission Integrated Network Control (MINC) program is to develop networking resource management technology to enable agile, self-healing, heterogeneous communications that adapt autonomously to battlefield situations and information needs. Technology developed by MINC will translate warfighter information needs and mission applications into requests for communication services and will autonomously discover and configure communications nodes and pathways to form and execute adaptive effects chains and move information where it is needed the most. Building on technologies developed in the Dynamic Network Adaptation for Mission Optimization (DyNAMO) program, budgeted in this PE/Project, MINC supports applications that will provide up-to-date information to support warfighter situational awareness, a customized common operating picture, and adaptive effects chains across joint all-domain operations in a highly contested environment. Technology from this program will transition to the Services. ***FY 2022 Plans:*** - Design a secure control overlay network that provides resilient discovery and control of network resources and mission services across heterogeneous networks. - Design network orchestration approaches and interfaces that provide semi-autonomous network and information management in support of mission objectives and information needs. - Develop shared interfaces and protocols across program technology aligned with the needs of transition partners and systems in order to enable flexibility in transition. ***FY 2023 Plans:*** - Improve network resource discovery techniques to include resource modeling and forecasting. - Improve network orchestration by responding to network dynamics, deploying intelligent edge functions, and demonstrating control decisions aligned with mission objectives.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Design semi-autonomous mission-driven networking approaches to map mission needs to information needs. - Demonstrate integration with multiple transition-oriented applications. - Interface with transition partners through program workshops in order to develop operationally-relevant capabilities. - Conduct Government-led code reviews and evaluate solution security. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects a shift from initial design to system integration.			
Title: Air Space Total Awareness for Rapid Tactical Execution (ASTARTE)	15.693	24.616	23.947
Description: The Air Space Total Awareness for Rapid Tactical Execution (ASTARTE) program will develop and demonstrate innovative approaches to create a joint, regional (covering the span of an Army division) airspace picture and dynamically managing local airspace operations in an Anti-Access/Area Denial (A2/AD) environment without requiring conventional high-power radars or communications. This capability will support airspace dynamic planning and real-time re-planning and deconfliction of a wide array of airborne systems and long-range fires. ASTARTE will identify and deconflict operational missions in a complicated environment filled with ground and airborne threats, friendly fires, precision guided munitions, manned and unmanned aircraft, and civilian aviation. Based on technologies developed in the Systems of Systems-Enhanced Small Units (SESU) program (budgeted in PE 0603766E/Project NET-01), ASTARTE will develop a virtual and live testbed for airspace management systems, a series of algorithms for airspace planning and operations, and a collection of sensors, leveraging existing and novel sensors for real-time spatial and temporal tracking of airborne platforms. ASTARTE will be compatible with legacy command and control (C2) airspace management tools to take advantage of prior investments in technologies, such as human-machine interfaces, and to minimize costs and the impact on training. Technologies from this program will transition to the Army and the Air Force. ***FY 2022 Plans:*** - Develop understanding and decision algorithms. - Conduct critical design review of algorithms and sensor systems. - Establish Army and Air Force testbeds that will interface to legacy test and training infrastructure. - Integrate understanding and decision algorithms and sensor models into testbed. - Conduct constructive and virtual integration experiments to evaluate technology performance. - Conduct virtual and live experimentation to assess operational use of ASTARTE technology in joint live exercises. ***FY 2023 Plans:*** - Implement understanding and decision algorithms in software to run in Army Command Post Computing environment. - Integrate ASTARTE sensor architecture with existing DoD sensor systems. - Evaluate ASTARTE sensor network performance in live fire exercises to verify predicted performance. - Conduct additional live experimentation to assess operational use of ASTARTE technology in joint exercises.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Refine ASTARTE understanding and decision software based on virtual and live experimentation. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.			
Title: Resilient Networked Distributed Mosaic Communications (RNDMC) ***Description:*** Resilient Networked Distributed Mosaic Communications (RNDMC) aims to provide Beyond-Line-Of-Sight (BLOS) tactical communications for an Anti-Access/Area Denial (A2/AD) environment by developing low-cost expendable transceivers that may be hand carried or hosted on ground platforms, autonomous air vehicles, high altitude platforms, and low-cost/low earth orbit satellites. RNDMC plans to use a combination of synchronized transceivers and tactical radios to enhance desired signals and reject intentional and unintentional interference. Based on technologies developed in the Protected Forward Communications (PFC) program (budgeted in this PE/Project), RNDMC will design, develop, and demonstrate a distributed field of expendable transceivers, providing a robust, low-cost, BLOS tactical communications system that degrades gracefully as transceiver nodes become unavailable. The RNDMC goal is a demonstration on ground and air platforms and will not be reliant on Global Positioning System (GPS). Technologies from this program will transition to the Services. ***FY 2022 Plans:*** - Refine system-level design of multiple-hop RNDMC system. - Build prototypes for low size, weight, power, and cost (SWaP-C) transceiver nodes. - Begin unit testing of transceiver nodes including tactical waveform augmentation and channel sounding. - Conduct lab testing of prototype system including gain enhancements from distributed coherent beamforming and interference suppression through distributed coherent beam-nulling. - Conduct long link air-to-ground test to validate RNDMC approach in a multipoint to point configuration. ***FY 2023 Plans:*** - Update system designs based on lessons learned from the long-link test. - Conduct terrestrial test to validate RNDMC approach in a multipoint to multipoint configuration. - Integrate RNDMC payload onto unmanned airborne platforms to support long-range relay testing. - Conduct field exercise to validate RNDMC approach in a multi-hop relay and multipoint to multipoint configuration. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.	10.965	22.153	21.762
Title: Composable Logistics and Information Omniscience (LogX) ***Description:*** The Composable Logistics and Information Omniscience (LogX) program is developing and demonstrating software for real-time logistics and supply chain system situational awareness (diagnosis), future state prediction (prognosis),	26.552	24.965	21.541

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
and resilience at unprecedented scale and speed. The software will integrate a range of technical innovations spanning human-machine interface, dynamic data visualization, and distributed/collaborative software design. Based upon technologies developed in the Prototype Resilient Operations Testbed for Expeditionary Urban Systems of Systems (PROTEUS) program (budgeted in PE 0603766E, Project NET-01), the LogX capability will allow users to achieve a more distributed and resilient logistics command and control (C2) system utilizing planned cloud-based data environments. The new capability will be tested in an experimental environment tied to current logistics datasets. Technologies from this program will be transitioned to the Services and Combatant Commands, including U.S. Transportation Command and the Defense Logistics Agency (DLA). ***FY 2022 Plans:*** - Demonstrate an integrated system ready for deployment to operational settings. - Demonstrate ability to assess resilience within the logistics enterprise. - Characterize the effect of supply chain fluctuations or disruptions. - Demonstrate dynamic adaptation of the system to mitigate disruptions and improve outcomes. ***FY 2023 Plans:*** - Demonstrate a scalable and deployable capability in a range of operational settings with transition partners. - Demonstrate ability to provide enhanced awareness using operational logistics and supply chain data to inform decision making across the logistics enterprise. - Demonstrate the ability to improve resilience within the logistics enterprise. - Document and transition software to hosting on Services' and/or Combatant Commands' information technology (IT) systems. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from integration and testing efforts to preparation for final demonstrations to transition partners.			
Title: Strategic Chaos Engine for Planning, Tactics, Experimentation and Resiliency (SCEPTER)	-	2.000	15.000
Description: Based on technologies developed under the Air Space Total Awareness for Rapid Tactical Execution (ASTARTE) program (budgeted in this PE/Project), the Strategic Chaos Engine for Planning, Tactics, Experimentation and Resiliency (SCEPTER) program will develop machine generated strategies for strategic planning. SCEPTER will discover novel and surprising Courses of Action (CoAs) by exploring the high complexity state-action space of military engagements at high machine speeds. High CoA exploration speed is enabled by tailorable abstraction of trusted, expert informed models. A few of the highest performing CoAs will be validated in higher fidelity simulators along with a thorough human review. Initially, SCEPTER will generate synthetic CoAs to identify vulnerabilities in human generated plans. In later stages of the program, SCEPTER will be applied in developing novel plans. Ultimately, SCEPTER will continually evaluate war plans as changes in theater occur (blue			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
and/or red force laydowns, new equipment, etc.) to find new opportunities and weaknesses and help prevent surprise from competitors. Technology developed under this program will transition to the Services. ***FY 2022 Plans:*** - Define military scenarios that will be used to evaluate SCEPTER technologies ***FY 2023 Plans:*** - Develop initial methods for incorporating unscripted goal-oriented agents into CoA generation and evaluation. - Develop initial methods for managing and controlling the exponential growth of the global state-action space. - Demonstrate the performance of machine derived plans against three or more military scenarios. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects a shift from initial evaluation planning to strategy development.			
Title: Protected Forward Communications (PFC)	14.545	11.325	10.360
Description: The collaborative application of combat power in ground tactical operations demands reliable exchange of rich information and precise coordination of actions across various echelons. These operations take place over three critical conversations: (1) to coordinate the actions of a local group, (2) to coordinate group and airborne assets, and (3) to interact with rear echelon command. The communication links over which these three conversations take place are at risk from jamming and geolocation operations conducted with increasingly sophisticated exploitation and denial technology employed by our adversaries. This problem is compounded by demands for ever-increasing capacity of these links. The Protected Forward Communications (PFC) program will build on technical advances in resilient, efficient, and aware communications technology to design a single communication architecture to protect all three conversations from jamming and geolocation. PFC is generally applicable to small unit operations and is particularly relevant to the close air support (CAS) function typically executed by the Joint Terminal Attack Controller (JTAC) or Forward Air Controller (FAC). The PFC program will transition to the Services. ***FY 2022 Plans:*** - Conduct engineering over-the-air test of system prototype to verify updates and modifications. - Conduct over-the-air testing of system prototype with service transition partner in an emulated anti-access, area denial environment. - Demonstrate air-to-air capability, integration of new anti-jam waveform, and multi-hop communications chain with different waveforms used for different hops. ***FY 2023 Plans:*** - Conduct testing of advanced networking capability to support communication across heterogeneous platforms and waveforms.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Demonstrate integrated communications capabilities to transition partners based upon mission scenarios and user needs. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects shift from prototyping and over-the-air testing to integration and demonstration.			
Title: Network Universal Persistence (Network UP) ***Description:*** Current radios send network control information and data using the same wireless link. This produces a common failure mode when that wireless link degrades. In many of today's military wireless networks, even brief wireless link outages create a loss of network connectivity that can take minutes to recover once the wireless link is re-established. During these network outages, data transmission is not possible. The Network UP program will develop and demonstrate radio technology that maintains network reliability through periods of frequent signal degradation that routinely occur in military operational environments. Isolation of critical control channel information in a separate, robust wireless link will allow creation of a protected control channel that can maintain network reliability even when the data channel is lost. The Network UP program will develop technology and a prototype system that enables military wireless networks to send data over dynamic, unstable wireless links. The program will develop approaches to separate the control and data planes across different wireless links and design and implement mechanisms to maintain synchronization across those separate links. Technologies developed under this program will transition to the Services. ***FY 2022 Plans:*** - Test and verify that the operation of the integrated hardware and software meets program goals. - Demonstrate network connectivity and data throughput on wireless channels in the presence of high levels of interference. ***FY 2023 Plans:*** - Transition Network UP technology into the U.S. Army's Integrated Network Technology program of record. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from demonstrations to transition efforts.	16.829	10.998	9.213
Title: Secure Handhelds on Assured Resilient networks at the tactical Edge (SHARE) ***Description:*** The goal of the Secure Handhelds on Assured Resilient networks at the tactical Edge (SHARE) program was to develop innovative networking and information sharing approaches to enable U.S. and coalition forces to coordinate tactical operations effectively, efficiently, and securely by eliminating today's prohibitive security cost and complexity barriers. SHARE provided the level of security provided by today's communications systems, while managing trust at the tactical edge, and provided new opportunities for U.S. and coalition forces to gain and maintain a tactical advantage on the battlefield. Coordination	5.234	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
included providing all the information required to enable the command and control necessary to plan and execute operations in all phases of warfare. Technology from this program transitioned to Special Operations and other Service components.			
Accomplishments/Planned Programs Subtotals	89.818	122.057	162.803

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	Project (Number/Name) CCC-06 / *COMMAND, CONTROL AND COMMUNICATION SYSTEMS*	

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
CCC-06: *COMMAND, CONTROL AND COMMUNICATION SYSTEMS*	-	130.366	129.737	142.247	-	142.247	100.385	49.270	26.250	16.500	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

This project funds classified DARPA programs that are reported in accordance with Title 10, United States Code, Section 119(a)(1) or its successor.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Classified DARPA Program	130.366	129.737	142.247
Description: This project funds Classified DARPA Programs. Details of this submission are classified. ***FY 2022 Plans:*** Details will be provided under separate cover. ***FY 2023 Plans:*** Details will be provided under separate cover. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	130.366	129.737	142.247

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603766E / *NETWORK-CENTRIC WARFARE 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	-	628.540	668.271	678.562	-	678.562	771.075	654.200	620.609	447.955	-	-
NET-01: *JOINT WARFARE SYSTEMS*	-	152.136	161.089	68.007	-	68.007	69.731	120.790	169.195	177.918	-	-
NET-02: *MARITIME SYSTEMS*	-	161.728	149.127	179.397	-	179.397	196.094	186.260	208.914	270.037	-	-
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	314.676	358.055	431.158	-	431.158	505.250	347.150	242.500	0.000	-	-

A. Mission Description and Budget Item Justification

The Network-Centric Warfare Technology Program Element is budgeted in the Advanced Technology Development budget activity because it addresses high payoff opportunities to develop and rapidly mature advanced technologies and systems required for today's network-centric warfare concepts. It is imperative for the future of the U.S. forces to operate flawlessly with each other, regardless of which services and systems are involved in any particular mission. The overarching goal of this program element is to enable technologies at all levels, regardless of service component, to operate as one system.

The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly increased capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents using systems that are flexible, robust, and difficult to neutralize; and (2) U.S. doctrine that limits the use of firepower to lessen the impact of operations on noncombatants. These problems are magnified in urban and semi-urban areas where combatants and civilians are often co-located and in peacekeeping operations where combatants and civilians are often indistinguishable. Meeting these challenges places a heavy burden on joint war planning. Understanding opponent networks is essential so that creative options can be developed to counter their strategies. Synchronization of air and ground operations to apply force only where needed and with specific effects is required. This project supports all levels of the force structure including: (1) the strategic/operational level by generating targeting options against opponents' centers of gravity that have complex networked relationships; (2) the tactical/operational level by managing highly automated forces with tight coupling between air and ground platforms; and (3) the focused tactical level by developing platforms and tools, which acquire targets of opportunity and cue network-based analysis of likely enemy operations thus maximizing the effectiveness of ground forces in stability and support operations.

The Maritime Systems project is identifying, developing and rapidly maturing critical advanced technologies and system concepts for the naval forces' role in today's network centric warfare concept. Improvements in communications between and among submarines, surface ships and naval aircraft have allowed these forces to operate seamlessly with each other and with other Service's network centric systems. Naval forces will play an ever-increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea, and their versatile ability to provide both rapid strike and project-sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network centric forces.

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603766E *I NETWORK-CENTRIC WARFARE TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	641.158	584.771	0.000	-	0.000
Current President's Budget	628.540	668.271	678.562	-	678.562
Total Adjustments	-12.618	83.500	678.562	-	678.562
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	83.500			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	8.026	0.000			
• SBIR/STTR Transfer	-20.644	0.000			
• Adjustments to Budget Year	-	-	678.562	-	678.562

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: NET-01: *JOINT WARFARE SYSTEMS*		
Congressional Add: *ABII Acceleration - Congressional Add*	-	50.000
Congressional Add Subtotals for Project: NET-01	-	50.000
Project: NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*		
Congressional Add: *Deployable Surveillance Systems - Congressional Add*	-	21.000
Congressional Add: *Ukraine Supplemental - Congressional Add*	-	12.500
Congressional Add Subtotals for Project: NET-06	-	33.500
Congressional Add Totals for all Projects	-	83.500

Change Summary Explanation

FY 2021: Decrease reflects SBIR/STTR transfer offset by reprogrammings.
FY 2022: Increase reflects Congressional adds for Program Increase-deployable surveillance systems, ABII acceleration, and Ukraine Supplemental.
FY 2023: FY 2023 funding increase reflects the fact that the FY 2022 President's Budget request did not include out-year funding.

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	Project (Number/Name) NET-01 / *JOINT WARFARE SYSTEMS*	

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
NET-01: *JOINT WARFARE SYSTEMS*	-	152.136	161.089	68.007	-	68.007	69.731	120.790	169.195	177.918	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly increased capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents using systems that are flexible, robust, and difficult to neutralize; and (2) U.S. doctrine that limits the use of firepower to lessen the impact of operations on noncombatants. These problems are magnified in urban and semi-urban areas where combatants and civilians are often co-located and in peacekeeping operations where combatants and civilians are often indistinguishable. Meeting these challenges places a heavy burden on joint war planning. Understanding opponent networks is essential so that creative options can be developed to counter their strategies. Synchronization of air and ground operations to apply force only where needed and with specific effects is required. This project supports all levels of the force structure including: (1) the strategic/operational level by generating targeting options against opponents' centers of gravity that have complex networked relationships; (2) the tactical/operational level by managing highly automated forces with tight coupling between air and ground platforms; and (3) the focused tactical level by developing platforms and tools, which acquire targets of opportunity and cue network-based analysis of likely enemy operations thus maximizing the effectiveness of ground forces in stability and support operations.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Assault Breaker II (ABII)	80.287	57.833	36.515
Description: Assault Breaker II (ABII) seeks to change the current warfighting paradigm of reliance on a Service-specific and platform centric force that executes prescribed kill chains to a highly adaptable and capability-based force. This new paradigm operates as a disaggregated kill web able to execute rapidly composable, joint, and all domain kill chains. Building upon technologies developed in the Cross Domain Maritime Surveillance and Targeting (CDMaST) program, budgeted in PE 0603766E, Project NET-02, ABII will exploit both existing and emerging technologies across the Services to address known capability gaps, opportunities, and threats. ABII will conduct mission-centric, multi-Service and multi-domain analyses, modeling & simulation (M&S), and experimentation to inform research and development and program of record recommendations. ABII will build an enduring, multi-service M&S environment to support complex mission level kill web analysis. ABII will also design and develop a Vanguard Force DevOps Environment (VFDE) and battle management enclave with physical nodes that will enable the transition of ABII technologies, concepts and architectures to the Services.			
FY 2022 Plans: - Initiate studies for the finalization of kill web architectures and effects.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Execute model development for the M&S environment. - Demonstrate model and simulation initial operating capability. - Demonstrate completed modules for the multi-domain, multi-level security environment. - Execute experimentation campaign utilizing VFDE and Distributed Experimentation Environment (DE2) capabilities. - Perform preliminary design for large scale exercise-based experiment. - Demonstrate completed modules of battle management command and control tool sets. - Demonstrate operational capability of VFDE and execute initial integration of battle management tools. ***FY 2023 Plans:*** - Identify kill web architectures and effects. - Evaluate mission scenario operability of the model catalogue within the M&S environment. - Demonstrate model and simulation fully operational capability. - Test and evaluate multi-domain, multi-level security environment. - Execute experimentation campaign utilizing VFDE and DE2 capabilities. - Participate in large scale exercise-based experiment. - Integrate battle management tools into VFDE. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the completion of the infrastructure stand up and shift to full modeling and simulation capabilities and execution of large-scale experiments.			
Title: Air Combat Evolution (ACE)	28.601	27.666	23.152
Description: As the Services develop new Joint Multi-Domain Battle warfighting concepts, there is a strong demand for innovative ways to assess architectures, advance technology, and support operators developing advanced multi-domain tactics. Based upon technologies developed in the System of Systems Integration Technology and Experimentation (SoSITE) program, budgeted in this PE/Project, the Air Combat Evolution (ACE) program will apply technologies and principles of distributed autonomy and artificial intelligence (AI) to aerial within-visual-range (WVR) maneuvering, colloquially known as a dogfight, in modeling and simulation (M&S), sub-scale, and ultimately full-scale vehicles. The program will deliver an initial instantiation of a scalable AI controller enabling aircraft autonomy at levels ranging from an advanced tactical autopilot for dynamic maneuver to a form of multi-domain mosaic battle management controller. Experiments will explore both augmentation of existing manned platforms and enhanced future unmanned systems. ACE will provide an early opportunity to build operator trust in combat autonomy and demonstrate adaptive human-machine teaming tools and architectures. Technology developed by this program will transition to the Services. ***FY 2022 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Refine and implement WVR algorithms onto sub-scale commercial unmanned aerial vehicles (UAVs) and test in 1v1, 2v1, and 2v2 scenarios. - Implement Human Machine Interfaces (HMIs) for full-scale aircraft trust assessments. - Conduct trust assessment events in M&S environment in more complex 2v1 and 2v2 scenarios. - Conduct extension of combat autonomy to more complex campaign scenarios. - Prepare for full-scale aircraft testing of combat autonomy. ***FY 2023 Plans:*** - Refine and implement WVR algorithms onto full-scale aircraft with progression from test to 1v1 and 2v1 scenarios. - Conduct full-scale aircraft trust assessment event. - Extend combat autonomy to more complex campaign scenarios with additional realism. - Conduct full-scale aircraft flight evaluations of combat autonomy. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from major autonomy development activities to implementation and test.			
Title: Systems of Systems-Enhanced Small Units (SESU)	18.487	17.560	8.340
Description: The System of Systems-Enhanced Small Unit (SESU) program is developing and demonstrating capabilities based on system-of-systems architecture that could enable a small unit to destroy, deceive, and/or disrupt the adversary's Anti-Access / Area Denial (A2/AD) capabilities in order to enable joint and coalition multi-domain operations at appropriate times and locations. SESU-developed capabilities will provide the small unit with improved awareness of enemy force composition, disposition, and intent. Technologies to accomplish this include command and control (C2) that operates in a contested environment; distributed sensing, including the ability to leverage indigenous information sources; hybrid effects that include a mix of kinetic, non-kinetic, and information operations capabilities; and autonomous systems to deliver effects and conduct sensing. A Campaign of Learning (CoL) will be conducted in partnership with the Army, and technologies produced by this program will be transitioned to the Services. ***FY 2022 Plans:*** - Conduct live and virtual demonstrations of full SESU capabilities of autonomous platforms, sensors, and effectors. - Conduct live, virtual, constructive experiments for government-provided missions in realistic environments to demonstrate the ability of the system to support new missions and transition. - Apply SESU technologies to new threats and geographies in live, virtual, and constructive experiments. - Conduct independent SESU system overall performance and operational analysis in SESU's ability to destroy, disrupt, degrade, and/or delay aspects of an adversary's A2/AD capabilities. ***FY 2023 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Analyze and report results from the Army's Project Convergence 2022 and other experimentation events. - Transition the SESU Program to the Army for continued operational experimentation, capability development, and incorporation of spin-out technologies into existing programs of record. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from technology refinement and experimentation to program transition to the Army.			
Title: Prototype Resilient Operations Testbed for Expeditionary Urban Systems of Systems (PROTEUS)	13.136	8.030	-
Description: The Prototype Resilient Operations Testbed for Expeditionary Urban Systems of Systems (PROTEUS) program is demonstrating that a dynamically composable Mosaic warfare approach provides superior performance and adaptability in the dynamic, uncertain environment imposed on U.S. warfighters by urban combat operations. PROTEUS will be adaptive to an inherently dynamic and fluid environment that will account for the environmental influence of non-combatants in urban combat as well as kinetic warfighting. Technologies will be integrated using systems of systems principles developed under the System of Systems Integration Technology and Experimentation (SoSITE) program, budgeted in this PE/Project. To support concept development, testing, and warfighter interaction, the program will also develop a supporting virtual testbed. Technologies from this program will be transitioned to the Services. ***FY 2022 Plans:*** - Document and transition software to Marine Corps for future use. - Support development of program software features requested by the Marine Corps. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: System of Systems Integration Technology and Experimentation (SoSITE)	11.625	-	-
Description: The System of Systems Integration Technology and Experimentation (SoSITE) program implemented an architecture framework capable of assessing and demonstrating potential operational benefits of integrating various system capabilities to improve mission success in contested environments. Such assessments optimized system-level trades of requirements and architectures to leverage an integrated set of system characteristics and capabilities. The demonstration assessment metrics measured individual and combined system performance to streamline resource allocation to maximize operational impact. In addition, providing a modeling and simulation (M&S) environment to assess complex systems enabled greater utility of emerging system technologies, since they can be assessed in near-real-world simulations without the real-world costs of testing fully integrated systems. The program also developed system synthesis and integration technologies that enabled rapid assimilation of new and off-the-shelf technologies into the system of systems architecture. These technologies are breaking down current barriers to entry that new technologies face in system of systems using formal methods, compositional reasoning,			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
and automated design space exploration. Technologies from this program transitioned to the U.S. Air Force's Spectrum Warfare Wing and SAF/AQL (Secretary of the Air Force/Special Programs).			
Accomplishments/Planned Programs Subtotals	152.136	111.089	68.007

	FY 2021	FY 2022
Congressional Add: ABII Acceleration - Congressional Add	-	50.000
FY 2022 Plans: Accelerate and expand multi-domain capabilities.		
Congressional Adds Subtotals	-	50.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	Project (Number/Name) NET-02 / *MARITIME SYSTEMS*	

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
NET-02: *MARITIME SYSTEMS*	-	161.728	149.127	179.397	-	179.397	196.094	186.260	208.914	270.037	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Maritime Systems project is identifying, developing and rapidly maturing critical advanced technologies and system concepts for the naval forces' role in today's network-centric warfare concept. Improvements in communications between and among submarines, surface ships and naval aircraft have allowed these forces to operate seamlessly with each other and with other Service's network-centric systems. Naval forces will play an ever-increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea, and their versatile ability to provide both rapid strike and project sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network-centric forces.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Manta Ray	23.562	29.500	38.569

Description: The Manta Ray program is developing and demonstrating a new class of long-duration, long-range unmanned underwater vehicles (UUVs) at an acquisition and lifecycle cost significantly less than current payload-capable UUVs. This new class of UUV will give the combatant commander an amplification of capacity without disrupting current operations by remaining independent of manned vessels and ports once deployed. The primary goal of the Manta Ray program is to open a design space for future UUVs capable of both long duration missions and large payload capacity. A secondary goal of the program is to advance key technologies benefiting other naval designs such as low lifecycle cost UUV operations, energy management technologies to enable long-duration operations, biofouling reduction technologies, and long-duration navigational enablers. The anticipated transition partner is the U.S. Navy.

FY 2022 Plans:
- Continue risk reduction testing of subsystems in controlled maritime environments.
- Conduct testing of vehicle software and autonomy in simulation and surrogate environments.
- Conduct scaled testing of integrated vehicle in controlled maritime environments.
- Commence fabrication and integration of full-scale vehicle.

FY 2023 Plans:
- Conduct at-sea demonstration of key subsystems.
- Complete fabrication and integration of full-scale vehicle.
- Conduct preliminary testing of full-scale vehicle in controlled maritime environments.

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Conduct at-sea demonstration of full-scale vehicle performing full range of behaviors and capabilities. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects a shift from technology demonstrations to integrated platform fabrication and full systems testing.			
Title: No Manning Required Ship (NOMARS) ***Description:*** No Manning Required Ship (NOMARS) is developing small, low-cost, disaggregated naval platforms to demonstrate the ability to perform persistent power projection and force application combat missions currently conducted from large, high-value capital ships. The NOMARS program will design a ship that can operate autonomously for long durations at sea, enabling a ship design process that eliminates considerations associated with crew. NOMARS focuses on exploring novel approaches to the design of the sea frame (the ship without mission systems) while accommodating representative payload size, weight, and power. The goal of the program is to demonstrate the feasibility of Unmanned Surface Vessels (USVs) that operate autonomously for months to years without human intervention, in large numbers, with only periodic, depot-based maintenance. This capability will enable disaggregated persistent USVs, allowing the surface fleet to credibly threaten peer adversaries and negate their investments in high-cost weapon systems designed to counter large naval targets such as aircraft carriers. A successful NOMARS program will prove feasibility of a small unmanned ship with significantly improved reliability and functional performance over current USVs providing a pathway to allow a distributed lethality concept to become viable: small ships, in large numbers, each of which is individually low-cost and low-value, but in aggregate presents a significant deterrent. The anticipated transition partner is the U.S. Navy. ***FY 2022 Plans:*** - Continue preliminary design of multiple concept vessels. - Conduct Preliminary Design Review of NOMARS concept vessels. - Initiate demonstrator vessel development. ***FY 2023 Plans:*** - Conduct detailed design for NOMARS demonstrator vessel. - Complete Critical Design Review for NOMARS demonstrator vessel. - Conduct subsystem risk reduction demonstrations. - Initiate integrated system-level fabrication. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects a shift to detailed design of the selected concept vessel(s), procurement of long lead items, sub-system integration and initial development of the demonstrator vessel.	24.000	30.600	38.500
Title: Sea Train	27.707	33.000	35.650

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The Sea Train program is supporting the delivery of masses of unmanned surface vessels into theater, without reliance on large, manned capital assets. The Sea Train program is developing and demonstrating approaches to exploit the efficiencies of longer slender hulls, while enabling a distributed fleet of tactical Unmanned Surface Vessels (USVs). The Sea Train concept enables vessels that are efficient for transoceanic transport while enabling dispersed operations as individual vessels. The Sea Train program is developing and demonstrating connectors and approaches to couple the vessels, the control laws required to drive the vessel in open ocean conditions, sensor approaches to understand the wave environment to efficiently navigate the vessel, and the autonomy required to connect and disconnect the vessels without human intervention. The goal of this effort is to improve transport efficiency over what can be achieved with current monohull designs. This allows for the efficient transport of smaller vessels into and out of theater, an operation that is normally accomplished today by carrying smaller vessels on board larger vessels or reliance on at-sea refueling of smaller vessels. The anticipated transition partner is the Navy. ***FY 2022 Plans:*** - Conduct scaled model testing, analysis, and simulation to inform the follow on one-quarter scale model design and demonstrator system Preliminary Design Review. - Conduct objective system Concept Design Review update. - Begin development of a one-quarter scale demonstrator system to support in-water testing of the fully assembled, self-powered vehicle. - Initiate demonstrations to evaluate control laws and autonomy behaviors of aggregated formations in high sea-state conditions. ***FY 2023 Plans:*** - Conduct one-quarter scale open water model testing, analysis and simulation to inform the demonstrator system conceptual and Preliminary Design Reviews. - Conduct objective system Concept Design Review update. - Initiate transition of Sea Train models to the Navy for follow on testing to support emerging Medium Unmanned Surface Vehicles (MUSV) operations and designs. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects minor program repricing.			
Title: Goblin	-	14.200	22.378
Description: The undersea domain has significant importance to national security and military operations, but manned missions are restricted in their operational ranges. The Goblin program will enhance U.S. autonomous capabilities in the challenging undersea domain by developing and demonstrating complex underwater systems able to search, locate, and execute mission objectives without the need for human control. Navigation approaches will focus on the use of commercial, low-cost navigation hardware combined with environmental feature-based algorithm approaches to eliminate reliance on the Global Positioning			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
System (GPS) for long duration missions. Key Goblin technical challenges include sensing techniques that provide high-resolution navigation without GPS, perception and effector strategies for objects with unknown parameters, long-duration autonomy approaches to support mission execution, and autonomy approaches that do not rely on human interaction. The anticipated transition is to the U.S. Navy. ***FY 2022 Plans:*** - Begin subsystems design, long-lead purchase items, and initial subsystems integration. - Test subsystems in a representative maritime environment. - Conduct risk reduction activities supporting preliminary development of fully integrated test system. ***FY 2023 Plans:*** - Conduct risk reduction activities supporting development of demonstrator systems. - Begin demonstrator development and continue subsystem integration. - Test demonstrator systems in a representative maritime environment. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects a shift from subsystem design to full demonstrator development.			
Title: Timely Information for Maritime Engagements (TIMEly)	23.259	16.500	16.000
Description: Integration of undersea elements for joint cross-domain operations is critical for developing the most effective distributed kill webs. The Timely Information for Maritime Engagements (TIMEly) program is creating a heterogeneous underwater network architecture that will span the ocean and bridge to other operating domains. Building upon technologies learned in the Positioning System for Deep Ocean Navigation (POSYDON) program, (previously budgeted in this PE/Project), TIMEly will provide an adaptive, heterogeneous, scalable communications capability to link undersea and cross-domain assets together into kill webs with minimal operator burden. The program will focus on developing architectures with the capability to transfer the right information to its intended recipient. TIMEly will work within commonly understood limitations, with a focus on protocols, quality of service, and information exchange. The program will leverage developments demonstrating short-range and long-range acoustic communications at higher bandwidth and greater reliability, while minimizing detectability. The program will also leverage recent developments in network interoperability to manage heterogeneous undersea and cross-domain networks. Technology developed by this program will transition to the Navy. ***FY 2022 Plans:*** - Fabricate prototype TIMEly nodes for in-water demonstration. - Refine data management architecture and TIMEly communication protocols. - Develop networking and node autonomy behaviors.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Conduct end-to-end testing of TIMEly architectures to evaluate performance. ***FY 2023 Plans:*** - Design and manufacture form-fit prototype hardware for demonstration. - Refine networking and autonomy behaviors. - Develop network user interface. - Conduct test preparations and integration for end-to-end demonstration with mission partners. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from fabrication to manufacturing and integration.			
Title: Multi-Azimuth Defense Fast Intercept Round Engagement System (MAD-FIRES)	-	6.000	8.300
Description: The Multi-Azimuth Defense Fast Intercept Round Engagement (MAD-FIRES) program is developing a point defense system against today's most stressing threats by developing a highly maneuverable, medium caliber, guided projectile, fire sequencing and control system capable of neutralizing large threat raids of high speed, highly maneuverable targets. Leveraging recent advancements in gun hardening, miniaturization of guided munition components, and long-range sensors, MAD-FIRES advances fire control technologies, medium caliber gun technologies, and guided projectile technologies enabling the multiple, simultaneous target, kinetic engagement mission at greatly reduced costs. MAD-FIRES will achieve lethality overmatch through accuracy rather than size, thus expanding the role of smaller combat platforms into missions where they have been traditionally outgunned. MAD-FIRES, sized as a medium caliber system, enhances flexibility for installment as a new ship self-defense system. This phase of the program is focused on demonstrating end-to-end system performance against surrogate supersonic targets. Prior to FY 2022, this program was funded in PE 0602702E, Project TT-03. ***FY 2022 Plans:*** - Initiate enhanced lethality study to refine threat defeat predictions. - Initiate development of software and hardware-in-the-loop simulations to improve fidelity of tactical models. ***FY 2023 Plans:*** - Validate lethality model through analysis of impact results. - Refine software and hardware-in-the-loop simulations for engagement of targets. - Initiate design cycle to mature projectile towards tactical capability against threats. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** FY 2023 increase reflects activities leading up to at sea testing of a fully integrated demonstrator.			
Title: Hunter	12.863	6.924	6.000

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The Hunter program seeks to develop novel concepts for Extra Large Unmanned Undersea Vehicles (XLUUVs) to deliver complex payloads. The program will explore efficient encapsulation and buoyancy control concepts to be implemented with advanced fiber handling capabilities for high bandwidth communications in order to create a highly modular and adaptable ocean interface. This interface will give XLUUVs significantly increased payload handling ability and allow them to deliver completely new capabilities previously delivered only by manned platforms. Building upon research conducted under the Cross Domain Maritime Surveillance and Targeting (CDMaST) program budgeted in this PE/Project, the Hunter program will establish a new capability for integration into maritime system of systems warfare architectures. Technologies developed under the Hunter program will transition to the Navy. ***FY 2022 Plans:*** - Upgrade Hunter carriage to accommodate hosting and deployment of alternate payloads. - Complete coordinated in-water system of systems testing. ***FY 2023 Plans:*** - Conduct end-to-end mission demonstration. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects the transition from system integration and test to final mission demonstration.			
Title: Advanced Propulsors, Experimental (APEX) ***Description:*** Current submarine propulsor and propeller designs have reached the technical limits of achieving significant improvements, constrain ship layouts, and maneuvering capabilities. The Advanced Propulsors, Experimental (APEX) program is developing and demonstrating a new generation of submarine propulsor designs enabling revolutionary improvements in submarine design, maneuverability, speed, and quieting that will transform future submarine designs. The APEX program is building upon technologies developed in the Maritime Defense program budgeted in PE 0602702E, Project TT-03. The anticipated transition is to the U.S. Navy. ***FY 2023 Plans:*** - Initiate mechanical design feasibility studies. - Complete the hydrodynamic design. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.	-	-	14.000
Title: Cross Domain Maritime Surveillance and Targeting (CDMaST)	11.326	3.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The Cross Domain Maritime Surveillance and Targeting (CDMaST) program seeks to identify and implement architectures consisting of novel combinations of manned and unmanned systems to execute long-range kill chains and develop a robust "kill web" against submarines and ships over large contested maritime areas. By exploiting promising new developments in unmanned platforms, seafloor systems, and emerging long-range weapon systems, the program will develop an advanced, integrated undersea and above sea warfighting capability. The CDMaST program will establish an analytical and experimental environment to explore architecture combinations in terms of operational effectiveness as well as engineering feasibility and robustness. The program will leverage enabling technologies needed for command, control, and communication (C3) between physical domains in order to support the architecture constructs. Through experimentation, the program will not only demonstrate integrated system performance, but also develop new tactics that capitalize on features created by the heterogeneous architecture. The CDMaST program will invest in technologies that will reduce cost, manage complexity, and improve reliability. Technologies from this program will transition to the Navy. ***FY 2022 Plans:*** - Complete the analysis of the final experimentation event and provide a report of program experimentation results. - Complete transition of hardware, software, and reports to the Navy. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Ocean of Things	13.011	5.403	-
Description: The goal of the Ocean of Things program is to advance oceanographic sensing and maritime awareness using low-power microelectronics and advanced data analytics. Ocean of Things builds upon advances made in the Cross Domain Maritime Surveillance and Targeting (CDMaST) program, budgeted in this PE/Project. Ocean of Things will develop large numbers of heterogeneous sensing floats to cover large ocean areas, while incorporating environmentally friendly construction materials. These platforms will leverage satellite communications to populate a large data repository with sensor outputs for shared processing. Ocean of Things will apply advanced analysis techniques to the stored data to synthesize and discover new signals and behaviors in the ocean environment. The program will research the spatio-temporal composability of sensors and develop applications for distributed platform behavior using an internet of things (IoT) architecture deployed across the world's oceans. Further research will examine additional platform capabilities and system impacts of communication rate and edge processing. The Ocean of Things program will improve ocean awareness and provide persistent coverage to areas between existing platforms. Technologies developed in Ocean of Things will transition to the Navy. ***FY 2022 Plans:*** - Develop advanced algorithms and automated performance.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Integrate analytic and ocean modeling products into Navy applications. - Test advanced algorithms on large-scale data. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Title: Angler ***Description:*** The undersea domain has significant importance to national security and military operations. Yet it is a challenging domain in which to operate due to extreme water pressures, restricted communications, ever changing bottom environments, and marine fouling and corrosion. The Angler program will improve U.S. operations in this domain by enabling underwater robotic systems significantly ahead of the state-of-the-art. These robotic systems would be able to search and manipulate objects autonomously, even in dark, turbulent, and semi-opaque sea conditions without the need for human control and without reliance on the Global Positioning System (GPS). Key Angler technical challenges include sensing techniques that provide high-resolution navigation without GPS, perception and manipulation strategies for objects with unknown parameters, long duration autonomy approaches to support mission execution, and autonomy approaches that do not rely on human intervention. This program was initiated in an applied research effort budgeted in FY 2020 PE 0602702E, Project TT-03. ***FY 2022 Plans:*** - Complete program closeout activities. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	26.000	4.000	-
Accomplishments/Planned Programs Subtotals	161.728	149.127	179.397

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	Project (Number/Name) NET-06 / *NETWORK-CENTRIC WARFARE 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
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	314.676	358.055	431.158	-	431.158	505.250	347.150	242.500	0.000	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

This project funds classified DARPA programs that are reported in accordance with Title 10, United States Code, Section 119(a)(1) or its successor.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Classified DARPA Program	314.676	324.555	431.158
Description: This project funds Classified DARPA Programs. Details of this submission are classified.			
FY 2022 Plans: Details will be provided under separate cover.			
FY 2023 Plans: Details will be provided under separate cover.			
FY 2022 to FY 2023 Increase/Decrease Statement: Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	314.676	324.555	431.158

	FY 2021	FY 2022
Congressional Add: Deployable Surveillance Systems - Congressional Add	-	21.000
FY 2022 Plans: Details will be provided under separate cover.		
Congressional Add: Ukraine Supplemental - Congressional Add	-	12.500
FY 2022 Plans: Details will be provided under separate cover.		
Congressional Adds Subtotals	-	33.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-06 / *NETWORK-CENTRIC WARFARE TECHNOLOGY*

D. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603767E / *SENSOR 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	-	189.051	294.792	314.502	-	314.502	263.612	286.862	267.969	266.433	-	-
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	-	22.753	36.785	35.838	-	35.838	31.201	21.301	9.568	8.568	-	-
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	-	41.203	84.248	92.659	-	92.659	115.000	195.768	244.001	257.865	-	-
SEN-06: *SENSOR TECHNOLOGY*	-	125.095	173.759	186.005	-	186.005	117.411	69.793	14.400	0.000	-	-

A. Mission Description and Budget Item Justification

The Sensor Technology program element is budgeted in the Advanced Technology Development Budget Activity because it funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability and battle damage assessment.

The Surveillance and Countermeasures Technology project funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability, and battle damage assessment. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a clandestine manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, low-power high-performance computing, and low-cost microelectronics to develop advanced surveillance and targeting systems. In addition, this project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats.

The Sensors and Processing Systems project develops and demonstrates the advanced sensor and processing technologies and systems necessary for Intelligence, Surveillance, and Reconnaissance (ISR) missions. Future battlefields will continue to be populated with targets that use mobility and concealment as key survival tactics, and high-value targets will range from specific individual insurgents and vehicles to groups of individuals and large platforms such as mobile missile launchers and artillery. The Sensors and Processing Systems project is primarily driven by four needs: (a) providing day-night ISR capabilities against the entire range of potential targets; (b) countering camouflage, concealment, and deception of mobile ground targets; (c) detecting and identifying objects of interest/targets across wide geographic areas in near-real-time; and (d) enabling reliable identification, precision fire control tracking, timely engagement, and accurate battle damage assessment of ground targets. The Sensors and Processing Systems project develops and demonstrates technologies and system concepts that combine novel approaches to sensing with emerging sensor technologies and advanced sensor and image processing algorithms, software, and hardware to enable comprehensive knowledge of the battlespace and detection, identification, tracking, engagement, and battle damage assessment for high-value targets in all weather conditions and combat environments.

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	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 0603767E / *SENSOR TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	190.220	294.792	0.000	-	0.000
Current President's Budget	189.051	294.792	314.502	-	314.502
Total Adjustments	-1.169	0.000	314.502	-	314.502
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	4.956	0.000			
• SBIR/STTR Transfer	-6.125	0.000			
• Adjustments to Budget Year	-	-	314.502	-	314.502

Change Summary Explanation

FY 2021: Decrease reflects SBIR/STTR transfer offset by reprogrammings.

FY 2022: N/A

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

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603767E / *SENSOR TECHNOLOGY*	Project (Number/Name) SEN-01 / *SURVEILLANCE AND COUNTERMEASURES 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
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	-	22.753	36.785	35.838	-	35.838	31.201	21.301	9.568	8.568	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Surveillance and Countermeasures Technology project funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability, and battle damage assessment. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a clandestine manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, low-power high-performance computing, and low-cost microelectronics to develop advanced surveillance and targeting systems. In addition, this project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Moving Target Recognition (MTR)	4.500	15.862	19.073

Description: Based on technologies developed under the Automatic Target Recognition (ATR) Technology program (previously budgeted in 0603767E, SEN-02), the Moving Target Recognition (MTR) program seeks to enable the use of synthetic aperture radar (SAR) sensors to detect, track, image, and automatically recognize moving ground targets within an area of interest. SAR sensors provide the capability to detect and identify high-value targets in all weather conditions but only when the targets are stationary due to limitations in traditional SAR processing. Ground moving target indicator (GMTI) radars are capable of detecting and tracking moving targets, but they cannot form recognizable images of targets. MTR will overcome the limitations of traditional SAR and improve the operational utility of widely deployed SAR sensors on many different types of platforms. The recognition capability will enable new concepts of operation for maintaining persistent custody of high-value targets on the move. Unlike GMTI, which loses custody if the track is broken due to terrain or other factors, MTR-enabled SAR sensors will be able to tolerate coverage gaps by reacquiring and reestablishing identification of the moving targets. Technology developed under MTR will transition to the Services.

FY 2022 Plans:

- Develop novel MTR algorithms for ground moving target detection, tracking, and imaging with SAR sensors.
- Plan and conduct airborne data collect experiments involving ground-truthed moving military vehicles to test the MTR algorithms and collection techniques.
- Analyze MTR algorithm performance using the airborne experiment data.

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-01 / *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Determine system requirements for objective SAR sensors to support the MTR algorithms. ***FY 2023 Plans:*** - Continue to develop and refine novel algorithms for moving target detection, tracking, and imaging with SAR sensors. - Conduct independent assessment of algorithm performance using airborne SAR data with ground truth. - Optimize software implementations of MTR algorithms for speed, efficiency, and robustness. - Initiate development of ATR algorithms for the moving target images. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects a shift from algorithm prototyping to mature and optimized software implementation and assessment.			
Title: All Source Combat Operations and Targeting (ASCOT) ***Description:*** The All Source Combat Operations and Targeting (ASCOT) program will allow maritime platforms to maintain robust battlespace awareness and survivability by combining data and coordinating operations using all available sensors. The program will create methods for optimal balancing of battlespace awareness and survivability by leveraging existing networked sensors and local platform sensors. The program builds upon technology developed as a part of the Resilient Synchronized Planning and Assessment Contested Environment (RSPACE) program, previously budgeted in PE 0603766E/Project NET-01. Key attributes of this program are survivability, information latency, reliability, and endurance. Demonstrations on relevant platforms in relevant environments will be used to validate the technology. Technologies from this program will transition to the Services. ***FY 2022 Plans:*** - Complete development of final payload and advanced targeting architecture. - Conduct performance evaluation and flight testing with final payload. - Perform sensor fusion, data analysis, and system integration development in support of a live demonstration in a joint exercise. ***FY 2023 Plans:*** - Integrate final flight payload with sensor fusion tool to create an organic battlespace awareness picture. - Perform sensor fusion, data analysis, and system integration to execute a real-time, at-sea demonstration. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from system testing to final technical integration and testing activities.	7.328	11.300	7.894
Title: Fiddler ***Description:*** The Fiddler program seeks to train an artificial intelligence (AI) algorithm to synthesize artificial Synthetic Aperture Radar (SAR) images at any arbitrary look angle, frequency, and polarization based on a few examples of real images. These artificial images will be used to train and improve the performance of Automatic Target Recognition (ATR) algorithms. This	-	-	8.871

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-01 / *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
capability will allow the government to collect a small amount of SAR imagery on a desired target and then rapidly develop new SAR-based ATR algorithms which are effective at detecting that target. Technology developed under this program will transition to the Services. ***FY 2023 Plans:*** - Create baseline version of the Fiddler image generation software. - Develop standardized interfaces for training and producing Synthetic Aperture Radar (SAR) imagery of objects. - Conduct laboratory testing and evaluation of baseline version of the software to demonstrate it can successfully create synthetic SAR imagery that can be used to train Automatic Target Recognition (ATR) algorithms. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects program initiation.			
Title: Aerial Dragnet ***Description:*** Aerial Dragnet seeks to detect multiple small Unmanned Aerial Systems (UAS) in complex and/or urban terrain before they are within Line-Of-Sight (LOS) of friendly assets. Unlike traditional air targets, small UASs pose a special threat in urban terrain for several reasons: they can fly at low altitudes between buildings, they are small making them difficult to sense, and they move at slow speeds making them difficult to differentiate from other moving objects. Moreover, the development of small UASs is driven by commercial technologies, which make them rapidly adaptable and very easy to use. Building upon research conducted in the System of Systems Integration Technology and Experimentation (SoSITE) program (budgeted in PE 0603766E, Project NET-01), Aerial Dragnet will perform surveillance using an architecture consisting of networked sensor payloads deployed on buildings, masts and aerial platforms. The ability to see over and into urban terrain allows Aerial Dragnet to detect, track, and classify UAS incursions rapidly, thus enabling multiple defeat options. Aerial Dragnet sensor payloads are low-cost and comprised of signal processing software, sensor hardware, and networking for distributed, autonomous operation. The system will be scalable to provide cost-effective surveillance coverage from neighborhood to city-sized areas. Aerial Dragnet technologies are expected to transition to the Army, Marine Corps, and Department of State. ***FY 2022 Plans:*** - Evaluate system performance, mission planning and modeling tools of the sensors in a persistent deployment (more than 30 days) within a dense urban environment. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	3.847	3.568	-
Title: Shosty	7.078	6.055	-

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-01 / *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: Shosty seeks to develop and demonstrate enhanced capabilities for high frequency (HF) over-the-horizon-radar (OTHR) systems. This program will develop techniques to characterize distributed skywave HF radar propagation channels and measure radar backscatter from the surface. System signal processing, modeling, analysis, and over-the-air experimentation will be conducted to assess performance. Technologies developed under the Shosty program will transition to the Services. ***FY 2022 Plans:*** - Update algorithms based on testing and needs of identified transition partners, and verify with modeling and simulation. - Perform end-to-end multi-site, multi-static over-the-horizon radar demonstration incorporating advanced waveforms. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.			
Accomplishments/Planned Programs Subtotals	22.753	36.785	35.838

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603767E / *SENSOR TECHNOLOGY*	Project (Number/Name) SEN-02 / *SENSORS AND PROCESSING SYSTEMS*	

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
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	-	41.203	84.248	92.659	-	92.659	115.000	195.768	244.001	257.865	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Sensors and Processing Systems project develops and demonstrates the advanced sensor and processing technologies and systems necessary for Intelligence, Surveillance, and Reconnaissance (ISR) missions. Future battlefields will continue to be populated with targets that use mobility and concealment as key survival tactics, and high-value targets will range from specific individual insurgents and vehicles to groups of individuals and large platforms such as mobile missile launchers and artillery. The Sensors and Processing Systems project is primarily driven by four needs: (a) providing day-night ISR capabilities against the entire range of potential targets; (b) countering camouflage, concealment, and deception of mobile ground targets; (c) detecting and identifying objects of interest/targets across wide geographic areas in near-real-time; and (d) enabling reliable identification, precision fire control tracking, timely engagement, and accurate battle damage assessment of ground targets. The Sensors and Processing Systems project develops and demonstrates technologies and system concepts that combine novel approaches to sensing with emerging sensor technologies and advanced sensor and image processing algorithms, software, and hardware to enable comprehensive knowledge of the battlespace and detection, identification, tracking, engagement, and battle damage assessment for high-value targets in all weather conditions and combat environments.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Painter	-	15.354	25.597
Description: The Painter program seeks to create revolutionary advancements in laser technologies for future active optical systems. Painter will translate efficiency benefits from critical laser components into compact optical sources. The objective of Painter is to simultaneously increase the power and decrease the size of laser sources compared to state of the art. Aggressive packaging objectives will be met by overcoming the thermal management challenges of state-of-the-art lasers. Painter development is guided and constrained by spectral properties required to support multiple mission applications. Technologies from Painter will transition to the Services.			
FY 2022 Plans: - Conduct application studies for Painter-enabled active optical systems. - Perform architectural studies for critical Painter components and sub-systems. - Model Painter effectiveness over multiple concepts of employment.			
FY 2023 Plans: - Define architecture for Painter laser technology. - Construct test bench for Painter hardware experimentation. - Evaluate initial Painter hardware in lab environment.			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Conduct preliminary design review for Painter laser technology. - Initiate construction of laboratory-based Painter laser. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase reflects shift from initial studies and modeling to construction of hardware for Painter technology.			
Title: Military Tactical Means (MTM) ***Description:*** The Military Tactical Means (MTM) program is developing sensors and exploitation techniques capable of performing wide-area search to detect high-value targets in order to task engagement systems to close effects-chains. Finding and prosecuting targets with distributed effects-chains requires the ability to detect, track, and maintain custody of targets across sensors with different modalities residing in various domains. This program will examine both the sensors and the exploitation needed to perform this wide-area search for missions in denied territories and maintain positive chain of custody hand-offs to one or more targeting sensors. The sensors developed under this program will concentrate on sensor modalities that are mostly geometry-invariant and have the potential to be used in highly proliferated systems, such as small satellite constellations and small terrestrial platforms (e.g., class-I or II unmanned aerial system). The exploitation portion of this program will develop algorithms to ensure consistency when passing chain of custody between sensors in different domains where there is the possibility of different sensing modalities and will also be designed to increase confidence and accuracy as targets are passed between sensors. Technology developed by this program will transition to the Services and other government agencies. ***FY 2022 Plans:*** - Integrate algorithms and sensors compatible with field experimentation. - Execute experiments to measure sensor and algorithm performance and effectiveness. - Evaluate both sensor and processor compatibility for objective platform size, weight, and power (SWaP). - Continue modeling and simulation of MTM capabilities against real world use cases developed jointly with operational stakeholders. - Perform objective system modeling to validate performance and effectiveness in military utilization. ***FY 2023 Plans:*** - Build and integrate a multi-modal sensor system following the design created in the brassboard demonstration. - Conduct detailed sensor performance testing on multi-modal sensor payload and processing. - Plan data collection campaigns to test airborne prototype sensor and processor. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects minor program repricing.	22.798	22.718	22.682
Title: Coho	7.582	16.534	15.683

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Description: The Coho program is developing advanced signal processing technologies and techniques for future Radio Frequency (RF) systems. These systems will create an asymmetric advantage for tactical operations in anti-access/area-denial environments by extending the real-time operating bandwidth of tactical signal processing, underpinning the ability of U.S. and Allied Forces to accurately orient and beneficially maneuver in the electromagnetic spectrum. Based on technologies developed under the All-Signal Tactical Real-time Analyzer (ASTRAL) program, previously budgeted in this PE and Project, the objective of Coho is to provide ultra wideband RF signal detection and recognition capabilities in a form factor suitable for tactical platforms. Coho seeks to provide capabilities for multiple mission areas. These capabilities include (1) surveillance: combining wide operating bandwidth with noise isolation for background electromagnetic search in the low signal to noise ratio environment, (2) filtering: isolating signals based on modulation features to process signals in the presence of co-channel interference, and (3) localization: supporting low-latency execution of multi-aperture processing for discrimination of signals based on angle of bearing. Technology from Coho will transition to the Services. ***FY 2022 Plans:*** - Conduct Conceptual Design Review for the Coho system. - Continue development of algorithms for signal recognition. - Develop brassboard Coho system. - Conduct initial testing of the brassboard system to determine efficacy of the technology. - Conduct Critical Design Review for final prototype system. ***FY 2023 Plans:*** - Conduct final evaluations of Coho signal recognition algorithms. - Optimize Coho system via hardware calibration and software interface revision. - Test prototype Coho system to verify performance. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from brassboard hardware development to final evaluation and testing.			
Title: Distributed Radar Image Formation Technology (DRIFT)	-	3.000	13.054
Description: Based on recent developments in small synthetic aperture radar (SAR) satellites in commercial industry, there are new opportunities to experiment with novel SAR-related concepts. Based on technologies developed in the Resilient Networked Distributed Mosaic Communications (RNDMC) program (budgeted in PE 0603760E/ Project CCC-02), the goal of the Distributed Radar Image Formation Technology (DRIFT) program is to demonstrate advanced capabilities enabled by a cluster of SAR satellites flown in formation. DRIFT seeks to acquire data from SAR satellites flown in formation and to demonstrate novel			

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
processing algorithms on this data. This will expand the utility of small SAR satellites, including commercial satellites, for military applications. Technology developed under this program will transition to the Services. ***FY 2022 Plans:*** - Establish conceptual design for DRIFT formation flying satellite data collection. ***FY 2023 Plans:*** - Create prototype DRIFT algorithms and test on simulated data. - Prepare satellites for on-orbit testing, including finalizing the hardware, ground software, and maneuver strategy. - Conduct modeling and simulation to develop detailed plans for satellite formation configurations and radar operations to be tested on orbit. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY2023 increase reflects a shift from conceptual design to prototyping and testing.			
Title: Thermal Imaging Technology Experiment-Recon (TITE-R) ***Description:*** The Thermal Imaging Technology Experiment-Recon (TITE-R) leverages and expands upon the successful technology demonstrations associated with the Small Satellite Sensors program, previously budgeted in this PE/Project. TITE-R will develop and demonstrate complimentary sensing modalities, advanced processing, and low size, weight, and power cross and downlinks which will more closely represent an objective tactical capability. TITE-R will develop sensors and software automation capable of supporting future tactical targeting operations implemented on small (< 250 kg) satellites. TITE-R will also develop mission software to support automated on-board processing and simplified operator tasking. This scalable tactical targeting approach will directly support tactical operations. TITE-R aims to rapidly develop and test an early-to-space prototype system to be made available to transition partners to integrate with space vehicles and conduct experimentation. Technology developed by this program will transition to the Services and other government agencies. ***FY 2022 Plans:*** - Complete payload design and build. - Conduct system-level preliminary design review (PDR) and critical design review (CDR). - Complete payload testing of all hardware components. - Implement a baseline set of mission software demonstrating mission feasibility. - Develop testing environment. ***FY 2023 Plans:*** - Perform detailed testing of mission software integrated with payload hardware within emulation environment. - Analyze technology utility for tactical use within operational constellations.	4.836	20.742	15.643

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency		Date: April 2022
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Begin transition of integrated software and hardware capability to transition partners. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects a shift from development, validation, and experimentation to systems integration and testing.			
Title: Dynamically Composed RF Systems ***Description:*** Dominance of the Radio Frequency (RF) spectrum is critical to successful U.S. military operations. Radar systems, electronic warfare (EW) systems, and communication systems require custom software and hardware that is costly and time-consuming to build and integrate onto platforms. The Dynamically Composed RF Systems program addresses these challenges by developing adaptive, converged RF array systems. This enables enhanced operational capability by dynamically adapting the system for tasks to support radar, communications, and EW in a converged manner. This program will design and develop: (1) a modular architecture for collaborative, agile RF systems; (2) advanced techniques for RF apertures and airframe integration and the associated wide-band agile electronics to support converged missions over those apertures; (3) a heterogeneous signal processing complex implementing hardware-agnostic RF operating modes (the RF Virtual Machine); (4) software tools for the control, coordination, and scheduling of RF functions and payloads at the element level to maximize overall task performance (a System and Sensor Resource Manager (SSRM)). This capability can be adapted to address diverse missions. Technology developed under this program will transition to the Services. ***FY 2022 Plans:*** - Conduct ground testing of SSRM on testbed aircraft and demonstrate ability to control both payloads on the ground. - Conduct flight tests of the SSRM controlling two third-party payloads and demonstrate ability to control those payloads in flight. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 decrease reflects program completion.	5.987	5.900	-
Accomplishments/Planned Programs Subtotals	41.203	84.248	92.659

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Defense Advanced Research Projects Agency			Date: April 2022
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603767E / *SENSOR TECHNOLOGY*	Project (Number/Name) SEN-06 / *SENSOR 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
SEN-06: *SENSOR TECHNOLOGY*	-	125.095	173.759	186.005	-	186.005	117.411	69.793	14.400	0.000	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

This project funds classified DARPA programs that are reported in accordance with Title 10, United States Code, Section 119(a)(1) or its successor.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Classified DARPA Program	125.095	173.759	186.005
Description: This project funds Classified DARPA Programs. Details of this submission are classified. ***FY 2022 Plans:*** Details will be provided under separate cover. ***FY 2023 Plans:*** Details will be provided under separate cover. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	125.095	173.759	186.005

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605001E / *MISSION SUPPORT*

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	-	75.246	73.145	86.869	-	86.869	88.503	90.192	91.924	93.699	-	-
MST-01: *MISSION SUPPORT*	-	75.246	73.145	86.869	-	86.869	88.503	90.192	91.924	93.699	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Mission Support Program Element provides funding for the costs of mission support activities for the Defense Advanced Research Projects Agency. The funds provide personnel compensation for mission support civilians as well as costs for building rent, physical security, travel, supplies and equipment, communications, printing and reproduction.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	74.334	73.145	0.000	-	0.000
Current President's Budget	75.246	73.145	86.869	-	86.869
Total Adjustments	0.912	0.000	86.869	-	86.869
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.912	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Adjustments to Budget Year	-	-	86.869	-	86.869

Change Summary Explanation

FY 2021: Increase reflects reprogrammings.

FY 2022: N/A

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

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Mission Support	75.246	73.145	86.869
Description: Mission Support			
FY 2022 Plans:			

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605001E / *MISSION SUPPORT*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- Fund mission support civilian salaries and benefits, and administrative support costs. - Fund travel, rent and other infrastructure support costs. - Fund security costs to continue access controls, uniformed guards, and building security requirements. ***FY 2023 Plans:*** - Fund mission support civilian salaries and benefits, and administrative support costs. - Fund travel, rent and other infrastructure support costs. - Fund security costs to continue access controls, uniformed guards, and building security requirements. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY2023 increase reflects standalone audit support costs, revised civilian personnel costs and the travel costs returning to pre-pandemic level.			
Accomplishments/Planned Programs Subtotals	75.246	73.145	86.869

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605502E / *SMALL BUSINESS INNOVATION RESEARCH*

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	-	109.867	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
SB-01: *SMALL BUSINESS INNOVATION RESEARCH*	-	109.867	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

In accordance with Public Law No: 116-92 (National Defense Authorization Act 2020) and the Small Business Act (15 U.S.C. 638), the DARPA Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats, thereby supporting DARPA's overall strategy to enable fundamental discoveries and technological breakthroughs that provide new military capabilities.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	0.000	0.000	0.000	-	0.000
Current President's Budget	109.867	0.000	0.000	-	0.000
Total Adjustments	109.867	0.000	0.000	-	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	109.867	0.000			

Change Summary Explanation

FY 2021: Increase reflects SBIR/STTR transfer.
FY 2022: N/A
FY 2023: N/A

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Small Business Innovation Research	109.867	0.000	0.000
Description: The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to enable fundamental discoveries and technological breakthroughs that provide new military capabilities. ***FY 2022 Plans:*** - Continue to utilize various funding pathways available to the SBIR/STTR programs. This includes, Phase I, Phase II, Direct to Phase II, co-funds, cross agency awards, Phase II Enhancements, and SBIR XL Pilot. - SBIR XL aims to increase opportunities for DARPA funded technology by reimagining SBIRs to transform ideas into successful small businesses that scale. The goals of SBIR XL include; (1) increase relevance of SBIR Program for Technology Development in DARPA; (2) emphasize transition and commercialization as part of evaluation process including establishment of concrete commercialization milestones; (3) raise award ceilings to support efforts for operation-scale deployment, increasing the probability of technology transition and commercialization; (4) decrease award timelines. - Topics will be developed and managed by DARPA and link to DoD OSD SBIR/STTR Key Technology Areas which include (1) Air Platforms; (2) Chemical / Biological Defense; (3) Information Systems Technology; (4) Ground and Sea Vehicles; (5) Materials / Processes; (6) Biomedical; (7) Sensors, Electronics and Electronic Warfare; (8) Space Platforms; (9) Human Systems; (10) Weapons; (11) Nuclear Technology; (12) Battlespace Environments. - DARPA will link wherever possible to the National Defense Strategy DoD Research, Technology & Laboratory Focus areas which include (1) 5G; (2) Artificial Intelligence (AI)/Machine Learning (ML); (3) Autonomy; (4) Biotechnology; (5) Cybersecurity; (6) Directed Energy (DE); (7) Hypersonics; (8) Microelectronics; (9) Networked Command, Control & Communication (C3); (10) Nuclear; (11) Quantum Science; (12) Space; (13) General Warfighting (GWR). ***FY 2023 Plans:*** - Continue to utilize various funding pathways available to the SBIR/STTR programs. This includes, Phase I, Phase II, Direct to Phase II, co-funds, cross agency awards, Phase II Enhancements, and SBIR XL Pilot. - SBIR XL aims to increase opportunities for DARPA funded technology by reimagining SBIRs to transform ideas into successful small businesses that scale. The goals of SBIR XL include; (1) increase relevance of SBIR Program for Technology Development in DARPA; (2) emphasize transition and commercialization as part of evaluation process including establishment of concrete commercialization milestones; (3) raise award ceilings to support efforts for operation-scale deployment, increasing the probability of technology transition and commercialization; (4) decrease award timelines. - Topics will be developed and managed by DARPA and link to DoD OSD SBIR/STTR Key Technology Areas which include (1) Air Platforms; (2) Chemical / Biological Defense; (3) Information Systems Technology; (4) Ground and Sea Vehicles; (5) Materials / Processes; (6) Biomedical; (7) Sensors, Electronics and Electronic Warfare; (8) Space Platforms; (9) Human Systems; (10) Weapons; (11) Nuclear Technology; (12) Battlespace Environments.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605502E / *SMALL BUSINESS INNOVATION RESEARCH*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
- DARPA will link wherever possible to the National Defense Strategy DoD Research, Technology & Laboratory Focus areas which include (1) 5G; (2) Artificial Intelligence (AI)/Machine Learning (ML); (3) Autonomy; (4) Biotechnology; (5) Cybersecurity; (6) Directed Energy (DE); (7) Hypersonics; (8) Microelectronics; (9) Networked Command, Control & Communication (C3); (10) Nuclear; (11) Quantum Science; (12) Space; (13) General Warfighting (GWR).			
Accomplishments/Planned Programs Subtotals	109.867	0.000	0.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605898E / *MANAGEMENT HQ - R&D*

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	-	14.154	12.740	14.636	-	14.636	14.595	14.344	14.440	14.537	-	-
MH-01: *MANAGEMENT HQ - R&D*	-	14.154	12.740	14.636	-	14.636	14.595	14.344	14.440	14.537	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

The Management HQ - R&D Program Element provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. This project provides funding for DARPA Management Headquarters Activities (MHA). The funds provide personnel compensation for management headquarters civilians as well as associated travel and support contract costs. Departmental Service Requirements Review Board (SRRB) reductions were taken in this PE. Mission support costs are reflected in PE 0605001E, Project MST-01.

B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	13.434	12.740	0.000	-	0.000
Current President's Budget	14.154	12.740	14.636	-	14.636
Total Adjustments	0.720	0.000	14.636	-	14.636
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.720	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Adjustments to Budget Year	-	-	14.636	-	14.636

Change Summary Explanation

FY 2021: Increase reflects reprogrammings.

FY 2022: N/A

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

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
Title: Management Headquarters	14.154	12.740	14.636
Description: Management Headquarters			

Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Defense Advanced Research Projects Agency	Date: April 2022
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide I* BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605898E *I MANAGEMENT HQ - R&D*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023
FY 2022 Plans: - Fund management headquarters civilian salaries, benefits, travel and support contract costs. ***FY 2023 Plans:*** - Fund management headquarters civilian salaries, benefits, travel and support contract costs. ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The FY 2023 increase is due to revised civilian personnel, travel, and support contract costs.			
Accomplishments/Planned Programs Subtotals	14.154	12.740	14.636

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A