Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Defense Advanced Research Projects Agency	Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
Total Program Element	-	424.332	404.370	311.531	-	311.531	358.978	396.651	429.334	462.789	-	-
CCS-02: *MATH AND COMPUTER SCIENCES*	-	273.345	231.916	179.433	-	179.433	202.697	244.776	265.979	294.634	-	-
ES-01: *ELECTRONIC SCIENCES*	-	12.926	17.645	12.854	-	12.854	22.678	30.682	32.410	37.410	-	-
ES-02: *BEYOND SCALING SCIENCES*	-	64.607	70.188	52.004	-	52.004	57.212	44.370	53.540	53.540	-	-
MS-01: *MATERIALS SCIENCES*	-	41.860	53.356	62.934	-	62.934	69.018	69.200	69.782	69.582	-	-
TRS-01: *TRANSFORMATIVE SCIENCES*	-	31.594	31.265	4.306	-	4.306	7.373	7.623	7.623	7.623	-	-

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) address the Basic Research associated with the Defense Research Sciences Program that 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. This PE 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 PE 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 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.

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 will provide DoD with new, improved, or potentially revolutionary device options for accomplishing these critical functions. The resulting technologies will 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, 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. Additionally, new design and manufacturing advances for three-dimensional microelectronics integration will underpin continued performance improvements as silicon transistor scaling plateaus. Beyond Scaling programs addressed fundamental exploration in 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 life sciences, data sciences, and manufacturing. Innovative technologies developed in this project will address multiple DoD challenges such as identification of and adaptation to emerging threats, access to DoD relevant critical materials for manufacturing and warfighter readiness. Successful programs in this project will integrate diverse disciplines and engineer complex biological systems to detect novel threat agents, accelerate warfighter injury recover, and develop new platform materials and manufacturing processes.

B. Program Change Summary ($ in Millions)	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total
Previous President's Budget	443.842	401.870	396.555	-	396.555
Current President's Budget	424.332	404.370	311.531	-	311.531
Total Adjustments	-19.510	2.500	-85.024	-	-85.024
• Congressional General Reductions	0.000	-10.500			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	13.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-2.406	0.000			
• SBIR/STTR Transfer	-17.104	0.000			
• TotalOtherAdjustments	-	-	-85.024	-	-85.024

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Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2022	FY 2023
Project: CCS-02: *MATH AND COMPUTER SCIENCES*		
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: *University Partnerships for AI Development - Congressional Add*	-	9.000
Congressional Add: *Advanced Predictive Analytics for Supply Chain Risk Management - Congressional Add*	-	4.000
Congressional Add Subtotals for Project: CCS-02	30.000	13.000
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	50.000	13.000

Change Summary Explanation

FY 2022: Decrease reflects SBIR/STTR transfer and reprogrammings.

FY 2023: Increase reflects Congressional adds for Advanced Predictive Analytics for Supply Chain Risk Management and University Partnerships for AI Development offset by a Congressional reduction to Reduce Carryover.

FY 2024: Decrease reflects completion of several basic research programs in FY 2023 including Safe Documents (SafeDocs), Learning with Less Labeling (LwLL), Ultra-Wide Bandgap Semiconductors (UWBG), Guaranteed Architectures for Physical Security (GAPS) and Biology for Security (BIOSEC) as well as a shift from development and testing to demonstration and evaluation activities in the Foundational Artificial Intelligence (AI) Science, Guaranteeing AI Robustness against Deception (GARD), Machine Common Sense (MCS) and Rapid Healing for Warfighter Injuries programs.

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
CCS-02: *MATH AND COMPUTER SCIENCES*	-	273.345	231.916	179.433	-	179.433	202.697	244.776	265.979	294.634	-	-

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 2022	FY 2023	FY 2024
Title: Foundational Artificial Intelligence (AI) Science	69.550	37.692	28.771
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 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.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
- Extend novelty generators and novelty-robust AI techniques to create and identify rapidly and respond appropriately to new environments, goals, and events. - 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 refine 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. - Apply and evaluate model performance against simulated climate intervention approaches. - Develop AI negotiation agents for multi-party interaction environments that include untrustworthy partnerships and dynamic goals. - Extend signature approaches for information deception tools in text, audio, and image generation to support additional machine learning attack attribution capabilities. - Identify scenarios, collect and analyze historical online and offline influence campaign pathways, and learn pathway models and patterns. - Develop foundational AI science, advance the state of the art in AI engineering, and create human-machine teaming approaches that support trustworthy AI for mission- and safety-critical domains. ***FY 2024 Plans:*** - Evaluate algorithmic decision maker's ability to align with a reference group of human decision makers, and validate baseline computational approaches for quantifying the measurement of alignment and the impact of alignment on trust of algorithmic decision makers. - Continue to develop foundational AI science, advance the state of the art in AI engineering, and create human-machine teaming approaches that support trustworthy AI for mission- and safety-critical domains. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects a shift in focus from technology demonstrations to algorithm evaluation for follow-on efforts.			
Title: Young Faculty Award (YFA) ***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,	17.000	17.000	17.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2023 Plans:*** - Award new FY 2023 grants for new two-year research efforts across YFA topic areas, establishing a new set of appropriate scientific approaches to solve current DoD challenges. - 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. ***FY 2024 Plans:*** - Award FY 2024 grants for new two-year research efforts across YFA topic areas, establishing a new set of scientific approaches to solve current DoD challenges. - Continue FY 2023 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 2022 participants to refine technology further and align to DoD needs.			
Title: Alternative Computing ***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.	28.000	28.000	20.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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. - 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 2024 Plans:*** - Create predictive and scalable benchmarks for quantifying the utility of quantum computers. - Calculate the hardware resources necessary to achieve key utility thresholds using quantum computers to solve transformational problems. - Perform benchmarking of quantum optimization algorithms against the best classical method to demonstrate and quantify quantum advantage. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects a shift in focus from design and fabrication to validation and verification.			
Title: Perceptually-Enabled Task Guidance (PTG)	12.234	20.300	17.500
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 connects 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 develops 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 develops 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, 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 2023 Plans:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
- Develop approaches for perceptual grounding as required for perceptually-enabled intelligent agents capable of learning how to recognize task-related terms for 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 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 and on a military task defined in collaboration with military stakeholders. ***FY 2024 Plans:*** - Integrate perceptual, reasoning, and augmented reality technology with technologies for knowledge transfer, perceptual grounding, and perceptual attention. - Develop demonstration scenarios for interactive technology and military user communication in the context of answering questions while the technology monitors users performing tasks. - Develop technologies to address user modeling of individuals performing tasks in multiple military use cases. - Perform assessments of task completion and user acceptance of the integrated technologies in the completion of tasks from application domains defined in collaboration with military stakeholders. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects ramping down of development and integration of perceptually-enabled intelligent agents, and emphasis shifting to demonstration and assessment of the technology on military task use cases.			
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.	12.061	17.300	16.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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-based knowledge management tools. ***FY 2024 Plans:*** - Evaluate novel AI knowledge management tools in common domain of potential military interest. - Incorporate personal sensor input modality into novel AI tools. - Extend novel AI knowledge management tools to scale to individuals in organizations. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects a shift from technology development to explorations of application spaces and evaluation.			
Title: Advanced Tools for Modeling and Simulation	3.000	3.000	5.000
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 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 2023 Plans:*** - Investigate new mathematics and computation tools to enable the discovery of transformations that make complex physical/ engineering problems more tractable. ***FY 2024 Plans:*** - Investigate the development of machine learning to generate transformations from large data sets and determine the limits of such transformations.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
- Explore combining machine learning with existing symbol manipulation approaches to develop digital engineering and scientific computing tools for complex designs. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 increase reflects a shift from initial technology investigations to new tool exploration and development.			
Title: Artificial Social Intelligence for Successful Teams (ASIST)	15.000	12.800	11.000
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 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 coach. - 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. ***FY 2024 Plans:*** - Demonstrate socially intelligent agents capable of partnering with complex teams comprising individuals with specialized skills in support of a selected use case. - Provide open access to datasets, testbed, and agent prototypes for continued development by human-machine teaming researchers and transition technology to military labs for experimentation on additional use cases. ***FY 2023 to FY 2024 Increase/Decrease Statement:***			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
The FY 2024 decrease reflects ramping down of work to develop agents with artificial social intelligence and focus shifting to technology demonstration and transition.			
Title: Guaranteeing AI Robustness against Deception (GARD) ***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. ***FY 2023 Plans:*** - Develop and validate measures of adversary costs and enhance AI/ML defense methods to impose asymmetric costs on the adversary. - Develop human-on-the-loop defense techniques that enable the early identification of digital evasion attacks on AI-enabled systems. - Demonstrate model training methods that reduce AI/ML vulnerability to data poisoning. - Extend evaluation framework to support simulation environments and test physically plausible threat models of interest to potential DoD and U.S. Government transition partners. ***FY 2024 Plans:*** - Extend adversarial AI techniques to federated learning systems. - Extend evaluation framework to support assessment of AI/ML defenses against multi-modal imaging attacks, audio speech recognition poisoning attacks, and federated learning poisoning attacks. - Demonstrate and transition AI/ML defense technology to DoD and U.S. Government transition partners. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects ramping down of work to develop techniques to defend against attacks on AI/ML systems and focus shifting to demonstration and transition of technology.	17.500	21.500	12.000
Title: Human Social Systems	15.000	14.000	7.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024

Description: The social and behavioral sciences provide essential theories and models that can enable deeper understanding of human social/behavioral systems relevant to national security such as mental health, 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/behavioral systems; (2) identifying methods to better characterize and quantify properties, dynamics, and behaviors of different social/behavioral systems to enable better and more confident forecasting of changes in such systems, particularly when under stress; (3) developing an understanding of the complex effect of context and incorporating these effects into 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/behavioral 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 2023 Plans:

- 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.
- Explore development of a new mechanistic understanding of mental health for transdiagnostic treatment.

FY 2024 Plans:

- 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 in new locations to test generalizability of methods.
- 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 in new locations to test generalizability of methods.
- 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 in new locations to test generalizability of methods.

FY 2023 to FY 2024 Increase/Decrease Statement:

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
The FY 2024 decrease reflects a shift from development to demonstration.			
Title: Machine Common Sense (MCS)	18.000	19.000	6.962
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 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 common-sense reasoning tasks and extend commonsense reasoning capabilities to utilize cross-modal (text, image, video) data to improve performance. - Extend the simulation environment to support modeling and performance assessment for environments with complexity, noise, and novelty. ***FY 2024 Plans:*** - Use the simulation environment to assess capability on benchmark common sense challenge problem suites in environments exhibiting high complexity, noise, and novelty. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects ramping down of efforts to develop machine common sense technologies and the simulation environment, and focus shifting to evaluation on benchmark common sense challenge problem suites.			
Title: Pipelined Reasoning of Verifiers Enabling Robust Systems (PROVERS)	-	8.000	17.200
Description: The Pipelined Reasoning of Verifiers Enabling Robust Systems (PROVERS) program is creating 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,			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency		Date: March 2023
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 integrates formal methods into a modern incremental and iterative development process by running tools at each code commit and delivering results to developers when they can most effectively remediate discovered issues. To achieve this, PROVERS is focusing 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:*** - Develop tools and data management techniques appropriate for pipelined software development processes that support incremental proof maintenance and repair. - Identify candidate mission-critical software applications and systems for controlled formal-methods-based experiments to quantify the improvements in development productivity and system security. ***FY 2024 Plans:*** - Develop and demonstrate formal methods approaches, tools, and data management techniques integrated in pipelined software development processes and quantify the costs related to adding formal methods-based assurances in development workflows. - Implement mathematical approaches for proof engineering at scale and demonstrate efficiency and quality of outputs within existing and modified workflows. - Collaborate with DoD stakeholders on controlled formal-methods-based experiments on selected mission-critical software systems to quantify the improvements in development productivity and system security. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 increase reflects scaling up efforts to develop mathematical approaches for proof engineering at scale and techniques and tools for continuous reasoning about complex systems that can support software development pipelines.			
Title: Environment-driven Conceptual Learning (ECOLE) ***Description:*** The Environment-driven Conceptual Learning (ECOLE) program, addressing basic research challenges identified in the Accelerating AI thrust (PE 0602303E, Project IT-04), will create AI agents capable of continually learning from linguistic and visual input to enable human-machine collaborative analysis of image, video, and multimedia documents during time-sensitive, mission-critical DoD analytic tasks, where reliability and robustness are essential. ECOLE will transform current machine	-	6.000	14.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
learning approaches by developing algorithms that can identify, represent, and ground the attributes that form the symbolic and contextual model for a particular object or activity through interactive learning with a human analyst. Knowledge of attributes and affordances, learned dynamically from data encountered within an analytic workflow, will enable joint reasoning with a human partner. This acquired knowledge will also enable the machine to recognize when an observed object or activity is novel, rather than misclassifying the newly observed object or action as a member of a previously-learned class, and readily learn a new symbolic representation through interaction with its human partner. ***FY 2023 Plans:*** - Explore alternative means for automated discovery of distinguishing features among objects and activities. - Devise approaches for utilizing interactions among objects and actions to understand affordances. ***FY 2024 Plans:*** - Formulate initial AI agents capable of continually learning from language and vision to enable human-machine collaborative analysis of image, video, and multimedia documents. - Develop initial algorithms that identify, represent, and ground novel attributes that form the symbolic and contextual model for a particular object or activity through interactive learning with a human analyst. - Initiate development of a suite of collaborative human-machine image analysis challenge problems based on inputs from potential transition partners in the defense and intelligence communities. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 increase reflects scaling up of efforts to create techniques to identify, represent, and ground novel attributes through human-machine collaborative analysis and to develop a suite of analytic challenge problems of interest to the DoD and IC.			
Title: Modular Meta-cognition (ModMetaCog) ***Description:*** The Modular Meta-cognition (ModMetaCog) program aims to develop machine introspection technologies that enable AI systems to analyze and explain their behavior and improve their performance. Current AI systems sometimes work well in the lab but then perform poorly in the field where they operate as part of larger systems that behave unpredictably and/or when they encounter situations not anticipated during training. ModMetaCog will develop and apply recent results in AI/ML saliency and explainability to create introspection capabilities for AI systems, in effect wrapping a second AI system around the original system. The second AI system acts to analyze and explain the behavior of the first, identify anomalies and potential problems, and either acts to make changes to the first system to fix the problem or to communicate its findings to a human operator for action. ModMetaCog will develop both basic theory of meta-cognition and prototype introspection modules for specific types of AI problems, such as classification, detection, control, and others. ModMetaCog will create machine introspection technologies that enable AI/ML systems to identify when they are performing poorly and to improve their performance when required.	-	-	7.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
FY 2024 Plans: - Formulate flexible modular meta-cognition architectures applicable to broad classes of AI and machine learning systems. - Initiate development of meta-cognition modules for diverse problem types such as classification, detection, control, and others. - Initiate development of a simulation test-bed to generate data for meta-cognition experimentation and evaluation on multiple AI problem types. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 increase reflects program initiation.			
Title: Safe Documents (SafeDocs) ***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 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 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects program completion.	12.500	8.000	-
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, formally deriving the limits of machine learning and adaptation,	12.500	6.324	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
and 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 2023 Plans:*** - Demonstrate capabilities of the LwLL tools in specific DoD relevant applications such as object identification, activity recognition, and target recognition, as well as adapting a trained model to a new set of conditions. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects program completion.			
Title: Agile Artificial Intelligence (AgAI) ***Description:*** The Agile Artificial Intelligence (AgAI) program sought 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 developed 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.	5.000	-	-
Title: World Modelers ***Description:*** The World Modelers program created 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 focused on regional and global systems with the goal of generating timely indications and warnings. Water and food security application domains were of particular interest, as persistent drought may cause crops to fail, leading to migration and regional conflicts. The World Modelers program developed 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.	6.000	-	-
Accomplishments/Planned Programs Subtotals	243.345	218.916	179.433

	FY 2022	FY 2023
Congressional Add: AI Cyber Data Analytics (AI) - Congressional Add	10.000	-

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	FY 2022	FY 2023
FY 2022 Accomplishments: - Explored approaches for supplementing AI systems with introspective meta-cognition capabilities that analyze, explain, and improve their learning behavior. - Developed improved algorithms and training strategies for machine learning systems and human-machine teaming. - Devised sim-to-real robotics training schemes to expand beyond machine proprioception to enable vision, grasping, and life-long adaptation capabilities. - Explored approaches for automated testing and identification of vulnerabilities with explainable breakdown for decision makers. - Extended user models for the mechanics use case to include what the user knows in context, what the user is doing, and the user's attentional state.		
Congressional Add: AI Cyber Data Analytics (Cyber) - Congressional Add	10.000	-
FY 2022 Accomplishments: - Extended techniques to provide verifiable, machine-readable linkages to descriptive text and a prototype framework for compiling dual machine and human-accessible hypertext content. - Formulated approaches for enhanced situational awareness of compromise for multi-component computing systems. - Developed capabilities to detect anomalous software engineering practices and development activities as a means for open-source software assurance.		
Congressional Add: AI Cyber Data Analytics (Data) - Congressional Add	10.000	-
FY 2022 Accomplishments: - Explored architectural modeling approaches for trusted information flows and integrity assurance of augmented reality systems in data-intensive and mission-critical environments. - Extended data description language techniques to enable the automated generation of arbitrary documents in specified formats and of polyglot files. - Formulated approaches to train negotiation agents on large, diverse datasets to reveal how data availability and accuracy can impact the agent's performance. - Enhanced the user interface to provide expanded access to a diverse array of data, models, and tools that facilitate understanding of risks and opportunities.		
Congressional Add: University Partnerships for AI Development - Congressional Add	-	9.000
FY 2023 Plans: - Initiate University Partnerships for AI Development.		
Congressional Add: Advanced Predictive Analytics for Supply Chain Risk Management - Congressional Add	-	4.000

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	FY 2022	FY 2023
FY 2023 Plans: - Initiate advanced predictive analytics for supply chain risk management.		
Congressional Adds Subtotals	30.000	13.000

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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
ES-01: *ELECTRONIC SCIENCES*	-	12.926	17.645	12.854	-	12.854	22.678	30.682	32.410	37.410	-	-

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 will provide DoD with new, improved, or potentially revolutionary device options for accomplishing these critical functions. The resulting technologies will 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, and new approaches to nanometer-scale structures, molecules, and devices.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Atomic-Photonic Integration (A-PhI)	8.000	9.000	8.854
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 disruption 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 2023 Plans: - Further improve atom trap gyroscope sensitivity. - Demonstrate an atomic clock physics package meeting size, frequency stability, and phase noise metrics. - 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. - Perform trade study on fundamental performance of quantum cascade lasers.			
FY 2024 Plans: - Test integrated photonics-based atomic clock by referencing to civilian and military time standards.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
- Demonstrate a trapped atom gyroscope with single measurement angle rate resolution and scale factor exceeding commercial gyroscopes. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects minor program repricing.			
Title: Robust Protection for Electronic Systems (ROPES) ***Description:*** The Robust Protection for Electronic Systems (ROPES) program will develop and mature ultra-wide bandgap (UWBG) materials and devices to achieve robust, high-power operation and fast switching speed required to protect sensitive RF electronics in harsh environments. ROPES will address the key technical challenges that limit the performance of conventional diodes and switches. These challenges include demonstrating materials and device architectures capable of simultaneous high current operation and low leakage current under high electric field, and simultaneously achieving low device resistance and capacitance resulting in fast switching speed. To be successful, ROPES will leverage advances in UWBG materials and innovative device architectures to enable high power, high speed, and low loss switches. ROPES will support multiple DoD platforms and arrays by enabling high-power (kilowatt class), low-loss front end receiver protect circuitry, as well as high voltage (10 kilovolt class), low-loss switches required for future electric ship power systems. This program has applied research efforts funded in PE 0602716E, Project ELT-01. ***FY 2024 Plans:*** - Develop growth techniques for UWBG materials such as aluminum nitride, diamond, cubic boron nitride or gallium oxide, demonstrating device-grade material quality with low defectivity and control of dopants. - Fabricate UWBG test structures to characterize and optimize material properties and quantify dopant concentration and material defectivity. - Develop approaches to create low resistance ohmic contacts required to minimize device resistance and loss. - Develop atomistic models that incorporate electrical, thermal, and mechanical properties of UWBG materials and device structures enabling accurate, multi-physics co-design. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 increase reflects program initiation.	-	-	4.000
Title: Ultra-Wide Bandgap Semiconductors (UWBG) ***Description:*** The Ultra-Wide Bandgap Semiconductors (UWBG) program seeks 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. The electrical bandgap of a material determines 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	4.926	8.645	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
made from the material. Consequently, ultra-wide bandgap materials 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, such as low-defect substrates, heteroepitaxial material growth, and high-concentration p-type and n-type doping, that currently prevent implementation of UWBG materials into power, RF, and optoelectronic devices and systems. ***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. - Analyze expected benefits of UWBG-enabled RF systems for radar, communications, directed energy, and electronic warfare applications. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects program completion.			
Accomplishments/Planned Programs Subtotals	12.926	17.645	12.854

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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
ES-02: *BEYOND SCALING SCIENCES*	-	64.607	70.188	52.004	-	52.004	57.212	44.370	53.540	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 addressed fundamental exploration in each of these areas.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
Title: Low Temperature Logic Technology (LTLT)	4.000	13.188	4.004
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. This program has applied research efforts funded in PE 0602716E, Project ELT-02. ***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. ***FY 2024 Plans:*** - Fabricate optimized transistors and generate compact device models. - Demonstrate compact, low power memory cells and experimentally show their performance at low temperature. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects a shift from initial design to demonstration of low power memory cells.			
Title: Next Generation Microelectronics - Advanced Manufacturing Science	-	20.000	16.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
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 2024 Plans:*** - Evaluate candidate electrical characterization techniques and metrology for representative three-dimensionally interconnected microsystems and thermally hardened microsystems. - Perform initial experiments to create precisely aligned, high-density interconnects for digital components. - Characterize candidate novel materials and material systems to extend temperature operation range and to improved management of thermal interfaces, leveraging artificial intelligence (AI) and additive manufacturing. - Evaluate advanced additive manufacturing techniques including aerosol ink jet printing, nano-composite materials, and selective etching for use in 3DHI electronics. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The decrease in FY 2024 reflects shifting from a large set of candidate materials and techniques to the evaluation and characterization of a narrower set of materials and techniques.			
Title: Compartmentalization and Privilege Management (CPM)	-	-	6.000
Description: The Compartmentalization and Privilege Management (CPM) program will develop new system frameworks, architectures, and tooling to provide fine grained, least privileged, compartmentalization that enables prevention and containment			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2022	FY 2023	FY 2024
of cyber attacks. Today's information systems are structured around a monolithic core (the kernel) that operates within a single protection domain at a single high privilege level. This monolithic kernel contains many separate components, but because there are no protection boundaries between these components, a single compromise anywhere in the system allows attackers effectively unlimited access through an extended sequence of exploits and steps of privilege escalation and lateral motion. CPM will develop technologies and tools to automatically compartmentalize large legacy software systems, and processor architectures and system software that enforce a compartment and privilege level regime. CPM tools and architectures will prevent initial penetrations from propagating into successful cyber attacks. ***FY 2024 Plans:*** - Formulate approaches and initiate development of a suite of tools to automatically compartmentalize legacy code and manage privilege levels. - Initiate development of processor architectures and system software that enforce a compartment and privilege level regime with low overhead. - Initiate development of a library of attack campaign test cases for quantifying compartmentalization effectiveness and overhead, and select DoD systems on which to demonstrate attack containment. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 increase reflects program initiation.			
Title: Joint University Microelectronics Program (JUMP) ***Description:*** The Joint University Microelectronics Program (JUMP) was a government-industry joint research program to explore computing, sensing, communication, and data storage innovations for applications beyond the 2030 horizon. The program recognized that the densely interconnected microsystems of the future would be built through the use of groundbreaking materials, revolutionary devices, advanced architectures, and unconventional computing. Therefore, JUMP sponsored academic research teams focused on related key technology areas that would impact future DoD capabilities and national security. The JUMP program not only pushed fundamental technology research but also established 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 enabled 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.	18.000	-	-
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,	-	26.000	26.000

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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 2022	FY 2023	FY 2024
and the semiconductor industry. The JUMP 2.0 program addresses the grand technical challenges of our increasingly connected 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 Intelligence 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 advanced monolithic and heterogeneous integration technology. - Investigate cognition, communications, sensing to action, intelligent memory, and distributed computing concepts. ***FY 2024 Plans:*** - Develop emerging materials, devices, and integration and packaging technologies for future microsystems. - Establish concepts for next-generation artificial intelligence, efficient communication, intelligent storage, novel sensing-to-action, and distributed computing architectures.			
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. This program has applied research efforts funded in PE 0602716E, Project ELT-02. ***FY 2023 Plans:*** - Demonstrate integration of provably-secure hardware into multi-level security architecture.	6.000	11.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency		Date: March 2023
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 2022	FY 2023	FY 2024
- Perform initial testing of integrated provably-secure hardware. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects program completion.			
Title: Beyond Scaling - Materials ***Description:*** The Beyond Scaling - Materials program investigated new materials to support next-generation logic and memory components. The program pursued 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 included 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 was funded within PE 0602716E, Project ELT-02.	5.000	-	-
Title: Beyond Scaling - Architectures and Designs ***Description:*** The Beyond Scaling - Architectures and Designs program investigated 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). This program investigated the potential for lowering the barriers to designing specialized circuits and to incorporating privacy and security protections. Approaches included the use of machine learning and automated design tools to program specialized hardware blocks, integrating them into existing designs, and deploying them in complex systems. This program also supported 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 was funded within PE 0602716E, Project ELT-02.	6.645	-	-
Title: Lifelong Learning Machines (L2M) ***Description:*** The Lifelong Learning Machines (L2M) program researched and developed fundamentally new machine learning mechanisms, enabling machines that learn continuously as they operate. L2M pursued learning approaches inspired by biological systems, which continuously learn and improve their skills without losing previous knowledge. L2M explored network structures that improved performance by processing new data seen in the field, learned new tasks without forgetting previous tasks, and incorporated context into their understanding of the environment. These capabilities will 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.	4.962	-	-
Accomplishments/Planned Programs Subtotals	44.607	70.188	52.004

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency		Date: March 2023
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** ES-02 / *BEYOND SCALING SCIENCES*

	FY 2022	FY 2023
Congressional Add: ERI 2.0 Congressional Add	20.000	-
FY 2022 Accomplishments: - Initiated development of new material systems to extend temperature operation range for thermally-hardened and high-reliability microsystems. - Initiated development of new materials for three-dimensional heterogeneous integration (3DHI) photonics. - Identified new materials and structures for passive components for 3DHI power modules. - Developed novel materials for reducing losses in vertical high frequency interconnects for 3DHI microsystems.		
Congressional Adds Subtotals	20.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
MS-01: *MATERIALS SCIENCES*	-	41.860	53.356	62.934	-	62.934	69.018	69.200	69.782	69.582	-	-

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 2022	FY 2023	FY 2024
Title: Fundamental Limits	20.760	27.356	36.934

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 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.
- Identify DoD relevant applications for room temperature, vapor cell-based electric and magnetic field sensors and quantum atom-light interfaces.
- 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.
- Commence modeling of high energy particle accelerator structures and particle source targets.
- Explore capabilities and applications of hybrid quantum/classical computational systems.
- Develop table-top Quantum Simulators to generate predictive governing models for complex systems.

FY 2024 Plans:

- Initial demonstration of compact, highly-sensitive atomic vapor-based electric and magnetic field sensor devices.
- Initial demonstration of compact vapor-based quantum device with high atom-photon interaction strength and quantum coherence.

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency		Date: March 2023
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 2022	FY 2023	FY 2024
- Perform an engineering analysis of atomic vapor benchtop devices to provide a blueprint for future fieldable systems tailored to DoD applications. - Complete initial modeling of high energy particle accelerator structures and particle source targets. - Define system requirements for compact and directional particle sources. - Analyze the needed fidelity in data and modeling and simulation to improve understanding of the behavior of the geosphere. - Begin development of new modeling and simulation tools for determining the atmospheric changes that could perturb climate and weather. - Develop the theoretical framework for transport of spin polarized electrons. - Initiate efforts to develop techniques to control chemical reaction pathways. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 increase reflects a shift from component development and integration to system demonstration and refinement.			
Title: Molecular Systems and Materials Assembly	18.000	26.000	26.000
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 will leverage novel materials to extend the range, duration, and capabilities of DoD systems and the warfighter. Through control of the arrangement, interactions, and assembly of atoms and molecules, new materials and manufacturing processes are being developed to address long-standing challenges in supply chains, logistics, and sustainment while simultaneously enhancing the warfighter's capabilities on the battlefield. 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 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. - Initiate efforts to achieve simultaneous production of four human macronutrients in microbial food. - Initiate efforts to demonstrate integration of all component processes required to produce microbial food in the field. - Initiate effort to demonstrate the ability to flavor microbial food. - Develop techniques for the precision control of electron and proton flow to carbon and nitrogen for military provisioning at point of need.			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency		Date: March 2023
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 2022	FY 2023	FY 2024
- Provide initial proof-of-concept for rare earth element and strategic mineral production approaches that provide foundations for economical, efficient, low-waste approaches that yield high purity single species from domestic sources and could easily be scaled up beyond laboratory scale. ***FY 2024 Plans:*** - Predict evolution of morphology and local gradients in electrochemical interfaces. - Demonstrate persistence improvements in solid-state laboratory scale battery test samples due to solid/solid morphogenic interfaces. - Demonstrate higher fatigue strength of test samples with morphogenic solid/liquid and solid/vapor interfaces in a corrosive environment. - Achieve simultaneous production of four human macronutrients in microbial food and initiate efforts to produce macro- and micro- nutrients in desired ratios. - Demonstrate, on a benchtop, each of the essential processes required to produce microbial food in the field and initiate efforts to reduce system size, weight, and power. - Demonstrate ability to flavor microbial food and initiate efforts to produce multiple flavors and formats.			
Title: Basic Photon Science ***Description:*** The Basic Photon Science thrust examined 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 explored development of a complex theoretical framework for maximum information extraction from complex scenes to guide development of new imaging technologies. Work in this thrust established the first-principles limits of photon detector performance in a variety of detector technologies enabling better, more sensitive detectors.	3.100	-	-
Accomplishments/Planned Programs Subtotals	41.860	53.356	62.934

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency			Date: March 2023
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 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total	FY 2025	FY 2026	FY 2027	FY 2028	Cost To Complete	Total Cost
TRS-01: *TRANSFORMATIVE SCIENCES*	-	31.594	31.265	4.306	-	4.306	7.373	7.623	7.623	7.623	-	-

A. Mission Description and Budget Item Justification

The Transformative Sciences project focuses on research and analysis that leverages converging technological forces and transformational trends in information-intensive subareas of life sciences, data sciences, and manufacturing. Innovative technologies developed in this project will address multiple DoD challenges such as identification of and adaptation to emerging threats, access to DoD relevant critical materials for manufacturing and warfighter readiness. Successful programs in this project will integrate diverse disciplines and engineer complex biological systems to detect novel threat agents, accelerate warfighter injury recovery, and develop new platform materials and manufacturing processes. This Project 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 2022	FY 2023	FY 2024
Title: Rapid Healing for Warfighter Injuries	15.902	20.421	2.970

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 wounds. 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 2023 Plans:
- Integrate sensors and actuators for one physiological wound healing process into a single platform.
- Demonstrate closed-loop control over at least one physiological wound healing process.
- 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 2024 Plans:
- Integrate sensors and actuators for all required physiological processes into a single platform.

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency		Date: March 2023
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 2022	FY 2023	FY 2024
- Demonstrate that the integrated system can fully heal wounds in half the time relative to current state of art or reduce deleterious effects of normal healing in vivo. - Demonstrate that the algorithmic model predicts the wound stage with at least 90% accuracy. - Initiate studies of gastrointestinal influence on synthesis and repair function of the skeletal and muscular systems. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects the completion of individual component development and testing activities in FY 2023 to focus on final system integration and demonstrations in FY 2024.			
Title: Engineering Functional Materials with Biology*	5.990	4.309	1.336
Description: *Formerly Engineered Living Materials (ELM) The Engineering Functional Materials with Biology 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, tunable magnetic and optical properties, etc.) not only because of the inherent biological components but also because of how those components are assembled together from microscopic to macroscopic scales. Engineering biology tools and techniques are now at a stage to improve the production, organization, and function of biomaterial systems for a variety of expanded capabilities, including those that can help DoD address supply chain challenges. This program is conducting research to enable information-driven assembly of hierarchical biological systems for materials as well as alternate approaches for the production 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 2023 Plans:*** - Demonstrate methods for alternate approaches to identify, engineer, and biomanufacture molecules in austere environments. - Initiate modeling to predict the feasibility, logistics, and economics of biomanufacturing in austere environments. - Engineer biological systems that predictably control the composition, size, and architecture of rare earth element (REE)-containing nanoparticles that exhibit optical and magnetic properties. ***FY 2024 Plans:*** - Characterize biological manufacturing approaches for increased performance of microbes in austere environments. - Refine models to predict the feasibility, logistics, and economics of biomanufacturing in austere environments based on experimental biological data.			

Exhibit R-2A, RDT&E Project Justification: PB 2024 Defense Advanced Research Projects Agency		Date: March 2023
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 2022	FY 2023	FY 2024
- Demonstrate fabrication of multiple REE-containing magnetic or optically active nanoparticles using a tunable biogenic method that offers benefits over conventional chemical approaches. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects reduction in biomanufacturing and engineering efforts to focus on characterization and model refinement.			
Title: Biology for Security (BIOSEC) ***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 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. ***FY 2023 to FY 2024 Increase/Decrease Statement:*** The FY 2024 decrease reflects program completion.	9.702	6.535	-
Accomplishments/Planned Programs Subtotals	31.594	31.265	4.306

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A