Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Defense Advanced Research Projects Agency	**Date:** May 2017
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* I BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602715E I *MATERIALS AND BIOLOGICAL TECHNOLOGY*

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
Total Program Element	-	193.471	220.456	224.440	-	224.440	232.700	234.871	242.097	245.928	-	-
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	117.132	121.703	112.050	-	112.050	120.957	121.928	125.928	125.928	-	-
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	76.339	98.753	112.390	-	112.390	111.743	112.943	116.169	120.000	-	-

A. Mission Description and Budget Item Justification

This program element is budgeted in the Applied Research Budget Activity because its objective is to develop material, biological and energy technologies that make possible a wide range of new military capabilities.

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

The Biologically Based Materials and Devices project acknowledges the growing and pervasive influence of the biological sciences on the development of new DoD capabilities. This influence extends throughout the development of new materials, devices, and processes and relies on the integration of biological breakthroughs with those in engineering and the physical sciences. Contained in this project are thrusts that apply biology's unique fabrication and manufacturing capabilities to produce novel chemicals and materials at scale, as well as research to develop new high-throughput methods and devices to analyze biological changes at the cellular and molecular level. Additional work leverages advances in synthetic biology to engineer novel biological systems and develop new approaches to biosecurity. This project also includes major efforts aimed at integrating biological, computational, and digital sensing methodologies to explore neuroscience technology and maintain human combat performance.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Defense Advanced Research Projects Agency	**Date:** May 2017
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*

B. Program Change Summary ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	206.115	220.456	233.910	-	233.910
Current President's Budget	193.471	220.456	224.440	-	224.440
Total Adjustments	-12.644	0.000	-9.470	-	-9.470
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-6.080	0.000			
• SBIR/STTR Transfer	-6.564	0.000			
• TotalOtherAdjustments	-	-	-9.470	-	-9.470

Change Summary Explanation

FY 2016: Decrease reflects reprogrammings and the SBIR/STTR transfer.
FY 2017: N/A
FY 2018: Decrease reflects drawdown of several Materials Processing Technology programs.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		Date: May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	117.132	121.703	112.050	-	112.050	120.957	121.928	125.928	125.928	-	-

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Materials Processing and Manufacturing	27.602	30.621	25.816

Description: The Materials Processing and Manufacturing thrust is exploring new manufacturing and processing approaches that will dramatically lower the cost and decrease the time required to fabricate DoD parts and systems. It will also develop approaches that yield new materials, materials capabilities and parts that cannot be made through conventional processing approaches, as well as address efficient, low-volume manufacturing. As a result of recent advances in manufacturing techniques such as 3D printing and manufacture on demand, and the push towards programmable hardware in embedded systems, the development cycle from design to production of both hardware and software is severely bottlenecked at the design phase. Integration of advanced materials with superior properties into manufacturing approaches is also complex and slow, hampering new materials integration and evolution of design. Research within this thrust will create methods to translate natural inputs into software code and mechanical design, as well as reduce manufacturing complexity through new material feedstock formats with reconfigurable processing technologies. This thrust is an aggregation of programs previously contained in Multifunctional Materials and Structures.

FY 2016 Accomplishments:
- Completed design of experiments-optimized model for the probabilistic process model.
- Demonstrated predictive capability of the probabilistic process model.
- Completed optimized phenomenological yield strength model for electron beam additive manufacturing (EBAM).
- Completed neural network and genetic numerical analysis for EBAM process.
- Identified candidate reinforced matrix compounds for enabling multiple platforms to be manufactured from a single tailorable feedstock material.
- Identified reconfigurable forming technologies for the rapid, cost-effective manufacture of complex shapes from matrix compounds reinforced with short, aligned elements.

FY 2017 Plans:

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
- Complete verification and validation of probabilistic processing model suite. - Validate phenomenological model framework. - Demonstrate rapid qualification capability on demonstration components. - Develop an aligned and tailorable planar material feedstock that meets or exceeds state-of-the-art aerospace materials performance. - Develop a reconfigurable forming method that maintains alignment and distribution in short-element reinforced matrix compounds when formed into complex shapes for DoD parts. - Initiate creation of a cost model that assesses cost competitiveness and rate insensitivity of the new material format and forming process. - Establish process limits of forming capabilities. ***FY 2018 Plans:*** - Demonstrate capability to fabricate metallic hardware using direct metal laser sintering (DMLS) displaying defect distribution similar to prediction of process simulation hardware. - Demonstrate ability of process-microstructure-tensile models to define optimized probabilistic process window for electron beam additive manufacturing (EBAM) to ensure fabricated material meets minimum properties. - Account for effects of scale in composite bond process model by building larger component box test articles. - Develop and demonstrate integrated hierarchical framework of empirical, process, and physics models that predicts cumulative density functions for component quantities of interest. - Demonstrate pilot-scale production of tailorable, high-performance carbon fiber-based feedstock that meets or exceeds state-of-the-art aerospace materials capability. - Demonstrate a reconfigurable forming method at production rate for short element reinforced matrix compounds that meets or exceeds current DoD performance. - Demonstrate that a multifunctional element can be incorporated into the feedstock while maintaining performance. - Demonstrate that a multifunctional component can be formed without degradation of performance in either the structural or functional component.			
Title: Chemical Processing for Force Protection* ***Description:*** *Formerly Materials for Force Protection Research in this thrust is focused on the development of new chemical approaches and technologies across a broad spectrum of DoD needs. One area involves development of innovative approaches for scalable small molecule synthesis coupled with predictive tools for route design, possibly offering a new strategy to discover how to make new molecules such as pharmaceuticals and explosives. Another focus combines existing strategies for destruction of chemical agents with development	24.431	28.604	24.234

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
of new processing methods to provide a remediation system that can process any chemical agent at the site of storage. In addition, investments in this thrust will advance chemical characterization, information management and analysis, and automation. ***FY 2016 Accomplishments:*** - Validated chemical remediation approaches against a series of DoD-relevant model compounds. - Demonstrated feasibility for achieving an efficiency of chemical agent remediation/conversion of >99%. - Expanded computational methods for reaction pathway design of structurally simple active pharmaceutical ingredients (APIs) such as ibuprofen and atropine. - Demonstrated continuous synthesis of APIs such as nevirapine and hydroxychloroquine. ***FY 2017 Plans:*** - Validate in-line analytical monitoring of newly developed chemical remediation approaches. - Increase chemical remediation/conversion of DoD-relevant model compounds to 99.9%. - Initiate designs for extension of small-scale, continuous flow molecular syntheses to metric ton/year equivalent. - Demonstrate the automated route design and continuous flow synthesis of one challenge molecule identified by DARPA. ***FY 2018 Plans:*** - Increase chemical remediation/conversion of DoD-relevant model compounds to 99.999%. - Integrate inline monitoring with remediation/conversion system to yield initial prototype. - Demonstrate the automated route design and continuous flow synthesis of a structurally complex API (with stereochemistry) such as naproxen or pregabalin. - Integrate the automated route design with the continuous flow system to yield a fully automated synthesis of a DARPA-defined challenge molecule.			
Title: Functional Materials and Devices ***Description:*** The Functional Materials and Devices thrust is developing advanced materials, components and systems to improve device performance for DoD sensing, imaging and communication applications. One focus of this thrust involves development of advanced transductional materials that convert one form of energy to another for DoD-relevant applications in areas such as thermoelectrics. While promising transduction materials are known for a variety of applications, integration into devices has not been realized. Another focus area involves development of new multi-functional materials and device designs that will radically decrease the size, weight and power requirements of neutron sources for high-resolution neutron and x-ray imaging. Such devices should enable fieldable detection units for non-destructive evaluation of parts, detection of explosives and other DoD-relevant targets. This thrust is an aggregation of programs previously contained in Compact Neutron Sources. ***FY 2016 Accomplishments:***	27.704	30.597	24.320

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		Date: May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
- Initiated the development of an open source model architecture and platform applicable for multiple transductional material domains (e.g., thermoelectric, magnetoelectric and multiferroic). - Continued the identification of canonical DoD relevant system specifications that will provide performance requirements for transductional material development efforts. - Began development of a multi-physics transductional material modeling capability that incorporates interface modeling and phonon engineering. - Designed, fabricated and characterized thermoelectric materials and devices with improved performance metrics over the state-of-the-art. - Designed, fabricated and characterized materials and devices based on multiferroic or phase change materials with improved performance metrics over the state-of-the-art. - Incorporated technical findings from component design and development into expected performance metrics for integrated accelerators. - Refined components and began integration into demonstration neutron source testbed. - Used component performance tests for design tool validation and development. ***FY 2017 Plans:*** - Finalize development of multi-physics transductional material modeling capability that incorporates interface modeling and phonon engineering. - Deliver proof of concept thermoelectric devices with improved performance over the state-of-the-art. - Deliver proof of concept devices based on multiferroic or phase change materials with improved performance over the state-of-the-art. - Identify successful compact neutron source components and integrate them into prototype systems. - Perform initial integrated compact neutron source prototype testing. ***FY 2018 Plans:*** - Demonstrate integrated transductional materials and device multi-physics models. - Perform final round of optimization of transductional materials and devices, and characterize their technical performance. - Provide updates to transductional models and deliver them in modeling software. - Integrate earlier developed materials/devices into a system proof of concept. - Refine final integrated compact neutron source prototypes. - Perform final integrated compact neutron source prototype testing.			
Title: Reconfigurable Systems* ***Description:*** *Formerly Reconfigurable Structures	17.613	24.141	19.980

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		Date: May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018**
In the Reconfigurable Systems thrust, new approaches are being developed to enable more rapid and robust adaptation of military systems and systems-of-systems to changing mission requirements and unpredictable environments. This includes development of capabilities across sensing, perception, planning and control for autonomous, high-speed operation in cluttered environments without Global Positioning System (GPS) information. Additional work in this thrust focuses on how systems and systems-of-systems are designed for real-time resilient response to dynamic, unexpected contingencies. Research is ongoing to develop a more unified view of system behavior that allows better understanding and exploitation of complex interactions among system components, including development of a formal mathematical approach to complex adaptive system composition and design. These capabilities will impact autonomous systems and systems-of- systems, including those that involve humans, in a variety of DoD-relevant contexts. ***FY 2016 Accomplishments:*** - Determined limits for GPS-free navigation for short duration missions. - Modeled and developed behavioral controls to enable an Intelligence Surveillance and Reconnaissance (ISR) mission in a moderate-clutter environment. - Evaluated performance of small integrated autonomous aircraft systems in simulated warehouse environment. - Exploited novel mathematical tools and techniques for understanding the fundamentals of design science and design phenomena in complex systems and systems-of-systems. ***FY 2017 Plans:*** - Demonstrate high speed (>10 meters per second (m/s)) GPS-free flight in low clutter environment. - Demonstrate fully autonomous GPS-free flight in unknown environment. - Develop novel representations and behaviors that enable an ISR mission in a high-clutter environment. - Establish new paradigms for how systems-of-systems and their constituent parts are represented, manipulated, integrated and optimized. - Demonstrate management of complexity to enable dynamic design and composition of system-of-systems and their capabilities. - Demonstrate utility of new mathematical and algorithmic methods for system-of-systems design challenges. ***FY 2018 Plans:*** - Demonstrate high speed (>10 m/s) GPS-free flight in moderate clutter. - Demonstrate end-to-end mission capabilities including transition from outdoor to indoor flight. - Demonstrate integration of new mathematical and algorithmic methods into design framework. - Determine limitations of composable abstractions and formally define composability constraints. - Validate time-dynamic function model against real-world data.			
Title: Accelerating Discovery and Innovation	3.680	7.740	17.700

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		Date: May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018**
Description: The Accelerating Discovery and Innovation thrust is developing new approaches, tools and technologies to speed the pace of scientific discoveries and technological innovations from idea generation and fundamental research through integration of technologies into fieldable products and systems in production. The path from idea generation to a discovery is a lengthy, complex process involving many unpredictable steps, cycles and stages across fundamental and applied research and development. Research in this thrust is an outgrowth from Multifunctional Materials and Structures that is focused on developing and implementing strategies to address many of the challenges and bottlenecks inherent along this path and to speed the rate at which an idea can be advanced into a concrete capability. Specific approaches include advanced multiplayer gaming technologies to catalyze development of new technology concepts, development of tools for data collection and visualization to accelerate fundamental and applied research, and strategies to understand how seemingly benign commercially available technologies may be converted or combined into threats to military operations, equipment or personnel. This program has basic research efforts funded in PE 0601101E, Project MS-01. This thrust is an aggregation of programs previously contained in Multifunction Materials and Structures. ***FY 2016 Accomplishments:*** - Engaged a broad range of technical specialists to assess and catalog threats to military operations posed by commercially available products and systems. ***FY 2017 Plans:*** - Build prototypes of commercially available threats and complete detailed assessments. - Develop methods to rapidly explore potential applications of newly discovered or newly developed science and technology data. - Develop computational methods to automate analysis of scientific and engineering data which improve its accessibility and enable new discoveries. - Execute pilot projects to analyze data collected in current DARPA programs and test the automated analysis methods. ***FY 2018 Plans:*** - Develop high rate, integrated assembly processes that bridge the nanometer to centimeter length scales. - Investigate the applicability of feedstock assembly techniques for complex and heterogeneous systems. - Test methods for accelerating discoveries in the research community to demonstrate reduction in time for new idea generation and technology application. - Define integrated technology demonstrations to support scientific discovery and engineering innovation in areas of agency focus. - Test software components for data ingest and discovery across multiple DARPA programs.			
Title: Multifunctional Materials and Structures	13.037	-	-

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: The Multifunctional Materials and Structures thrust developed new methods for synthesis of high value materials, as well as compressing the timeline for integration of new materials into DoD structures, parts and systems. Research in this thrust included development of new methods for scalable, low-temperature growth of thin films for applications such as microelectronics and wear resistance. In addition, this thrust explored new approaches to compress applied materials development and integration into military platforms by at least 75% based on development of a design intent methodology that closely couples materials development with part or platform performance needs. Examples of DoD applications that benefited from this thrust include advanced electronics, lower weight and higher performance aircraft, erosion-resistant rotor blades and high-temperature materials for operation in hypersonic environments. ***FY 2016 Accomplishments:*** - Delivered thin film and coating materials with technical summaries to transition partners, Army Research Office and the Naval Research Laboratory. - Demonstrated initial integrated material, process, design and manufacturing tool demonstrations for hypersonic hot structure aeroshell. - Created material system development and designed framework and linked material informatics results to identify aeroshell mission performance drivers. - Generated a sub-component design concept and a sub-element design for hypersonic hot structure aeroshell. - Established an independent test and evaluation capability for hypersonic hot structure aeroshell.			
Title: Manufacturable Gradient Index Optics (M-GRIN) ***Description:*** The Manufacturable Gradient Index Optics (M-GRIN) program sought to advance the development of gradient index optics (GRIN) lenses from a Technology Readiness Level (TRL) 3 to a Manufacturing Readiness Level (MRL) 6. The program expanded the application of GRIN by providing compact, lightweight, and cost-effective optical systems with controlled dispersion and aberrations that will replace large assemblies of conventional lenses. The ability to create entirely new optical materials and surfaces created the potential for new or significantly improved military optical applications, such as solar concentrators, portable designators, highly efficient fiber optics and imaging systems. The program also sought to extend GRIN manufacturing technologies to glass, ceramic and other inorganic materials to allow for small, lightweight, customized optical elements for mid-wave and long-wave infrared (MWIR and LWIR) applications. A key component of the program was to develop new design tools that enabled optics designers to incorporate dynamic material properties, fabrication methods and manufacturing tolerances. The integration of new materials, design tools and manufacturing processes enabled previously unattainable 3-D optical designs to be manufactured. ***FY 2016 Accomplishments:***	3.065	-	-

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		Date: May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
- Completed prototype builds to demonstrate system performance and/or size, weight and power (SWaP) improvement from GRIN optical systems. - Completed thermal models and implemented them in optical system designs to mitigate thermal effects on optical performance. - Completed demonstration of rapid redevelopment/prototyping capability.			
Accomplishments/Planned Programs Subtotals	117.132	121.703	112.050

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		Date: May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	76.339	98.753	112.390	-	112.390	111.743	112.943	116.169	120.000	-	-

A. Mission Description and Budget Item Justification

This project acknowledges the growing and pervasive influence of the biological sciences on the development of new DoD capabilities. This influence extends throughout the development of new materials, devices, and processes and relies on the integration of biological breakthroughs with those in engineering and the physical sciences. Contained in this project are thrusts that apply biology's unique fabrication and manufacturing capabilities to produce novel chemicals and materials at scale, as well as research to develop new high-throughput methods and devices to analyze biological changes at the cellular and molecular level. Additional work leverages advances in synthetic biology to engineer novel biological systems and develop new approaches to biosecurity. This project also includes major efforts aimed at integrating biological, computational, and digital sensing methodologies to explore neuroscience technology and maintain human combat performance.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: BioDesign	14.435	15.265	12.962
Description: BioDesign will employ system engineering methods in combination with advances in biological and chemical technologies to create novel methods for threat response. This thrust will develop new high-throughput technologies for monitoring the function of cellular machinery at the molecular level and the response(s) of that machinery to physical, chemical, or biological threats. While conventional approaches typically require decades of research, new high-throughput approaches will permit rapid assessment of the impact of known or unknown threats on identified biomolecules and cell function. Successful research in this thrust will both reduce the time required to understand the mechanism of action for new pharmaceutical compounds and enhance response capabilities for emerging and engineered threats. ***FY 2016 Accomplishments:*** - Demonstrated the ability to localize relevant molecules and events to one or more intracellular compartment(s) (e.g., membrane, nucleus, or cytoplasm) upon the application of a challenge compound. - Demonstrated the ability to identify intracellular components and events that occur within minutes after the application of a challenge compound. - Reconstructed and confirmed greater than 60 percent of the molecules and mechanistic events that comprise the canonical mechanism of action for a demonstration compound which has been applied to cells. ***FY 2017 Plans:*** - Continue to demonstrate the ability to localize relevant molecules and events to one or more intracellular compartment(s) (e.g., membrane, nucleus, or cytoplasm) upon the application of a challenge compound.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		Date: May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
- Demonstrate the ability to identify intracellular components and events that occur within seconds after the application of a challenge compound. - Reconstruct and confirm greater than 80 percent of the molecules and mechanistic events that comprise the canonical mechanism of action for a demonstration compound which has been applied to cells. ***FY 2018 Plans:*** - Demonstrate the ability to localize relevant molecules and events to all intracellular compartment(s) (e.g., membrane, nucleus, or cytoplasm) upon the application of a challenge compound. - Demonstrate the ability to identify intracellular components and events that occur within milliseconds after the application of a challenge compound. - Reconstruct and confirm greater than 95 percent of the molecules and mechanistic events that comprise the canonical mechanism of action for a demonstration compound which has been applied to cells. - Demonstrate the ability to detect proteins at low concentrations after exposure to a challenge compound.			
Title: Living Foundries ***Description:*** The goal of the Living Foundries program is to create a revolutionary, biologically-based manufacturing platform for the DoD and the Nation. With its ability to perform complex chemistries, be flexibly programmed through DNA code, scale, adapt to changing environments, and self-repair, biology represents one of the most powerful manufacturing platforms known. Living Foundries seeks to develop the foundational technological infrastructure to transform biology into an engineering practice, speeding the biological design-build-test-learn cycle and expanding the complexity of systems that can be engineered. Ultimately, Living Foundries aims to provide game-changing manufacturing paradigms for the DoD, enabling adaptable, on-demand production of critical and high-value molecules. Research thrusts will focus on the development and demonstration of open technology platforms to prove out capabilities for rapid (months vs. years) design and construction of new bio-production systems. The result will be an integrated, modular infrastructure across the areas of design, fabrication, debugging, analysis, optimization, and validation -- spanning the entire development life-cycle and enabling the ability to rapidly assess and improve designs. Key to success will be tight coupling of computational design, fabrication of systems, debugging using multiple characterization data types, analysis, and further development such that iterative design and experimentation will be accurate, efficient and controlled. Demonstration platforms will be challenged to build a variety of DoD-relevant, novel molecules with complex functionalities, such as synthesis of advanced, functional chemicals, materials precursors, and polymers (e.g., those tolerant of harsh environments). This program has basic research efforts funded in PE 0601101E, Project TRS-01. ***FY 2016 Accomplishments:*** - Demonstrated the ability of infrastructure pipelines to rapidly generate target molecules.	27.945	23.712	21.020

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		Date: May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
- Initiated pressure tests of the foundries to test capabilities of the design and prototyping pipelines in demonstrating the speed, breadth, and efficacy of the infrastructure designs. - Implemented learn capabilities into design algorithms based on testing and characterization of previously prototyped targets in order to improve the processes. - Improved forward design and rapid optimization of target molecules via the prototyping facility's established processes. - Initiated development of computational infrastructure to link component technologies and enable end-to-end process monitoring. ***FY 2017 Plans:*** - Further advance infrastructure pipelines capable of rapidly prototyping and generating DoD-relevant molecules, with significant emphasis on system integration, throughput, and process optimization. - Continue pressure tests of the infrastructure facilities to test capabilities of the design and prototyping pipelines in demonstrating the speed, breadth, and efficacy of the infrastructure designs. - Test the ability to produce ten molecules that are relevant to the DoD. - Incorporate learn capabilities into design algorithms based on testing and characterization of previously prototyped targets in order to improve the processes. - Begin developing the infrastructure pipelines to prototype production of molecules. ***FY 2018 Plans:*** - Demonstrate infrastructure pipelines capable of rapidly prototyping and generating DoD-relevant molecules in a semi-automated manner and initiate efforts to achieve full automation. - Test the ability to produce an additional set of ten molecules that are relevant to the DoD. - Demonstrate that the infrastructure pipeline is capable of prototyping strains that produce molecules. - Characterize impact of machine learning capabilities on design algorithms and identify increases in prototyping process efficiency.			
Title: Adaptive Immunomodulation-Based Therapeutics ***Description:*** The Adaptive Immunomodulation-Based Therapeutics program will develop platform technologies to interrogate and define the biological pathways that modulate the immune response and critical organ function. One approach to achieve this capability will require the development of new tools to stimulate and measure responses of the nervous system in order to map the bioelectric code. This program will also identify immune function correlates for health and early detection of disease. An additional approach involves characterizing the host response in patients with severe infections, and developing a quantitative framework that can be used to guide modulation of the immune response. Algorithms will be developed to evaluate and predict various physiological conditions within an individual. Advances made under the Adaptive Immunomodulation-Based Therapeutics program will improve our response capability against severe infectious diseases and biological threats and offer new avenues for treating disease or organ function.	23.435	24.654	16.962

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		Date: May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
FY 2016 Accomplishments: - Developed novel interface technologies to monitor and stimulate peripheral nerves to selectively alter organ function. - Compared specificity of novel interface technologies with state of the art whole-nerve stimulation devices. - Initiated development of input/output models of mammalian autonomic functions such as the immune system and/or the autonomic stress response. - Identified peripheral intervention points and modulation parameters for control of mammalian autonomic function for improving health or treating disease. - Developed multi-site electrode array and stimulator to improve targeting of vagal nerve stimulation. ***FY 2017 Plans:*** - Initiate demonstrations of advanced peripheral nerve interface technologies in small and large animal models to improve inflammatory and neuropsychiatric disease outcomes. - Develop computational models to simulate noninvasive peripheral nerve modulation approaches for desired physiological outcome. - Elucidate mechanisms of action for peripheral nerve modulation via noninvasive techniques. - Identify panels of relevant biomarkers that are indicative of diseased state and provide a reliable and specific surrogate measure to track physiological response to peripheral nerve modulation. ***FY 2018 Plans:*** - Refine anatomical maps and computational models of function for target neurophysiological circuits. - Quantify on-target responses to neurostimulation to validate computational models of feedback signals and therapeutic benefit. - Demonstrate the components comprising an integrated, closed-loop neuromodulation system to control health status in human or large animal studies. - Conduct in vivo safety and efficacy studies to evaluate long-term bio-interface functionality.			
Title: Biological Robustness in Complex Settings (BRICS) ***Description:*** The Biological Robustness in Complex Settings (BRICS) program will leverage newly developed technologies to enable radical new approaches for gene editing and engineering biology. This area will focus on the creation of enabling technologies that will facilitate the development and integration of fundamental tools and methods being explored under the BRICS program. Research within this area may focus on the development of tools for safe genetic engineering of new species, such as plants, as well as traditionally intractable species, and tools for high-resolution characterization of biological communities. Ultimately, this area seeks to integrate the fundamental component technologies developed under PE 0601101E, TRS-01 into a platform technology capable of engineering robust, stable, and safe communities for the prevention and treatment of disease. ***FY 2016 Accomplishments:***	10.524	12.521	10.962

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
- Developed technologies to design and build biological pathways that will function in undomesticated microbial species from a wide range of phyla (prokaryotic or eukaryotic). - Developed theoretical tools that allow the prediction of metrics of behavior and community dynamics, such as species composition, resource utilization, and small molecule communication within a multi-species consortium. - Fabricated generalizable culture substrates that provide control over community structure and composition and support the growth of both prokaryotic and eukaryotic cells. - Investigated novel strategies for temporal and spatial control of gene editing. ***FY 2017 Plans:*** - Identify promising component technologies that may be readily adapted into a platform for engineering robust, stable, and safe biological communities. - Demonstrate reliable function of engineered microbial communities in laboratory environments. - Demonstrate potential for safe use of engineered consortia under conditions relevant to specific applications. ***FY 2018 Plans:*** - Integrate promising component technologies to engineer a functional microbial community. - Test the robustness, stability, and safety of newly engineered microbial communities. - Evaluate limits for engineered microbial communities.			
Title: Enhancing Neuroplasticity ***Description:*** The Enhancing Neuroplasticity program will explore and develop stimulation methods and non-invasive devices to promote synaptic plasticity that is expected to impact higher cognitive functions. Key advances anticipated from this research will both create an anatomical and functional map of the underlying biological circuitry that mediates plasticity and optimize stimulation and training protocols to enable long-term retention. Once successfully identified, the underlying mechanisms of targeted plasticity training can be applied to a broad range of cognitive skill training within the Department of Defense, including foreign language learning, or data and intelligence analysis. ***FY 2017 Plans:*** - Determine the effects of peripheral nerve stimulation parameters on brain regions that modulate plasticity. - Compare effectiveness of nerve stimulation sites in promoting synaptic plasticity and improving performance on cognitive skill learning tasks. - Demonstrate effects of training on neurons in task-specific sensory and/or motor areas of the brain. - Initiate studies to compare efficacy of invasive and noninvasive stimulators. ***FY 2018 Plans:*** - Demonstrate effects of training on neurons and neuronal network connectivity in task-specific areas of the brain.	-	15.601	19.430

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
- Evaluate the acute effects of targeted neuroplasticity training on brain neurophysiology and learning rate. - Investigate mechanisms for modulating neuroplasticity in humans with peripheral neurostimulation devices. - Test for off-target effects of peripheral neurostimulation and training.			
Title: Biosecurity for Biotechnology ***Description:*** The Biosecurity for Biotechnology program will develop new biological tools to contain, control, and reverse the activities of engineered genes. This research will investigate new approaches for developing tunable controls to enable the safe and predictable use of synthetic genes and pathways. Additional work will develop protecting measures to prevent or limit unintended genome editing or engineering and explore new tools to recall or reverse engineered changes. The Biosecurity for Biotechnology program builds upon technologies investigated in the Biological Robustness in Complex Settings program. ***FY 2017 Plans:*** - Investigate novel gene editing controller mechanisms and failure modes. ***FY 2018 Plans:*** - Investigate novel small molecule and genetic countermeasures to prevent genome editing in cells. - Design and create engineered, reversible genetic elements for evaluation in a laboratory testbed. - Characterize the efficacy, stability, and fitness of engineered genetic constructs and countermeasures in a contained laboratory testbed. - Refine computational models to inform the design and function of engineered genetic controls and countermeasures and predict experimental outcomes.	-	3.750	11.844
Title: Accelerated Agricultural Engineering ***Description:*** Changes in the environment including drought, salt-water intrusion, and acute or chronic flooding, as well as introductions of invasive pests and pathogens, present a significant risk to agricultural production. Conventional methods, such as plant breeding, are generally slow and ineffective against such changes. Research within this program will investigate novel methods for transmission of genetic materials and the controlled integration of selected genetic elements into plant genomes. The goal is to develop technologies that can reduce the timeline for agricultural countermeasure development and dissemination, and increase agricultural stability and resilience against evolving environmental changes and pathogens. The Accelerated Agricultural Engineering program builds upon technologies investigated in the Biological Robustness in Complex Settings program. ***FY 2017 Plans:*** - Investigate novel approaches for delivery of gene editing technology to multiple plant tissues. ***FY 2018 Plans:*** - Develop a flexible plant transformation platform to genetically modify plants.	-	3.250	10.700

Exhibit R-2A, RDT&E Project Justification: FY 2018 Defense Advanced Research Projects Agency		**Date:** May 2017
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018**
- Demonstrate deployment of transgenes in contained greenhouse settings using environmental vectors that can be managed. - Integrate technologies developed for controlled deployment of genetic materials with the late-stage plant gene alteration methods. - Demonstrate the alteration of plant protein production through emerging gene editing technologies in a contained laboratory testbed.			
Title: Engineering Function ***Description:*** The Engineering Function program will leverage advances in synthetic biology and bioengineering to enhance the natural capabilities of biological systems. To date, imparted functionality in engineered living systems has been limited by the vast biological complexity of the system and lack of understanding of the relationship between the living system and its local environment. This program will include research to develop discovery and automation tools as well as synthesis techniques that expand upon the toolbox of genetically encoded constructs and biologic structures for engineered living systems. This program will enable the design of engineered living systems, expanding approaches for multi-cellular system engineering for natural and extreme environments, higher levels of complexity and system-of-system designs, and self-assembled manufacturing. ***FY 2018 Plans:*** - Assess the feasibility of intracellular and intercellular engineering to enhance cellular function. - Investigate methods for effectively assessing the compatibility of newly engineered functionalities in biological systems across multiple size scales and in multiple environments. - Begin development of new automation technologies with the ability to engineer complex biological systems and integrate self-assembled manufacturing.	-	-	8.510
Accomplishments/Planned Programs Subtotals	76.339	98.753	112.390

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.