Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Chemical and Biological Defense Program	Date: February 2020
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601384BP / *CHEMICAL/BIOLOGICAL DEFENSE (BASIC RESEARCH)*

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	-	40.901	48.238	45.300	-	45.300	45.314	45.310	45.300	45.300	Continuing	Continuing
LF1: *Life Sciences (Basic Research)*	-	25.272	29.730	29.764	-	29.764	29.778	29.775	29.768	29.768	Continuing	Continuing
PS1: *Physical Sciences (Basic Research)*	-	15.629	18.508	15.536	-	15.536	15.536	15.535	15.532	15.532	Continuing	Continuing

A. Mission Description and Budget Item Justification

The projects in this program element (PE) advance fundamental knowledge in life and physical sciences. These are basic research efforts directed at promoting theoretical and experimental research in Life and Physical Sciences.

Individual projects include:
- Life Sciences (LF1): fundamental efforts to understand living systems' response to biological or chemical agents, to support detection, diagnostics, protection, and medical treatment (e.g. microbiology, biochemistry, pathogenic mechanisms, cell and molecular biology, immunology, nanoscale science, and information science).

- Physical Sciences (PS1): fundamental scientific phenomena to support investigation of physical and chemical properties and interactions for enhanced functionalities important to detection, diagnostics, protection, and decontamination (e.g. chemistry, physics, materials science, nanotechnologies, nanoscale science, and environmental science).

B. Program Change Summary ($ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	42.103	45.238	45.369	-	45.369
Current President's Budget	40.901	48.238	45.300	-	45.300
Total Adjustments	-1.202	3.000	-0.069	-	-0.069
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	0.000	3.000			
• Congressional Directed Transfers	0.000	-			
• Reprogrammings	-0.416	-			
• SBIR/STTR Transfer	-0.786	-			
• Other Adjustments	0.000	-	-0.069	-	-0.069

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Change Summary Explanation

Funding: FY19 (-$0.416 Million): Reprogrammings to support Protection & Hazard Mitigation projects in advanced technology development and CBDP Defense Finance and Accounting System transactions.
FY19 (-$0.786 Million): Transfer of funding to support Small Business Innovative Research/Small Business Technology Transfer efforts.

FY20 (+$3.000 Million): Congressional Add for Water Jet Technology.

FY21 (-$0.069 Million): Departmental economic adjustment.

Schedule: N/A

Technical: N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Chemical and Biological Defense Program			Date: February 2020
Appropriation/Budget Activity 0400 / 1	R-1 Program Element (Number/Name) PE 0601384BP / *CHEMICAL/BIOLOGICAL DEFENSE (BASIC RESEARCH)*	Project (Number/Name) LF1 / *Life Sciences (Basic Research)*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
LF1: *Life Sciences (Basic Research)*	-	25.272	29.730	29.764	-	29.764	29.778	29.775	29.768	29.768	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project (LF1) focuses on fundamental efforts to understand living systems' responses to biological or chemical agents, to support detection, protection, diagnostics, and medical treatment. Research focuses on studying factors which influence the behavior of chemicals, toxins, and pathogens in relation to the host or target. Understanding of host/agent interactions can drive exploration of novel approaches to detect, diagnose or protect against threats. Research also focuses on medical countermeasures for improved efficacy against a wide array of current and future threat agents.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: 1) Life Sciences	25.272	29.730	29.764
Description: Focuses on fundamental efforts to understand living systems' responses to biological agents, providing knowledge and capabilities that support medical countermeasure development for prophylaxis and therapeutic interventions. ***FY 2020 Plans:*** - Blood-brain barrier - Develop a comprehensive model of the blood-brain barrier molecular antidotes to demonstrate mechanisms of transport for modulators and alphaviruses. Continue to elucidate transport vehicles in established mouse models of blood-brain barrier transport. - Viral pathogenesis - Continue modeling of viral structures to second pathogen and begin correlation of data in mouse models. Begin screening delivery molecules for bioavailability and immunogenicity and assess efficacy of single dose protection against multiple viral targets. - Biomarkers - Begin testing microneedles and microfluidic extraction studies in vivo and validating biomarker results against industry standards. Correlate biomarkers of various threats against different animal models to understand where further research may be needed. - Enabling Science - Continue developing robust genetic control architectures for guidance of antimicrobials against bio threats. - Chemical scavengers - Continue to assess the expression of lung alveoli cellular inflammatory receptors and test with potential therapeutic molecules. Assess how cholinergic stimulation of astrocyte networks are affected by chemical agents and therapeutics. Continue to evaluate transport of antibody-targeted nanoparticles loaded with oxime. - Animal Models - Initiate selection of animal models and threat/therapeutic classes for data validation. Characterize tissue models against known targets to assess comparability to human organ response. Begin validation of organ and animal models against clinical data. - STEM - Supporting Science Technology, Engineering and Math (STEM) strategic efforts to develop talent across the education continuum to enrich our current and future DoD workforce to meet defense technological challenges.			

Exhibit R-2A, RDT&E Project Justification: PB 2021 Chemical and Biological Defense Program		Date: February 2020
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601384BP / *CHEMICAL/BIOLOGICAL DEFENSE (BASIC RESEARCH)*	**Project (Number/Name)** LF1 / *Life Sciences (Basic Research)*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Programs ending in FY20: - Blood-brain barrier - Complete the development of a comprehensive model of the blood-brain barrier molecular antidotes to demonstrate mechanisms of transport for modulators and alphaviruses. - Enabling Science - Complete the evaluation of collected biomarkers that can indicate infection and give information on the type of infection. ***FY 2021 Plans:*** - Microbial pathogenesis - Complete the identification of host pathogen interactions utilizing model organisms, such as Burkholderia, Q Fever Filovirus and Alphavirus, to advance knowledge about biological targets in both the pathogen and host. - Animal model development - Continue to enhance animal model knowledge so as to predictively model human disease caused by biological infectious agents and toxins, and enable identification of common targets that facilitate broad-spectrum protection against classes of biological threat agents. - Animal Models Selection and Validation - Continue selection of animal models and threat/therapeutic classes for data validation. Continue to characterize tissue models against known targets to assess comparability to human organ response. Continue validation of organ and animal models against clinical data. - Enabling Technologies - Continue to develop platform technologies, such as artificial intelligence, machine learning, organ-on-a-chip technologies, and nanoparticles to advance broad-spectrum protection strategies engineered to target multiple biological agents, which will provide knowledge useful for development of medical countermeasures capable of defeating broad classes of biological toxins, viruses and bacteria. - Platform Technology - Begin to validate genomic targets for broad anti-alphavirus treatment and establish a screening database of preclinical countermeasures. - Artificial Intelligence (AI) for Early Drug Discovery - Explore the application of machine learning, AI, and other computational tools to inform rational drug discovery, design, optimization, decision support, and medical modeling. Develop a machine learning algorithm to aid in identifying optimal candidates for advanced development of monoclonal antibody biologics. - STEM - Supporting Science Technology, Engineering and Math (STEM) strategic efforts to develop talent across the education continuum to enrich our current and future DoD workforce to meet defense technological challenges. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Increase due to change in program/project technical parameters.			
Accomplishments/Planned Programs Subtotals	25.272	29.730	29.764

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Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601384BP / *CHEMICAL/BIOLOGICAL DEFENSE (BASIC RESEARCH)*	**Project (Number/Name)** LF1 / *Life Sciences (Basic Research)*	

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
• CB2: *Chemical Biological Defense (Applied Research)*	72.352	87.773	103.497	-	103.497	103.969	108.132	109.257	109.258	Continuing	Continuing
• NT2: *Non-Traditional Agents Defense (Applied Research)*	43.859	52.902	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	96.761
• TM2: *Techbase Medical Defense (Applied Research)*	73.403	74.382	98.310	-	98.310	104.666	102.200	102.280	104.075	Continuing	Continuing
• CB3: *Chemical Biological Defense (ATD)*	22.956	19.798	24.448	-	24.448	24.946	25.239	24.090	24.293	Continuing	Continuing
• NT3: *Non-Traditional Agents Defense (ATD)*	21.494	24.180	15.308	-	15.308	18.396	18.388	18.384	18.384	Continuing	Continuing
• TM3: *Techbase Medical Defense (ATD)*	86.713	120.526	137.829	-	137.829	135.016	129.004	129.543	140.685	Continuing	Continuing

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2021 Chemical and Biological Defense Program			Date: February 2020
Appropriation/Budget Activity 0400 / 1	R-1 Program Element (Number/Name) PE 0601384BP / *CHEMICAL/BIOLOGICAL DEFENSE (BASIC RESEARCH)*	Project (Number/Name) PS1 / *Physical Sciences (Basic Research)*	

COST ($ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
PS1: *Physical Sciences (Basic Research)*	-	15.629	18.508	15.536	-	15.536	15.536	15.535	15.532	15.532	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project (PS1) advances fundamental scientific knowledge in physical science areas that include chemistry, physics, materials science, environmental science, and nanotechnology that could potentially lead to transformational CB defensive capabilities enhancing Warfighter performance and safety.

Individual efforts in this project include:
- Research results in physics, chemistry, and materials science that have potential application in point and remote detection, diagnostics, protection and decontamination.
- Surface and environmental science focus on the study of physical and chemical properties and phenomena of interactions, especially with regard to Non-Traditional Agents (NTAs), in order to improve capabilities such as detection, protection, and decontamination.
- Research in nanotechnology and nanoscale sciences, such as nanoelectromechanical systems, molecular motors, nano-mechanical resonance sensing, and nano-meter imaging. Potential applications across CB capability areas include decreasing detection response times, increasing medical countermeasure effectiveness against a wider array of threat agents, and providing currently unavailable modalities like detection imbedded in fabrics.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
Title: 1) Physical Sciences	15.629	18.508	15.536
Description: Focuses on fundamental scientific phenomena including chemistry, physics, materials science, environmental science, and nanotechnology. ***FY 2020 Plans:*** - Environmental Availability - Determine genetic changes that occur when bacteria enter nonculturable state. Determine conditions that resuscitate bacteria and assess virulence after resuscitation. - Photonics - Complete the design and fabrication of photonic components, including nano-scale thermal resonators, functionalized metallic nanohole arrays, and selective sensor coatings for optical resonators. Complete the proof of concept for chemical sensing using these components. - Chemical Reactivators - Define mechanistic and structural studies of the aged reactivator complexes. - Multifunctional Materials - Synthesize a polymer composition containing the desired volume fraction of polymer blocks as required for successful and stable membrane generation. - Catalysts for CB Defense- Combine experimental data and modeling data to determine degradation mechanism. Synthesize metal organic framework (MOF) hybrids and quantify effects of interferent molecules.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2019	FY 2020	FY 2021
- Biomimetic - Evaluate molecules for bioremediation conditions that mimic field conditions. Begin to screen catalysts in libraries to validate chemistry. - Novel Destruction - Continue to optimize chemical surrogates and design modifications of lab reactor for use with threat agents. - Conduct fundamental research into water jet technology for tactical CB defeat. Notes: - Environmental Availability - name changes to Bio Characterization. - Catalysts for CB Defense - projects realigned to Design Rules For Materials. ***FY 2021 Plans:*** - Bio Characterization - Determine drivers of genetic change and behavior of pathogens in a nonculturable state. Continue to determine conditions that resuscitate bacteria and assess virulence after resuscitation - Photonics - Begin to characterize photonic component sensitivity and integration of multi-agent chemical sensing. Begin assessment of selectivity needs and testing against mixture vapors. - Chemical Reactivators - Continue mechanistic and structural studies of the aged reactivator complexes. - Multifunctional Materials - Continue to synthesize polymer compositions and modify structures based on mechanical analysis. Begin understanding requirements for scale-up of synthesis and integration into woven fibers. - Design Rules for Materials - Investigate the effects of topology and pore size of metal organic frameworks, and test against simulant molecules. Revise computational models to predict material reaction rates. - Biomimetic - Understand design rules for catalytic hydrolysis of target molecules. Begin characterization of polymers through simulation and comparison to experimental data. - Novel Destruction - Develop a kinetic rates model for organic compounds and Chemical Warfare Agents (CWA) surrogates. Investigate new nano-catalyst synthesis method to reduce material costs and improve catalytic activity. ***FY 2020 to FY 2021 Increase/Decrease Statement:*** Decrease due to change in program/project technical parameters.			
Accomplishments/Planned Programs Subtotals	15.629	18.508	15.536

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
• CB2: *Chemical Biological Defense (Applied Research)*	72.352	87.773	103.497	-	103.497	103.969	108.132	109.257	109.258	Continuing	Continuing

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Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601384BP / *CHEMICAL/BIOLOGICAL DEFENSE (BASIC RESEARCH)*	**Project (Number/Name)** PS1 / *Physical Sciences (Basic Research)*	

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
• NT2: *Non-Traditional Agents Defense (Applied Research)*	43.859	52.902	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	96.761
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• NT3: *Non-Traditional Agents Defense (ATD)*	21.494	24.180	15.308	-	15.308	18.396	18.388	18.384	18.384	Continuing	Continuing
• TM3: *Techbase Medical Defense (ATD)*	86.713	120.526	137.829	-	137.829	135.016	129.004	129.543	140.685	Continuing	Continuing

Remarks

D. Acquisition Strategy

N/A