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Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Chemical and Biological Defense Program **Date:** May 2021

Appropriation/Budget Activity 0400: <i>Research, Development, Test & Evaluation, Defense-Wide</i> / BA 1: <i>Basic Research</i>	R-1 Program Element (Number/Name) PE 0601384BP / <i>CHEMICAL/BIOLOGICAL DEFENSE (BASIC RESEARCH)</i>
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COST (\$ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
Total Program Element	-	44.240	50.300	34.708	-	34.708	-	-	-	-	-	-
LF1: <i>Life Sciences (Basic Research)</i>	-	27.925	29.764	19.172	-	19.172	-	-	-	-	-	-
PS1: <i>Physical Sciences (Basic Research)</i>	-	16.315	20.536	15.536	-	15.536	-	-	-	-	-	-

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)

	<u>FY 2020</u>	<u>FY 2021</u>	<u>FY 2022 Base</u>	<u>FY 2022 OCO</u>	<u>FY 2022 Total</u>
Previous President's Budget	48.238	45.300	45.314	-	45.314
Current President's Budget	44.240	50.300	34.708	-	34.708
Total Adjustments	-3.998	5.000	-10.606	-	-10.606
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	0.000	5.000			
• Congressional Directed Transfers	0.000	-			
• Reprogrammings	-1.365	-			
• SBIR/STTR Transfer	-2.633	-			
• Other Adjustments	0.000	-	-10.606	-	-10.606

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

Project: PS1: *Physical Sciences (Basic Research)*

Congressional Add: *Water Jet Technology*

Congressional Add Subtotals for Project: PS1

Congressional Add Totals for all Projects

	FY 2020	FY 2021
	-	5.000
	-	5.000
	-	5.000

Change Summary Explanation

Funding: FY20 (-\$1.364 Million): Reprogramming to Applied Research to support developing a predictive analytic in the emerging environment to enable earlier warning of pathogen exposure.

FY20 (-\$2.633 Million): Transfer of funding to support Small Business Innovative Research/Small Business Technology Transfer efforts.

FY21 (+\$5.000 Million): Congressional Add for Water Jet Technology.

FY22 (-\$10.606 Million): Program adjustments to higher priority science & technology efforts.

Schedule: N/A

Technical: N/A

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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)
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COST (\$ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
LF1: Life Sciences (Basic Research)	-	27.925	29.764	19.172	-	19.172	-	-	-	-	-	-

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 2020	FY 2021	FY 2022
<p>Title: 1) Life Sciences</p> <p>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.</p> <p>FY 2021 Plans:</p> <ul style="list-style-type: none"> - 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. 	27.925	29.764	19.172

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2020	FY 2021	FY 2022
<p>- 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.</p> <p>FY 2022 Plans:</p> <ul style="list-style-type: none"> - Animal Models - Transition animal models to applied program for validation. - Enabling Technologies - Continue biotechnologies investments into organs-on-a-chip to address mechanisms of actions as well as drug model development as well as high throughput screen purification and screening. - Platform Technology - Continue to validate genomic targets for broad anti-alphavirus treatment and establish a screening database of preclinical countermeasures. - Artificial Intelligence (AI) for Early Drug Discovery - Continue to 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. - Viral Pathogenesis - Continue pathogenesis in mouse models as well as antimicrobial peptide development. - Biomarkers - Begin assessing gene expression in various tissues after alphavirus exposure. Begin integration of machine learning (ML), to predict cellular binding site targets. - Inflammation Mapping - Initiate comparison of genomic models of expression to inflammatory response data. Assess how RNA regulation changes after exposure to chemical agents. Begin integration of machine learning (ML) to screen small molecule library for potential therapeutics. <p>Program ending in FY22:</p> <ul style="list-style-type: none"> - STEM - Complete STEM strategic efforts to develop talent across the education continuum to enrich our current and future DoD workforce to meet defense technological challenges. <p>FY 2021 to FY 2022 Increase/Decrease Statement: Decrease due to change in program/project technical parameters.</p>			
Accomplishments/Planned Programs Subtotals	27.925	29.764	19.172

C. Other Program Funding Summary (\$ in Millions)											
<u>Line Item</u>	<u>FY 2020</u>	<u>FY 2021</u>	<u>FY 2022</u> <u>Base</u>	<u>FY 2022</u> <u>OCO</u>	<u>FY 2022</u> <u>Total</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>FY 2025</u>	<u>FY 2026</u>	<u>Cost To</u> <u>Complete</u>	<u>Total Cost</u>
• CB2: Chemical Biological Defense (Applied Research)	82.539	103.497	104.362	-	104.362	-	-	-	-	-	-
• NT2: Non-Traditional Agents Defense (Applied Research)	49.222	0.000	0.000	-	0.000	-	-	-	-	-	-

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C. Other Program Funding Summary (\$ in Millions)

<u>Line Item</u>	<u>FY 2020</u>	<u>FY 2021</u>	<u>FY 2022</u> <u>Base</u>	<u>FY 2022</u> <u>OCO</u>	<u>FY 2022</u> <u>Total</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>FY 2025</u>	<u>FY 2026</u>	<u>Cost To</u> <u>Complete</u>	<u>Total Cost</u>
• TM2: <i>Techbase Medical Defense (Applied Research)</i>	69.344	98.310	102.594	-	102.594	-	-	-	-	-	-
• CB3: <i>Chemical Biological Defense (ATD)</i>	26.426	27.448	27.146	-	27.146	-	-	-	-	-	-
• NT3: <i>Non-Traditional Agents Defense (ATD)</i>	28.344	15.308	18.396	-	18.396	-	-	-	-	-	-
• TM3: <i>Techbase Medical Defense (ATD)</i>	142.123	137.829	137.495	-	137.495	-	-	-	-	-	-

Remarks

D. Acquisition Strategy

N/A

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COST (\$ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
PS1: <i>Physical Sciences (Basic Research)</i>	-	16.315	20.536	15.536	-	15.536	-	-	-	-	-	-

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 chemical biological (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 2020	FY 2021	FY 2022
Title: 1) Physical Sciences	16.315	15.536	15.536
Description: Focuses on fundamental scientific phenomena including chemistry, physics, materials science, environmental science, and nanotechnology.			
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.			

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2020	FY 2021	FY 2022
<p>- 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.</p> <p>FY 2022 Plans:</p> <ul style="list-style-type: none"> - 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 - Continue investigating 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 - Continue understanding design rules for catalytic hydrolysis of target molecules. Continue characterization of polymers through simulation and comparison to experimental data. - Novel Destruction - Continue developing a kinetic rates model for organic compounds and CWA surrogates. Continue investigating new nano-catalyst synthesis method to reduce material costs and improve catalytic activity. - Photocatalysis - Begin to evaluate thermal chemistry of various materials for baseline metrics. Model performance metrics of material characteristics and kinetics with and without chemical simulants. <p>Programs ending in FY22:</p> <ul style="list-style-type: none"> - Bio Characterization - Complete determination for drivers of genetic change and behavior of pathogens in a nonculturable state. Complete conditions that determine that resuscitate bacteria and assess virulence after resuscitation. - Photonics - Complete characterization of photonic component sensitivity and integration of multi-agent chemical sensing. Complete assessment of selectivity needs and testing against mixture vapors. - Chemical Reactivators - Complete mechanistic and structural studies of the aged reactivator complexes. 			
Accomplishments/Planned Programs Subtotals	16.315	15.536	15.536

	FY 2020	FY 2021
Congressional Add: Water Jet Technology	-	5.000
FY 2021 Plans: - Develop and test Water Jet Technology for the destruction of chemical agent munitions using a stream of high pressure water.		
Congressional Adds Subtotals	-	5.000

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C. Other Program Funding Summary (\$ in Millions)

<u>Line Item</u>	<u>FY 2020</u>	<u>FY 2021</u>	<u>FY 2022</u> <u>Base</u>	<u>FY 2022</u> <u>OCO</u>	<u>FY 2022</u> <u>Total</u>	<u>FY 2023</u>	<u>FY 2024</u>	<u>FY 2025</u>	<u>FY 2026</u>	<u>Cost To</u> <u>Complete</u>	<u>Total Cost</u>
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• CB3: <i>Chemical Biological Defense (ATD)</i>	26.426	27.448	27.146	-	27.146	-	-	-	-	-	-
• NT3: <i>Non-Traditional Agents Defense (ATD)</i>	28.344	15.308	18.396	-	18.396	-	-	-	-	-	-
• TM3: <i>Techbase Medical Defense (ATD)</i>	142.123	137.829	137.495	-	137.495	-	-	-	-	-	-

Remarks

D. Acquisition Strategy

N/A