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Exhibit R-2, RDT&E Budget Item Justification: PB 2024 Air Force **Date:** March 2023

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>
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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
Total Program Element	-	142.906	144.303	160.599	0.000	160.599	155.407	155.289	158.405	167.513	Continuing	Continuing
622068: <i>Advanced Guidance Technology</i>	-	61.381	75.017	88.179	0.000	88.179	90.401	97.777	93.771	99.179	Continuing	Continuing
622502: <i>Ordnance Technology</i>	-	81.525	69.286	72.420	0.000	72.420	65.006	57.512	64.634	68.334	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program investigates, develops, and establishes the technical feasibility and military utility of guidance and ordnance technologies for conventional munitions. The effort supports core technical competencies of munitions aerodynamics, guidance, navigation, and control; terminal seeker sciences; fuze technology; energetic materials; damage mechanisms; and munition systems effects. Technologies and associated models and simulation assets to be developed include seekers that provide high-confidence target discrimination and classification with precise target location and robust terminal tracking; navigation technologies that do not rely upon the Global Positioning System (GPS); blast, fragmentation, penetrating, low-collateral-damage, and multi-mission warheads; collaborative, synchronized fuzing; and high-performance and insensitive explosives.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of such program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602605F, 0602788F, 0602298F, and 0602020F.

This program element may include necessary expenses to support the operation and maintenance of facilities to manage, execute, and deliver science and technology capabilities.

This program is in Budget Activity 2, Applied Research because this budget activity includes studies, investigations, and non-system specific technology efforts directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

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B. Program Change Summary (\$ in Millions)	FY 2022	FY 2023	FY 2024 Base	FY 2024 OCO	FY 2024 Total
Previous President's Budget	151.757	137.303	140.602	0.000	140.602
Current President's Budget	142.906	144.303	160.599	0.000	160.599
Total Adjustments	-8.851	7.000	19.997	0.000	19.997
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	10.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-0.003	0.000			
• SBIR/STTR Transfer	-2.778	0.000			
• Other Adjustments	-6.070	-3.000	19.997	0.000	19.997

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

Project: 622502: *Ordnance Technology*

Congressional Add: *Convergence technology research*

Congressional Add Subtotals for Project: 622502

Congressional Add Totals for all Projects

	FY 2022	FY 2023
	0.000	10.000
	0.000	10.000
	0.000	10.000

Change Summary Explanation

FY 2024 adjustment of \$19.997 million reflects increased emphasis on networked collaborative autonomous weapon technology and alternative navigation concepts for high speed/hypersonic weapons.

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Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602602F / <i>Conventional Munitions</i>				Project (Number/Name) 622068 / <i>Advanced Guidance Technology</i>			
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
622068: <i>Advanced Guidance Technology</i>	-	61.381	75.017	88.179	0.000	88.179	90.401	97.777	93.771	99.179	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project investigates, develops, and evaluates conventional munitions guidance technologies to establish technical feasibility and military utility of innovative munition seekers, weapon aerodynamics, navigation and control, and guidance subsystem integration/simulation. Project payoffs include adverse-weather, Global Positioning System (GPS)-degraded and Global Positioning System-denied, networked, and autonomous precision munition guidance capability; increased number of kills per sortie; increased aerospace vehicle survivability; improved weapon reliability and affordability; and improved weapon survivability and effectiveness.

B. Accomplishments/Planned Programs (\$ in Millions)

<p>Title: Seeker Technologies</p> <p>Description: Develops seeker technologies for munitions to provide high-confidence target discrimination and classification, precise target location, and robust terminal tracking.</p> <p>FY 2023 Plans: Continue emphasizing technology development of multi-function sensors, rapid data compression for targeting, bio-inspired information processing and data fusion, and low-power computation. Continue developing technologies that simplify, increase flexibility, and reduce the cost of advanced seeker concepts. Continue to develop algorithmic approaches integrating weapons into the kill chain to enable distributive, flexible seeker targeting with or without an operator in the loop. Continue development and testing of innovative engagements for fifth generation aircraft and beyond. Continue development of weapon radomes and apertures to improve transmission and optical performance while increasing protection from operational environments including directed energy and rain. Continue exploring incorporation of open architecture principles to reduce cost and enable technology refresh within seeker sub-systems. Continue exploring specific techniques for seeker cost reduction with performance improvement such as sparse sensing and compressive sensing. Continue research on integrated processing techniques to enable networked systems. Continue multi-function radio frequency technique development to enable coherent multi-weapon operation. Continue developing weapon open system architecture with extended view and integration into weapon mission computer to enable cooperative weapon operation. Continue open seeker architecture integration into the weapon open system architecture and evaluate the impact with respect to cyber vulnerability. Continue developing and demonstrate coherent collaborative radio frequency seeker operation.</p> <p>FY 2024 Plans: Continue emphasizing technology development of multi-function sensors, rapid data compression for targeting, bio-inspired information processing and data fusion, and low-power computation. Continue developing technologies that simplify, increase flexibility, and reduce the cost of advanced seeker concepts. Continue to develop algorithmic approaches integrating weapons</p>	FY 2022	FY 2023	FY 2024
	14.528	14.421	17.675

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2022	FY 2023	FY 2024	
<p>into the kill chain to enable distributive, flexible seeker targeting with or without an operator in the loop. Continue seeker algorithm development, modeling, simulation, and testing of innovative engagements against fifth-generation threat aircraft. Continue development of weapon radomes and apertures to improve transmission and optical performance while increasing protection from operational environments including directed energy and rain. Complete incorporation of open architecture principles to reduce cost and enable technology refresh within seeker sub-systems. Continue exploring specific techniques for seeker cost reduction with performance improvement such as sparse sensing and compressive sensing. Continue research on integrated processing techniques to enable networked systems. Continue multi-function radio frequency technique development to enable coherent multi-weapon operation. Complete development of weapon open system architecture with extended view and integration into weapon mission computer to enable cooperative weapon operation. Continue open seeker architecture integration into the weapon open system architecture and evaluate the impact with respect to cyber vulnerability. Continue development and demonstration of coherent collaborative radio frequency seeker operation.</p> <p>FY 2023 to FY 2024 Increase/Decrease Statement: FY 2024 increased compared to FY 2023 by \$3.254 million. Funding increased due to increased emphasis on addressing weapon cyber vulnerabilities and accelerating munition targeting across multiple platforms.</p>					
<p>Title: Aerodynamics, Navigation, and Control Technologies</p> <p>Description: Develops weapon aerodynamic control, navigation, and networking technologies for munitions to provide precise, agile flight, networked effects, and immunity to countermeasures.</p> <p>FY 2023 Plans: Continue novel position, navigation and timing technology development for global positioning system denied environments with intent to insert into demonstration programs. Continue investigation of cooperative, autonomous, and collaborative weapon behaviors to develop robust algorithms and swarming playbooks. Continue experiments demonstrating precision navigation, emphasizing cruise missile, form-factored optics and tracker for celestial aided navigation at supersonic cruise missile speeds and trajectory. Continue flight testing of articulating head missile at supersonic speeds at full scale to include analysis of range extension through airframe morphing and articulation. Continue kinetic and electronic attack swarm plays incorporating cyber domain, electric warfare, and kinetic effects. Continue flight demonstration of network aided navigation autonomy playbook. Continue flight demonstration of high-speed, high-performance weaponized quadrotor in a complex environment in support of autonomy tactics development and maturation. Continue machine learning to develop tactics for multi-weapon engagements. Initiate synthetic aperture radar based alternative-navigation technology investigation. Initiate post-weapon deployment data analytics to improve guidance, navigation, and controls models and autonomy tactics.</p> <p>FY 2024 Plans: Continue novel position, navigation and timing technology development for global positioning system denied environments with intent to insert into demonstration programs. Continue investigation of cooperative, autonomous, and collaborative weapon</p>		25.367	34.217	39.535	

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2022	FY 2023	FY 2024
<p>behaviors to develop robust algorithms and swarming play-books. Continue experiments demonstrating precision navigation, emphasizing cruise missile, form-factored optics and tracker for celestial-aided navigation at supersonic cruise missile speeds and trajectory. Continue flight testing of articulating head missile at supersonic speeds at full scale to include analysis of range extension through airframe morphing and articulation. Continue kinetic and electronic attack swarm plays incorporating cyber domain, electronic warfare, and kinetic effects. Continue flight demonstration of network-aided navigation autonomy play-book. Complete flight demonstration of high-speed, high-performance weaponized quad-rotor in a complex environment in support of autonomy tactics development and maturation. Continue machine learning to develop tactics for multi-weapon engagements. Continue synthetic aperture radar-based alternative-navigation technology investigation. Continue post-weapon deployment data analytics to improve guidance, navigation, and controls models and autonomy tactics.</p> <p>FY 2023 to FY 2024 Increase/Decrease Statement: FY 2024 increased compared to FY 2023 by \$5.318 million. Funding increased due to acceleration of networked collaborative autonomous (NCA) weapons technology to include incorporation of artificial intelligence and machine learning as well as enhanced focus on alternative navigation solutions for high speed/hypersonic weapons.</p>			
<p>Title: Guidance Technologies</p> <p>Description: Develops guidance subsystem integration and evaluation technologies to provide open and closed-loop ground testing, flight test risk reduction, and digital simulation of novel concepts.</p> <p>FY 2023 Plans: Continue development of cruise missile behaviors for distributed, cooperative, collaborative strategies and other advanced guidance capabilities. Continue improvement of constructive and virtual analysis tools for design, development, and analysis of advanced missile concepts in representative environments. Continue engagement level analysis on high-speed and air-to-air weapon concepts providing design, performance, and trade space analysis to the program offices. Continue improvement of simulation technologies evaluating innovative air-to-air and air-to-surface engagements to include guidance and control evaluation. Continue inclusion of additional targets and improved terrain resolution to radar, millimeter wave, infrared, and ultraviolet signature generation capability for testing algorithms in real-time software and hardware in-the-loop environments. Continue development of high-speed hardware-in-the-loop simulation technology, including thermal environment, aerodynamic control uncertainty, seeker modeling, and navigation sensor effectiveness. Continue development of infrared light emitting diode target simulator technology to create higher frame rate and higher resolution target simulator technology. Continue providing weapon oriented multi-security level, cross-domain distributed modeling and simulation support using distributed connectivity between Eglin Air Force Base facilities and other geographic locations. Continue development of 6-degrees of freedom and scene generation modules for the extended modeling and simulation community using Air Force Simulator. Continue hardware-</p>	21.486	26.379	30.969

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2022	FY 2023	FY 2024
<p>in-the-loop activities in support of international cooperative research efforts. Initiate exploration of guidance technologies for potential United States Space Force applications.</p> <p><i>FY 2024 Plans:</i> Continue development of cruise missile behaviors for distributed, cooperative, collaborative strategies and other advanced guidance capabilities. Continue improvement of constructive and virtual analysis tools for design, development, and analysis of advanced missile concepts in representative environments. Continue engagement-level analysis on high-speed and air-to-air weapon concepts providing design, performance, and trade-space analysis to the program offices. Continue improvement of simulation technologies evaluating innovative air-to-air and air-to-surface engagements to include guidance and control evaluation. Continue inclusion of additional targets and improved terrain resolution to radar, millimeter wave, infrared, and ultraviolet signature generation capability for testing algorithms in real-time software and hardware in-the-loop environments. Continue development of high-speed hardware-in-the-loop simulation technology, including thermal environment, aerodynamic control uncertainty, seeker modeling, and navigation sensor effectiveness. Continue development of infrared light-emitting diode target simulator technology to create higher frame rate and higher resolution target simulator technology. Continue providing weapon-oriented multi-security level, cross-domain distributed modeling and simulation support using distributed connectivity between Eglin Air Force Base facilities and other geographic locations. Continue development of 6-degrees of freedom and scene generation modules for the extended modeling and simulation community using Air Force Simulator. Continue hardware-in-the-loop activities in support of international cooperative research efforts. Complete exploration of guidance technologies for potential United States Space Force applications.</p> <p><i>FY 2023 to FY 2024 Increase/Decrease Statement:</i> FY 2024 increased compared to FY 2023 by \$4.590 million. Funding increased due to acceleration of networked collaborative autonomous (NCA) weapons technology to include incorporation of artificial intelligence and machine learning as well as high speed/hypersonic guidance components and algorithms.</p>			
Accomplishments/Planned Programs Subtotals	61.381	75.017	88.179

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

Remarks

D. Acquisition Strategy
Not Applicable

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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
622502: <i>Ordnance Technology</i>	-	81.525	69.286	72.420	0.000	72.420	65.006	57.512	64.634	68.334	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project investigates, develops, and evaluates conventional ordnance technologies to establish technical feasibility and military utility for advanced explosives, fuzes, warheads, sub-munitions, and weapon airframes, carriage, and dispensing. The project also assesses the lethality and effectiveness of current and planned conventional weapons technology programs and assesses target vulnerability. The payoffs include improved storage capability and transportation safety of fully assembled weapons, improved warhead and fuze effectiveness, improved sub-munitions dispensing, low-cost airframe/subsystem components and structures, and reduced aerospace vehicle and weapon drag.

B. Accomplishments/Planned Programs (\$ in Millions)

<p>Title: Energetic Materials Technology</p> <p>Description: Investigates and develops energetic materials and technology that safely and securely optimize survivability, cost, and weapon lethality for munitions.</p> <p>FY 2023 Plans: Continue advancement and development of selected energetic materials to increase energy density over traditional explosives while enhancing damage mechanisms and lethality for mass and volume-constrained applications. Continue building and implementing experimental techniques/capabilities to quantify dynamic and mechanical properties as well as survivability of energetic materials in extreme temperature and vibrational environments. Continue developing tools and analysis techniques to further the understanding of energy partitioning in order to optimize lethality against a broad spectrum of targets. Continue maturation of additive manufacturing techniques to increase the design space for kinetic weapon lethality. Continue formulation of novel explosive fill to satisfy severe environmental constraints. Continue development of large scale nano-energetic material fabrication.</p> <p>FY 2024 Plans: Continue advancement and development of selected energetic materials, specifically nano-intermetallic compounds, to increase energy density over traditional explosives while enhancing damage mechanisms and lethality for mass and volume-constrained applications. Continue building and implementing experimental techniques/capabilities to quantify dynamic and mechanical properties as well as survivability of energetic materials in extreme temperature and vibrational environments. Continue development of tools and analysis techniques to further the understanding of energy partitioning between blast/fragmentation and combined effects in order to optimize lethality against a broad spectrum of targets. Continue maturation of additive manufacturing techniques to increase the design space for kinetic weapon lethality and to facilitate distributed manufacturing processes.</p>	FY 2022	FY 2023	FY 2024
	7.593	6.620	9.613

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2022	FY 2023	FY 2024
<p>Continue formulation of novel explosive fill to satisfy severe environmental constraints. Continue development of large-scale nano-energetic material fabrication.</p> <p>FY 2023 to FY 2024 Increase/Decrease Statement: FY 2024 increased compared to FY 2023 by \$2.993 million. Funding increased due to increased emphasis upon agile manufacturing of ordnance components at point of demand and activation of technical facilities at the Advanced Munitions Technology Complex.</p>				
<p>Title: Fuze Technologies</p> <p>Description: Investigate and develop fuzing technology for weapons to ensure reliable and optimal function to maximize weapon lethality for all engagement scenarios.</p> <p>FY 2023 Plans: Completed development of testing capabilities for munitions penetration scenarios and modeling and simulation capabilities to reduce research and development costs and timelines. Continue development and demonstration of alternative packaging technology for survivable fuze electronic components. Continue investigating the reliability and survivability of electronic components for prediction and measurement of fuze performance during munition penetration at high-impact speeds. Continue research facilitating tailored lethal effects and enable optimum fuzing solutions across the spectrum of weapon and target interactions. Continue research for distributed and multi-point fuzing concepts. Continue implementing additive manufacturing techniques to increase fuze reliability. Continue fuze explosive interfaces analysis for robust definition of explosive train reliability and performance. Continue fuze endgame, active imaging for target detection and aim point selection.</p> <p>FY 2024 Plans: Initiate implementation of digital engineering tools to enable digital design of munition fuzes. Continue development and demonstration of alternative packaging technology for survivable fuze electronic components. Continue investigating the reliability and survivability of electronic components for prediction and measurement of fuze performance during munition penetration at high-impact speeds. Continue research facilitating tailored lethal effects that enable optimum fuzing solutions across the spectrum of weapon and target interactions as enabling technologies for agile weapon effect concepts. Continue research for distributed and multi-point fuzing concepts as enabling technologies for agile weapon effect concepts. Continue implementing additive manufacturing techniques to increase fuze reliability and to facilitate distributed manufacturing. Continue fuze explosive interfaces analysis for robust definition of explosive train reliability and performance. Continue fuze endgame, active imaging for target detection and aim point selection.</p> <p>FY 2023 to FY 2024 Increase/Decrease Statement:</p>		9.295	6.479	9.803

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2022	FY 2023	FY 2024	
FY 2024 increased compared to FY 2023 by \$3.324 million. Funding increased due to enhanced focus on ordnance technologies for agile weapons providing dynamic effects on the tactical edge and high speed weapons versus maritime targets.					
<p>Title: Warhead Technologies</p> <p>Description: Investigate and develop innovative warhead kill mechanisms for weapons that maximize weapon lethality for all engagement scenarios.</p> <p>FY 2023 Plans: Continue maturation of small, multi-output warhead technologies for soft-surface targets, to include limited penetration capability of hardened structures. Continue evolving test capabilities to enhance quantification of the mechanical response under high-rate, high-pressure loading conditions for use in high-fidelity modeling and simulation tools, to include materials used in additive manufacturing processes. Continue development of additive manufacturing techniques and produce optimized sub-scale articles for test. Complete demonstration of technologies for effective and survivable high-speed penetration. Continue development of warhead concepts for the air targets in peer engagement scenarios. Continue research and develop cumulative damage mechanisms taking advantage of distributed blast, as well as shock wave and reactive particle interactions. Continue subsystem warhead technology integration. Continue the development of topological optimization in support of additive manufacturing. Complete studies of composite-based warheads for penetrator/perforator applications.</p> <p>FY 2024 Plans: Continue maturation of small, multi-output warhead technologies for soft-surface targets, to include limited penetration capability of surface-hardened structures. Continue evolving test capabilities to enhance quantification of the mechanical response under high-rate, high-pressure loading conditions for use in high-fidelity modeling and simulation tools, to include materials used in additive manufacturing processes, enabling digital engineering of warhead concepts. Continue developing additive manufacturing techniques and produce optimized sub-scale articles for test. Initiate demonstration of technologies for effective and survivable high-speed penetration, specifically focusing on maritime and surface targets relevant to Joint Warfighting Concept. Continue development of warhead concepts for the air targets in peer engagement scenarios. Continue research and develop cumulative damage mechanisms taking advantage of coordinated and distributed impact. Continue subsystem warhead technology integration. Complete the development of topological optimization in support of additive manufacturing.</p> <p>FY 2023 to FY 2024 Increase/Decrease Statement: FY 2024 increased compared to FY 2023 by \$2.423 million. Funding increased due to increased emphasis on high speed ordnance technology versus maritime targets and activation of technical facilities at the Advanced Munitions Technology Complex.</p>		13.229	11.225	13.648	
<p>Title: Ordnance Technologies</p> <p>Description: Investigate and develop ordnance sub-system (energetics, fuzes and war-heads) and integrated system concepts using both high-fidelity and fast-running engineering level Modeling and Simulation tools.</p>		51.408	34.962	39.356	

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2022	FY 2023	FY 2024
<p><i>FY 2023 Plans:</i> Continue developing validated mesoscale modeling and simulation tools for computational physics sciences. Continue developing engineering-level simulation architecture capability to enable weapon sub-system and system-level technology assessments. Continue implementing cost-effective and rapid transition warhead technologies for inventory weapons. Continue modeling and simulation efforts exploring the ordnance technology trade space for low-cost, long-range munition concepts. Continue developing predictive techniques for munition effectiveness tools used in concept development and assessment as well as studies involving analysis of alternatives. Continue developing test capability and data collection for modeling and simulation tools to characterize lethality, survivability, and performance of sub-systems and integrated ordnance systems. Continue the development of ordnance test and evaluation capabilities that include thermal and vibration management for hypersonic and high-speed flight. Initiate investigation of machine learning technologies for ordnance. Initiate and explore connection of ordnance modeling and simulation and lethality tools to the broader digital engineering ecosystem.</p> <p><i>FY 2024 Plans:</i> Continue developing validated mesoscale modeling and simulation tools for computational physics sciences. Continue to develop engineering-level simulation architecture capability to enable weapon sub-system and system-level technology assessments. Continue implementing cost-effective and rapid- transition warhead technologies for inventory weapons. Continue modeling and simulation efforts exploring the ordnance technology trade-space for low-cost, long-range munition concepts. Continue developing predictive techniques for munition effectiveness tools used in concept development and assessment as well as studies involving analysis of alternatives. Continue developing test capability and data collection for modeling and simulation tools to characterize lethality, survivability, and performance of sub-systems and integrated ordnance systems. Complete the development of ordnance test and evaluation capabilities that include thermal and vibration management for hypersonic and high-speed flight. Continue investigation of machine learning technologies for ordnance. Continue exploring the connection of ordnance modeling and simulation and lethality tools to the broader digital engineering ecosystem.</p> <p><i>FY 2023 to FY 2024 Increase/Decrease Statement:</i> FY 2024 increased compared to FY 2023 by \$4.394 million. Funding increased due to enhanced focus in lethality tools for automated Advanced Battle Management System/Joint All-Domain Command and Control and improved modeling and simulation tools for weapons design and weaponeering.</p>			
Accomplishments/Planned Programs Subtotals	81.525	59.286	72.420

	FY 2022	FY 2023
<i>Congressional Add:</i> Convergence technology research	0.000	10.000

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	FY 2022	FY 2023
FY 2022 Accomplishments: Not applicable.		
FY 2023 Plans: Conduct Congressionally directed efforts.		
Congressional Adds Subtotals	0.000	10.000

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

N/A

Remarks

D. Acquisition Strategy

Not Applicable.