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**Exhibit R-2, RDT&E Budget Item Justification:** PB 2023 Air Force **Date:** April 2022

<b>Appropriation/Budget Activity</b> 3600: <i>Research, Development, Test &amp; Evaluation, Air Force I BA 2: Applied Research</i>	<b>R-1 Program Element (Number/Name)</b> PE 0602602F / <i>Conventional Munitions</i>
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COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
Total Program Element	-	118.541	151.757	137.303	0.000	137.303	140.602	142.749	140.399	143.572	Continuing	Continuing
622068: <i>Advanced Guidance Technology</i>	-	66.041	101.070	75.017	0.000	75.017	76.797	78.045	79.700	81.440	Continuing	Continuing
622502: <i>Ordnance Technology</i>	-	52.500	50.687	62.286	0.000	62.286	63.805	64.704	60.699	62.132	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.

Funds in this PE may be used to investigate specified technology advancements in air, space and/or cyber domains.

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>B. Program Change Summary (\$ in Millions)</b>	<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023 Base</b>	<b>FY 2023 OCO</b>	<b>FY 2023 Total</b>
Previous President's Budget	127.193	151.757	0.000	0.000	0.000
Current President's Budget	118.541	151.757	137.303	0.000	137.303
Total Adjustments	-8.652	0.000	137.303	0.000	137.303
• 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	-0.003	0.000			
• SBIR/STTR Transfer	-3.352	0.000			
• Other Adjustments	-5.297	0.000	137.303	0.000	137.303

**Change Summary Explanation**

Decrease in FY 2021 reflects adjustments and reprogramming to support Research and Development Projects, 10 U.S.C. Section 2363, an amendment to PL 110-417, 10 U.S.C. Section 2358 and 10 U.S.C. 2805(d)(1)(B).

The FY 2022 President's Budget submittal did not reflect FY 2023 through FY 2026 funding. Therefore, an explanation of the change between the two budget positions for FY 2023 cannot be made in a relevant manner.

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<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2023 Air Force										<b>Date:</b> April 2022		
<b>Appropriation/Budget Activity</b> 3600 / 2					<b>R-1 Program Element (Number/Name)</b> PE 0602602F / <i>Conventional Munitions</i>				<b>Project (Number/Name)</b> 622068 / <i>Advanced Guidance Technology</i>			
<b>COST (\$ in Millions)</b>	<b>Prior Years</b>	<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023 Base</b>	<b>FY 2023 OCO</b>	<b>FY 2023 Total</b>	<b>FY 2024</b>	<b>FY 2025</b>	<b>FY 2026</b>	<b>FY 2027</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
622068: <i>Advanced Guidance Technology</i>	-	66.041	101.070	75.017	0.000	75.017	76.797	78.045	79.700	81.440	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><b>Title:</b> Seeker Technologies</p> <p><b>Description:</b> Develops seeker technologies for munitions to provide high-confidence target discrimination and classification, precise target location, and robust terminal tracking.</p> <p><b>FY 2022 Plans:</b> Continue to emphasize technology development of multi-function sensors, rapid data compression for targeting, bio-inspired information processing and data fusion, and low-power computation. Continue to develop 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 materials research efforts on radomes and apertures to improve transmission and optical performance while increasing protection from operational environments including directed energy and rain. Continue to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker sub-systems. Continue to explore 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 to develop Open Seeker Architecture with extended view and continue 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 to develop and demonstrate coherent collaborative radio frequency seeker operation.</p> <p><b>FY 2023 Plans:</b> Continue to emphasize technology development of multi-function sensors, rapid data compression for targeting, bio-inspired information processing and data fusion, and low-power computation. Continue to develop technologies that simplify, increase flexibility, and reduce the cost of advanced seeker concepts. Continue to develop algorithmic approaches integrating weapons</p>	<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023</b>
	11.465	23.921	14.421

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023</b>
<p>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 to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker sub-systems. Continue to explore 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 to develop 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 to develop and demonstrate coherent collaborative radio frequency seeker operation.</p> <p><b>FY 2022 to FY 2023 Increase/Decrease Statement:</b> FY 2023 decreased compared to FY 2022 by \$9.500 million. Funding decreased due to higher Air Force priorities.</p>				
<p><b>Title:</b> Aerodynamics, Navigation, and Control Technologies</p> <p><b>Description:</b> Develops weapon aerodynamic control, navigation, and networking technologies for munitions to provide precise, agile flight, networked effects, and immunity to countermeasures.</p> <p><b>FY 2022 Plans:</b> Continue novel position, navigation and timing technology development for global positioning system denied environments with intent to insert into demonstration programs. Continue to investigate 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. Completed flight demonstration of heterogeneous collaborative capability which integrated kinetic swarm plays with electronic attack swarm plays. Initiate new phase of 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. Complete machine learning of visual servos. Initiate machine learning to develop tactics for multi-weapon engagements.</p> <p><b>FY 2023 Plans:</b> Continue novel position, navigation and timing technology development for global positioning system denied environments with intent to insert into demonstration programs. Continue to investigate 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</p>		32.616	41.770	34.217

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023</b>
<p>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><b>FY 2022 to FY 2023 Increase/Decrease Statement:</b> FY 2023 decreased compared to FY 2022 by \$7.553 million. Funding decreased due to higher Air Force priorities.</p>				
<p><b>Title:</b> Guidance Technologies</p> <p><b>Description:</b> 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><b>FY 2022 Plans:</b> Continue low-cost cruise missile demonstration of critical behaviors for distributed, cooperative, collaborative strategies and other advanced guidance capabilities. Continue to improve constructive and virtual analysis tools for design, development, and analysis of advanced low-cost cruise missile concepts in representative environments. Continue engagement level analysis on hypersonic and air-to-air weapon concepts providing design, performance, and trade space analysis to the program offices. Continue to improve simulation technologies evaluating innovative air-to-air and air-to-surface engagements to include guidance and control evaluation. Continue to add 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 hypersonic hardware-in-the-loop simulation technology, including thermal environment, aerodynamic control uncertainty, seeker modeling, and navigation sensor effectiveness. Complete simulator upgrades to accommodate resolution requirements for navigation quality synthetic aperture radar target and background modeling. 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.</p> <p><b>FY 2023 Plans:</b> Continue development of cruise missile behaviors for distributed, cooperative, collaborative strategies and other advanced guidance capabilities. Continue to improve 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-</p>		21.960	35.379	26.379

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	FY 2021	FY 2022	FY 2023
<p>air weapon concepts providing design, performance, and trade space analysis to the program offices. Continue to improve simulation technologies evaluating innovative air-to-air and air-to-surface engagements to include guidance and control evaluation. Continue to add 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. Initiate exploration of guidance technologies for potential United States Space Force applications.</p> <p><b><i>FY 2022 to FY 2023 Increase/Decrease Statement:</i></b> FY 2023 decreased compared to FY 2022 by \$9.000 million. Funding decreased due to higher Air Force priorities.</p>			
<b>Accomplishments/Planned Programs Subtotals</b>	66.041	101.070	75.017

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not Applicable

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<b>COST (\$ in Millions)</b>	<b>Prior Years</b>	<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023 Base</b>	<b>FY 2023 OCO</b>	<b>FY 2023 Total</b>	<b>FY 2024</b>	<b>FY 2025</b>	<b>FY 2026</b>	<b>FY 2027</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
622502: <i>Ordnance Technology</i>	-	52.500	50.687	62.286	0.000	62.286	63.805	64.704	60.699	62.132	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)**

	<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023</b>
<b>Title:</b> Energetic Materials Technology	4.833	4.721	6.620
<b>Description:</b> Investigates and develops energetic materials and technology that safely and securely optimize survivability, cost, and weapon lethality for munitions.			
<b>FY 2022 Plans:</b> Continue to advance and develop selected energetic materials to increase energy density over traditional explosives while enhancing damage mechanisms and lethality for mass and volume-constrained applications. Continue to build and implement experimental techniques/capabilities to quantify dynamic and mechanical properties as well as survivability of energetic materials in extreme temperature and vibrational environments. Continue to develop tools and analysis techniques to further the understanding of energy partitioning in order to optimize lethality against a broad spectrum of targets. Complete liner technologies formulation and test to improve Insensitive Munitions performance. Continue to mature 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.			
<b>FY 2023 Plans:</b> Continue to advance and develop selected energetic materials to increase energy density over traditional explosives while enhancing damage mechanisms and lethality for mass and volume-constrained applications. Continue to build and implement experimental techniques/capabilities to quantify dynamic and mechanical properties as well as survivability of energetic materials in extreme temperature and vibrational environments. Continue to develop tools and analysis techniques to further the understanding of energy partitioning in order to optimize lethality against a broad spectrum of targets. Continue to mature 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.			
<b>FY 2022 to FY 2023 Increase/Decrease Statement:</b>			

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023</b>
FY 2023 increased compared to FY 2022 by \$1.899 million. Funding increased due to increased emphasis on improving energy density and lethality of energetic materials.				
<p><b>Title:</b> Fuze Technologies</p> <p><b>Description:</b> Investigate and develop fuzing technology for weapons to ensure reliable and optimal function to maximize weapon lethality for all engagement scenarios.</p> <p><b>FY 2022 Plans:</b> Continue to develop testing capabilities for munitions penetration scenarios and increase modeling and simulation capabilities to reduce research and development costs and timelines. Continue to develop and demonstrate alternative packaging technology for survivable fuze electronic components. Continue to investigate the reliability and survivability of electronic components to predict and measure fuze performance during munition penetration at high-impact speeds. Continue research to facilitate 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><b>FY 2023 Plans:</b> Completed development of testing capabilities for munitions penetration scenarios and increase modeling and simulation capabilities to reduce research and development costs and timelines. Continue to develop and demonstrate alternative packaging technology for survivable fuze electronic components. Continue to investigate the reliability and survivability of electronic components to predict and measure fuze performance during munition penetration at high-impact speeds. Continue research to facilitate 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><b>FY 2022 to FY 2023 Increase/Decrease Statement:</b> FY 2023 increased compared to FY 2022 by \$0.700 million. Funding increased due to increase emphasis on fuzing at high-speeds for improved survivability and reliability.</p>		5.977	5.779	6.479
<p><b>Title:</b> Warhead Technologies</p> <p><b>Description:</b> Investigate and develop innovative warhead kill mechanisms for weapons that maximize weapon lethality for all engagement scenarios.</p> <p><b>FY 2022 Plans:</b></p>		8.691	8.225	14.225

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023</b>
<p>Continue to mature small, multi-output warhead technologies for soft-surface targets, to include limited penetration capability of hardened structures. Continue to evolve 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 to develop additive manufacturing techniques and produce optimized sub-scale articles for test. Continue to demonstrate technologies for effective and survivable high-speed penetration into hard targets. Continue to develop warhead concepts for the air targets in near-peer engagement scenarios. Continue to research and develop cumulative damage mechanisms taking advantage of distributed blast, as well as shock wave and reactive particle interactions. Continue integration of warhead research with related activities planned for the advanced/integrated ordnance sub-systems research capability. Continue the development of topological optimization in support of additive manufacturing. Continue studies of composite-based warheads for penetrator/perforator applications.</p> <p><b>FY 2023 Plans:</b> Continue to mature small, multi-output warhead technologies for soft-surface targets, to include limited penetration capability of hardened structures. Continue to evolve 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 to develop additive manufacturing techniques and produce optimized sub-scale articles for test. Continue to demonstrate technologies for effective and survivable high-speed penetration. Continue to develop warhead concepts for the air targets in peer engagement scenarios. Continue to 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><b>FY 2022 to FY 2023 Increase/Decrease Statement:</b> FY 2023 increased compared to FY 2022 by \$6.000 million. Funding increased due to additional emphasis in warhead technologies for high speed and hypersonic applications.</p>				
<p><b>Title:</b> Ordnance Technologies</p> <p><b>Description:</b> 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> <p><b>FY 2022 Plans:</b> Continue to develop 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 to implement cost-effective and rapid transition warhead technologies for inventory penetrators. Continue modeling and simulation efforts exploring the ordnance technology trade space for low-cost, long-range munition concepts. Continue to develop predictive techniques for munition effectiveness tools used in concept development and assessment as well as studies involving</p>		32.999	31.962	34.962

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023</b>
<p>analysis of alternatives. Continue to develop 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.</p> <p><b><i>FY 2023 Plans:</i></b> Continue to develop 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 to implement 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 to develop predictive techniques for munition effectiveness tools used in concept development and assessment as well as studies involving analysis of alternatives. Continue to develop 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. Initiate exploration of ordnance technologies for potential United States Space Force applications.</p> <p><b><i>FY 2022 to FY 2023 Increase/Decrease Statement:</i></b> FY 2023 increased compared to FY 2022 by \$3.000 million. Funding increased due to additional emphasis in modeling and simulation and physical test infrastructure needs for hypersonic and digital transformation applications.</p>			
<b>Accomplishments/Planned Programs Subtotals</b>	52.500	50.687	62.286

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not Applicable.