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**Exhibit R-2, RDT&E Budget Item Justification:** PB 2022 Air Force **Date:** May 2021

<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 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	-	132.090	127.193	151.757	0.000	151.757	-	-	-	-	-	-
622068: <i>Advanced Guidance Technology</i>	-	75.300	73.016	101.070	0.000	101.070	-	-	-	-	-	-
622502: <i>Ordnance Technology</i>	-	56.790	54.177	50.687	0.000	50.687	-	-	-	-	-	-

**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 air-launched munitions. The effort supports core technical competencies of fuze technology; energetic materials; damage mechanisms; munitions aerodynamics, guidance, navigation, and control; terminal seeker sciences; and munition systems effects. Technologies to be developed include blast, fragmentation, penetrating and low-collateral-damage warheads, hard-target fuzing, precise terminal guidance, 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, 1206601SF, and 0602298F.

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.

<b>B. Program Change Summary (\$ in Millions)</b>	<b>FY 2020</b>	<b>FY 2021</b>	<b>FY 2022 Base</b>	<b>FY 2022 OCO</b>	<b>FY 2022 Total</b>
Previous President's Budget	142.772	132.425	147.652	0.000	147.652
Current President's Budget	132.090	127.193	151.757	0.000	151.757
Total Adjustments	-10.682	-5.232	4.105	0.000	4.105
• Congressional General Reductions	0.000	-0.232			
• Congressional Directed Reductions	0.000	-5.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.324	0.000			
• SBIR/STTR Transfer	-3.762	0.000			
• Other Adjustments	-7.244	0.000	4.105	0.000	4.105

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**Exhibit R-2A, RDT&E Project Justification:** PB 2022 Air Force **Date:** May 2021

<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>			
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
622068: <i>Advanced Guidance Technology</i>	-	75.300	73.016	101.070	0.000	101.070	-	-	-	-	-	-

**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)**

	FY 2020	FY 2021	FY 2022
<b>Title:</b> Seeker Technologies	8.216	13.790	23.921
<b>Description:</b> Develops seeker technologies for air-delivered munitions to provide high-confidence target discrimination and classification, precise target location, and robust terminal tracking.			
<b>FY 2021 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 subsystems. 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. Further development of Open Seeker Architecture with extended view to integrate into weapon mission computer to enable cooperative weapon operation. Continue integration of the Open Seeker architecture 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.			
<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			

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2020</b>	<b>FY 2021</b>	<b>FY 2022</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 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 2021 to FY 2022 Increase/Decrease Statement:</b> FY 2022 increased compared to FY 2021 by \$10.131 million. Funding increased due to additional emphasis on seeker development for contested engagement settings with cluttered backgrounds to support convergence effects for precision weapon delivery.</p>					
<p><b>Title:</b> Aerodynamics, Navigation, and Control Technologies</p> <p><b>Description:</b> Develops weapon aerodynamic control, navigation, and networking technologies for air-delivered munitions to provide precise, agile flight, networked effects, and immunity to countermeasures.</p> <p><b>FY 2021 Plans:</b> Continue execution of Global Positioning System denied navigation demonstration programs. Initiate cooperative weapon swarming playbooks, demonstrating autonomous and collaborative behaviors, with various legacy weapon systems. 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. Continue flight demonstration on heterogeneous capability integrating kinetic swarm plays with electronic attack swarm plays. Continue flight demonstration of network aided navigation autonomy playbook. Continue flight demonstration of high-speed, high-performance weaponized quadrotor in a complex environment. Continue to use machine learning of a visual servo; learn servo commands from drone pilots using front looking camera.</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</p>		27.076	34.941	41.770	

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2020</b>	<b>FY 2021</b>	<b>FY 2022</b>
<p>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 2021 to FY 2022 Increase/Decrease Statement:</b> FY 2022 increased compared to FY 2021 by \$6.829 million. Funding increased due to increased emphasis on alternate navigation technologies.</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 2021 Plans:</b> Continue low-cost cruise missile demonstration of critical behaviors for distributed, cooperative, collaborative strategies and other advanced guidance capabilities. Further 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/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. Initiate simulator upgrades to accommodate resolution requirements for navigation quality synthetic aperture radar target and background modeling. Continue development of infrared light emitting diode infrared target simulator technology to create higher framerate and higher resolution target simulator technology. Continue providing multi-security level, cross-domain distributed modeling and simulation support for munition research and development using distributed connectivity between multiple Eglin Air Force Base facilities. Continue development of 6-degrees of freedom and scene generation modules for the extended modeling and simulation community using Air Force Simulator. Initiate hardware-in-the-loop activities in support of international cooperative research efforts. Complete hardware-in-the-loop facility expansion by adding optics lab for infrared target simulator development.</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</p>		20.342	24.285	35.379

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2020</b>	<b>FY 2021</b>	<b>FY 2022</b>
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<p>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 2021 to FY 2022 Increase/Decrease Statement:</b> FY 2022 increased compared to FY 2021 by \$11.094 million. Funding increased due to additional emphasis on guidance and seeker modeling activities.</p>			
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<p><b>Title:</b> Future AF Capabilities Applied Research</p> <p><b>Description:</b> Investigate, design, and develop science and technologies supporting future Air Force capabilities to provide compelling advantage to the warfighter. To the greatest extent practical, research efforts will utilize modeling and simulation and cross-discipline systems integration (For example: air and space vehicles, avionics, propulsion, materials, human performance, cybersecurity, command, control, communications, computer and intelligence, sensors, electronic warfare, and conventional/unconventional weapons).</p> <p>The National Defense Strategy and Air Force Science and Technology (S&amp;T) Strategy will inform investments over the FYDP.</p> <p><b>FY 2021 Plans:</b> Starting in FY 2021, this work is performed in PE 0602020F, Future AF Capabilities Applied Research, Project 620200, Enterprise Transformational Applied Research, Transformational Capability Incubator effort.</p> <p><b>FY 2022 Plans:</b> Not applicable</p> <p><b>FY 2021 to FY 2022 Increase/Decrease Statement:</b></p>	19.666	0.000	0.000
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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	FY 2020	FY 2021	FY 2022
Not applicable.			
<b>Accomplishments/Planned Programs Subtotals</b>	75.300	73.016	101.070

**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 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
622502: <i>Ordnance Technology</i>	-	56.790	54.177	50.687	0.000	50.687	-	-	-	-	-	-

**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)**

	FY 2020	FY 2021	FY 2022
<p><b>Title:</b> Energetic Materials Technology</p> <p><b>Description:</b> Investigates and develops energetic materials and technology that safely and securely optimize survivability, cost, and weapon lethality for air-delivered munitions.</p> <p><b>FY 2021 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 understanding of energy partitioning in order to optimize lethality against a broad spectrum of targets. Continue to formulate and test liner technologies 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.</p> <p><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.</p> <p><b>FY 2021 to FY 2022 Increase/Decrease Statement:</b></p>	4.772	4.833	4.721

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2020</b>	<b>FY 2021</b>	<b>FY 2022</b>
FY 2022 decreased compared to FY 2021 by 0.112 million. Funding decreased due to higher Air Force priorities.				
<p><b>Title:</b> Fuze Technologies</p> <p><b>Description:</b> Investigate and develop fuzing technology for air-delivered weapons to ensure reliable and optimal function to maximize weapon lethality for all engagement scenarios.</p> <p><b>FY 2021 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 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 2021 to FY 2022 Increase/Decrease Statement:</b> FY 2022 decreased compared to FY 2021 by 0.198 million. Funding decreased due to higher Air Force priorities.</p>		6.103	5.977	5.779
<p><b>Title:</b> Warhead Technologies</p> <p><b>Description:</b> Investigate and develop innovative warhead kill mechanisms for air-delivered weapons that maximize weapon lethality for all engagement scenarios.</p> <p><b>FY 2021 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</p>		9.980	8.691	8.225

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2020</b>	<b>FY 2021</b>	<b>FY 2022</b>
<p>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 subsystems 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 2022 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 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 2021 to FY 2022 Increase/Decrease Statement:</b> FY 2022 decreased compared to FY 2021 by \$0.466 million. Funding decreased due to higher Air Force priorities.</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 2021 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 war-head technologies for inventory penetrators. Continue to 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</p>		35.935	34.676	31.962

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	FY 2020	FY 2021	FY 2022
<p>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 2022 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 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 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 2021 to FY 2022 Increase/Decrease Statement:</i></b> FY 2022 decreased compared to FY 2021 by \$2.714 million. Funding decreased due to higher Air Force priorities.</p>			
<b>Accomplishments/Planned Programs Subtotals</b>	56.790	54.177	50.687

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

N/A

**Remarks**

**D. Acquisition Strategy**

Not Applicable.