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**Exhibit R-2, RDT&E Budget Item Justification:** PB 2019 Air Force **Date:** February 2018

<b>Appropriation/Budget Activity</b> 3600: Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research					<b>R-1 Program Element (Number/Name)</b> PE 0602602F I Conventional Munitions							
<b>COST (\$ in Millions)</b>	<b>Prior Years</b>	<b>FY 2017</b>	<b>FY 2018</b>	<b>FY 2019 Base</b>	<b>FY 2019 OCO</b>	<b>FY 2019 Total</b>	<b>FY 2020</b>	<b>FY 2021</b>	<b>FY 2022</b>	<b>FY 2023</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
Total Program Element	-	110.074	112.195	112.841	0.000	112.841	129.393	137.159	146.218	139.010	Continuing	Continuing
622068: <i>Advanced Guidance Technology</i>	-	53.158	55.925	57.513	0.000	57.513	65.023	68.807	72.176	68.758	Continuing	Continuing
622502: <i>Ordnance Technology</i>	-	56.916	56.270	55.328	0.000	55.328	64.370	68.352	74.042	70.252	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 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 war-heads, hard-target fuzing, precise terminal guidance, and high-performance and insensitive explosives. This program is in Budget Activity 2, Applied Research, and projects in this program have been coordinated through the Department of Defense Science and Technology Executive Committee process to harmonize efforts and eliminate duplication.

This program element may include necessary civilian pay expenses required to manage, execute, and deliver science & technology capabilities. The use of program funds in this PE would be in addition to the civilian pay expenses budgeted in program elements 0601102F, 0602102F, 0602201F, 0602202F, 0602203F, 0602204F, 0602601F, 0602605F, 0602788F, 1206601F, and 0602298F.

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 2017</b>	<b>FY 2018</b>	<b>FY 2019 Base</b>	<b>FY 2019 OCO</b>	<b>FY 2019 Total</b>
Previous President's Budget	109.649	112.195	113.831	0.000	113.831
Current President's Budget	110.074	112.195	112.841	0.000	112.841
Total Adjustments	0.425	0.000	-0.990	0.000	-0.990
• 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	2.271	0.000			
• SBIR/STTR Transfer	-1.846	0.000			
• Other Adjustments	0.000	0.000	-0.990	0.000	-0.990

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Appropriation/Budget Activity 3600: Research, Development, Test & Evaluation, Air Force I BA 2: Applied Research		R-1 Program Element (Number/Name) PE 0602602F I Conventional Munitions
<u>Change Summary Explanation</u> Increase in FY 2017 reflects reprogramming to support Research and Development Projects, 10 U.S.C Section 2358.		

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Exhibit R-2A, RDT&E Project Justification: PB 2019 Air Force										Date: February 2018		
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 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622068: <i>Advanced Guidance Technology</i>	-	53.158	55.925	57.513	0.000	57.513	65.023	68.807	72.176	68.758	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-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)**

	<b>FY 2017</b>	<b>FY 2018</b>	<b>FY 2019</b>
<b>Title:</b> Seeker Technologies	10.529	9.495	10.480
<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 2018 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 and mathematical approaches to integrate weapons into the kill chain and enable distributive, flexible seeker imaging targeting with or without an operator in the loop. Continue to explore terminal seeker technologies that enable innovative air-to-air engagements for fifth-generation aircraft and beyond. Continue to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker subsystems. Continue to develop distributed, low-cost seeker technology hardware. Continue to explore specific techniques for seeker cost reduction with performance improvement; novel technical approaches such as sparse sensing and compressive sensing will be investigated. Continue to conduct research on integrated processing techniques to enable networked systems. Initiate small, air-to-air, self-defense munitions research effort.			
<b>FY 2019 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 and mathematical approaches to integrate weapons into the kill chain and enable distributive, flexible seeker imaging targeting with or without an operator in the loop. Continue development and testing of innovative air-to-air engagements for fifth generation and beyond. Continue to explore incorporation of open architecture principles to reduce cost and enable technology refresh within seeker subsystems. Continue to develop distributed, low-cost seeker technology hardware. Continue to explore specific techniques for seeker cost reduction with			

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2017	FY 2018	FY 2019
performance improvement; novel technical approaches such as sparse sensing and compressive sensing will be investigated. Continue to conduct research on integrated processing techniques to enable networked systems. Continue development and early testing of small, air-to-air, self-defense munitions seeker technology including initial captive flight testing and hardware in the loop testing. Continue to develop open seeker architecture software in the loop integration laboratory. Initiate the investigation of the technical challenges of cooperative radio frequency functions including coherent on transmit and coherent on receive operation. Initiate software development kit for Open Seeker Architecture to enable rapid technology insertion into software-defined, multi-function seekers. Initiate the development of tools for evaluation of deep-learning networks to evaluate feasibility for weapon seekers. Initiate exploration of Open Architecture systems' cyber vulnerabilities and formulate software resilient techniques. Initiate data collection experiments to support cooperative radio frequency systems.				
FY 2018 to FY 2019 Increase/Decrease Statement: FY 2019 increased compared to FY 2018 by \$0.985 million. Justification for increase is described in the plans above.				
Title: Aerodynamics, Navigation, and Control Technologies		29.569	28.178	28.716
Description: Develops weapon aerodynamic, control, navigation, and networking technologies for air-delivered munitions to provide precise, agile flight, networked effects, and immunity to countermeasures.				
FY 2018 Plans: Continue to mature linked aero-structural-thermal computational tools to predict flight performance of hypersonic weapons and tools to develop prototype concepts for further analysis. Continue to mature algorithms for guidance and control of advanced weapons concepts in a contested electromagnetic environment. Continue to develop technologies that achieve precision navigation under Global Positioning System-degraded and Global Positioning System-denied conditions. Continue development of weapon platform interfaces, including advanced high capacity carriage and release technology. Continue to integrate algorithms to support distributed, multi-strategy weapon concept-of-operations to defeat enemy defenses. Continue to develop airframe and control technologies that enable innovative air-to-air engagements. Continue conducting flight demonstrations of precision navigation of weapons without Global Positioning System experiments to characterize innovative air-to-air high off-bore sight missile maneuverability and hit-to-kill agility. Continue conducting experiments to demonstrate precision navigation using celestial aiding for long-range flights at high and low altitudes. Continue conducting experiments to demonstrate algorithms implementing cooperation and collaboration between multiple surrogate weapon platforms. Continue the development and demonstration of component modular and service-oriented weapon architectures for seeker navigation, and data services that use reconfigurable weapon sensors. Continue conducting flight innovative air-to-air high off-bore sight missile maneuverability and hit-to kill agility. Continue conducting ground tests of rocket motor component technologies to evaluate their ability to increase weapon range and reduce size and weight. Initiate small, air-to-air, self-defense munitions research effort.				
FY 2019 Plans:				

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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>		
B. Accomplishments/Planned Programs (\$ in Millions)			FY 2017	FY 2018	FY 2019
<p>Continue the maturation of linked aero-structural-thermal computational tools to predict flight performance of hypersonic weapons and tools to develop prototype concepts for further analysis. Initiate the transition of linked aero-structural-thermal computational tools to the hypersonic weapons program office. Initiate assistance of program office to assess contractor concepts.</p> <p>Continue to refine and demonstrate via captive and surrogate flight test, a precision navigation method that does not rely on Global Positioning System. Initiate the demonstration via captive and surrogate flight test, of a precision navigation method that does not rely on Global Positioning System. Initiate the transition M-Code compliant anti-jam Global Positioning System chip set. Continue development of weapon platform interfaces. Initiate a weapon demonstration concept and showing an increase of load-out by double. Complete the integration of algorithms to support distributed, multi-strategy weapon concept-of-operations to defeat enemy defenses. Initiate development of flight test algorithms for multi-agent navigation aiding that uses data link information to bound drift of a swarm of weapons on small, large-scale airframes. Continue ground testing of advanced guidance laws and actuators that enable innovative air-to-air engagements and hyper agility including hit-to-kill. Continue conducting experiments to demonstrate precision navigation using celestial aiding for long-range flights at high and low altitudes. Continue small, air-to-air, self-defense munitions research effort.</p> <p>Initiate demonstration, via flight test, cooperation, and collaboration of a swarm of small cruise missiles flying into an operationally relevant threat environment having the ability to find, locate, and overwhelm targets. Initiate flight test of a multi vehicle mapping without Global Positioning System and saturation approach of the entrance of a hardened deeply buried facility or tunnel target, design the ingress method to include packaging multi rotor aircraft into common launch tubes. Complete conducting ground tests of rocket motor component technologies to evaluate their ability to increase weapon range and reduce size and weight. Initiate the development of defensive cyber algorithms for autopilot and navigation functions, including swarms.</p> <p><b>FY 2018 to FY 2019 Increase/Decrease Statement:</b> FY 2019 increased compared to FY 2018 by \$0.538 million. Justification for increase is described in the plans above.</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 2018 Plans:</b> Continue to support flight demonstrations of critical behaviors for Distributed, Cooperative, Collaborative strategies. Continue to develop improved simulation technologies that evaluate innovative air-to-air engagements. Continue to develop a real-time radar/millimeter wave signature generation capability for testing algorithms in real-time software and hardware in-the-loop environments. Continue to develop simulation technologies that evaluate cooperative, flexible munition target engagements. Continue to develop a modular radio frequency hardware-in-the-loop capability to support munitions concepts with high speed</p>			13.060	18.252	18.317

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<b>Exhibit R-2A, RDT&amp;E Project Justification:</b> PB 2019 Air Force		<b>Date:</b> February 2018	
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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2017</b>	<b>FY 2018</b>
<p>target engagement. Continue to develop new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems.</p> <p><b>FY 2019 Plans:</b> Continue to support flight demonstrations of critical behaviors for Distributed, Cooperative, Collaborative strategies and other advanced guidance capabilities by improving constructive and virtual analysis tools for design, development, and analysis of advanced weapon concepts in representative environments. Continue to perform constructive and virtual analysis on numerous weapon concepts providing design, performance, and trade space analysis to the program offices. Continue to develop improved simulation technologies that evaluate innovative air-to-air engagements to include guidance evaluation. Continue to develop a real-time radar/millimeter wave signature generation capability for testing algorithms in real-time software and hardware-in-the-loop environments. Continue to develop simulation technologies that evaluate cooperative, flexible monition target engagements. Continue to transition our engineering models to Air Force mission level simulation for analysis. Initiate constructive and virtual analysis on numerous weapon concepts to provide design, performance, and trade space analysis to the program offices. Continue to develop a modular radio frequency Hardware-in-the-loop capability to support munitions concepts with high speed target engagement. Continue to improve capabilities of our reconfigurable radio frequency hardware-in-the-loop chamber to handle faster and more complex scenes. Continue to develop new infrared projection capabilities to evaluate a new class of multi-aperture sensor systems. Initiate and complete the startup of a Modeling and Simulation center at multi-level security enabling cross-domain, distributed, multi-level security Modeling and Simulation activities. Initiate a help desk and configuration control of higher fidelity simulation codes for mission level analysis.</p> <p><b>FY 2018 to FY 2019 Increase/Decrease Statement:</b> FY 2019 increased compared to FY 2018 by \$0.065 million. Justification for increase is described in the plans above.</p>			
<b>Accomplishments/Planned Programs Subtotals</b>		53.158	55.925
<b>C. Other Program Funding Summary (\$ in Millions)</b>			
N/A			
<b>Remarks</b>			
<b>D. Acquisition Strategy</b>			
Not Applicable			
<b>E. Performance Metrics</b>			
Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.			

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Appropriation/Budget Activity 3600 / 2					R-1 Program Element (Number/Name) PE 0602602F / Conventional Munitions				Project (Number/Name) 622502 / Ordnance Technology			
COST (\$ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
622502: Ordnance Technology	-	56.916	56.270	55.328	0.000	55.328	64.370	68.352	74.042	70.252	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 2017</b>	<b>FY 2018</b>	<b>FY 2019</b>
<b>Title:</b> Energetic Materials Technology	10.098	9.981	9.744
<b>Description:</b> Investigates and develops energetic materials and technology that safely and securely optimize survivability, cost, and weapon lethality for air-delivered munitions.			
<b>FY 2018 Plans:</b> Continue to mature and develop selected energetic materials to increase energy density over that of 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 theoretical and virtual formulation and processing techniques for energetic materials and provide the second release of the tool/software to the energetics community. 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.			
<b>FY 2019 Plans:</b> Continue to mature and develop selected energetic materials to increase energy density over that of 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 theoretical and virtual formulation and processing techniques for energetic materials and provide the second release of the tool/software to the energetics community. 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.			
<b>FY 2018 to FY 2019 Increase/Decrease Statement:</b>			

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>			<b>FY 2017</b>	<b>FY 2018</b>	<b>FY 2019</b>
FY 2019 decreased compared to FY 2018 by \$0.237 million. Justification for decrease is described in the plans above.					
<b>Title:</b> Fuze Technologies			10.697	9.756	9.430
<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.					
<b>FY 2018 Plans:</b> Continue to develop testing capabilities for munitions penetration scenarios and increase Modeling and Simulation capabilities to reduce research and development costs and time lines. 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.					
<b>FY 2019 Plans:</b> Continue to develop testing capabilities for munitions penetration scenarios and increase Modeling and Simulation capabilities to reduce research and development costs and time lines. 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.					
<b>FY 2018 to FY 2019 Increase/Decrease Statement:</b> FY 2019 decreased compared to FY 2018 by \$0.326 million. Justification for decrease is described in the plans above.					
<b>Title:</b> Warhead Technologies			20.123	19.657	19.375
<b>Description:</b> Investigate and develop innovative warhead kill mechanisms for air-delivered weapons that maximize weapon lethality for all engagement scenarios.					
<b>FY 2018 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 air-to-air missile warhead concepts for the air targets in near-peer engagement scenarios. Continue to research and develop cumulative damage mechanisms that take advantage of distributed blast, as well as shock wave and reactive					



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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2017	FY 2018	FY 2019
particle interactions. Begin integration of warhead research with related activities planned for the advanced/integrated ordnance subsystems research capability.  FY 2019 Plans: 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 air-to-air missile warhead concepts for the air targets in near-peer engagement scenarios. Continue to research and develop cumulative damage mechanisms that take advantage of distributed blast, as well as shock wave and reactive particle interactions. Begin integration of warhead research with related activities planned for the advanced/integrated ordnance subsystems research capability.  FY 2018 to FY 2019 Increase/Decrease Statement: FY 2019 decreased compared to FY 2018 by \$0.282 million. Justification for decrease is described in the plans above.				
Title: Ordnance Technologies  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.  FY 2018 Plans: Continue to develop validated mesoscale Modeling and Simulation tools for computational physics sciences. Continue to mature 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 conduct Modeling and Simulation that explores 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. Initiate the development of Modeling and Simulation tools and analysis techniques to understand energy partitioning in order to optimize lethality with a focus on blast wave interactions, cumulative and collaborative damage, and distributed blast.  FY 2019 Plans: Continue to develop validated mesoscale Modeling and Simulation tools for computational physics sciences. Continue to mature 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 conduct Modeling and Simulation that explores the ordnance technology trade space for low-cost, long-range munition concepts. Continue		15.998	16.876	16.779

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>		<b>FY 2017</b>	<b>FY 2018</b>
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. Complete the development of Modeling and Simulation tools and analysis techniques to understand energy partitioning in order to optimize lethality with a focus on blast wave interactions, cumulative and collaborative damage, and distributed blast.			
<b>FY 2018 to FY 2019 Increase/Decrease Statement:</b> FY 2019 decreased compared to FY 2018 by \$0.097 million. Justification for decrease is described in the plans above.			
<b>Accomplishments/Planned Programs Subtotals</b>		56.916	55.328
<b>C. Other Program Funding Summary (\$ in Millions)</b> N/A			
<b>Remarks</b>			
<b>D. Acquisition Strategy</b> Not Applicable.			
<b>E. Performance Metrics</b> Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.			