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Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Air Force **Date:** February 2019

Appropriation/Budget Activity 3600: <i>Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)</i>					R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>							
COST (\$ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	-	34.694	47.426	36.586	0.000	36.586	38.181	38.770	39.667	40.553	Continuing	Continuing
632100: <i>Laser Hardened Materials</i>	-	15.930	14.786	15.807	0.000	15.807	16.739	16.304	16.698	17.084	Continuing	Continuing
633153: <i>Non-Destructive Inspection Development</i>	-	3.507	6.375	6.501	0.000	6.501	6.631	6.659	6.843	7.020	Continuing	Continuing
633946: <i>Materials Transition</i>	-	15.257	26.265	14.278	0.000	14.278	14.811	15.807	16.126	16.449	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates advanced materials technologies that enhance protection for Air Force aircrews to ensure safety and to enable aircrews to perform required missions in threat environments. Advanced materials technologies are also developed and demonstrated to enhance protection for Air Force sensors and systems to ensure safety, survivability, and operability in threat environments.

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, 0602602F, 0602605F, 0602788F, 1206601F, and 0602298F.

As directed in the FY 2018 NDAA, Sec 825, amendment to PL 114-92 FY 2016 NDAA, Sec 828 Penalty for Cost Overruns, the FY 2018 Air Force penalty total is \$14.373M. The calculated percentage reduction to each research, development, test and evaluation and procurement account will be allocated proportionally from all programs, projects, or activities under such account.

This program is in Budget Activity 3, Advanced Technology Development because this budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment.

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Appropriation/Budget Activity		R-1 Program Element (Number/Name)			
3600: Research, Development, Test & Evaluation, Air Force I BA 3: Advanced Technology Development (ATD)		PE 0603112F I Advanced Materials for Weapon Systems			
B. Program Change Summary (\$ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	37.856	34.426	36.584	0.000	36.584
Current President's Budget	34.694	47.426	36.586	0.000	36.586
Total Adjustments	-3.162	13.000	0.002	0.000	0.002
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	13.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-0.022	0.000			
• SBIR/STTR Transfer	-0.970	0.000			
• Other Adjustments	-2.170	0.000	0.002	0.000	0.002
Congressional Add Details (\$ in Millions, and Includes General Reductions)					
Project: 633946: Materials Transition					
Congressional Add: Program increase - Materials Transition of Metals for Hypersonics					
Congressional Add: Program increase - Metals Affordability Research					
Congressional Add Subtotals for Project: 633946					
Congressional Add Totals for all Projects					
Change Summary Explanation					
Decrease in FY 2018 in Other Adjustments is due to realignment of funds to PE 0602212F to support Research and Development Projects, 10 U.S.C. Section 2358.					

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Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force										Date: February 2019		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>				Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>			
COST (\$ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
632100: <i>Laser Hardened Materials</i>	-	15.930	14.786	15.807	0.000	15.807	16.739	16.304	16.698	17.084	Continuing	Continuing
A. Mission Description and Budget Item Justification This project develops and demonstrates advanced materials technologies that enhance protection for Air Force aircrews to ensure safety and to enable aircrews to perform required missions in threat environments. Advanced materials technologies are also developed and demonstrated to enhance protection for Air Force sensors and systems to ensure safety, survivability, and operability in threat environments.												
B. Accomplishments/Planned Programs (\$ in Millions)								FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Aerospace Systems Protection								7.960	6.949	7.429	0.000	7.429
Description: Develop and demonstrate materials technologies that enhance hardening for sensors, avionics, and components to increase survivability and mission effectiveness of aerospace systems.												
FY 2019 Plans: Continue to validate and continue to develop protection materials for visual/Near Infrared (NIR) Intelligence, Surveillance, & Reconnaissance (ISR) sensors. Assess the demonstrated results and pursue the use of protection technologies for future sensor designs and strategies to mitigate directed energy damage for NIR, Space, Shortwave Infrared Midwave(SWIR), and Midwave Infrared (MWIR) detectors. Apply gained technologies and integrate the developments into survivable electro-optic sensors that provide full spectrum protection for missile warning. Analyze the performance impact of damage-limiting semiconductor materials designed to harden electro-optic imaging sensors. Continue transition of developed laser countermeasures for survivability of dynamic electro-optic/infrared imagers. Continue to advance the employment and integration of evolved computational materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings development for use in sensor hardening. Continue technology stimulation and maturation to develop defensive capability for air systems airframe and anti-access munitions hardening assessments and solutions.												
FY 2020 Base Plans: Demonstrate, validate and continue to develop protection materials for visual/NIR ISR sensors. Assess the demonstrated results and transition the use of protection technologies for future sensor designs and strategies to mitigate directed energy damage for visual/NIR, SWIR, and MWIR detectors. Transition gained technologies and integrate the developments into light, operator friendly survivable electro-optic sensors that provide full												

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Appropriation/Budget Activity 3600 / 3		R-1 Program Element (Number/Name) PE 0603112F / Advanced Materials for Weapon Systems		Project (Number/Name) 632100 / Laser Hardened Materials		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
spectrum protection for missile warning. Continue analyzing the high-performance properties of damage-limiting semiconductor materials designed to harden electro-optic imaging sensors. Transition developed laser countermeasures for survivability of dynamic electro-optic/infrared imagers. Advance the employment and integration of evolved computational materials science to model materials characteristics to increase accuracy and shorten design cycle time of coatings development for use in sensor hardening. Transition and continue technology development and maturation to develop defensive capability for air systems airframe and anti-access munitions hardening assessments and solutions. FY 2020 OCO Plans: Not Applicable FY 2019 to FY 2020 Increase/Decrease Statement: FY 2020 increased compared to FY 2019 by \$0.480 million. Justification for the increase is described in the plans above.						
Title: Aircrew Protection Description: Develop and demonstrate materials technologies that enhance protection for Air Force aircrews to ensure safety and to enable aircrews to perform required missions in a threat environment. FY 2019 Plans: Continue to develop, validate, and demonstrate laser protection materials and technologies for personnel protection. Continue to validate and develop helmet-mounted sensor hardening materials focusing on next-generation nighttime sensors. Continue to advance development of visor based aircrew protection materials with agile protection. Continue to evaluate advances in characterization and demonstration of eye protection technologies using computational materials science tools. Continue to validate, mature, and test improvements to functionality and performance of personnel protection technologies in expected operational conditions. FY 2020 Base Plans: Continue to develop, validate, demonstrate, and transition laser protection materials and technologies for personnel protection. Continue to validate and develop light-weight helmet-mounted sensor hardening materials focusing on next-generation nighttime specialized sensors. Advance transition efforts and development of visor based aircrew protection materials with agile protection. Evaluate and assess new materials and advances in characterization and demonstration of eye protection technologies using computational materials science tools. Transition, validate, mature, and test improvements to functionality and performance of personnel protection		7.970	7.837	8.378	0.000	8.378

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Appropriation/Budget Activity 3600 / 3		R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>		Project (Number/Name) 632100 / <i>Laser Hardened Materials</i>	
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO
technologies in expected operational conditions. Continue development and testing of materials technologies to protect against nuclear flash blindness.					
FY 2020 OCO Plans: Not Applicable					
FY 2019 to FY 2020 Increase/Decrease Statement: FY 2020 increased compared to FY 2019 by \$0.541 million. Justification for the increase is described in the plans above.					
Accomplishments/Planned Programs Subtotals		15.930	14.786	15.807	0.000
C. Other Program Funding Summary (\$ in Millions) N/A					
Remarks					
D. Acquisition Strategy N/A					
E. Performance Metrics 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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Exhibit R-2A, RDT&E Project Justification: PB 2020 Air Force										Date: February 2019		
Appropriation/Budget Activity 3600 / 3					R-1 Program Element (Number/Name) PE 0603112F / Advanced Materials for Weapon Systems				Project (Number/Name) 633153 / Non-Destructive Inspection Development			
COST (\$ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
633153: Non-Destructive Inspection Development	-	3.507	6.375	6.501	0.000	6.501	6.631	6.659	6.843	7.020	Continuing	Continuing
A. Mission Description and Budget Item Justification												
This project develops and demonstrates advanced nondestructive inspection and evaluation (NDI/E) technologies to monitor performance integrity and to detect failure causing conditions in weapon systems components and materials. NDI/E capabilities greatly influence and/or limit many design, manufacturing, and maintenance practices. This project provides technology to satisfy Air Force requirements to extend the lifetime of current systems through increased reliability and cost-effectiveness at field and depot maintenance levels. Equally important is assuring manufacturing quality, integrity, and safety requirements.												
B. Accomplishments/Planned Programs (\$ in Millions)								FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Advanced Engine Inspection Technologies								0.810	1.594	1.625	0.000	1.625
Description: Develop and demonstrate advanced technologies to improve capabilities to inspect for cracks and other damage to extend the total safe life of turbine engines.												
FY 2019 Plans: Continue to develop nondestructive inspection/evaluation approaches to assess materials and damage state of critical turbine engine components for the purpose of extending the useful life without increasing risk of in-flight failure of fracture critical to gas turbine engine components. Continue to assess model prediction, accuracy, and effectiveness of digital nondestructive inspection technologies and demonstrate tool automation for high confidence repeatable results.												
FY 2020 Base Plans: Continue nondestructive inspection/evaluation approaches to include additive manufacturing and to assess materials and damage state of critical turbine engine components for the purpose of extending the useful life without increasing risk of in-flight failure of fracture critical to gas turbine engine components. Advance the validation process for model prediction, accuracy, and effectiveness of digital nondestructive inspection technologies and demonstrate tool automation for high confidence repeatable results, to include advanced manufacturing processes.												
FY 2020 OCO Plans: Not Applicable												
FY 2019 to FY 2020 Increase/Decrease Statement:												

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Appropriation/Budget Activity 3600 / 3		R-1 Program Element (Number/Name) PE 0603112F / Advanced Materials for Weapon Systems		Project (Number/Name) 633153 / Non-Destructive Inspection Development		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2020 increased compared to FY 2019 by \$0.031 million. Justification for the increase is described in the plans above.						
Title: Special Material Inspection Technologies (formerly known as "Low-Observable Inspection Technologies") Description: Develop and demonstrate advanced inspection technologies supporting low-observable (LO) systems to enhance affordability and ensure full performance and survivability. FY 2019 Plans: Continue to transition improved methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of special materials that enables/ensures more affordable coatings assessment. Continue to validate tools to improve characterization of specialty multilayer coatings. Continue to develop robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization. FY 2020 Base Plans: Continue the transition process to depots and flight lines for improved methods to acquire and analyze data to facilitate improved characterization, registration, and tracking of degradation and damage of special materials that enables/ensures more affordable coatings assessment. Validate tools to improve characterization and failure modes of specialty multilayer coatings. Continue to develop automation for robotic technologies for visual inspections that will realize human-assisted inspection capabilities and begin to provide capabilities for automated multi-spectral characterization. FY 2020 OCO Plans: Not Applicable FY 2019 to FY 2020 Increase/Decrease Statement: FY 2020 increased compared to FY 2019 by \$0.024 million. Justification for the increase is described in the plans above.		0.847	1.211	1.235	0.000	1.235
Title: Advanced System Monitoring Technologies Description: Develop and demonstrate advanced systems status monitoring technologies to provide on-board and embedded sensing to gain continuous awareness of the state of key subsystems. FY 2019 Plans:		1.850	3.570	3.641	0.000	3.641

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Appropriation/Budget Activity 3600 / 3		R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>		Project (Number/Name) 633153 / <i>Non-Destructive Inspection Development</i>		
B. Accomplishments/Planned Programs (\$ in Millions)						
		FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
<p>Continue demonstrating analytical methods to assess the location of damage in multi-layered structure base on nondestructive inspection data and results. Continue to transition robotic nondestructive inspection methods to minimize disassembly and reduced maintenance burden to perform inspections of aircraft structures. Continue development of novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. Continue enhanced methods for collecting and analyzing digital Non-Destructive Inspection/Evaluation (NDI/E) data necessary for improved damage detection and characterization. Continue the integration of computational materials science tools with life prediction methods to enable risk-based life management.</p> <p><i>FY 2020 Base Plans:</i> Continue to demonstrate advanced analytical methods to more accurately assess the location, and register spatial location, of damage detected using nondestructive inspection data and results. Continue to transition automated robotic nondestructive inspection methods to minimize disassembly and reduced maintenance burden to perform inspections of aircraft structures. Continue development and transition of novel approaches to collect, analyze, transport, archive, and use digital nondestructive inspection data and information. Continue enhanced methods for compiling, reporting, collecting and rapidly analyzing digital Non Destructive Testing/Evaluation (NDI/E) data necessary for improved damage detection and characterization. Continue the transition and integration of computational materials science tools with life prediction methods to enable risk-based life management.</p> <p><i>FY 2020 OCO Plans:</i> Not Applicable</p> <p><i>FY 2019 to FY 2020 Increase/Decrease Statement:</i> FY 2020 increased compared to FY 2019 by \$0.071 million. Justification for the increase is described in the plans above.</p>						
Accomplishments/Planned Programs Subtotals		3.507	6.375	6.501	0.000	6.501
C. Other Program Funding Summary (\$ in Millions)						
N/A						
Remarks						
D. Acquisition Strategy						
N/A						

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Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>	Project (Number/Name) 633153 / <i>Non-Destructive Inspection Development</i>

E. Performance Metrics

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 / 3					R-1 Program Element (Number/Name) PE 0603112F / <i>Advanced Materials for Weapon Systems</i>				Project (Number/Name) 633946 / <i>Materials Transition</i>				
COST (\$ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost	
633946: <i>Materials Transition</i>	-	15.257	26.265	14.278	0.000	14.278	14.811	15.807	16.126	16.449	Continuing	Continuing	

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced materials and processing technologies for fielded and planned Air Force weapon, airframe, and propulsion applications. Advanced materials and processes that have matured beyond applied research are characterized, critical data are collected, and critical evaluations in the proposed operating environment are performed. This design and scale-up data improves the overall affordability of promising materials and processing technologies, providing needed initial incentives for their industrial development.

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

	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: Air Vehicle Materials Technologies	12.770	11.065	8.136	0.000	8.136
Description: Develop and demonstrate materials and processes technologies for air vehicle and subsystems to enhance lift, propulsion, Low-Observable (LO) performance, power generation management, and affordability of air vehicles.					
FY 2019 Plans: Transition magneto-resistive sensing and materials and processes to increase special materials affordability. Continue development of advanced directed energy protection technologies. Continue development of technologies for electromagnetic hardening acquisition and field support. Continue development of technologies for organic engine lifing analysis for enhanced engine component risk management capability.					
FY 2020 Base Plans: Continue development and transition of advanced directed energy protection technologies. Continue development of advanced technologies for electromagnetic hardening acquisition and field support. Assess date, compile, report and continue development of technologies for organic engine lifing analysis for enhanced engine component risk management capability. Transition development of materials to protect infrared apertures on next generation hardened assets. Validate and verify results of microstruture-sensitive lifing methodologies that lower life cycle cost and advance performance characteristics of airframe and engine components in order to initiate development of next generation modeling tools that incorporate residual stress effects on component life.					
FY 2020 OCO Plans: Not Applicable					
FY 2019 to FY 2020 Increase/Decrease Statement:					

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Appropriation/Budget Activity 3600 / 3		R-1 Program Element (Number/Name) PE 0603112F / Advanced Materials for Weapon Systems		Project (Number/Name) 633946 / Materials Transition		
B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2020 decreased compared to FY 2019 by \$2.929 million. Funding decreased due to higher Technology Readiness Level achievement of organic life analysis.						
<p>Title: High Temperature Material Technologies</p> <p>Description: Develop and demonstrate affordable, novel high temperature materials/structures and thermal management concepts to enable future defense capabilities for prompt global strike concepts.</p> <p>FY 2019 Plans: Continue work on multimaterial structures that optimally address operational temperature zones for hot structure and expendable thermal protection systems made out of advanced ceramics, ceramic matrix composites, hybrids, advanced and affordable metals, and intermetallics. Transition 2700-degree Fahrenheit ceramic matrix composites for turbine hot section components to industry. Continue to develop high performance and affordable metals for next-generation turbine disk and low cost propulsion, aerostructure and munitions components. Continue development of low cost metallic turbine engine disks made via powder processing technologies for use in high temperature, aggressive environment.</p> <p>FY 2020 Base Plans: Continue to work on multimaterial structures that optimally address operational temperature zones for hot structure and expendable thermal protection systems made out of advanced ceramics, ceramic matrix composites, hybrids, advanced and affordable metals, and intermetallics. Continue to transition 2700-degree Fahrenheit ceramic matrix composites for turbine hot section components to industry. Continue to develop high performance and affordable metals for next-generation turbine disk and low cost propulsion, aerostructure and munitions components. Continue development and demonstrate advanced materials and process control to enable complex structural components via additive manufacturing. Initiate establishment of a metallic additive design center. Continue development of low cost metallic turbine engine disks made via powder processing technologies for use in high temperature, aggressive environment. Transition computational and data analytics tools that enable production of affordable, complex shape metal components made via additive manufacturing.</p> <p>FY 2020 OCO Plans: Not Applicable</p> <p>FY 2019 to FY 2020 Increase/Decrease Statement:</p>		2.487	2.200	2.142	0.000	2.142

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B. Accomplishments/Planned Programs (\$ in Millions)		FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
FY 2020 decreased compared to FY 2019 by \$0.058 million. Justification for the decrease is described in the plans above.						
Title: Pervasive and Affordable Metals Technologies Description: Develop and demonstrate affordable, novel high temperature powder processing materials/ structures and additive metals technology concepts to enable future defense capabilities air vehicle propulsion and computational prediction models. FY 2019 Plans: In FY2019 and prior, this work is performed under multiple efforts and projects within PE 0603112F, Advanced Materials for Weapons Systems. FY 2020 Base Plans: Continue to demonstrate affordable metallic turbine engine disks made through powder processing technologies through high temperature, aggressive environment testing. Continue to develop low cost, complex shape metallic component made through additive manufacturing for advanced weapon system component prototypes. Continue to develop computational methodologies that incorporate impact of surface residual stress on ability to extend life and lower life cycle cost of air vehicle propulsion system components. FY 2020 OCO Plans: Not Applicable FY 2019 to FY 2020 Increase/Decrease Statement: FY 2020 increased compared to FY 2019 by \$4.000 million. Funding increased due to realignment and consolidation of Pervasive and Affordable Metals work within PE 0603112F, Advanced Materials for Weapon Systems.		0.000	0.000	4.000	0.000	4.000
Accomplishments/Planned Programs Subtotals		15.257	13.265	14.278	0.000	14.278
		FY 2018	FY 2019			
Congressional Add: Program increase - Materials Transition of Metals for Hypersonics		0.000	3.000			
FY 2018 Accomplishments: Not Applicable						
FY 2019 Plans: Conduct congressional directed efforts.						
Congressional Add: Program increase - Metals Affordability Research		0.000	10.000			

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		FY 2018	FY 2019
FY 2018 Accomplishments: Not Applicable			
FY 2019 Plans: Conduct congressional directed efforts.			
Congressional Adds Subtotals		0.000	13.000
C. Other Program Funding Summary (\$ in Millions) N/A			
Remarks			
D. Acquisition Strategy N/A			
E. Performance Metrics 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.			