Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force											Date: May 2017	
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*							
COST ($ in Millions)	**Prior Years**	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	-	45.359	58.250	60.551	0.000	60.551	61.945	62.607	64.800	62.016	Continuing	Continuing
633720: *EW Quick Reaction Capabilities*	-	26.497	30.912	31.254	0.000	31.254	34.200	35.531	38.072	34.887	Continuing	Continuing
63431G: *RF Warning & Countermeasures Tech*	-	14.622	19.671	18.284	0.000	18.284	17.012	15.106	14.560	14.688	Continuing	Continuing
634335: *Cyber Concepts*	-	0.000	2.635	6.087	0.000	6.087	5.876	7.017	7.116	7.288	Continuing	Continuing
63691X: *EO/IR Warning & Countermeasures Tech*	-	4.240	5.032	4.926	0.000	4.926	4.857	4.953	5.052	5.153	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program develops and demonstrates technologies to support Air Force electronic combat warfighting capabilities. The program focuses on developing components, subsystems, and technologies with potential aerospace combat, special operations, and airlift electronic combat applications. It develops and demonstrates technologies for integrating electronic combat sensors and systems into a fused and seamless whole. It integrates and focuses research efforts in electronic warfare (EW) and cyber warfare to rapidly demonstrate a capability for rapid fielding. It develops and demonstrates technologies for navigation and timing in radio frequency (RF) contested and denied environments. It develops and demonstrates advanced technologies for RF electronic combat suites and advanced warning and countermeasure technologies to defeat electro-optical, infrared, and laser threats to aerospace platforms. It also develops and demonstrates technologies that identify and mitigate avionics system cyber vulnerabilities as well as protects avionics and other critical technologies. This program has been coordinated through the Department of Defense (DoD) Science and Technology (S&T) Executive Committee process to harmonize efforts and eliminate duplication.

Starting in FY 2017 to improve reporting to Congress, Project 634335, Cyber Concepts was created to capture all cyber activity that was previously performed under Project 633720, EW Quick Reaction Capabilities.

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.

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Air Force					Date: May 2017
Appropriation/Budget Activity 3600: *Research, Development, Test & Evaluation, Air Force* / BA 3: *Advanced Technology Development (ATD)*		**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*			
B. Program Change Summary ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	46.946	58.250	60.851	0.000	60.851
Current President's Budget	45.359	58.250	60.551	0.000	60.551
Total Adjustments	-1.587	0.000	-0.300	0.000	-0.300
• 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	-0.510	0.000			
• SBIR/STTR Transfer	-1.077	0.000			
• Other Adjustments	0.000	0.000	-0.300	0.000	-0.300

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 633720 / *EW Quick Reaction Capabilities*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
633720: *EW Quick Reaction Capabilities*	-	26.497	30.912	31.254	0.000	31.254	34.200	35.531	38.072	34.887	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project establishes a capability to rapidly assess, develop and demonstrate new electronic warfare concepts, techniques, and capabilities as well as the required navigation technologies and capabilities in the context of systemic electronic warfare (EW) effects (EW-threat interactions) in a congested/contested electromagnetic spectrum (EMS), system-of-systems (SoS) environment of the future. It develops disruptive EW and countermeasures concepts specifically selected for high-impact, game-changing effects; evaluates them in high fidelity virtual and hardware evaluation settings; and demonstrates them in an operationally relevant environment. It establishes and maintains an all-source, physics-based, threat-to-countermeasures EW systems engineering methodology. It develops a core analytic function, supported by simulation-based wargaming and interactive engineering modeling capabilities to evaluate advanced countermeasures concepts.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Disruptive EW and Countermeasure Technologies	11.792	13.790	13.943
Description: Develop disruptive EW and countermeasure concepts specifically selected for rapidly fieldable, high-impact effects and demonstrate them in an operational environment. ***FY 2016 Accomplishments:*** Leveraged developments in directed energy and cyber techniques to effectively simulate electronic attack against a modeled integrated air defense network to determine deficiencies in the attack capability. Focused research methods to mitigate the determined deficiencies in attack methodology and developed alternative strategies for employment to enable successful suppression of threat representative integrated air defense systems. Began to develop capabilities to integrated RF/infrared (IR) sensors to improve situational awareness & self protection. ***FY 2017 Plans:*** Continue to develop capability to use RF electronic attack (EA) techniques to deliver cyber effects. Continue supporting the cyber efforts in Project 634335, Cyber Concepts, to model cyber effects on an integrated air defense system and simulate their utility. Continue to develop, integrate and demonstrate required navigation and timing technologies required for distributed EA concepts. Continue to develop and evaluate countermeasures to adversary use of satellite navigation. Continue to integrate RF/IR sensors to improve situational awareness and self protection. ***FY 2018 Plans:*** Conduct sense, learn, and adapt demonstrations illustrating advancements in electromagnetic spectrum awareness, reasoning, and collaborative effects. Demonstrate advanced counter satellite navigation techniques			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 633720 / *EW Quick Reaction Capabilities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
in an operational environment. Begin the development and demonstration efforts to prove the concepts for “full spectrum” countermeasures capabilities.			
Title: Threat-to-Countermeasure System of Systems (SoS) Methods ***Description:*** Establish and maintain an all-source, physics-based, design-level, red-blue, comparative, threatto-countermeasure SoS techniques methodology. This systems engineering-based EW approach will inform programmatic planning, quantify desirable research areas with realistic SoS metrics, and foster improved understanding of future concept contributions to EW warfighting capabilities. ***FY 2016 Accomplishments:*** Demonstrated improvements in SoS analysis capability through virtual simulation mechanisms. Used metrics to show the value added proposition of multi-spectral techniques to address the threat to countermeasure system performance. ***FY 2017 Plans:*** Continue to use system engineering analysis techniques to identify the requirements for SoS operations in anti-access/area-denial (A2/AD) environments. Specifically work toward showing how EW techniques and capabilities can be modeled and show support of mission operations (such as Intelligence Surveillance Reconnaissance (IRS) or strike) in A2/AD scenarios. Continue to develop, integrate and demonstrate required navigation technologies required for SoS operations in A2/AD environments. ***FY 2018 Plans:*** Demonstrate robust distributed time transfer in a Global Positioning System (GPS) jamming environment. Demonstrate effects of a coordinated EA capability.	6.871	8.000	8.089
Title: Evaluation of Advanced Countermeasure Concepts ***Description:*** Develop a core analytic function, supported by simulation-based wargaming and engineering modeling capabilities for evaluation, development, and demonstration of advanced EW, cyber, directed energy (DE) and integrated/systemic, non-kinetic concepts to include special capability programs. ***FY 2016 Accomplishments:*** Demonstrated reconfigurable closed-loop hardware-in-the-loop (HWIL) assessment capability for discovering and evaluating advanced EW techniques, including diverse distributed concepts. This development of advanced techniques will ensure aircraft survivability against future threats with highly agile and adaptable waveform structures. Demonstrated in-house analysis and	7.834	9.122	9.222

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 633720 / *EW Quick Reaction Capabilities*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
assessment technologies for countering A2/AD scenarios. Demonstrated the Proactive Mid-Infrared Situation Awareness (MISA) system in tower and field tests. ***FY 2017 Plans:*** For FY 2016, the navigation work in this effort was performed in Program 0603203F, Advanced Aerospace Sensors, Project 63655A, Advanced Aerospace Sensors Technology, under the effort Integrated Navigation Technologies. For FY2017 and beyond, the advanced cyber technology work accomplished under this effort will be reported in Project 634335, Cyber Concepts, under the efforts, Avionics Cyber Vulnerabilities and Avionics Cyber Protections. Continue development, integration and demonstration of required navigation technologies required for operations in contested and denied environments. Develop adaptable threat emulation capability to simulate modern and expected threats for future conflicts. Use these simulations to assess blue force hardware against these future red force systems. Conduct flight tests of the MISA system. Analyze the data and refine the requirements for AFSOC scenarios. Begin the data collection and analysis of the advanced defeat concepts for imaging sensors. Refine requirements for lasers required to defeat this threat class. ***FY 2018 Plans:*** Continue data collection on advanced imaging sensor defeat mechanisms and conduct requirements trades for system transition architectures. Continue the development of advanced missile warning technologies for long-range detection. Demonstrate adaptable threat emulation capability to simulate modern and expected future EW threats. Demonstrate trusted use of foreign satellite navigation signals through signal authentication techniques, constellation signal monitoring and data dissemination, and jamming countermeasure techniques. Address size, weight and power (SWAP)requirements for application to the whole range of Air Force platforms. Begin the incorporation of the proactive situational awareness (SA) and countermeasures capabilities into engagement models.			
Accomplishments/Planned Programs Subtotals	26.497	30.912	31.254

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.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 63431G / *RF Warning & Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
63431G: *RF Warning & Countermeasures Tech*	-	14.622	19.671	18.284	0.000	18.284	17.012	15.106	14.560	14.688	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates advanced technologies for radio-frequency electronic combat suites, including the required navigation technologies and capabilities, to enhance the survivability of aerospace vehicles and to provide crew situational awareness. The research addresses technologies for missile/threat warning, radio-frequency receivers, electronic combat pre-processors, advanced sorting/pre-processing algorithms, and expert software for applications on existing and future electronic combat systems. The research also focuses on the development and demonstration of subsystems and components for generating on-board/ off-board radio-frequency countermeasure techniques. This includes the development of electronic countermeasures techniques, as well as advanced electronic countermeasures technologies such as antennas, power amplifiers, and preamplifiers.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Electronic Attack	14.622	19.671	18.284
Description: Develop aerospace platform jamming concepts, technologies and techniques to counter advanced RF threats associated with current and future aerospace weapon systems. Provide navigation system resilience via open architecture solutions.			
FY 2016 Accomplishments: Collected and analyzed high fidelity RF data representative of airborne high threat engagements. Leveraged advances in cognitive machine learning from DARPA and industry to perform demonstrations and assessments that measured improved abilities to autonomously identify modern adaptive programmable threats. Developed concepts/techniques to ascertain the efficacy of advanced EA methods employed against modern threats to close the loop allowing optimization of the EA technique. Prototyped an example government reference architecture on the next generation of embedded GPS inertial (EGI) system avionics. Initiated requirements definition and systems engineering analysis for an advanced EW receiver algorithm and architecture project.			
FY 2017 Plans: For FY 2016, the navigation work in this effort originally was performed in Program 0603203F, Advanced Aerospace Sensors, Project 63655A, Advanced Aerospace Sensors Technology, under the effort Integrated Navigation Technologies. Continue to collect and analyze high fidelity RF data representative of airborne high threat engagements. Continue to develop concepts/techniques and advanced EA methods (techniques and employment) against modern threats to close the loop allowing a more optimized EA effectiveness. Perform demonstrations and assessments in cognitive machine learning from Air Force,DARPA and industry that measure improved abilities to autonomously identify modern adaptive programmable threats.			

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 63431G / *RF Warning & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Develop algorithms for vision aiding the navigation solution in a targeting pod. Initiate an external industry-led project in advanced EW receiver algorithms and architectures. ***FY 2018 Plans:*** Continue efforts in advanced electronic warfare (EW) receiver algorithms and architectures, as well as machine learning ("cognitive") algorithms. Continue research into innovative EA concepts/techniques including use of closed loop, cooperatively controlled, distributed unmanned aerial vehicles (UAVs) and their performance against integrated air defense networks and adaptable techniques for use against any threats. Fabricate and demonstrate an advanced capability EA pod against emerging, high priority threats. Develop, integrate and demonstrate distributed EA concepts and their required navigation and datalink technologies. Demonstrate integration of navigation signals of opportunity and vision aiding into an open EGI system prototype.			
Accomplishments/Planned Programs Subtotals	14.622	19.671	18.284

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.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 634335 / *Cyber Concepts*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
634335: *Cyber Concepts*	-	0.000	2.635	6.087	0.000	6.087	5.876	7.017	7.116	7.288	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates methods to discover cyber susceptibilities, assess avionics systems, formulate mitigation strategies, and investigate use of tools and technologies to automate this process. It is designed to apply developed vulnerability discovery, vulnerability mitigation, and cyber protection technology to avionics systems and components and embedded systems.

Project 634335, Cyber Concepts is new for FY 2017. Work from this effort was previously performed under Project 633720, EW Quick Reaction Capabilities, in this program.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Avionics Cyber Vulnerabilities	0.000	1.464	3.382
Description: Develop and demonstrate methods, techniques, and technical tools to enable, assist, and improve the vulnerability discovery processes. Use developed tools and techniques to assess avionics boxes, systems, busses, and components. ***FY 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** For FY 2016, the work for this effort originally was performed in Project 633720, EW Quick Reaction Capabilities, under the effort Evaluation of Advanced Countermeasure Concepts. Prototype and demonstrate a series of cyber testing tools that assess vulnerabilities related to deficiencies in traditional testing (i.e. positive testing) that does not consider cyber effects. Assess USAF platforms (manned, unmanned aircraft) and weapon systems for specific cyber vulnerabilities and develop avionics enhancements to increase security and resiliency. ***FY 2018 Plans:*** Continue vulnerability investigations with the intent to provide a standardized methodology and set of tools for performing a thorough cyber vulnerability assessment of a weapon system. Transition assessment tools to DoD test communities. Continue to develop and transition protection/mitigation technologies.			
Title: Avionics Cyber Protections	0.000	1.171	2.705

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 634335 / *Cyber Concepts*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Description: Develop and demonstrate advanced automated analysis tools and protection techniques to prevent exploitation of cyber susceptibilities in avionics systems. This strategy would include discovery and mitigation of likely attack vectors, remediation of susceptibilities, and safeguards to assure the integrity of embedded software. ***FY 2016 Accomplishments:*** N/A ***FY 2017 Plans:*** For FY 2016, the work for this effort originally was performed in Project 633720, EW Quick Reaction Capabilities, under the effort Evaluation of Advanced Countermeasure Concepts. Prototype and demonstrate a suite of protection tools composed of application, operating system kernel, hypervisor and hardware-assisted technologies to provide defense-in-depth of avionics, sensors, and weapon systems. This demonstration will focus on protections for a representative intelligence surveillance and reconnaissance (ISR) platform. Develop a patterns database that detects and classifies benign and malicious behaviors, and validate proof-of-concept for x86 computer architectures. Create other architecture specific translators (e.g. PowerPC) to further validate concept. ***FY 2018 Plans:*** Continue to extend 2017 work on a suite of protection tools with focus on their application to unmanned aircraft systems (UAS) platforms. Prototype and demonstrate a platform independent malware feature selection capability. Investigate automation and optimization of malware detection and classification work using machine learning techniques.			
Accomplishments/Planned Programs Subtotals	0.000	2.635	6.087

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.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force			Date: May 2017
Appropriation/Budget Activity 3600 / 3	R-1 Program Element (Number/Name) PE 0603270F / *Electronic Combat Technology*	Project (Number/Name) 63691X / *EO/IR Warning & Countermeasures Tech*	

COST ($ in Millions)	Prior Years	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
63691X: *EO/IR Warning & Countermeasures Tech*	-	4.240	5.032	4.926	0.000	4.926	4.857	4.953	5.052	5.153	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project develops and demonstrates the advanced warning and countermeasure technologies required to negate electro-optical / infrared, (EO/IR) and laser threats to aerospace platforms. Develops off-board (decoys and expendables) and on-board countermeasure technologies for aircraft self-protection to provide robust, affordable solutions for protection against infrared missiles with autonomous seekers, multi-spectral threats, laser-guided weapons, and EO/IR tracking systems used to direct EO/IR and radar-guided missiles.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Title: Advanced Electro-Optical (EO)/Infrared (IR) Warning and Countermeasure Technologies	4.240	5.032	4.926

Description: Analyze the vulnerabilities of current IR missile systems and future imaging IR sensors. Develop advanced countermeasure system technologies to exploit vulnerabilities for use against IR and EO guided missile threats. Develop advanced optical and infrared sensor systems for airborne and space situational awareness and threat warning.

FY 2016 Accomplishments:

Characterized and exploited several advanced threat IR guided missiles and collected laboratory and field data on many EO/IR fire-control systems and sensors including night vision goggles and thermal imagers. Continued the development of high-fidelity surrogates and associated algorithms, scene generation and modeling and simulation for testing and countermeasure development and verification/correlation to hardware in the loop results. Defined the requirements for novel countermeasure effects against advanced IR and multispectral threats. Conducted data collection using advanced next generation missile warning sensors and hostile fire indication system. Transitioned an advanced laser warning and protection capability to the US Army.

FY 2017 Plans:

Develop advanced capability to defeat imaging optical sensors across the EO spectrum from ultra-violet (UV) to long-wave infrared wavelengths. Investigate low size, weight, power, and cost systems for smaller/expendable platforms to enhance their survivability in active threat areas using the modeling and HWIL simulation capability established through this funding area. Perform verification and validation activities utilizing the MOdeling System for Advanced Investigation of Countermeasures (MOSAIC), infrared countermeasure (IRCM) engagement model and correlate results with the Guided Weapon Evaluation Facility and the US Navy laboratories at China Lake.

FY 2018 Plans:

Exhibit R-2A, RDT&E Project Justification: FY 2018 Air Force		Date: May 2017
Appropriation/Budget Activity 3600 / 3	**R-1 Program Element (Number/Name)** PE 0603270F / *Electronic Combat Technology*	**Project (Number/Name)** 63691X / *EO/IR Warning & Countermeasures Tech*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018
Continue characterization and exploitation of newly acquired advanced threats. Correlate the results from the at-range testing of EO/IR adjuncts to integrated air defense systems (IADS) and refine the requirements for the detection and countermeasure concepts and demonstration system to defeat multi-spectral threats.			
Accomplishments/Planned Programs Subtotals	4.240	5.032	4.926

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.