RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)

DATE: February 1999

BUDGET ACTIVITY: 2 - Applied Research

PE NUMBER AND TITLE: 0602204F Aerospace Sensors

	COST *($ In Thousands*)	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	57,766	63,719	64,988	69,245	71,392	75,438	80,236	82,263	Continuing	Continuing
2000	Electronic Countermeasures Technology	14,448	15,440	15,969	16,426	17,936	19,932	20,958	22,262	Continuing	Continuing
2001	Electro-Optical Technology	6,011	463	495	597	997	1,698	2,598	2,005	Continuing	Continuing
2002	Microwave Technology	9,167	9,039	9,387	10,505	9,976	10,194	10,465	10,754	Continuing	Continuing
2003	Avionics System Design Technology	5,410	9,282	9,362	9,728	10,314	11,010	11,302	11,616	Continuing	Continuing
6095	Sensor Fusion Technology	6,539	11,345	12,395	13,333	14,367	14,943	16,046	16,324	Continuing	Continuing
6096	Microelectronics Technology	8,600	9,180	7,703	8,548	7,409	6,978	6,898	7,032	Continuing	Continuing
7622	Radio Frequency Sensor Technology	7,591	8,970	9,677	10,108	10,393	10,683	11,969	12,270	Continuing	Continuing
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

(U) A. Mission Description: This Applied Research program develops the technology base for Air Force aerospace sensors. Advances in aerospace sensors are required to increase combat effectiveness by providing "anytime, anywhere" surveillance, reconnaissance, precision targeting, and electronic warfare capabilities for ground, air, and space platforms. Advances in aerospace sensor technology will also reduce life cycle costs, facilitate affordable modernization of aging and future aerospace platforms, and provide protection against emerging hostile threat systems. Meeting these needs necessitates simultaneous advances in multiple, interrelated disciplines including: airborne and spaceborne sensors (e.g., infrared, radar, etc.); multi-function high-power electronic devices; target detection, classification, and recognition techniques; fire control; sensor fusion methods; communication and navigation subsystems; and electronic warfare technologies.

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(U) B. Budget Activity Justification: This program is in Budget Activity 2, Applied Research, since it develops and determines the technical feasibility and military utility of evolutionary and revolutionary sensor, electronics, and electronic combat technologies.

(U) C. Program Change Summary ($ in Thousands):

	FY 1998	FY 1999	FY 2000	FY 2001	Total Cost
(U) Previous President's Budget/FY 1999 PB	61,025	65,549	67,461	72,064	Cont
(U) Appropriated Value	64,144	65,549			
(U) Adjustments to Appropriated Value					Cont
a. Congressional/General Reductions	-2,464	-1,830			
b. SBIR	-739				
c. Omnibus/Other Above Threshold Reprogrammings	-1,671				
d. Below Threshold Reprogrammings	-1,504				
(U) Adjustments to Budget Year Since FY 1999 PB			-2,473	-2,819	
(U) Current Budget Submit/FY 2000 PB	57,766	63,719	64,988	69,245	Cont

(U) Significant Program Changes: Changes to this program since the previous President's Budget are due to higher priorities within the Science and Technology (S&T) Program.

FY 1999: $719 identified as a source for SBIR.

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BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 2000

COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
2000 Electronic Countermeasures Technology	14,448	15,440	15,969	16,426	17,936	19,932	20,958	22,262	Continuing	Continuing

(U) A. Mission Description: This program determines the feasibility of active and passive electronic countermeasure technologies and explores, develops, expands, and refines the most promising and cost-effective technologies. The technologies pursued support passive sensing of the entire electromagnetic spectrum in order to provide signal collection, detection, recognition, analysis, identification, location, and countering of enemy electronic emissions whether intentional or unintentional. This project includes development of countermeasure concepts against radar, infrared (IR), and electro-optical threat weapon systems as well as against communication command and control networks. Various links and sensors of threat air defense systems are analyzed and a database of countermeasure techniques and technologies is generated from which specific self-protection or support countermeasures equipment can be developed. Specifically, the program exploits emerging technologies to provide increased capability for: 1) radar warning, radio frequency (RF) electronic warfare, and electronic intelligence applications; 2) IR detection for passive missile warning, IR signature exploitation, and IR countermeasures; 3) laser detection for threat warning and countermeasures; 4) passive and combined passive/active off-board expendables (chaff, decoys, etc.); and 5) hardware and software for associated processing and technology integration needs. These countermeasure capabilities are vital for survival of operational aerospace platforms facing advanced threats in future hostile environments.

(U) FY 1998 ($ in Thousands):

- (U) $3,255 Developed technologies for on-board and off-board (active IR decoys) countermeasures to counter IR-guided missiles and electro-optical threats, including evaluating techniques against imaging missile seekers, developing a shielded narrow band IR source, downselecting laser beamrider missile concepts, and developing cooperative on-board and off-board countermeasure concepts.
- (U) $4,126 Developed affordable RF jamming technology and concepts to degrade enemy radar, missile, and command and control systems, including testing countermeasures to monopulse tracking radars, evaluating digital RF memory architectures for defeating coherent doppler radars, developing digital jamming metrics, and examining countermeasures to covert featureless waveform communication links.
- (U) $771 Developed off-board (expendable) RF countermeasure concepts, including designing active decoys to counter microwave and millimeter wave radars, developing methods to predict the effectiveness of advanced chaff, and developing and testing environmentally degradable and electromagnetically tailorable chaff designs.
- (U) $1,542 Developed technology for generic software modules to enable low-cost block upgrades to electronic warfare receivers, including ground testing combined de-interleaving, correlation, and threat identification software and completing a preliminary design of advanced threat parameter normalization software.
- (U) $3,854 Developed affordable RF receiver and antenna technology for use in operational and future aircraft, including testing a wideband digital receiver brassboard, developing wideband receiver specialized software, developing narrowband digital receiver technology, completing design of six-to-eight gigahertz conformal array, and transitioning software for design and evaluation of flush-mounted conformal arrays.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 1999
BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors
	PROJECT 2000

- (U) $900 Developed missile and laser warning technology to accurately cue countermeasures, including developing laser warning discrimination techniques, evaluating infrared (IR) clutter rejection techniques, developing and evaluating multifrequency, non-mechanical filters, and developing a laser warning breadboard.
- (U) $14,448 Total

(U) FY 1999 ($ in Thousands):

- (U) $4,150 Develop countermeasure technologies for on-board and off-board (active IR decoys) to counter IR-guided missiles and electro-optic threats, including continuing to evaluate techniques against imaging missile seekers, developing cooperative jammer and decoy concepts, and demonstrating night vision device countermeasure concepts.
- (U) $2,677 Develop affordable radio frequency (RF) jamming technology and concepts to degrade enemy radar, missile, and command and control (C2) systems, including completing covert featureless waveform study, developing advanced deception countermeasures techniques, developing techniques for degrading enemy modern communication networks, and evaluating RF countermeasure techniques in the laboratory.
- (U) $305 Develop off-board (expendable) RF and combined IR/RF countermeasure concepts, including design tools and analytic methods to predict effectiveness of advanced decoys.
- (U) $2,095 Develop technology for generic software modules to enable low-cost block upgrades to electronic warfare receivers, including testing of combined de-interleaving, correlation, and threat identification software modules.
- (U) $4,689 Develop affordable antenna technology for use in operational and future aircraft, including demonstrating first wideband digital receiver, developing new techniques for wideband to narrowband cueing, and investigating the electromagnetic characterization of and demonstrating dual-use conformal array technology.
- (U) $1,305 Develop missile and laser warning technology to accurately cue countermeasures and improve survivability. This includes continued development of laser warning techniques and evaluation of IR clutter rejection techniques.
- (U) $219 Identified as a source for SBIR.
- (U) $15,440 Total

(U) FY 2000 ($ in Thousands):

- (U) $3,524 Develop countermeasure technologies against IR-guided missiles and electro-optic threats, including continuing to evaluate techniques against imaging missile seekers and demonstrating cooperative jammer and decoy concepts.
- (U) $3,007 Develop affordable RF jamming technology and concepts that enhance aircraft survivability by degrading enemy radar, missile, and C2 systems, including completing covert evaluation of featureless waveform detection, optimizing advanced deceptive countermeasure techniques, and continuing to develop techniques for degrading enemy modern communication networks.
- (U) $491 Develop off-board (expendable) radio frequency (RF) and combined infrared/RF countermeasure concepts for affordable survivability, including demonstrating countermeasure effectiveness of advanced decoys against dual-mode missile seekers.

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BUDGET ACTIVITY: 2 - Applied Research	PE NUMBER AND TITLE: 0602204F Aerospace Sensors
	PROJECT: 2000

- (U) $2,341 Develop technology for generic software modules to enable low-cost block upgrades to electronic warfare (EW) receivers, including completing tests of combined de-interleaving correlation and threat identification software modules for aerospace EW receivers.
- (U) $3,045 Develop affordable RF receiver technology for use in operational and future EW receivers, including continuing to demonstrate a wideband digital receiver brassboard, evaluating narrowband receiver technology, and developing wideband analog-to-digital circuits (ADCs).
- (U) $2,058 Develop affordable antenna technology for use in operational and future aerospace platform electronic receivers and apertures, including developing low-frequency direction-finding antennas, demonstrating advanced pattern control of multimode/multifunction antennas, and demonstrating wideband phase shifters and transmit/receive module technology.
- (U) $1,503 Develop aerospace missile and laser warning technologies to accurately cue countermeasures, including devising laser warning discrimination methods, assessing hyperspectral imaging technology for missile warning, and demonstrating infrared clutter rejection techniques.
- (U) $15,969 Total

(U) FY 2001 ($ in Thousands):

- (U) $2,999 Develop countermeasure technologies against infrared-guided missiles and electro-optic threats, including continuing to evaluate techniques against imaging missile seekers and demonstrating cooperative jammer and decoy concepts.
- (U) $3,776 Develop affordable RF jamming technology and concepts that enhance aircraft survivability by degrading enemy radar, missile, and command and control systems, including developing a wide bandwidth microwave tube for EW transmitters, testing optimized deception countermeasure techniques, and testing techniques to degrade modern communication networks.
- (U) $1,145 Develop technology for generic software modules to enable low-cost block upgrades to EW receivers, including designing threat identification software modules for next-generation space-based threat warning receivers.
- (U) $3,258 Develop affordable RF receiver technology for use in operational and future aerospace platform EW receivers. This includes demonstrating a wideband all-digital receiver brassboard for space-based applications that incorporates new hardware and software elements, evaluating the utility of narrowband receivers technology for affordable space-based receivers, and demonstrating high-speed, wideband ADCs.
- (U) $2,886 Develop affordable antenna technology for use in operational and future aerospace platform electronic receivers and apertures, including continuing to demonstrate advanced pattern control of multimode/multifunction antennas.
- (U) $2,362 Develop aerospace missile and laser warning technologies to accurately cue countermeasures, including developing advanced temporal and spectral tracking algorithms, refining hyperspectral imaging techniques, and demonstrating laser warning discrimination methods.
- (U) $16,426 Total

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	PROJECT 2000

(U) B. Project Change Summary - Description of Significant Changes: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:
- (U) PE 0603270F, Electronic Combat Technology.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 1999
BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 2001

COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
2001 Electro-Optical Technology	6,011	463	495	597	997	1,698	2,598	2,005	Continuing	Continuing

(U) A. Mission Description: This project focuses on the development of military unique and essential devices and components for aerospace optical sensing, optical processing, and integration of electro-optical technology into avionics sensor systems. Electro-optical technologies provide faster, more accurate detection and targeting capability combined with the benefits of low weight and low-power requirements. The results of this technology provide the warfighter with increased situational awareness, enhanced defense suppression, and improved precision weapon delivery.

(U) FY 1998 ($ in Thousands):
- (U) $1,162 Developed ultraviolet technology for applications such as missile threat warning, communications, and jet engine analysis.
- (U) $311 Developed high-speed opto-electronics technology for faster interfaces between electronic components for high-speed analog-to-digital converters, digital radar, and real-time image/target recognition.
- (U) $747 Developed affordable, supportable, manufacturable high definition/resolution displays with all digital interface and sunlight readability.
- (U) $1,369 Developed advanced electro-optical sensor technologies, including non-mechanical beam steering techniques, for a single compact, affordable navigation and targeting sensor.
- (U) $2,422 Developed and demonstrated frequency agile electro-optical technologies to enhance air-to-ground and to air-to-air sensor performance, increase target detection and identification ranges, and defeat heat-seeking missiles.
- (U) $6,011 Total

(U) FY 1999 ($ in Thousands):
- (U) $457 Develop advanced electro-optical sensor technologies, including non-mechanical beam steering techniques, for a single compact, affordable navigation and targeting sensor.
- (U) $6 Identified as a source for SBIR.
- (U) $463 Total

(U) FY 2000 ($ in Thousands):
- (U) $495 Develop optical transmitter technology capable of sensing multiple target characteristics to provide robust non-cooperative combat identification, including performing proof-of-concept demonstrations and critical design of single imaging and non-imaging transmitters.
- (U) $495 Total

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	PROJECT 2001

(U) FY 2001 ($ in Thousands):

- (U) $597 Develop optical transmitter technology capable of sensing multiple target characteristics to provide robust non-cooperative target identification, to include fabricating a single imaging and non-imaging transmitter.
- (U) $597 Total

(U) B. Project Change Summary - Description of Changes: Changes to this project since the previous President's Budget are due to higher priorities within the Science and Technology (S&T) Program.

(U) C. Other Program Funding Summary:

(U) Related Activities:

- (U) PE 0603203F, Advanced Aerospace Sensors.
- (U) PE 0602702F, Command, Control, and Communications (C3).
- (U) PE 0603270F, Electronic Combat Technology.
- (U) PE 0602712E, Materials and Electronics Technology.
- (U) PE 0603739E, Advanced Electronics Technology.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 1999
BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 2002

COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
2002 Microwave Technology	9,167	9,039	9,387	10,505	9,976	10,194	10,465	10,754	Continuing	Continuing

(U) A. Mission Description: This project focuses on the generation, control, reception, and processing of microwave and millimeter wave power. Develops technologies such as solid state and vacuum electronic power devices and amplifiers, low noise and signal control components, high-temperature electronics, multi-function monolithic integrated circuits, and high density packaging and interconnects. Develops techniques for integrating various combinations of these technologies to demonstrate significantly improved performance with smaller size, lower weight, lower cost, and higher reliability in military-specific applications. The requirements for device and component technology developments are based on Air Force and other DoD weapon systems needs in the areas of radar, communications, electronic warfare (EW), navigation, and smart weapons applications.

(U) FY 1998 ($ in Thousands):

- (U) $1,450 Developed military essential mixed-mode (e.g., high-power/low-noise, microwave/digital, electronic/electro-optical, etc.) multi-function components for radar and EW receivers and for digital phased array radars. Application of this compact and more flexible sensor technology will improve warfighter situational awareness, enhance defense suppression, and improve precision weapon delivery.
- (U) $3,015 Developed high-power (1 to 100 watts), military unique, solid state transmitters for radar and communications applications. This technology will enable the warfighter to detect and track low radar cross-section targets at greater ranges, improve situational awareness, and enable development of compact affordable transmitters for smaller platforms such as advanced unmanned air vehicles.
- (U) $1,780 Developed high-operating-temperature, military essential, solid state microwave transmitters used in ground-based and airborne radar applications. This technology allows compact transmitters to be located in remote areas of the platform for increased sensor coverage.
- (U) $1,417 Developed military unique, very high-power (100 to 1,000 watts) vacuum electronics devices and components for EW, radar, and communications applications which will result in modular, very compact and affordable microwave and millimeter wave transmitters.
- (U) $1,505 Developed military unique millimeter wave integrated circuits for terminal guidance and communications systems with reduced size and weight, thereby, enabling the inclusion of these sensors on very small platforms.
- (U) $9,167 Total

(U) FY 1999 ($ in Thousands):

- (U) $2,316 Develop compact, affordable, mixed-mode, multi-function receiver and phased array components for radar and EW, including designing miniature digital receiver components and refining advanced component evaluation methods to reduce non-recurring engineering costs.
- (U) $2,506 Develop high-power (1 to 100 watts), military unique, solid state transmitters for radar and communications applications, including transmit amplifiers to improve range and kill probability of precision guided munitions and advanced microwave amplifiers for improved power dissipation and reliability.

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	PROJECT 2002

- (U) $2,833 Develop high yield process technologies to enable high-operating-temperature, military essential, solid state microwave transmitters used in ground-based and airborne radar applications, including evaluating candidate materials for improved transistor reliability and demonstrating integrated circuits and high power internally matched transistors.
- (U) $1,256 Develop military unique, very high-power (100 to 1,000 watts) vacuum electronics devices and components for affordable microwave and millimeter wave transmitters, including designing advanced microwave tube components.
- (U) $128 Identified as a source for SBIR.
- (U) $9,039 Total

(U) FY 2000 ($ in Thousands):

- (U) $4,510 Develop compact, affordable, mixed-mode, multi-function receiver and phased array components for radar and electronic warfare (EW), including fabricating miniature digital receiver components, direct digital waveform transmitters, and very low power (<0.5W) analog-to-digital converters for space-based sensors and refining advanced component evaluation methods.
- (U) $2,437 Develop high-efficiency radio frequency power amplifiers for military space-based sensors, including designing a 10 GHz power amplifier for space-based radar and compact, affordable, reliable transistors and devising fabrication techniques for microwave amplifiers that have improved power dissipation.
- (U) $332 Develop microwave technologies to enable high operating temperature, solid state microwave transmitters used in military ground-based and airborne radar applications, including robust high-speed, high-power III-nitride transistors.
- (U) $318 Demonstrate high-power, internally matched transistors that will allow replacement of S-band vacuum tube transmitters to increase the reliability and lower the life cycle cost of high-power, ground-based radars.
- (U) $903 Develop aerospace surface protective coatings and packaging technologies for high-performance, mixed analog/digital microwave circuits to improve reliability and lower the cost of components that operate in harsh military environments, including developing advanced packaging and interconnect processes for phased array antennas and EW transmitters. (In FY 2000, this work moved from PE 0602204F, Project 6096.)
- (U) $887 Develop military unique, very high-power (100 to 1,000 watts) vacuum electronics devices and components for compact, affordable microwave and millimeter wave transmitters used in EW, radar, and communications applications, including fabricating of advanced microwave tube components.
- (U) $9,387 Total

(U) FY 2001 ($ in Thousands):

- (U) $4,119 Develop compact, affordable mixed-mode multi-function receiver and phased array components for radar and electronic warfare, including demonstrating miniature airborne digital receiver components, fabricating direct digital waveform transmitters and very low power (<0.5W) analog-to-digital converters for space-based sensors, and demonstrating and refining advanced component evaluation methods.

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	PROJECT 2002

- (U) $2,783 Develop high-efficiency radio frequency power amplifiers for military space-based sensors, including fabricating a 10 GHz power amplifier for space-based radar and demonstrating compact, affordable, reliable transistors and fabrication techniques for microwave amplifiers that have improved power dissipation.
- (U) $756 Develop microwave technologies to enable high operating temperature, solid state microwave transmitters used in military ground-based and airborne radar applications, including robust high-speed, high-power III-nitride transistors and high temperature silicon-carbide amplifiers.
- (U) $645 Develop and laboratory test aerospace surface protective coatings and packaging technologies for high performance mixed analog/digital microwave circuits to improve reliability and lower the cost of components that operate in harsh military environments, including testing advanced packaging and interconnect processes for phased array antennas and electronic warfare transmitters.
- (U) $736 Demonstrate military-unique, very high-power (100 to 1,000W) vacuum electronics devices and components for compact, affordable microwave and millimeter wave transmitters used in electronic warfare, radar, and communications applications, including demonstrating advanced microwave tube components.
- (U) $1,466 Develop space sensor component technology, including direct digital synthesis for waveform generation and miniaturized receiver technology.
- (U) $10,505 Total

(U) B. Project Change Summary - Description of Significant Changes: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:
- (U) PE 0603203F, Advanced Aerospace Sensors.
- (U) PE 0603270F, Electronic Combat Technology.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.

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COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
2003 Avionics System Design Technology	5,410	9,282	9,362	9,728	10,314	11,010	11,302	11,616	Continuing	Continuing

(U) A. Mission Description: Develops advanced aerospace sensor and avionics technology for electro-optical (EO) dectection, track, and identification of difficult targets, digital processing, software tools and techniques, and systems architectures. Develops new concepts, demonstrates feasibility, and advances technology for avionics system needs. Develops new concepts and demonstrates the feasibility of passive and active hyperspectral imaging sensors and algorithms for detection of airborne and ground-based targets in the presence of severe weather. These sensors are critical to future air and space-based surveillance and targeting capabilities. Additional technology development is being conducted in digital processing hardware, sensor integration, and real-time distributed software to improve weapon system performance, reduce life cycle costs, and increase avionics mission readiness.

(U) FY 1998 ($ in Thousands):

- (U) $1,066 Developed avionics software engineering technologies to improve reliability, quality, and supportability of both existing and next-generation weapon systems software. Successful re-engineering of existing software will dramatically improve the cost of modernizing aging avionics.
- (U) $1,632 Developed advanced machine intelligence technologies to provide a capability for enhanced management of critical on-board sensors and detection/recognition of targets.
- (U) $2,712 Developed advanced integration technology and evaluate the feasibility of integrating commercial-off-the-shelf components for affordable avionics modernization.
- (U) $5,410 Total

(U) FY 1999 ($ in Thousands):

- (U) $2,547 Develop software engineering technologies to promote assured performance and affordability of complex existing and next-generation air and space platform software, including demonstrating automated means to ensure correctness of cockpit display and console software, developing capability for performing in-flight self-checking of mission critical weapons and information systems software, and continuing to develop new techniques for rapidly incorporating new functions and hardware into scaleable systems.
- (U) $3,829 Develop advanced machine intelligence technologies to provide a capability for enhanced management of critical on-board sensors and detection/recognition of targets, including demonstrating enhanced, real-time embedded avionics database management system, demonstrating advanced multi-target, multi-source identification capability, demonstrating an advanced tactical surveillance sensor manager, and developing and applying efficient target recognition and combat information fusion techniques.
- (U) $2,775 Develop and demonstrate avionics integration technologies that allow rapid re-allocation of avionics hardware to meet changing operational requirements. These technologies dramatically reduce warfighter timelines for interoperability and adaptability in changing threat environments.

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	PROJECT: 2003

- (U) $131 Identified as a source for SBIR.
- (U) $9,282 Total

(U) FY 2000 ($ in Thousands):

- (U) $2,298 Develop software engineering technologies to promote assured performance and affordability of complex existing and next-generation air and space platform software, including continuing to demonstrate automated means to ensure correctness of cockpit display and console software, developing and applying capability for performing in-flight self-checking of mission critical weapons and information systems software, and continuing to develop new techniques for rapidly incorporating new hardware/software functions into scaleable, plug-and-play systems.
- (U) $2,566 Develop technologies to find and fix deep hide targets in day and night from high altitude and/or space in time to support precision targeting, including developing aerospace infrared hyperspectral sensor components and fusion algorithms, and continue validating sensor target models.
- (U) $1,119 Develop technology for non-cooperative identification of airborne and ground-based platforms, including investigating target background and atmospheric phenomenology effects on sensor performance, generating multi-dimensional/multi-functional sensor platform concepts, and developing coherent image processing/extraction algorithms.
- (U) $1,839 Develop electro-optical technology to enable passive or active targeting of difficult targets, including investigating ways of mitigating atmospheric phenomenology effects on extreme range aerospace sensors, developing turbulence compensation techniques for precision targeting, target signatures and phenomenology models, and selecting multifunction sensor target characteristics. (Prior to FY 2000, this work was performed under PE 0602702F, Project 4600.)
- (U) $451 Develop military-unique optical transmission components to enable information dominance, including fabricating laboratory high-speed optical communication subsystem.
- (U) $1,089 Develop innovative techniques and components to target difficult objects in degraded atmospheric conditions, including fabricating components for active multispectral imaging, assessing active imaging systems for their ability to penetrate weather and obscurants, and designing improved capabilities into existing systems.
- (U) $9,362 Total

(U) FY 2001 ($ in Thousands):

- (U) $1,979 Develop software engineering technologies to promote assured performance and affordability of complex existing and next-generation air and space platform software, including continuing to develop and apply capability for performing in-flight self-checking of mission critical weapons and information systems software, and continuing to develop new techniques for rapidly incorporating new hardware/software functions into scaleable, plug-and-play systems.

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	PROJECT 2003

- (U) $2,308 Develop technologies to find and fix deep hide targets in day and night from high altitude and/or space in time to support precision targeting, including fabricating aerospace infrared hyperspectral sensor components, developing data extraction algorithms, and analyzing performance.
- (U) $1,005 Develop technology for non-cooperative identification of airborne and ground-based platforms, including designing long-range sensors, testing coherent image processing/extraction algorithms, and flight-demonstrating a multifunction ladar.
- (U) $2,800 Develop electro-optical technology to enable passive or active targeting of difficult targets, including examining mitigating atmospheric phenomenology effects on extreme range aerospace sensors, generating turbulence compensation techniques for precision targeting, target signatures and phenomenology models, and validating multifunction sensor target characteristics.
- (U) $419 Develop military-unique optical transmission components to enable information dominance, including demonstrating useful commercial-off-the-shelf technologies integrated with military-unique components.
- (U) $1,217 Develop innovative techniques and components to target difficult objects in degraded atmospheric conditions, including analyzing and demonstrating concepts based on high precision range gating and image processing.
- (U) $9,728 Total

(U) B. Project Change Summary - Description of Significant Changes: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:
- (U) PE 0603253F, Advanced Sensor Integration.
- (U) PE 0602301E, Intelligence System Program.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 1999
BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 6095

COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
6095 Sensor Fusion Technology	6,539	11,345	12,395	13,333	14,367	14,943	16,046	16,324	Continuing	Continuing

(U) A. Mission Description: Develops the baseline technologies required to perform management and fusion of on-board sensor information for timely, comprehensive situation awareness, automatic target recognition (ATR), integrated fire control, and bomb damage assessment. This project determines the feasibility of technologies and concepts for fire control that aid in precisely locating, identifying, and targeting airborne and surface targets (with emphasis on reduced signature targets and targets of opportunity) to enable new covert tactics for successful accomplishments of air-to-air and air-to-surface strike scenarios.

(U) FY 1998 ($ in Thousands):

- (U) $1,351 Developed and evaluated multi-sensor management technologies to optimize search techniques, increase air combat situational awareness, increase detection ranges, allow high-confidence target identification, and enhance surface strike applications.
- (U) $2,416 Demonstrated rapid evaluation of multi-sensor system concepts to support all-aspect fire control, target tracking, and situation awareness.
- (U) $554 Applied emerging open software architecture standards and practices to the development and evaluation of real-time, on-board, adaptive information fusion systems for reduced targeting errors and enhanced situation awareness.
- (U) $1,220 Developed low-cost techniques using on-board sensors for cooperative air-to-ground identification of friendly forces to reduce fratricide and increase mission effectiveness.
- (U) $998 Developed advanced ATR techniques, including extracting radar "signature fingerprints" and evaluating thermal invariance features.
- (U) $6,539 Total

(U) FY 1999 ($ in Thousands):

- (U) $1,335 Develop, evaluate, and demonstrate air-to-air single and multisensor tracking, sensor management, fire control, situation awareness, and identification algorithms to dramatically improve air combat capability.
- (U) $5,062 Develop, evaluate, and demonstrate air-to-ground single and multi-sensor tracking, sensor management, fire control, situation awareness, and identification algorithms to dramatically improve reconnaissance, surveillance, and strike operations.
- (U) $2,772 Develop, evaluate, and demonstrate feasibility of single and multi-sensor ATR algorithms to dramatically improve capability to recognize hostile ground forces.
- (U) $1,216 Develop and demonstrate ATR enabling technologies for long-range, high-altitude air and space vehicles.
- (U) $800 Develop precision time, position, and velocity sensors to generate a common precision reference and enable platforms to share sensor data.
- (U) $160 Identified as a source for SBIR.
- (U) $11,345 Total

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(U) FY 2000 ($ in Thousands):

- (U) $3,773 Develop, evaluate, and demonstrate single and multisensor lethality algorithms to dramatically improve air combat capability, including performing a ground station emulation, simulating real-time information into the cockpit (RTIC) targeting, and developing adaptive resource allocation.
- (U) $3,573 Develop, evaluate, and demonstrate air-to-ground single and multi-sensor radar target signature models to support automatic target recognition (ATR) in strike operations, including investigating computational electromagnetics (CEM) techniques, generating geometric target models, and characterizing clutter.
- (U) $1,712 Develop, evaluate, and demonstrate feasibility of multi-sensor ATR algorithms for on- and off-board sensor-to-shooter image and data fusion to rapidly attack time-critical targets, including completing the evaluation of a sensor-to-shooter algorithm, devising multi-sensor performance metrics, and evaluating multisensor ATR algorithms.
- (U) $2,281 Develop and demonstrate enabling ATR technologies for long-range, high-altitude air and space vehicles, including investigating physics-based and adaptive learning techniques.
- (U) $1,056 Develop precision time, position, and velocity sensors, leveraging on the Global Positioning System (GPS), and to enable multiple platforms to share sensor data with reduced jamming vulnerability and increased precision targeting accuracy, including conducting trade studies to determine optimal mix and density of digital devices, and developing detailed designs for advanced direct signal acquisition techniques for increased jam resistance of GPS user equipment.
- (U) $12,395 Total

(U) FY 2001 ($ in Thousands):

- (U) $4,142 Develop, evaluate, and demonstrate single and multi-sensor lethality algorithms to dramatically improve air combat capability, including performing a live-feed to ground station emulation, evaluating RTIC targeting schemes, and optimizing adaptive resource allocation methods.
- (U) $3,893 Develop, evaluate, and demonstrate air-to-ground single and multi-sensor radar target signature models to support ATR in strike operations, including generating geometric target models and incorporating clutter effects on target recognition.
- (U) $1,748 Develop, evaluate, and demonstrate feasibility of multi-sensor ATR algorithms for on- and off-board sensor-to-shooter image and data fusion to rapidly attack time-critical targets, including completing multi-sensor performance metrics and evaluating multi-sensor ATR algorithms.
- (U) $2,912 Develop and demonstrate enabling ATR technologies for long-range, high-altitude air and space vehicles, including continuing to investigate physics-based and adaptive learning techniques.
- (U) $638 Develop technologies for reduced jamming vulnerability and increased precision targeting and strike accuracy of GPS, including completing detailed designs of advanced direct signal acquisition techniques for increased jam resistance of GPS user equipment and testing signal acquisition techniques.
- (U) $13,333 Total

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(U) B. Project Change Summary - Description of Significant Changes: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:

- (U) PE 0603203F, Advanced Aerospace Sensors.
- (U) PE 0602602F, Conventional Munitions.
- (U) PE 0603270F, Electronic Combat Technology.
- (U) PE 0603226E, Experimental Evaluation of Major Innovative Technologies.
- (U) PE 0603762E, Sensor and Guidance Technology.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.

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BUDGET ACTIVITY: 2 - Applied Research	PE NUMBER AND TITLE: 0602204F Aerospace Sensors	PROJECT: 6096

COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
6096 Microelectronics Technology	8,600	9,180	7,703	8,548	7,409	6,978	6,898	7,032	Continuing	Continuing

(U) A. Mission Description: This project focuses on military unique, sensor aspects of microelectronics and radio frequency (RF) photonics such as photonic sub-systems and components for the control and distribution of RF signals; high-speed devices and circuits; packaging and power distribution; design tools; and hardware design languages. The warfighter requirements for technology developments are based on Air Force and other DoD weapon systems needs in the areas of radar, communications, electronic warfare (EW), navigation, and smart weapons applications. Future surveillance and sensor information processing systems will require very small, environmentally robust, high-speed, low power, lightweight components and sub-systems using both microelectronics and photonics in the following areas: electronic and photonic analog-to-digital converter circuits, fiber optic signal control and distribution sub-systems, high-temperature electronics, multi-function monolithic integrated circuits, high density photonic interconnects, and RF distributions and radar beamforming. Computer-aided engineering technology is key to addressing the low-cost, very high performance, low power, tough environmental, multi-organization development, and high complexity challenges of our warfighting electronics. The developed technology is unavailable through commercial sources.

(U) FY 1998 ($ in Thousands):

- (U) $2,486 Developed advanced high-speed devices and fabrication processes for digital integrated circuits to allow high-speed military sensors to interface with slower commercial processing components, thereby eliminating bulky, costly, and temperature-sensitive down-conversion electronics. These technologies include very high-speed analog-to-digital converter circuits, digital RF memory chips, etc.
- (U) $2,316 Developed surface protective coatings, distributed power management, and packaging technologies for high performance digital integrated circuits to improve reliability and lower the cost of components that are required to operate in harsh military aerospace environments.
- (U) $1,744 Developed and integrated advanced design tools into a commercial software environment for affordable model year upgrades.
- (U) $2,054 Developed next generation hardware design languages to enable more effective interchange of replacement part design information, better control of obsolete parts, and reduced logistics support costs.
- (U) $8,600 Total

(U) FY 1999 ($ in Thousands):

- (U) $3,107 Develop advanced high-speed devices and fabrication processes for digital integrated circuits (e.g., very high-speed, analog-to-digital converters and digital RF memory chips) to allow high-speed military sensors to interface with slower commercial processors, thereby eliminating bulky, costly, and temperature-sensitive down-conversion electronics. This includes demonstrating fabrication processes and devices for a transceiver chip set and augmenting analog-to-digital conversion circuits to enable use of commercial-of-the-shelf components in radar, EW, and other sensors.

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– (U) $2,609 Develop surface protective coatings and packaging technologies for high performance, mixed analog/digital microwave circuits to improve reliability and lower component cost for space sensor components, including developing advanced packaging and interconnect processes for phased array antennas and electronic warfare transmitters and receivers. (In FY 2000 this work moves to PE 0602204F, Project 2002.)

– (U) $2,528 Develop advanced design tools to reduce the cost and time required to create complex Air Force electronic systems, including assessing and refining tools for next-generation "systems-on-a-chip" and reconfigurable computer design.

– (U) $805 Develop next generation design representations and system-level modeling and simulation capability to support the complexity in implementing the Air Force's "system of systems" vision, including developing extensions to industry standard hardware description and design language tools for developing complex military information systems.

– (U) $131 Identified as a source for SBIR.

– (U) $9,180 Total

(U) FY 2000 ($ in Thousands):

– (U) $2,487 Develop advanced high-speed device technologies to enable affordable, compact space-based sensors, including designing radio frequency (RF) components and analog-to-digital converters for high dynamic range, high sensitivity micro-receivers.

– (U) $1,771 Develop advanced design tools to reduce the cost and time required to create complex Air Force electronic systems, for example mixed analog and digital systems, including demonstrating tools for reconfigurable computers and for describing hardware behavior.

– (U) $775 Develop next-generation design representations and system-level modeling and collaborative engineering capability to support the complexity in implementing the Air Force's "system of systems" vision, including specifying required representations and developing advanced techniques for analyzing life cycle cost/performance trade offs.

– (U) $2,270 Develop RF photonics technologies to demonstrate compact, affordable, wide bandwidth, high data rate sensors, to include designing photonic interconnect architectures for high performance digital receivers and processors. (In FY 1999, this work was performed in PE 0602702F, Project 4600.)

– (U) $400 Develop, as part of an international cooperative effort, the three-dimensional multilayer microwave packaging and interconnect multichip assembly technologies needed for next-generation aircraft and space-based radars.

– (U) $7,703 Total

(U) FY 2001 ($ in Thousands):

– (U) $3,397 Develop high-speed device technologies to enable affordable, compact space-based sensors, including designing and fabricating low power, radiation tolerant analog-to-digital converters for high dynamic range, high sensitivity micro-receivers.

– (U) $1,812 Develop advanced design tools to reduce the cost and time required to create complex Air Force electronic systems, for example mixed analog and digital systems, including continuing to demonstrate tools for reconfigurable computing.

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- (U) $760 Develop next-generation design representations and system-level modeling and collaborative engineering capability to support the complexity in implementing the Air Force's "system of systems" vision, including implementing required representations and demonstrating advanced techniques for analyzing life cycle cost/performance trade offs.
- (U) $2,579 Develop radio frequency photonics technologies to demonstrate compact, affordable, wide bandwidth, high data rate sensors, including fabricating photonic interconnect components for high performance digital receivers and processors.
- (U) $8,548 Total

(U) B. Project Change Summary - Description of Significant Changes: Changes to this project since the previous President's Budget are due to higher priorities within the Science and Technology (S&T) Program.

(U) C. Other Program Funding Summary:

(U) Related Activities:
- (U) PE 0603203F, Advanced Aerospace Sensors.
- (U) PE 0603270F, Electronic Combat Technology.
- (U) PE 0602702F, Command, Control and Communications.
- (U) PE 0602705A, Electronics and Electronic Devices.
- (U) PE 0602234N, Materials, Electronics and Computers.
- (U) PE 0602712E, Materials and Electronics.
- (U) PE 0603739E, Manufacturing Technology.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.

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BUDGET ACTIVITY: 2 - Applied Research

PE NUMBER AND TITLE: 0602204F Aerospace Sensors

PROJECT: 7622

COST *($ In Thousands)*	FY 1998 Actual	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
7622 Radio Frequency Sensor Technology	7,591	8,970	9,677	10,108	10,393	10,683	11,969	12,270	Continuing	Continuing

(U) A. Mission Description: Determines feasibility of technology for reliable, all-weather, reconnaissance and precision strike radio frequency (RF) sensors and information transfer systems. Emphasis is on acquisition of surface and airborne targets with difficult to detect signatures due to reduced radar cross sections, concealment and camouflage measures, severe clutter, and/or heavy jamming. This project also develops technology to satisfy the growing need to transmit data between aerospace vehicles with high integrity, low probability of detection, and high jam resistance. Assured low probability of detection communications are required to reduce aircraft physical and electromagnetic vulnerability and provide major improvements in strike effectiveness by eliminating the requirement for "no communications" operations.

(U) FY 1998 ($ in Thousands):

- (U) $2,995 Developed advanced microwave sensor technology for air-to-air radar and target detection, including electronic protection, multi-dimensional image processing, and adaptive algorithms, to improve performance and reduce life cycle costs.
- (U) $2,802 Developed advanced airborne sensors for air-to-ground targeting and attack with robust performance in adverse weather, severe jamming, natural clutter, or concealment by foliage or camouflage.
- (U) $1,794 Developed technology for information transmission between airborne vehicles and cooperating assets with high fidelity, low probability of detection, and high jam resistance to improve strike effectiveness.
- (U) $7,591 Total

(U) FY 1999 ($ in Thousands):

- (U) $3,742 Develop advanced microwave sensor technologies, such as electronic protection, multi-dimensional image processing, and adaptive algorithms, for high-performance, lower life cycle cost air-to-air radar and target detection, including testing integrated RF techniques, developing adaptive algorithms for interference and lobe cancellation, and continuing to develop radar engineering tools to evaluate targeting errors.
- (U) $3,666 Develop advanced airborne sensors for air-to-ground targeting and attack with robust performance in adverse weather, severe jamming, natural clutter, or concealment by foliage or camouflage, including developing improved targeting scenes for synthetic aperture radars (SAR) and continuing to develop analytical tools to predict SAR performance.
- (U) $1,435 Develop technology for information transmission between airborne vehicles and cooperating assets with high fidelity, low probability of detection, and high jam resistance to improve strike effectiveness, including integrating a communication asset management system and completing a preliminary design for a non-linear adaptive interference limiter to reduce interference.
- (U) $127 Identified as a source for SBIR.
- (U) $8,970 Total

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(U) FY 2000 ($ in Thousands):

- (U) $568 Develop aerospace microwave sensor technologies for air-to-air radar and target detection that supports surveillance, reconnaissance, protection, targeting, attack, and electronic warfare, including designing electromagnetic interference mitigation techniques and validating advanced radar performance/cost analysis tools.
- (U) $1,759 Develop adaptive microwave processing algorithms for detecting and locating advanced cruise missiles and slow airborne and ground targets, including designing techniques to mitigate clutter and jamming on airborne monostatic and bistatic radars.
- (U) $1,577 Develop advanced aerospace sensors for air-to-ground targeting and attack, providing synthetic aperture radar (SAR) targeting solutions for maneuvering tactical aircraft under hostile environment, including performing an independent assessment of various current and future airborne and space surveillance sensors.
- (U) $743 Develop technology for detecting and attacking concealed targets, including developing innovative foliage- and ground-penetrating radar waveforms and targeting algorithms.
- (U) $1,199 Develop technology for information transmission between airborne vehicles and cooperating assets with high fidelity, low probability of detection, and high jam resistance to improve strike effectiveness, including completing a dual-use, integrated communication/navigation system demonstrator, developing a design for a non-linear adaptive interference limiter, and continuing propagation characterization studies and experiments.
- (U) $491 Develop technology to accurately determine algorithm and sensor performance from airborne and space-based platforms in realistic airborne surveillance and combat scenarios, including testing bistatic adjuncts on unmanned aerial vehicles. (Prior to FY 2000, this effort was conducted under PE 0602702F, Project 4506.)
- (U) $2,139 Develop advanced electromagnetic aperture technology, including demonstrating the feasibility of a space-based radar subarray; completing an antenna element/aperture design for a digital beam-formed bistatic radar multibeam antenna, evaluating advanced antenna concepts for sparse distributed satellite arrays, and demonstrating a three-dimensional optically excited antenna array. (Prior to FY 2000, this effort was conducted under PE 0602702F, Project 4600.)
- (U) $1,201 Develop electromagnetic technologies for advanced surveillance systems applications for the detection of low-observable airborne targets within severe clutter from airborne or space-based surveillance platforms. (Prior to FY 2000, this effort was conducted under PE 0602702F, Project 4600.)
- (U) $9,677 Total

(U) FY 2001 ($ in Thousands):

- (U) $1,377 Develop aerospace microwave sensor technologies for air-to-air radar and target detection that supports surveillance, reconnaissance, protection, targeting, attack, and electronic warfare, including developing electromagnetic interference mitigation components.
- (U) $1,142 Develop adaptive microwave processing algorithms for detecting and locating advanced cruise missiles and slow airborne and ground targets, including laboratory testing techniques to mitigate clutter and jamming in airborne monostatic and bistatic radars.

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- (U) $1,129 Develop advanced aerospace sensors for targeting and attack, including developing a high fidelity space-based radar evaluation tool for performing an independent assessment of surveillance and reconnaissance sensors.
- (U) $1,325 Develop technology for detecting and attacking concealed targets, including evaluating innovative foliage- and ground-penetrating radar waveforms and targeting algorithms, devising techniques to prevent discovery by the enemy, and assessing potential for embedded communications.
- (U) $1,379 Develop technology for information transmission between airborne vehicles and cooperating assets with high fidelity, low probability of detection, and high jam resistance to improve strike effectiveness, including completing the design of a non-linear adaptive interference limiter and continuing wide-band propagation characterization experiments.
- (U) $893 Develop technology to accurately determine algorithm and sensor performance from airborne and space-based platforms in realistic airborne surveillance and combat scenarios, including demonstrating performance on airborne surveillance and fighter platforms such as bistatic adjunct unmanned aerial vehicles (UAV), airborne foliage penetration assets, and space-based radar platforms.
- (U) $2,058 Develop advanced electromagnetic aperture technology, including demonstrating algorithms for a digital beam-formed bistatic radar multibeam antenna, demonstrating switched multi-function phased array employing micro-machined electromechanical system technology, and demonstrating a broadband antenna horn array for a UAV foliage penetration radar.
- (U) $805 Develop electromagnetic technologies for advanced surveillance systems applications for the detection of low-observable airborne targets within severe clutter from airborne or space-based surveillance platforms, including continuing to build a laboratory bistatic radar cross section measurement capability.
- (U) $10,108 Total

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(U) B. Project Change Summary - Description of Significant Changes: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:
- (U) PE 0603203F, Advanced Aerospace Sensors.
- (U) PE 0603253F, Advanced Avionics Integration.
- (U) PE 0602782A, Command, Control and Communications (C3) Technology.
- (U) PE 0602232N, Navy C3 Technology.
- (U) PE 0603792N, Advanced Technology Transition.
- (U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy: Not Applicable.

(U) E. Schedule Profile: Not Applicable.