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

DATE: June 2001

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602204F Aerospace Sensors

	COST ($ in Thousands)	FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	59,653	67,024	84,149	81,697	83,482	86,248	88,921	91,475	Continuing	TBD
2000	Electronic Countermeasures Technology	14,339	0	0	0	0	0	0	0	Continuing	TBD
2002	Electronic Component Technology	6,562	19,228	19,984	18,854	19,196	19,573	20,062	20,567	Continuing	TBD
2003	EO Sensors & Countermeasures Tech	8,883	11,746	14,217	14,210	15,423	15,493	15,997	16,515	Continuing	TBD
4916	Electromagnetic Tech	0	0	7,327	7,031	7,205	7,320	7,528	7,744	Continuing	TBD
6095	Sensor Fusion Technology	11,258	13,190	14,582	14,942	15,575	15,879	16,327	16,791	Continuing	TBD
6096	Microelectronics Technology	10,155	0	0	0	0	0	0	0	Continuing	TBD
7622	RF Sensors & Countermeasures Tech	8,456	22,860	28,039	26,660	26,083	27,983	29,007	29,858	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2001, work performed under this PE, Project 2000, moved to this PE, Projects 2002, 2003, and 7622. Additionally in FY 2001, work performed under this PE, Project 6096, moved to this PE, Project 2002. In FY 2002, work performed under PE 0602702F, Project 4600, moves to this PE, Project 4916. Apparent project ramps are due only to realignment of the projects. This realignment aligns projects with the Air Force Research Laboratory organization. Project realignment does not affect work planned for the overall program element or the budget topline. FY 2003 - FY 2007 budget numbers do not reflect the DOD Strategy Review results.

(U) A. Mission Description

This 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. To achieve this progress, this program pursues simultaneous advances in: 1) generating, controlling, receiving, and processing electronic and photonic signals for radio frequency (RF) sensor aerospace applications; 2) electro-optical (EO) aerospace sensor technologies for a variety of offensive and defensive uses; 3) RF antennas and associated electronics for airborne and space-based

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors

(U) A. Mission Description Continued

surveillance, together with active and passive electro-optical (EO) sensors; 4) technologies to manage and fuse on-board sensor information for timely, comprehensive situational awareness; and 5) technology for reliable, all-weather surveillance, reconnaissance, and precision strike radio frequency (RF) sensors and electronic combat systems. Note: In FY 2001, Congress added $2.0 million for Three-Dimensional (3-D) Non-Volatile Memory interconnects and packaging.

(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 2000	FY 2001	FY 2002	Total Cost
(U)	Previous President's Budget (FY 2001 PBR)	63,922	65,644	69,294	
(U)	Appropriated Value	64,331	67,644		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-42			
	b. Small Business Innovative Research	-1,516			
	c. Omnibus or Other Above Threshold Reprogram				
	d. Below Threshold Reprogram	-2,726			
	e. Rescissions	-394	-620		
(U)	Adjustments to Budget Years Since FY 2001 PBR			14,855	
(U)	Current Budget Submit/FY 2002 PBR	59,653	67,024	84,149	TBD

(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.

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

DATE: June 2001

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602204F Aerospace Sensors

PROJECT: 2000

COST ($ in Thousands)		FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
2000	Electronic Countermeasures Technology	14,339	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2001, this work transferred to this PE, Projects 2002, 2003, and 7622.

(U) A. Mission Description

This project determines the feasibility of active and passive electronic countermeasure technologies. It explores, develops, expands, and refines the most promising and cost-effective candidate technologies. These technologies will support passive sensing of the entire electromagnetic spectrum to improve signal collection, detection, recognition, analysis, identification, location, and countering of enemy electronic emissions, whether intentional or unintentional. The project also develops countermeasure concepts against radar, infrared (IR), and electro-optical (EO) threat weapon systems. In addition, it develops countermeasure concepts against networks for command, control, and communication. The project analyzes links and sensors of threat air defense systems. It generates a database of countermeasure techniques and technologies to support development of specific self-protection or support countermeasures equipment. Specifically, the project exploits emerging technologies to provide increased capability for: 1) radar warning, radio frequency (RF) electronic warfare (EW), 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 (e.g., chaff, decoys, etc.); and 5) hardware and software for associated processing and technology integration needs. The project advances countermeasure capabilities that are vital to the survival of operational aerospace platforms facing future threats in hostile environments.

(U) FY 2000 ($ in Thousands)

(U) $3,201 Developed countermeasure technologies against IR-guided missiles and EO threats. Continued evaluating techniques against imaging missile seekers and demonstrated cooperative jammer and decoy concepts. Developed optical transmitter technology capable of sensing multiple target characteristics to provide robust non-cooperative combat identification. (In FY 2001, this work transferred to Project 2003.)

(U) $2,687 Developed affordable RF jamming technology and concepts that enhance aircraft survivability by degrading enemy radar, missile, and command and control systems. Completed evaluation of alternative methods for covert featureless waveform detection. Optimized advanced deceptive countermeasure techniques. Continued to develop techniques for degrading enemy modern communication networks. (In FY 2001, this work transferred to Project 7622.)

(U) $475 Developed off-board (expendable) RF and combined IR/RF countermeasure concepts for affordable survivability. Demonstrated countermeasure effectiveness of advanced decoys against dual-mode missile seekers. (In FY 2001, this work transferred to Project 2003.)

(U) $2,021 Developed technology for generic software modules to enable low-cost block upgrades to EW receivers. Completed tests of combined de-interleaving correlation and threat identification software modules for aerospace EW receivers. (In FY 2001, this work transferred to Project 7622.)

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PROJECT: 2000	

(U) A. Mission Description Continued

(U) FY 2000 ($ in Thousands) Continued

(U)	$2,725	Developed affordable radio frequency (RF) receiver technology for use in operational and future electronic warfare (EW) receivers. Continued to demonstrate a wideband digital receiver brassboard. Evaluated narrowband receiver technology. Developed wideband analog-to-digital circuits. (In FY 2001, this work transferred to Project 2002.)
(U)	$1,738	Developed affordable antenna technology for use in operational and future aerospace platform electronic receivers and apertures. Developed low-frequency direction-finding antennas. Demonstrated advanced pattern control of multimode/multifunction antennas. Demonstrated phase shifters and transmit/receive module technology. (In FY 2001, this work transferred to Project 7622.)
(U)	$1,492	Developed aerospace missile and laser warning technologies to accurately cue countermeasures. Devised laser warning discrimination methods. Assessed hyperspectral imaging technology for missile warning. Demonstrated infrared clutter rejection techniques. (In FY 2001, this work transferred to Project 2003.)
(U)	$14,339	Total

(U) FY 2001 ($ in Thousands)

(U)	$0	Efforts transferred to this PE, Projects 2002, 2003, and 7622.
(U)	$0	Total

(U) FY 2002 ($ in Thousands)

(U)	$0	Effort conducted in this PE, Projects 2002, 2003, and 7622.
(U)	$0	Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(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

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BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors
PROJECT 2000	

(U) E. Schedule Profile Continued

(U) Not Applicable.

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

DATE: June 2001

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602204F Aerospace Sensors

PROJECT: 2002

COST ($ in Thousands)	FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
2002 Electronic Component Technology	6,562	19,228	19,984	18,854	19,196	19,573	20,062	20,567	Continuing	TBD

Note: In FY 2001, work previously performed under this PE, Projects 2000 and 6096, transferred into Project 2002.

(U) A. Mission Description

This project focuses on generating, controlling, receiving, and processing electronic and photonic signals for radio frequency (RF) sensor aerospace applications. The enabling technologies developed under this project will be used for intelligence, surveillance, reconnaissance, electronic warfare (EW), and precision engagement. The technologies developed include: solid state and vacuum electronic power devices and amplifiers; low noise and signal control components; high-temperature electronics; photonic components for RF links; signal control and distribution, signal processing; multi-function monolithic integrated circuits; high-speed analog-to-digital and digital-to-analog mixed mode integrated circuits; power distribution; multi-chip modules; and high density packaging and interconnect technologies. This project also designs, develops, fabricates, and evaluates techniques for integrating combinations of these electronic component technologies. The project aims to demonstrate significantly improved military sensors of smaller size, lower weight, lower cost, lower power dissipation, higher reliability, and improved performance. The device and component technology developments under this project are military unique; they are based on Air Force and other DoD weapon systems requirements in the areas of radar, communications, EW, navigation, and smart weapons.

(U) FY 2000 ($ in Thousands)

(U) $4,122 Developed compact, affordable, mixed-mode, multi-function receiver and phased array components for radar and EW. Fabricated miniature digital receiver components, direct digital waveform transmitters, and very low-power (<0.5W) analog-to-digital converters for air- and space-based sensors. Refined advanced RF component evaluation, modeling, and simulation methods.

(U) $332 Developed microwave technologies to enable high operating temperature, solid state microwave transmitters used in military ground-based and airborne radar applications. Developed robust high-speed, high-power III-nitride transistors.

(U) $318 Demonstrated 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 Developed 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. Developed advanced packaging and interconnect processes for phased array antennas and EW transmitters. (In FY 2000, this work moved from Project 6096.)

(U) $887 Developed 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. Fabricated advanced microwave tube components.

(U) $6,562 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE June 2001
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors
PROJECT 2002	

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands)

(U)	$5,076	Develop compact, affordable, multi-function receiver and phased array components for radar, electronic warfare (EW), and other intelligence, surveillance, and reconnaissance (ISR) sensors. Demonstrate miniature airborne digital receiver components. Design and fabricate direct digital waveform transmitters and high-resolution (10-16 bit), ultra-low power (<3.0W) analog-to-digital converters. Demonstrate and refine advanced component evaluation methods. (In FY 2000, portions of this work were performed in Project 6096.)
(U)	$4,523	Develop microwave technologies for advanced radio frequency (RF) apertures and phased array antennas used in military ISR sensors. Fabricate a high operating temperature, high-efficiency power amplifier to allow dispersed placement of active arrays. Demonstrate S-band (2-4 GHz) silicon carbide transistors for air defense networks. Demonstrate advanced vacuum electronics components. Conduct a reliability evaluation of high-power heterojunction bipolar transistors for ground and airborne radars and EW transmitters. (In FY 2000, portions of this work were performed in Project 2000.)
(U)	$3,854	Develop packaging and integration technologies for high performance aerospace RF sensor components. Demonstrate device and multi-chip module surface protective coatings and mixed analog/digital microwave circuits to improve reliability and lower the cost of components operating in harsh military environments. Test advanced packaging and interconnect processes for phased array antennas and EW transmitters. (In FY 2000, portions of this work were performed in Project 6096.)
(U)	$1,114	Develop signal control components and techniques to meet RF loss levels required for future radar, EW, and ISR sensors. Design micro-electro-mechanical phase shifters with a 300% improvement in RF loss performance. Develop miniature filters for high performance channelized radar and EW receivers.
(U)	$2,661	Develop RF photonics technologies to demonstrate compact, affordable, wide bandwidth, high data rate aerospace sensors. Fabricate photonic components for high performance digital receivers and signal processors. (Prior to FY 2001, this work was performed in Project 6096.)
(U)	$2,000	Develop three-dimensional (3-D) interconnects and packaging technologies for 3-D non-volatile memory.
(U)	$19,228	Total

(U) FY 2002 ($ in Thousands)

(U)	$5,851	Develop compact, affordable, multi-function receiver and phased array components for radar, EW, and other ISR sensors. Demonstrate Gallium Arsenide (GaAs), Indium Phosphide (InP), and silicon-on-insulator (SOI) RF components for bench-level evaluation of radar and EW digital receiver modules. Develop a brassboard low-power (< 1.0W) analog-to-digital converter and deliver for testing in a space-qualified silicon package. Complete study and design phase of a multi-mode/multi-function digital receiver prototype module, and complete a feasibility trade study on performing wideband direct digital synthesis from space platforms.
(U)	$4,686	Develop microwave technologies for advanced radio frequency (RF) apertures and phased array antennas used in military intelligence,

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BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 2002

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

surveillance, and reconnaissance (ISR) sensors. Develop and demonstrate robust components for L-band and X-band transmitters and receivers that operate with limited environmental controls. The components will be greater than 60% efficient with no active cooling, provide 20 Watts of output power, designed for radiation tolerance to 1 Mrad and greater than 200 degrees Celsius operating temperature.

(U) $4,499 Develop packaging and integration technologies for high performance aerospace RF sensor components. Demonstrate ten-fold cost reduction in an aerospace 20 GHz transmitter and a Ku-to -X-Band down-converter using low-cost packaging techniques. Develop a novel, flexible membrane to enable an ultra lightweight transmit/receive subarray. Develop mixed signal multichip modules, and evaluate three-dimensional interconnects, chip coatings, and advanced design techniques to enable high density micro-electro-mechanical systems and flexible assemblies for aerospace applications.

(U) $1,499 Develop signal control components and techniques to meet RF loss levels required for future radar, electronic warfare, and ISR sensors. Fabricate and characterize micro-electro-mechanical systems phase shifters for 300% improvement in RF loss performance operating over a 3:1 bandwidth.

(U) $2,249 Develop RF photonic technologies to demonstrate compact, affordable, wide bandwidth, high data rate aerospace sensors. Develop low-loss, low-voltage broadband modulators for compact digital receiver applications. Design high-performance components for wideband phased array antennas. Investigate the integration of photonic solutions for long time delays with the micro-electro-mechanical phase shifters for short delays to increase bandwidth.

(U) $1,200 Develop innovative transmitter and receiver concepts along with the associated component technology alternatives required for an affordable space-based RF surveillance sensor system. Design architectures that maximize predicted transmitter and receiver technology payoffs, and identify long lead-time RF sub-components required for space-based moving target indication.

(U) $19,984 Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(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.

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BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602204F Aerospace Sensors
	PROJECT: 2002

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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

DATE: June 2001

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602204F Aerospace Sensors

PROJECT: 2003

COST ($ in Thousands)		FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
2003	EO Sensors & Countermeasures Tech	8,883	11,746	14,217	14,210	15,423	15,493	15,997	16,515	Continuing	TBD

Note: In FY 2001, portions of this effort transferred into this project from this PE, Projects 2000 and 2001.

(U) A. Mission Description

This project determines the technical feasibility of advanced electro-optical (EO) aerospace sensor technologies for a variety of offensive and defensive uses. The sensor technologies under development range from the ultraviolet (UV) through the infrared (IR) portion of the spectrum. Related efforts include improvements in avionics integration, digital processing, analysis tools, and sensor architectures. One of the project's main goals is to improve EO and related technologies for the detection, tracking, and identification of non-cooperative and difficult targets, such as those obscured by camouflage. This project also develops the passive and active hyperspectral imaging sensors and algorithms needed to enable precision targeting in severe weather. These technologies are critical to future air- and space-based surveillance and targeting. Other project goals include advanced EO threat warning and countermeasures.

(U) FY 2000 ($ in Thousands)

(U) $2,068 Developed software engineering technologies to promote assured performance and affordability of complex existing and next-generation air and space platform software. Continued to demonstrate automated means to ensure correctness of cockpit display and console software. Developed and applied capability for performing in-flight self-checking of mission critical weapons and information systems software. Continued to develop new techniques for rapidly incorporating new hardware/software functions into scaleable, plug-and-play systems.

(U) $2,337 Developed sensor component technologies to detect, locate, and identify low-contrast ground and aerospace targets from high altitude and space. Developed aerospace infrared hyperspectral sensor components and fusion algorithms. Validated sensor target models.

(U) $1,113 Developed technology for non-cooperative identification of airborne and ground-based platforms. Investigated target background and atmospheric phenomenology effects on sensor performance. Generated multi-dimensional/multi-functional sensor platform concepts. Developed coherent image processing/extraction algorithms.

(U) $1,833 Developed EO technology to enable passive or active targeting of difficult targets. Investigated ways of mitigating atmospheric phenomenology effects on extended range aerospace sensors. Developed turbulence compensation techniques for precision targeting, target signatures, and phenomenology models. Selected multifunction sensor target characteristics.

(U) $445 Developed military-unique optical transmission components to enable information dominance. Fabricated high-speed optical communication subsystem in the laboratory.

(U) $1,087 Developed innovative techniques and components to target difficult objects in degraded atmospheric conditions. Fabricated components for active multispectral imaging. Assessed active imaging systems for their ability to penetrate weather and obscurants and improve capabilities in

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PROJECT 2003	

(U) A. Mission Description Continued

(U) FY 2000 ($ in Thousands) Continued

existing systems.

(U) $8,883 Total

(U) FY 2001 ($ in Thousands)

(U) $2,209 Develop day/night electro-optical (EO) sensor component technologies to detect, locate, and identify low contrast ground and aerospace targets from high altitude and space. Develop imaging spectrometer techniques and multispectral focal plane array components. Perform laboratory and field tests on techniques and components. Assess performance.

(U) $1,766 Develop technology for non-cooperative identification of airborne and ground-based platforms. Design long-range sensors. Test coherent image processing/extraction algorithms. Flight demonstrate a multifunction ladar.

(U) $673 Develop military-unique optical transmission components to enable information dominance. Demonstrate useful commercial-off-the-shelf technologies integrated with military-unique components.

(U) $1,239 Develop innovative techniques and components to target difficult objects in degraded atmospheric conditions. Fabricate components for active multispectral imaging. Assess active imaging systems for their ability to penetrate weather and obscurants. Design generic modules to improve capabilities of existing systems. Analyze and demonstrate concepts based on high precision pointing, range gating, and image processing.

(U) $3,506 Develop countermeasure technologies against infrared-guided missiles and EO threats. Design components and refine techniques to defeat imaging missile seekers. (Prior to FY 2001, this work was conducted in Project 2000.)

(U) $1,859 Develop aerospace missile and laser warning technologies to accurately cue countermeasures. Develop temporal and spectral tracking algorithms, advancing from two-color to multispectral imaging techniques. Test advanced sensor hardware. (Prior to FY 2001, this work was conducted in Project 2000.)

(U) $494 Develop optical transmitter technology capable of sensing multiple target characteristics to provide robust non-cooperative target identification. Fabricate a single imaging and non-imaging transmitter. (In FY 2001, this effort transferred from this PE, Project 2000.)

(U) $11,746 Total

(U) FY 2002 ($ in Thousands)

(U) $4,995 Develop technology for non-cooperative identification of airborne and ground-based platforms. Conduct ground-to-air demonstration of long-range combat identification (CID) sensors. Test coherent image processing/extraction algorithms including three-dimensional (3-D) block registration algorithms. Conduct measurements and evaluate advanced 3-D focal planes for CID application. Continue passive hyperspectral model development, validation, and performance predictions. Continue analysis and evaluation of multifunction ladar flight demonstration data for CID.

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PROJECT 2003	

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U)	$1,419	Develop optical transmitter technology capable of sensing multiple target characteristics for robust non-cooperative target identification. Continue development of a pulsed vibration/imaging sensing system for long-range combat identification. Investigate and demonstrate critical components of a monolithic, solid state coherent ladar architecture.
(U)	$2,412	Develop innovative techniques and components to target difficult objects in degraded atmospheric conditions. Begin utility analysis of high altitude active sensors. Test components for active multispectral imaging. Demonstrate electro-optical (EO) imaging through weather and obscurants. Develop concepts based on high precision pointing, range gating, and image processing. Evaluate non-mechanical EO beam steering devices. Investigate component designs for ladar apertures.
(U)	$2,128	Develop countermeasure technologies for use against infrared-guided missiles and EO. Continue to design components and refine techniques to defeat imaging missile seekers. Continue exploitation of advanced infrared missile technology.
(U)	$3,263	Develop aerospace missile and laser warning technologies to accurately cue countermeasures. Laboratory test temporal and spectral tracking algorithms focused on multi-spectral imaging techniques. Evaluate advanced laser warning sensor component hardware for application in a space environment.
(U)	$14,217	Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(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

(U) Not Applicable.

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DATE: June 2001

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602204F Aerospace Sensors

PROJECT: 4916

COST ($ in Thousands)	FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
4916 Electromagnetic Tech	0	0	7,327	7,031	7,205	7,320	7,528	7,744	Continuing	TBD

Note: In FY 2002, this work transferred from PE 0602702F, Project 4600.

(U) A. Mission Description

This project develops technology for sensor systems that cover the electromagnetic spectrum--from radio frequency (RF) to optical. It develops RF antennas and associated electronics for airborne and space-based surveillance. It also investigates RF scattering phenomenology for applications in ground and air moving target indicators in extremely cluttered environments. The project develops active and passive electro-optical sensors for use in concert with RF sensors. It develops low-cost active sensors that use reliable high-performance solid state components for target detection and identification and missile threat warning. The project also develops passive multi-dimensional sensors to improve battlefield awareness and identify threats at long-range.

(U) FY 2000 ($ in Thousands)

(U) $0 Effort conducted in PE 0602702F, Project 4600.

(U) $0 Total

(U) FY 2001 ($ in Thousands)

(U) $0 Effort conducted in PE 0602702F, Project 4600.

(U) $0 Total

(U) FY 2002 ($ in Thousands)

(U) $1,800 Develop experimental and theoretical techniques for the characterization of electromagnetic scattering from targets and terrain as applied to the detection of difficult airborne and ground-based targets in clutter from airborne or space-based surveillance platforms.

(U) $1,948 Design and develop antennas for airborne and space-based surveillance. Design, analyze, and build advanced large lightweight antenna arrays. Develop new algorithms for digital beam-formed multi-beam antennas. Develop antenna front-end high-speed electronics.

(U) $1,679 Design and develop next generation electro-optical techniques and advanced components for use in detection and identification of concealed targets. Design and fabricate multifunction sensor arrays and innovative materials and device technologies for optical beamsteering. Design and develop active components and advanced integration techniques for autonomous ladar-guided munitions and other imaging applications. Develop optical processing techniques for optical aberration in aircraft-generated turbulence.

(U) $1,900 Develop hardware and software for passive multi-dimensional sensing in the thermal infrared spectral wavelength range at high frame rates. Establish the viability of tomographic hyperspectral sensing techniques for missions that have not been able to capitalize on the power of spectral

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PROJECT 4916	

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

target identification tools. Evaluate the applicability of these and new tomographic hyperspectral sensor concepts to the characterization of explosions and missile launches, and to the development of techniques for real-time bomb damage assessment.

(U) $7,327 Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(U) Related Activities:

(U) PE 0602702F, Command Control and Communications

(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

(U) Not Applicable.

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DATE: June 2001

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602204F Aerospace Sensors

PROJECT: 6095

COST ($ in Thousands)		FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
6095	Sensor Fusion Technology	11,258	13,190	14,582	14,942	15,575	15,879	16,327	16,791	Continuing	TBD

(U) A. Mission Description

This project develops the technologies required to perform management and fusion of on-board sensor information for timely, comprehensive situational 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 help to precisely locate, identify, and target airborne and surface targets. The project emphasizes finding reduced signature targets and targets of opportunity. It will enable new covert tactics for successful air-to-air and air-to-surface strikes.

(U) FY 2000 ($ in Thousands)

(U) $4,059 Developed, evaluated, and demonstrated single and multi-sensor lethality algorithms to dramatically improve air combat capability. Performed a ground station emulation. Simulated targeting with real-time information-into-the-cockpit. Developed adaptive resource allocation.

(U) $3,860 Developed, evaluated, and demonstrated air-to-ground single and multi-sensor radar target signature models to support ATR in strike operations. Investigated computational electromagnetics techniques. Generated geometric target models. Characterized clutter.

(U) $1,999 Developed, evaluated, and demonstrated feasibility of multi-sensor ATR algorithms for on- and off-board sensor-to-shooter image and data fusion to rapidly attack time-critical targets. Completed evaluation of a sensor-to-shooter algorithm. Devised multi-sensor performance metrics. Evaluated multisensor ATR algorithms.

(U) $1,340 Developed precision time, position, and velocity sensors capable of operating in jamming environments enabling multiple platform sensor-to-shooter operations. This includes simultaneous localization using diverse power level reference signals and optimal co-location of reference sensors as the key to the next generation jam resistant technology.

(U) $11,258 Total

(U) FY 2001 ($ in Thousands)

(U) $4,029 Develop, evaluate, and demonstrate single and multi-sensor lethality algorithms to dramatically improve air combat capability. Perform a live-feed to ground station emulation to evaluate real-time information-into-the-cockpit targeting schemes, and to optimize adaptive resource allocation methods. Complete demonstration of real-time, on-board ATR and information fusion using live threat emitter data.

(U) $3,875 Develop, evaluate, and demonstrate single and multi-sensor radar target signature models to support ATR in strike operations. Transition the ground target signature database to an operational air-to-ground ATR system. Develop physics-based dynamic complex synthetic aperture radar (SAR) scene simulation capability using advanced modeling and simulation (M&S) techniques. Develop innovative target recognition techniques using advanced scattering phenomenology analysis. Transition advanced phenomenology-based target recognition techniques to the

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BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors
PROJECT 6095	

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

intelligence community.

(U) $2,144 Develop, evaluate, and demonstrate feasibility of multi-sensor automatic target recognition (ATR) algorithms for on- and off-board sensor-to-shooter image and data fusion to rapidly attack time-critical targets. Develop full, collaborative sensor-to-shooter algorithm environment utilizing the most advanced DoD laboratory capabilities from across the country. Evaluate sensor-to-shooter technologies and develop operational concepts.

(U) $634 Develop sensors to provide precise time, position, and velocity measurements to enable multiple-platform, sensor-to-shooter operations in jamming environments. Develop Global Positioning System (GPS) specific jamming mitigation techniques for operation in hostile radio frequency environments. Assess the advantages for signal tracking of collocating an inertial measurement unit with the phase center of a GPS antenna, and devise techniques to exploit this capability for navigation and strike. Design and implement methods to enable GPS receivers to simultaneously handle strong signals from nearby differential reference sources and the weak signals from GPS satellites to improve jam-resistance and positional accuracy.

(U) $2,508 Develop and demonstrate enabling ATR technologies for future intelligence, surveillance, and reconnaissance (ISR) applications. Evaluate physics-based and adaptive learning techniques to reduce cost and increase capabilities of follow-on ISR systems. Using ground-based technology demonstrations and hardware-in-the-loop simulations, continue developing high-impact technologies needed to provide extremely high altitude, long-range targeting and attack capabilities.

(U) $13,190 Total

(U) FY 2002 ($ in Thousands)

(U) $4,345 Develop and evaluate single and multi-sensor lethality algorithms to dramatically improve air combat capability. Perform laboratory demonstration of adaptive resource allocation methods for ATR. On embedded high-performance computing systems, develop real-time ATR algorithms for time-critical targets. Develop and evaluate algorithms and concepts for detecting and targeting targets under trees.

(U) $4,151 Develop and evaluate single and multi-sensor radar target signature models to support ATR in strike operations. Develop target signature models for multi-sensor fusion of synthetic aperture radar (SAR), electro-optical (EO) multispectral systems, and signals intelligence in reconnaissance ground stations. Sensor fusion will provide the ability to maintain tracks of vehicle groupings through multiple platforms and missions with a high probability of detection and a less than 1% false alarm rate.

(U) $2,297 Develop and evaluate the feasibility of multi-sensor ATR algorithms for on- and off-board sensor-to-shooter image and data fusion to rapidly attack time-critical targets. Validate multi-sensor performance metrics utilizing measured and synthetic data. Continue evaluating multi-sensor ATR algorithms.

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PROJECT: 6095	

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U)	$679	Develop precision time, position, and velocity sensors capable of operating in jamming environments enabling multiple platform sensor-to-shooter operations. Continue development of Global Positioning System specific jamming mitigation techniques for operation in hostile radio frequency environments.
(U)	$2,687	Develop and demonstrate enabling automatic target recognition (ATR) technologies for intelligence, surveillance, and reconnaissance applications. Continue evaluating physics-based and adaptive learning techniques.
(U)	$423	Develop ATR and Sensor Fusion performance assessment technology. Conduct ATR performance evaluation theory research.
(U)	$14,582	Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(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

(U) Not Applicable.

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

DATE: June 2001

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602204F Aerospace Sensors

PROJECT: 6096

COST ($ in Thousands)	FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
6096 Microelectronics Technology	10,155	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2001, this effort transferred to this PE, Project 2002.

(U) A. Mission Description

This project focuses on military unique aspects of microelectronics and radio frequency (RF) photonics, as applied to military sensors. This technology includes photonic subsystems and components for controlling and distributing RF signals; high-speed devices and circuits; packaging and power distribution; design tools; and 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 subsystems. These components and subsystems will use electronic and photonic analog-to-digital converter circuits; fiber optic signal control and distribution subsystems; high-temperature electronics; multi-function monolithic integrated circuits; high density photonic interconnects; and RF distributions and radar beamforming. Computer-aided engineering technology is a key component of the project and will assist in addressing the low-cost, very high performance, low power, tough environmental, multi-organization development, and high complexity challenges of our warfighting electronics. The technology this project develops is unavailable through commercial sources.

(U) FY 2000 ($ in Thousands)

(U) $2,240 Developed advanced high-speed device technologies to enable affordable, compact space-based sensors. Designed RF components and analog-to-digital converters for high dynamic range, high sensitivity micro-receivers. (In FY 2001, this work transferred to this PE, Project 2002.)

(U) $1,752 Developed advanced design tools to reduce the cost and time required to create complex Air Force electronic systems such as mixed analog and digital systems. Demonstrated tools for reconfigurable computers and for describing hardware behavior. (In FY 2001, this work transferred to this PE, Project 2002.)

(U) $3,527 Developed 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. Specified required representations. Developed advanced techniques for analyzing life cycle cost/performance trade offs.

(U) $2,251 Developed RF technologies to demonstrate compact, affordable, wide bandwidth, high data rate sensors. Designed photonic interconnect architectures for high performance digital receivers and processors. (Prior to FY 2000, this work was performed under PE 0602702F, Project 4600. In FY 2001, this work transferred to this PE, Project 2002.)

(U) $385 Developed, as part of an international cooperative effort, the three-dimensional multilayer microwave packaging and interconnect multichip

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BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors
PROJECT 6096	

(U) A. Mission Description Continued

(U) FY 2000 ($ in Thousands) Continued

assembly technologies needed for next-generation airborne moving target indicator radars. (In FY 2001, this work transferred to this PE, Project 2002.)

(U) $10,155 Total

(U) FY 2001 ($ in Thousands)

(U) $0 Effort transferred to this PE, Project 2002.

(U) $0 Total

(U) FY 2002 ($ in Thousands)

(U) $0 No Activity.

(U) $0 Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(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

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: June 2001
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602204F Aerospace Sensors — PROJECT: 7622

	COST ($ in Thousands)	FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
7622	RF Sensors & Countermeasures Tech	8,456	22,860	28,039	26,660	26,083	27,983	29,007	29,858	Continuing	TBD

(U) A. Mission Description

This project develops and assesses technology for reliable, all-weather surveillance, reconnaissance, and precision strike radio frequency (RF) sensors and electronic combat systems. It emphasizes the detection and tracking of surface and airborne targets that have RF signatures that are difficult to detect due to reduced radar cross sections, concealment and camouflage measures, severe clutter, and/or heavy jamming. This project also develops the RF warning and countermeasure technology for advanced electronic combat applications. Specifically, it develops techniques and technologies to detect and counter the links and sensors of threat air defense systems and command and control networks. The project also exploits emerging technologies and components to provide increased capability for offensive and defensive RF sensors, including radar warning, RF electronic combat, and electronic intelligence applications.

(U) FY 2000 ($ in Thousands)

(U) $1,174 Developed aerospace microwave sensor technologies for air-to-air radar and target detection that support surveillance, reconnaissance, protection, targeting, attack, and electronic warfare. Designed electromagnetic interference mitigation techniques. Validated advanced radar performance/cost analysis tools.

(U) $1,665 Developed adaptive microwave processing algorithms for detecting and locating advanced cruise missiles and slow airborne and ground targets. Designed techniques to mitigate clutter and jamming on airborne monostatic and bistatic radars.

(U) $1,484 Developed advanced aerospace sensors for air-to-ground targeting and attack, providing synthetic aperture radar targeting solutions for maneuvering tactical aircraft in a hostile environment. Performed an independent assessment of various current and future airborne and space surveillance sensors.

(U) $732 Developed technology for detecting and attacking concealed targets. Developed innovative foliage- and ground-penetrating radar waveforms and targeting algorithms.

(U) $980 Developed technology to accurately determine algorithm and sensor performance from airborne and space-based platforms in realistic airborne surveillance and combat scenarios. Tested bistatic adjuncts on unmanned aerial vehicles. (In FY 2000, this work transferred from PE 0602702F, Project 4506.)

(U) $1,108 Developed 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) $1,313 Developed RF space protection technology. Investigated techniques to provide warning and countermeasures against RF interference with

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BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors
PROJECT 7622	

(U) A. Mission Description Continued

(U) FY 2000 ($ in Thousands) Continued

satellite operations.

(U) $8,456 Total

(U) FY 2001 ($ in Thousands)

(U) $4,144 Develop aerospace microwave sensor technologies for detecting, locating, and engaging airborne and ground targets. Develop high fidelity analytical tools for evaluating and predicting the performance of integrated air moving target indication, ground moving target indication, and synthetic aperture radar modes. Conduct airborne radar data collection. Perform laboratory analysis for application of advanced surveillance techniques. (This effort incorporates work previously performed under PE 0602702F, Project 4506.)

(U) $3,519 Develop aerospace microwave processing algorithms for detecting and locating advanced cruise missiles and slow airborne targets, as well as stationary and moving ground targets in severe clutter and jamming environments. Analyze individual algorithms for improved air and ground moving target indication algorithm performance. Develop adaptive processing techniques that incorporate knowledge-based approaches.

(U) $3,849 Develop technology for detecting and attacking concealed targets. Evaluate innovative foliage- and ground-penetrating radar waveforms and targeting algorithms, devising techniques to prevent discovery by the enemy, and assessing potential for detecting buried command and control centers.

(U) $2,970 Develop affordable radio frequency jamming technology and concepts that enhance aerospace vehicle survivability by degrading enemy radar, missile, and command and control systems. Evaluate ability to detect covert/featureless waveforms. Test optimized deception countermeasure techniques, and techniques to degrade modern communication networks. (Prior to FY 2001, this work was conducted in this PE, Project 2000.)

(U) $2,555 Develop technology for generic software modules to enable low-cost block upgrades to electronic warfare receivers. Design threat identification software modules for next-generation threat warning receivers. (Prior to FY 2001, this work was conducted in this PE, Project 2000.)

(U) $5,823 Develop affordable antenna technology for use in operational and future aerospace platform electronic receivers and apertures. Demonstrate, in the laboratory, an integrated ensemble of low-frequency direction-finding antennas. Develop highly precise, wideband, interferometric multimode direction-finding antennas. Demonstrate a micro-electro-mechanical phase shifter controlled array. Demonstrate design tools to predict antenna performance. (Prior to FY 2001, this work was conducted in this PE, Project 2000.)

(U) $22,860 Total

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PROJECT 7622	

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands)

(U) $6,535 Develop aerospace microwave sensor technologies for detecting, locating, and engaging airborne and ground targets. Conduct airborne radar target and clutter phenomenology data collections used to evaluate, validate, and improve engineering tools supporting intelligence, surveillance, and reconnaissance (ISR) and multi-intelligence sensor concept studies and system analyses. Evaluate sensor performance through in-flight experiments and simulations.

(U) $3,733 Develop aerospace microwave processing algorithms for detecting and locating advanced cruise missiles and slow airborne targets, as well as stationary and moving ground targets in severe clutter and jamming environments. Develop multi-mission adaptive radar algorithms to support various operational modes including air and ground target detection, ground target imaging, electronic protection, and passive radio frequency (RF) emission detection. Develop advanced waveforms to achieve transmit adaptivity and simultaneous multi-mode operation. Improve interference rejection, self-protection, and target identification by exploiting diversity in frequency, delay, polarization, modulation, and coding.

(U) $3,981 Develop technology for detecting and precisely locating concealed targets using standoff aerospace platforms. Develop and evaluate technology for airborne ground-penetrating radar. Develop and evaluate signal processing algorithms for improving detection and false alarm performance in foliage-penetrating radar.

(U) $3,484 Develop affordable RF jamming technology and concepts that enhance aerospace vehicle survivability by degrading enemy radar, missile, and command and control systems. Develop multifunction electronic warfare (EW) technique waveforms. Evaluate exploitations of advanced RF threats. Develop optimized EW techniques to degrade modern radar, communication, and missile threat systems.

(U) $2,488 Develop technology to enable low-cost upgrades to RF signal receivers. Model threat identification algorithms for next-generation threat warning receivers. Evaluate state-of-the-art digital receiver subsystems. Design advanced very-high frequency receiver improvements for detecting targets under trees. Design novel RF photonic analog-to-digital converter circuitry for order-of-magnitude gains in performance accuracy versus current state-of-the-art.

(U) $5,723 Develop affordable antenna technology for use in operational and future aerospace platform electronic receivers and apertures. Evaluate wideband, high precision, interferometric, multimode, direction-finding antennas in the laboratory. Develop design tools to predict antenna performance installed on host platform models. Develop robust ultra-wideband front end electronics to handle large signals.

(U) $1,100 Develop and validate, via a global infosphere experiment, the radar architectures, aperture technology, and signal processing to support a space-based moving target indication sensor. Use the collaborative engineering environment to model and assess RF architectures and signal processing techniques. Analyze the utility of a space-based sensor architecture.

(U) $995 Design and validate multi-intelligence sensor technologies for total battlefield awareness. Evaluate single platform technologies for common waveform utilization, knowledge-based function scheduling, and superior difficult target detection for both in-the-clear and concealed targets. Develop and evaluate hybrid sensor systems, including space/air/ground combinations delivering improved location accuracies and tracking

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PROJECT 7622	

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

strategies.

(U) $28,039 Total

(U) B. Project Change Summary

Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)

(U) Related Activities:

(U) PE 0603203F, Advanced Aerospace Sensors.

(U) PE 0603253F, Advanced Avionics Integration.

(U) PE 0602782A, Command, Control, Communications 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

(U) Not Applicable.