DEPARTMENT OF THE AIR FORCE

FISCAL YEAR (FY) 2004/2005 BIENNIAL BUDGET ESTIMATES

RESEARCH, DEVELOPMENT, TEST AND EVALUATION (RDT&E)

DESCRIPTIVE SUMMARIES, VOLUME I

SCIENTIFIC AND TECHNOLOGY BUDGET ACTIVITIES 1 - 3

FEBRUARY 2003

Fiscal Year 2004/2005 Biennial Budget Estimates
RDT&E Descriptive Summaries, Volume I
Scientific and Technology Budget Activities 1 - 3
February 2003

INTRODUCTION AND EXPLANATION OF CONTENTS

1. (U) GENERAL
   A. This document has been prepared to provide information on the United States Air Force (USAF) Research, Development, Test and Evaluation (RDT&E) program elements and projects in the FY 2004 President's Budget.
      1) All exhibits in this document have been assembled in accordance with DoD 7000.14R, Financial Management Regulation, Volume 2B, Chapter 5, Section 050402. Exceptions:
         a) Exhibit R-1, RDT&E Program, which was distributed under a separate cover due to classification.
         b) Exhibit R-4/4a, RDT&E Program Schedule Profile/Detail, the USAF could not modify its documentation preparation software in time to include the new R-4/4a exhibit in this submission. The previous schedule profile is presented in this submission in order to provide the data now required by the R-4/4a exhibit.
      2) All exhibit formats in this document are in accordance with guidelines prescribed in DoD 7000.14R, Financial Management Regulation, Volume 2B, Chapter 5, Section 050402. Exceptions:
         a) Exhibits R-2/2a, RDT&E Budget Item Justification/Project Justification, the USAF could not modify its documentation preparation software in time to include the revised R-2/2a exhibit format in this submission, however, all required information is provided within the previous R-2/2a format.
         b) Exhibit R-3, RDT&E Project Cost Analysis, the USAF could not support the R-3 format matrix because it does not track programs in the manner required to complete the revised exhibit, however, all required information is provided within the previous R-3 format.
      3) Other comments on exhibit contents in this document:
         a) Funding ($) is presented in the previous cost table format using thousands as the smallest increment. (e.g. $1,000 = 0.001)
         b) Exhibits R-2/2a and R-3 provide narrative information for all RDT&E program elements and projects within the USAF FY 2004 RDT&E program with the exception of classified program elements. The formats and contents of this document are in accordance with the guidelines and requirements of the Congressional committees insofar as possible.
         c) The "Other Program Funding Summary" portion of the R-2 includes, in addition to RDT&E funds, Procurement funds and quantities, Military Construction appropriation funds on specific development programs, Operations and Maintenance appropriation funds where they are essential to the development effort described, and where appropriate, Department of Energy (DOE) costs.
         d) "Facilities Exhibits", Military Construction Project Data, (DD 1391), for improvements to and construction of government-owned facilities funded in RD&E, are included at the end of Volume III.

2. (U) CLASSIFICATION
   A. All exhibits contained in Volumes I, II, and III are unclassified. Classified exhibits are not included in the submission due to the level of security classification and necessity of special security clearances.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

ALPHABETICAL LISTING

ALPHABETICAL LISTING

ALPHABETICAL LISTING

ALPHABETICAL LISTING

ALPHABETICAL LISTING

ALPHABETICAL LISTING

ALPHABETICAL LISTING

PROGRAM ELEMENT COMPARISON SUMMARY

PROGRAM ELEMENT (By BUDGET ACTIVITY		REMARKS
BUDGET ACTIVITY #1: BASIC RESEARCH (Volume I)		
0601103F	University Research Initiatives	In FY 2004, this is a new PE. Project 5094, University Research Initiatives, efforts were transferred from the Office of the Secretary of Defense (OSD).
0601108F	High Energy Laser Research Initiatives	In FY 2004, this is a new PE. In FY 2004, Project 5097, High Energy Laser Research Initiatives, efforts were transferred from OSD.
BUDGET ACTIVITY #2: APPLIED RESEARCH (Volume I)		
0602102F	Materials	In FY 2004, Project 2015, Rocket Materials Technology, efforts transferred to PE 0602500F, Multi-Disciplinary Space Technologies, Project 5025, Space Materials Development, as a result of the Space Commission recommendation to consolidate all space unique activities.
0602203F	Aerospace Propulsion	In FY 2004, Project 4847, Rocket Propulsion Technologies, efforts were transferred to PE 0602500F, Multi-Disciplinary Space Technologies, Project 5026, Rocket Propulsion Component Technologies, in conjunction with the Space Commission recommendation to consolidate all space unique activities.
0602204F	Aerospace Sensors	In FY 2004, Project 4916, Electromagnetic Technologies, efforts were transferred to PE 0602500F, Multi-Disciplinary Space Technologies, Project 5026, Rocket Propulsion Component Technologies, as a result of the Space Committee recommendation to consolidate all space unique activities.
0602500F	Multi-Disciplinary Space Technologies	In FY 2004, efforts in Projects 5024, Human Centered Applied Space Technologies, were terminated. . In FY 2004, space antenna efforts in PE 0602204F, Aerospace Sensors, Project 4916, Electromagnetic Technologies, were transferred to Project 5025, Rocket Propulsion Component Technologies, as a result of the Space Commission recommendation to consolidate all space unique activities. In FY 2004, efforts in Project 5024, Human Centered Applied Space Technologies, were terminated due to restructuring of the Science and Technology Program.

		In FY 2004, Project 5026, Rocket Propulsion Component Technologies, efforts transferred from PE 0602203F, Aerospace Propulsion, Project 4847, Rocket Propulsion Technologies, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities.
		In FY 2004, Project 5026, Rocket Propulsion Component Technologies, efforts were transferred from PE 0602102F, Materials, Project 5015, Rocket Materials Technology, as a result of the Space Commission recommendation to consolidate all space unique activities.
0602890F	High Energy Laser Research	In FY 2004, this is a new PE.
		In FY 2004, Project 5096, High Energy Laser Research, efforts were transferred from OSD.

BUDGET ACTIVITY #3: ADVANCED TECHNOLOGY DEVELOPMENT (Volume I)

0401840F	AMC Command & Control System	In FY 2004, this is a new PE.
		In FY 2004, Project 5119, Agile Transporation 2001, efforts were transferred from OSD.
0603211F	Aerospace Technology Development & Demonstration	In FY 2004, Project 5099, National Aerospace Initiatives, includes new start efforts.
0603216F	Aerospace Propulsion and Power Technology	In FY 2004, Project 5098, Advanced Aerospace Initiatives, includes new start efforts.
0603311F	Ballistic Missile Technologies	In FY 2004, Project 4091, Missile Electronics, efforts were transferred to PE 0603401F, Advanced Spacecraft Technology, Project 5083, Ballistic Missile Technologies, in order to align projects within the Air Force Research Laboratory organization.
0603401F	Advanced Spacecraft Technology	In FY 2004, Project 5083, Ballistic Missile Technologies, efforts were transferred from PE 0603311F, Ballistic Missile Technology, Project 4091, Missile Electronics, in order to align projects within the Air Force Research Laboratory organization.
0603755F	High Performance Computing Modernization Program	In FY 2004, this is a new PE.
		In FY 2004, Project 5093, High Performance Computing Modernization Program, efforts were transferred from OSD.
0603924F	High Energy Laser Advanced Technology Program	In FY 2004, this is a new PE.
		In FY 2004, Project 5095, High Energy Laser Advanced Technology Program, efforts were transferred from OSD.
0804757F	Joint National Training Center	In FY 2004, this is a new PE.

		In FY 2004, Project 5124, Training Transformation, efforts were transferred from OSD.

BUDGET ACTIVITY #4: ADVANCED COMPONENT DEVELOPMENT & PROTOTYPE (Volume II)

0603287F	Physical Security Equipment	In FY 2004, this is a new PE.
		In FY 2004, Project 5121, Physical Security Equipment, efforts were transferred from OSD.
0603430F	Advanced EHF Milsatcom (Space)	In FY 2004, Project 4050, Advanced MILSATCOM, efforts were transferred to PE 0303601F, MILSATCOM Terminals, Project , in order to align the engineering support efforts with the funding element.
0603438F	Space Control Technology	In FY 2004, Project A007, Space Range, efforts were transferred from Project 2611, Technology Insertion and Planning Analysis, in order to realign activities.
		In FY 2004, Project 2611, Technology Insertion Planning and Analysis, efforts were transferred to Project A007, Space Range, in order to realign activities.
0603790F	NATO Cooperative R&D	In FY 2004, Project NATO, NATO Cooperative R&D, includes new start efforts.
0603791F	International Space Cooperative R&D	In FY 2004, Project 5035, International Cooperative Space R&D, includes new start efforts.
0603851F	ICBM - Demonstration & Validation	In FY 2004, Project 4209, Long Range Planning, includes a new start efforts.
0603854F	Wideband MILSATCOM (Space)	In FY 2004, Project 4944, Advanced Wideband System, efforts were transferred to PE 0303601F, MILSATCOM Terminals, Project 2487, MILSATCOM Terminals, in order to properly align funding.
0603856F	Air Force/National Program Cooperation	In FY2004, Project 4782, Air Force/National Program Cooperation (AFNPC), efforts were transferred to PE 0604441F, Space Based Infrared Systems (SBIRS) High EMD, Project 3616, SBIRS High Element EMD, in order to consolidate all SBIRS development efforts.
0604435F	Interim Polar	In FY 2004, this is a new PE.
		In FY 2004, Project A010, Advanced Polar System, includes new start efforts.
0604855F	Operationally Responsive Launch	In FY 2004, this is a new PE.
		In FY 2004, Project A013, Operationally Responsive Launch, includes new start efforts.
0604856F	Common Aero Vehicle	In FY 2004, this is a new PE.
		In FY 2004, Project A012, Common Aero Vehicle, includes new start efforts.

BUDGET ACTIVITY #5: SYSTEM DEVELOPMENT & ENGINEERING DEVELOPMENT (Volume II)

0207256F	**UCAV Joint Program Office**	**In FY 2004, this is a new PE.** **In FY 2004, Project 5118, UCAV Joint Program Office, includes new start efforts.**
0305176F	**Combat Survivor Evader Locator**	**In FY 2004 Project 4522, CSAR EMD, will be completed.**
0604226F	**B-1B**	**In FY 2004, Project 4596, Conventional Mission Upgrades, includes new start efforts.** **In FY 2004, Project 4596, Conventional Mission Upgrades, efforts were transferred to PE 0207446F, Bomber Tactical Data Link, Project 4596, Bomber Tactical Data Link.**
0604240F	**B-2 Adavanced Technology Bomber**	**In FY 2004, Project 3843, B-2 Advanced Technology Bomber, efforts were transferred to PE 0207446F, Bomber Tactical Data Link, Project 5041, Bomber Tactical Data Link.**
0604270F	**EW Development**	**In FY 2004, Project 3945, RF Towed Decoy Systems, was changed to TEWS Upgrade, to reflect restructuring of the EW program.** **In FY 2004, Project 8462, MALD, was changed to Airborne Electronic Attack, to reflect restructuring of the EW program.**
0604287F	**Physical Security Equipment**	**In FY 2004, this is a new PE.** **Project 5120, Physical Security Equipment SD&DD, efforts were transferred from OSD.**
0604441F	**Counterspace Systems**	**In FY2004, Project 4782, Air Force/National Program Cooperation (AFNPC) SBIRS Technical Intelligence (TI) efforts were transferred from PE 0603856F, Air Force/National Program Cooperation, Project 4782, Air Force/National Program Cooperation, in order to consolidate all SBIRS development efforts.**
0604617F	**Agile Combat Support**	**In FY 2004, Project 2895, Civil Engineering Readiness, includes new start efforts.**
0604735F	**Combat Training Ranges**	**In FY 2004, Project 2286, Combat Training Range Equipment, includes new start efforts.**
0604851F	**ICBM - Engineering, Manufacturing & Development**	**In 2004, Project 5080, ICBM Security, is a new start effort.**
0604853F	**Evolved Expendable Launch Vehicle - EMD**	**In FY 2004, Project 0004, Evolved Expendable Launch Vehicle, includes new start efforts.**

BUDGET ACTIVITY #6: MANAGEMENT & SUPPORT (Volume II)

0604759F	**Major T&E Investment**	**In FY 2004, Project 4597, Air Force Test Investments, includes new start efforts.**

0605807F	**Test & Evaluation Support**	**In FY 2004, Project 06TS, T&E Support, efforts transferred to PE 0605976F, Facility Restoration & Modernization - T&E, Project 06MC, Facility Restoration & Modernization - T&E.**
		In FY 2004, Project 06TS, T&E Support, efforts transferred to PE 0605978F, Facility Sustainment - T&E Support, Project 06MR, Faciltiy Sustainment - T&E Support.
0605976F	**Facility Restoration & Modernization - T&E**	**In FY 2004, this is a new PE.**
		In FY 2004, Project 06MC, Facility Restoration & Modernization - T&E, efforts were transferred from PE 0605807F, Test & Evaluation Support, Project 06TS, T&E Support.
0605978F	**Facility Sustainment - T&E Support**	**In FY 2004, this is a new PE.**
		In FY 2004, Project 06MR, Facility Sustainment - T&E Support, efforts were transferred from PE 0605807F, Test & Evaluation Support, Project 06TS, T&E Support.
0804731F	**General Skills Training**	**In FY 2004, Project 4980, Research and Development of Computer Forensic Analyst Tools, includes new start efforts.**

BUDGET ACTIVITY #7: OPERATIONAL SYSTEMS DEVELOPMENT (Volume III)

0101113F	**B-52 Squadrons**	**In FY 2004, Project 4810, Avionics Midlife Improvement, efforts were transferred to PE 0207446F, Bomber Tactical Data Link.**
0101120F	**Advanced Cruise Missile**	**In FY 2003, Project 4798, Life Extension Study, was changed to Life Extension Program.**
		In FY 2004, Project 4797, Flight Testing & Navigation Enhancement, includes new start efforts.
		In FY 2004, Project 4798, Life Extension Program, includes new start efforts.
0207134F	**F-15E Squadrons**	**In FY 2004, Project 0131, Initial Operational Test & Evaluation, includes new start efforts.**
0207138F	**F-22 Squadrons**	**In FY 2004, Project 4785, F-22, includes new start efforts.**
0207141F	**F-117A Squadron**	**In FY 2004, Project 3956, F-117A Stealth Fighter, includes new start efforts.**
0207417F	**AWACS**	**In FY 2004, Project 411L, AWACS, efforts were transferred to PE 0207448F, C2ISR Tactical Data Link, Project 5045, C2ISR Tactical Data Link.**
0207446F	**Bomber Tactical Data Link**	**In FY 2004, this is a new PE.**
		In FY 2004, Project 5041, Bomber Tactical Data Link, efforts were transferred from PE 0101113F, B-52 Squadrons, Project 4810, Avionics Midlife Improvement.

		In FY 2004, Project 5041, Bomber Tactical Data Link, efforts were transferred from PE 0604226F, B-1B, Project 4596, Conventional Mission Upgrades.
		In FY 2004, Project 5041, Bomber Tactical Data Link, efforts were transferred from PE 0604240F, B-2 Advanced Technology Bomber, Project 3843, B-2 Advanced Technology Bomber.
0207448F	C2ISR Tactical Data Link	In FY 2004, this is a new PE.
		In FY 2004, Project 5045, C2ISR Tactical Data Link, efforts were transferred from PE 0207417F, AWACS, Project 411L, AWACS.
		In FY 2004, Project 5045, C2ISR Tactical Data Link, efforts were transferred from PE 0207581F, JSTARS, Project 0003, JSTARS.
0207581F	JSTARS	In FY 2004, Project 0003, JSTARS, efforts were transferred to PE 0207448F, C2ISR Tactical Data Link, Project 5045, C2ISR Tactical Data Link.
0207601F	USAF Modeling & Simulation	In FY 2004, Project 4567, Joint Modeling and Simulation System, includes new start efforts.
		In FY 2004, Project 5122, C4ISR Warfighting Integration, includes new start efforts.
0303131F	Minimum Essential Emergency Communications Network	In FY 2004, project 5047, Ground Element MEECN System (GEMS), includes new start efforts.
0303140F	Information Systems Security Program	In FY 2004, Project 4861, Cryptologic 2000, efforts were transferred from PE 030401F, Communications Security, Project 4861.
0303141F	Global Combat Support System (GCSS)	In FY 2004, Project Number 4928, Electronic Business/Electronic Commerce (EB/EC), efforts were transferred to PE 0303200F, Air Force CIO Ops and Support.
0303401F	Communications Security	In FY 2004, Project 4861, Cryptologic 2000, efforts were transferred to PE 33140F, Information Systems Security Program, Project 4861, Cryptologic 2000.
0303601F	MILSATCOM Terminals	In FY 2004, Project 2487, MILSATCOM Terminals, efforts were transferred from PE 0603854F, Wideband MILSATCOM (Space), Project 4944, Advanced Wideband System, in order to properly align funding.
0305160F	Defense Meteorological Satellite Program	In FY2004, Project 04758, DMSP Program, was completed.
0305111F	Weather Service	In FY 2004, Project 2738, Weather Service, includes new start efforts.
0305174F	Space Warfare Center	In FY 2004, this is a new PE.
		In FY 2004, Project A011, Space Analysis and Application Development, includes new start efforts.

0305207F	Manned Reconnaissance Systems	In FY 2004, Project 4754, Cobra Ball, includes new start efforts.
0305906F	NCMC - TW/AA System	In FY 2004, Project 4806, N/UWSS, changed to CCIC2CS to more correctly depict end-user weapon system capabilities.
0305910F	SPACETRACK	In FY 2004, Project A009, Orbital Deep Space Imager, includes new start efforts.
		In FY 2004, Project , , includes new start efforts due to the Navy Space Surveillance Fence, PE 35927N, being transferred from the Navy to the Air Force.
		Project 5011, Space Situational Awareness Initiatives , efforts were transferred to Project A009, Orbital Deep Space Imager.
		Project A009, Orbital Deep Space Imager, efforts were transferred from Project 5011, Space Situational Awareness Initiatives.
		FY 2004, Project 5011, Space Situational Awareness Initiatives, efforts were transferred to Project A008, Sensor SLEP.
		In FY 2004, Project A008, Sensor SLEP, efforts were transferred from Project 5011, Space Situational Awareness Initiatives.
0305917F	Space Architect	In FY 2004, this is a new PE.
		In FY 2004, Project 4746, National Security Space Architect, efforts were transferred from OSD.
0401134F	Large Aircraft Infra-Red Countermeasures Program (LAIRCM)	In FY 2004, Project 4942, LAIRCM, includes new start efforts.
0708612F	Computer Resources Support Improvement Program (CRSIP)	In FY 2004, Project 4851, Embedded CRSIP, was terminated.
0901212F	Service Wide Support	In FY2004 efforts within Project 5060, Joint Personal Adjudication System, will transfer to OSD due to a newly re-aligned Defense Security Service (DSS) under ASD (C3I)

The following are Program Elements not providing RDT&E exhibits due to classification:

0101815F	Advanced Strategic Programs
0207248F	Special Evaluation Program
0207424F	Evaluation and Analysis Program
0207591F	Advanced Program Evaluation
0208160F	Technical Evaluation System
0208161F	Special Evaluation System
0304311F	Selected Activities
0603801F	Special Programs

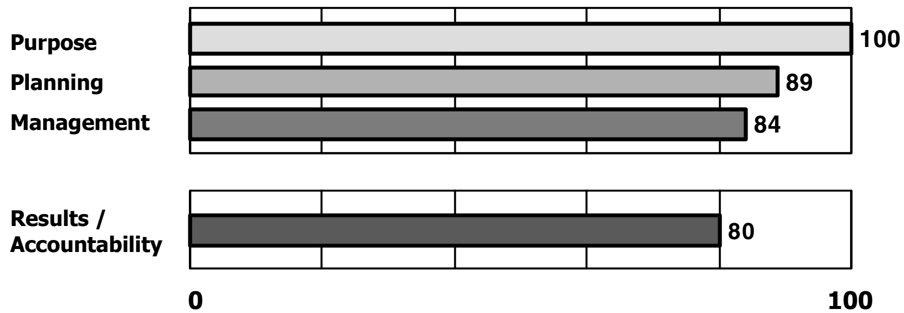
PROGRAM ASSESSMENT SUMMARY

This year, the Administration undertook a comprehensive review of 20% of the programs of the Executive Branch, including the same portion of programs within the Department of Defense. The Basic Research programs of the Department were reviewed as a whole, including Basic Research programs of the Air Force. The Basic Research program merited a rating of "Effective". A summary sheet describing the rating from the Basic Research evaluation follows.

Program: *Basic Research*

Agency: *Department of Defense--Military*

Bureau: *Research, Development, Test, and Evaluation*



☑ Results Achieved
☐ Results Not Demonstrated
☑ Measures Adequate
☐ New Measures Needed

Key Performance Measures

Key Performance Measures	Year	Target	Actual
Certification in biennial reviews by technically competent independent reviewers that the supported work, as a portfolio, is of high quality, serves to advance the national security and is efficiently managed and carried out.	2003 and later	100%	
Long-term Measure: Portion of funded research that is chosen on the basis of merit review Reduce non-merit-reviewed and -determined projects by one half in two years (from 6.0% to 3.0%)	2005	-50%	

Rating: *Effective*

Program Type: *Research and Development*

Program Summary:

The Basic Research program includes scientific study and experimentation to increase fundamental knowledge in the physical, engineering, environmental and life sciences and consists of a wide portfolio of projects. The program is carried out primarily through grants to universities and non-profits. The results of this research are expected to improve the country's defense capabilities, although the actual results of any specific project are unpredictable. Notable successes in the past have led to advances in satellite communications and imagery, precision navigation, stealth, night vision and technologies allowing greatly expanded battlefield awareness. Due to the long-term nature of research results, the R&D PART emphasizes assessment of the process of choosing funded projects and independent assessments of how well the research portfolio is managed.

The assessment indicates that the basic research program has clear purposes of providing options for new weapons systems, helping prevent technological surprise by adversaries, and developing new scientists who will contribute to the DoD mission in the future. DoD can document--through its contracts and grants management regulations, public announcements of award competitions and results from independent review panels--the methodical management of its program. Additional findings include:
1. The grants/contract solicitation, review and award processes are competitive.
2. The program is reviewed regularly by technically capable outside reviewers, which recommend improvements they would like to be implemented. They indicate that the work is of overall high quality.
3. The program has competent planning and management.
4. Earmarking of projects in the program has increased in the past decade and contribute less than the typical research project to meeting the agency's mission.

In response to these findings, the Administration will:
1. Continue to emphasize the use of independent review panels in assessing the performance of the program.
2. Work with the research community and Congress to explain the need to limit claims on research grant funds to proposals that independently can meet the standards of a strict merit-review process.

Program Funding Level (in millions of dollars)

2002 Actual	2003 Estimate	2004 Estimate
1,334	1,417	1,309

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

DATE
February 2003

BUDGET ACTIVITY
01 - Basic Research

PE NUMBER AND TITLE
0601102F Defense Research Sciences

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	221,683	217,863	204,754	218,188	232,030	257,669	246,689	249,160	Continuing	TBD
2301	Physics	23,481	24,180	22,769	23,795	24,064	27,431	24,945	25,272	Continuing	TBD
2302	Solid Mechanics and Structures	11,152	11,567	11,741	11,744	11,868	12,080	12,273	12,456	Continuing	TBD
2303	Chemistry	28,084	28,810	27,178	29,902	30,703	34,149	31,336	31,766	Continuing	TBD
2304	Mathematical and Computer Sciences	34,200	32,211	29,625	33,383	34,231	37,741	38,723	39,237	Continuing	TBD
2305	Electronics	26,809	23,918	23,856	25,280	27,001	29,383	29,793	30,183	Continuing	TBD
2306	Materials	15,946	14,608	15,164	17,598	19,223	21,457	20,771	20,079	Continuing	TBD
2307	Fluid Mechanics	9,705	10,320	10,985	11,901	12,024	12,241	12,437	12,623	Continuing	TBD
2308	Propulsion	22,060	23,216	13,245	13,774	21,851	22,208	22,563	22,903	Continuing	TBD
2311	Space Sciences	16,293	15,123	15,654	16,268	16,446	19,670	17,984	18,235	Continuing	TBD
2312	Biological Sciences	13,535	14,005	14,352	14,720	14,879	18,072	15,389	15,621	Continuing	TBD
2313	Human Performance	14,097	12,700	12,776	12,218	12,337	15,489	12,767	12,958	Continuing	TBD
4113	External Research Programs Interface	6,321	7,205	7,409	7,605	7,403	7,748	7,708	7,827	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	Continuing	TBD

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

DATE February 2003

BUDGET ACTIVITY
01 - Basic Research

PE NUMBER AND TITLE
0601102F Defense Research Sciences

(U) A. Mission Description

This program comprises extramural research activities in academia and industry along with in-house investigations performed in the Air Force Research Laboratory. This program funds fundamental broad-based scientific and engineering research in areas critical to Air Force weapon systems. All projects are coordinated through the Defense Reliance process to harmonize efforts, eliminate duplication, and ensure the most effective use of funds across the Department of Defense. All research areas are subject to long-range planning and technical review by both Air Force and tri-Service scientific planning groups. Note: In FY 2003, Congress added $1.923 million for the Center for Adaptive Optics and $2.5 million for Coal-Based Jet Fuel.

(U) B. Budget Activity Justification

This program is Budget Activity 1, Basic Research, because it funds scientific study and experimentation. Through this program, the Air Force invests in research directed toward increasing knowledge and understanding in those fields of science and engineering related to long-term national security needs.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	226,322	219,144	228,597	
(U)	Appropriated Value	228,419	223,744		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-2,097	-3,591		
	b. Small Business Innovative Research	-5,057			
	c. Omnibus or Other Above Threshold Reprogram		-2,290		
	d. Below Threshold Reprogram	1,500			
	e. Rescissions	-1,082			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-23,843	
(U)	Current Budget Submit/FY 2004 PBR	221,683	217,863	204,754	TBD

(U) Significant Program Changes:

Changes to this program since the previous President's Budget are a result of emphasis on other programs.

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

DATE **February 2003**

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
01 - Basic Research	**0601102F Defense Research Sciences**	**2301**

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2301 Physics	23,481	24,180	22,769	23,795	24,064	27,431	24,945	25,272	Continuing	TBD

(U) A. Mission Description

Physics research aims to revolutionize advances in laser technologies, sensors and imaging, miniature satellites, and communications to allow superior strategic awareness. It expands fundamental knowledge of optics, electromagnetics, as well as microwaves and plasmas. The goals are to enable and enhance technologies critical to Air Force lasers, optics, avionics, and microwaves and to improve technologies associated with non-intrusive/non-destructive testing and analysis. Research topics focus on revolutionary improvements in electromagnetic countermeasures, protection against nuclear weapons effects, communications, small satellites, and novel sensors. The primary areas of research investigated by this project are laser and optical physics; atomic, molecular, and imaging physics; senor/space environment interactions; and plasma physics.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $9,687 Performed laser and optical physics research for new concepts in solid state lasers, especially fiber lasers, to attain compact, inexpensive modules in the one kilowatt average power range. The results of this research further enabled spoofing and fatal damage of infrared-seeking missiles and improved high performance radars. Studied techniques for integrating modules to achieve multiple power levels at affordable cost and useful size for application to airborne or space platforms. Investigated concepts for achieving very high resolution of deep space objects using very large aperture adaptive telescopes. Explored novel low-cost light sources for high-power ultraviolet lasers capable of high intensity and spectral brightness for disinfection of biological agents, the synthesis of chemical agents, and safely stripping aircraft paint.

(U) $7,554 Continued to conduct research in plasma physics to investigate fundamental interactions between charged particles and electromagnetic fields for future affordable low-observables and space communications/surveillance. Explored physics relating to the power-efficient production and maintenance of substantial volumes of low-temperature plasma at atmospheric pressures for plasma-based aerodynamic drag reduction. Investigated the controlled resistive, conducting, and dielectric behavior of plasmas, and the effects of plasmas on absorption, reflection, and transmission of electromagnetic waves to create new stealth aircraft mechanisms. Examined the viability of using collisional ionized gas volumes to shield friendly assets.

(U) $4,308 Studied atomic, molecular, and imaging physics to evaluate the interaction of atoms, molecules, and ions for use in improved explosives and fuels, enhanced space surveillance, superior communications, precision navigation, and the neutralization of biological threats. Continued efforts to quantify interactions of atoms in strong electromagnetic fields so as to enable novel lasers for Air Force applications. Continued research on isomeric, very high density energy storage for flash radiation devices to diminish or eliminate refueling on long endurance flights.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2301**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

Further investigated the use of holographic films for correction of distortion and aberration in space surveillance telescopes.

(U) $1,932 Continued to enhance the research performance of the new 30-meter infrared adaptive optical telescope at the Center for Astronomical Active Optics. Continued research studies on adaptive optics to enable adaptive telescopes for laser beam projection into space, space reconnaissance, space power collectors, and space-based lasers.

(U) $23,481 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $9,441 Explore laser and optical physics to study the effect of combining high power solid state lasers with integrated nonlinear and pulse forming optics. Study concepts to achieve high output powers at wavelengths required for space applications. Continue studies of large aperture adaptive telescopes for very high resolution deep space imaging. Explore large, lightweight adaptive optics for space surveillance applications. Study laser micro-machining techniques for producing specialized space micro-systems for multi-functional micro- and nano-satellites.

(U) $8,133 Conduct research in plasma physics to investigate fundamental interactions between charged particles and electromagnetic fields for future directed energy weapons, affordable low-observables, and space communications and surveillance. Explore physics topics relating to the dynamic molecular interactions in combustion and high energy density propellants. Examine the detailed physics of material, surface, and air breakdown in the presence of strong electric fields. These fundamental findings will facilitate creation of more compact, lighter weight, portable pulsed power systems to power future directed energy weapon systems.

(U) $4,646 Study atomic, molecular, and imaging physics to evaluate the interaction of atoms, molecules, and ions to provide basic information to improve explosives and fuels, enhanced space surveillance, superior communications, precision navigation, and the neutralization of biological threats. Investigate fundamental interplay between atoms and strong electromagnetic fields to create new classes of lasers for Air Force applications. Develop isomeric, high energy density storage for flash radiation devices to diminish or eliminate refueling requirements on long endurance flights. Continue basic research of holographic films for correction of distortion and aberration in space surveillance telescopes. Measure ultraviolet emission cross sections from electron impact to provide fundamental data needed in satellite surveillance.

(U) $1,960 Enhance the research performance of the 30-meter infrared adaptive optical telescope at the Center for Astronomical Active Optics. Expand research studies on adaptive optics to further enable adaptive telescopes for laser beam projection into space, space reconnaissance, space power collectors, and space-based lasers.

(U) $24,180 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2301

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$10,181	Expand studies of high power fiber lasers, in particular those using novel material combinations, which support large-core, single-mode fibers. Study direct and nonlinear optical methods for combining beams of fiber lasers to achieve power levels needed for multiple directed energy applications. Continue research to convert wavelengths of high-power laser arrays to values needed for space applications and aircraft protection. Extend studies of large aperture adaptive telescopes for very high-resolution deep space imaging. Continue large, lightweight adaptive optics studies for space surveillance applications. Study new optical techniques to achieve very large aperture, very wide-band phased array radars in space.
(U)	$8,012	Enhance research studies in plasma physics to probe the fundamental interactions between charged particles and electromagnetic fields for all-electric military platforms, high-bandwidth communications, advanced long-distance covert surveillance, and space communications and surveillance. Explore physics topics relating to the dynamics of molecular interactions in combustion and high energy density propellants. Examine the detailed physics of material, surface, and air breakdown in the presence of strong electric fields. Exploit fundamental findings to facilitate creation of more compact, lighter weight, portable pulsed power systems in order to power future directed energy weapons. Expand the frontiers of understanding the effects of short-pulse intense electric fields on biological cells.
(U)	$3,281	Conduct research on the interaction of systems and sensors with the air and space environments. Investigate means to expand models of sensor performance to incorporate measurements of terrestrial and space backgrounds and radiation. Continue the study of methods to enhance hyperspectral imagery using polarization and hypertemporal information. Develop models to predict the atmospheric effects on laser propagation. Examine methods of using holographic techniques for dynamic correction of distortion and aberration in space surveillance telescopes.
(U)	$1,295	Study atomic, molecular, and imaging physics to evaluate the interaction of atoms, molecules, and ions to improve explosives and fuels, enhance surveillance, provide superior communications, improve precision navigation, and neutralize biological threats. Continue investigation into the fundamental interplay between atoms and strong electromagnetic fields to create new classes of lasers for Air Force applications. Explore uses for laser cooled and trapped atoms. Expand development of isomeric, high energy density storage for flash radiation devices that will diminish or eliminate refueling requirements on long endurance flights. Continue measurement of ultraviolet emission cross sections from electron impact to provide fundamental data needed in satellite surveillance.
(U)	$22,769	Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2301**

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

(U) Related Activities:

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0602204F, Aerospace Sensors.

(U) PE 0602500F, Multi-Disciplinary Space Technology.

(U) PE 0602601F, Space Technology.

(U) PE 0602605F, Directed Energy Technology.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2302

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2302	Solid Mechanics and Structures	11,152	11,567	11,741	11,744	11,868	12,080	12,273	12,456	Continuing	TBD

(U) **A. Mission Description**

Solid Mechanics and Structures basic research aims to dramatically improve the behavior of air and space materials and structures via better description of wear and damage dynamics. The research expands the fundamental knowledge of the aeroelastic and acoustic behavior of airframes and engine structures, as well as the fluid behavior of launch vehicles and space structures. The goals are cost-effective development and safe, reliable operation of superior Air Force weapons and defensive systems for assured global reach and air and space persistence. Research topics include: designing advanced material structures on the micro- and nano-scale; modeling and simulation of the dynamic behavior of aircraft, missiles, and large space structures; and technology integration for the performance and survivability enhancement of these systems. The primary areas of research investigated by this project are mechanics of composite materials, structural mechanics, and structural dynamics.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,340 Further studied mechanics of materials to accelerate utilization of advanced materials such as composites, high-temperature alloys, and ceramic matrix composites in air and space vehicles, turbine engines, space systems, and weapon systems. Explored synergistic combinations of information technology and multi-scale modeling to design new materials and new structures. Continued to explore nanomechanics to bridge the gap between continuum mechanics and atomistic modeling. Further probed theoretical foundations for multi-functional mechanics, including nonlinear behavior, to enable the development of multi-functional structures used in advanced space systems such as micro-satellites and micro-vehicles.

(U) $4,846 Conducted research into structural and material aspects of high-cycle metal fatigue and other aging mechanisms of aircraft. Continued to develop techniques for predictive computer simulation of structural response. Explored research into metal fatigue-generation due to vibration of jet engine compressor and turbine blades and the interaction of blade motion with fluid mechanics. Studied material science to identify and mitigate material degeneration in a timely and cost-efficient manner. Enhanced techniques to analyze vehicle integrity and significantly increase the structural longevity of Air Force weapon systems.

(U) $3,966 Conducted structural mechanics research to examine innovative adaptive structure concepts for deployment of space-based systems and multi-mission uninhabited air vehicles. Continued to evaluate the behavior of distributed sensor and actuator systems to improve the design and performance prediction of air and space systems. Furthered research into predictive techniques capable of modeling the interaction of structural motion with high-speed aerodynamics characteristic of uninhabited air vehicles. Continued investigating the mechanical and dynamic behavior of micro-scale structures to enable micro-electro-mechanical systems that can sense environments and respond accordingly (smart structures).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2302

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued
(U) $11,152 Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,540	Research mechanics of advanced materials to accelerate their use as composites, high-temperature alloys, and ceramic matrix composites. Results will have direct application in air and space vehicles, turbine engines, space systems, and weapon systems. Develop methods to synergistically combine multi-scale modeling and information technology to design new materials and structures. Establish foundations of nanomechanics that transition between continuum mechanics and atomistic modeling. Apply multi-functional mechanics with nonlinear behavior to design multi-functional materials and structures used in advanced air and space systems such as micro-satellites and micro-vehicles.
(U)	$4,672	Research the structural and material aspects of high-cycle metal fatigue and other aging mechanisms of aircraft. Develop fundamental computer simulations to predict structural response to assorted stimuli. Explore metal fatigue-generation caused by vibration of compressor and turbine blades and blade motion/fluid flow coupling. Study material science to quickly and inexpensively identify and mitigate material degeneration and degredation. Develop novel system techniques to analyze vehicle integrity to significantly increase the robustness of Air Force weapon systems.
(U)	$4,355	Conduct structural mechanics research to examine innovative adaptive structure concepts for deployment of space-based systems and multi-mission unmanned aerial vehicles (UAV). Investigate the behavior of distributed sensor and actuator systems to improve the design and performance characterization of air and space systems. Develop models to predict the interaction between structural motion and high-speed aerodynamics characteristic of UAVs. Exploit the mechanical and dynamic behavior of micro- and nano-scale structures to achieve exceptional capabilities in micro-electro-mechanical systems and nano-electro-mechanical systems.
(U)	$11,567	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,478	Enhance research in the mechanics of advanced materials to accelerate their use as composites, high-temperature alloys, and ceramic matrix composites. Continue development of methods to combine multi-scale modeling and information technology to design new materials and structures. Further examine the foundations of nanomechanics in transitioning between continuum mechanics and atomistic modeling. Continue to apply multi-functional mechanics with nonlinear behavior to enhance design of multi-functional materials and structures used in advanced air and space systems such as micro-satellites and micro-vehicles.
(U)	$5,015	Investigate structural and material aspects of high-cycle metal fatigue and other aging mechanisms of aircraft. Expand and enhance fundamental

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2302

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

computer simulations to predict structural response to assorted stimuli. Continue to explore metal fatigue-generation caused by vibration of compressor and turbine blades and blade motion/fluid flow coupling. Explore material science research to quickly and inexpensively identify and mitigate material degeneration and degradation. Continue to develop novel system techniques to analyze vehicle integrity to significantly increase the robustness of Air Force weapon systems and allow effective air and space persistence.

(U) $4,248 Continue research studies in structural mechanics to examine innovative adaptive structure concepts for deployment of space-based systems and multi-mission unmanned aerial vehicles (UAVs). Further probe the behavior of distributed sensor and actuator systems to improve the design and performance characterization of air and space systems. Expand models to predict the interaction between structural motion and high-speed aerodynamics characteristic of UAVs. Exploit the mechanical and dynamic behavior of micro- and nano-scale structures to achieve exceptional capabilities in micro-electro-mechanical systems and nano-electro-mechanical systems.

(U) $11,741 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602102F, Materials.
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602202F, Human Effectiveness Applied Research.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0603211F, Aerospace Structures.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)											DATE February 2003
BUDGET ACTIVITY 01 - Basic Research					PE NUMBER AND TITLE 0601102F Defense Research Sciences						PROJECT 2303
COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2303	Chemistry	28,084	28,810	27,178	29,902	30,703	34,149	31,336	31,766	Continuing	TBD

(U) A. Mission Description

Chemistry research seeks bold innovations in understanding, modeling, and controlling chemical reactions for developing new materials, improving synthesis of existing materials, controlling energy flow and storage, and regulating interactions between materials and their environments. Studies expand fundamental understanding of properties regulating the chemical dynamics and energy transfer processes that foster advances in lasers; the infrared, optical, and radar signatures of reaction products and intermediates that advance reliable target assessment and tracking; and the synthesis of new chemical propellants that allow space access and assured operations. Critical research topics include: novel synthesis and characterization of lower cost, higher performance functional and structural materials, electronics, and photonic materials; nano-structures; electromagnetic and conventional weaponry; and propellants. Focused investigations include the effects of chemical and morphological structures on functional and mechanical properties of polymeric materials and the exploration of atomic and molecular surface interactions that limit performance of electronic devices, compact power sources, and lubricant materials. Primary areas of research include molecular dynamics and theoretical chemistry, polymer chemistry, and surface and interfacial science.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $11,505 Performed molecular dynamics and theoretical chemistry research to identify and predict techniques to control molecular reactivity and energy flow, and developed predictive tools for designing new materials and processes for advanced propellants. Sought understanding of mechanisms of using ion and plasma chemistry to reduce drag and/or enhance combustion. Continued to synthesize novel chemical monopropellants for satellite and rocket applications. Further explored the gain and loss mechanisms in chemical laser systems to permit operation at higher powers. Identified inputs required to model chemically reacting flows in rocket plumes. Further developed theoretical methods to predict properties of structural materials.

(U) $8,891 Conducted polymer chemistry research to improve fundamental understanding of chemical structures and processing conditions to develop advanced polymeric materials for significantly improved Air Force systems performance and life spans. Explored chemistry concepts based on organic materials that will enable protection of Air Force personnel and sensors from agile lasers. Investigated nanocomposites to improve thermal and mechanical properties of polymers for lightweight aerospace structures. Probed means to control nanostructure assembly to attain new photonic and electronic functions.

(U) $5,755 Studied the chemistry of surface and interfacial processes for accurate detection and prevention of corrosion and degradation of air and space systems, and development and design of novel lubricants. Developed new long-life, low-friction surface structures and coatings for terrestrial

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2303

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		and space environments. Examined environmentally compliant nanostructured coating systems for corrosion protection of aluminum aircraft. Investigated novel three-dimensional surface nanostructures for sensor, optical, and power applications. Continued examinations of nano-scale surface structures with enhanced energy densities for significantly improved weapon system energy storage and delivery. Furthered development of theoretical and predictive methods for surface and interfacial chemical processes.
(U)	$1,933	Conducted research in chemical synthesis and detection techniques, chemical theory, and modeling and simulation that will ultimately lead to breakthroughs in new fuels and rocket propellants that are environmentally benign, have reduced signatures, and are less sensitive to accidental detonations. Investigated lifecycle applications of these potential fuels in flight vehicles. Studied application of any potential fuels breakthroughs to the development of hydrocarbon-fueled scramjets and combined-cycle engines for space applications.
(U)	$28,084	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$11,051	Conduct molecular dynamics and theoretical chemistry research to identify and predict techniques to control molecular reactivity and energy flow. Results will enable development of next generation predictive tools for designing new materials and processes for advanced, super energetic propellants. Explore uses of ion and plasma chemistry for flow control applications. Model interactions between aerospace systems and the space environment. Investigate concepts of reactive energetic nano-structures for applications to propulsion and munitions. Develop and validate theoretical methods to predict and design behavior and properties of nano-structures. Model chemically reacting flows associated with hypersonic vehicles. Research new chemical sources of electronic excited states needed to fuel chemical laser systems.
(U)	$9,547	Explore polymer chemistry sciences to improve fundamental understanding of chemical structures, reactivity, and processing conditions to develop advanced polymeric materials. Research findings aimed at significantly improving Air Force systems performance and life-spans. Explore magnetic, conductive, and optical properties of coating materials to achieve smart skin concepts with on-demand tunable properties. Investigate biologically inspired polymer concepts to achieve enhanced photonic properties and photonic bandgap structures. Explore molecular conformational changes to achieve controllable mechanical actuation in polymeric materials. Exploit transportable large optics technology.
(U)	$6,176	Investigate the chemistry of surface and interfacial processes for accurate detection and prevention of corrosion and degradation of air and space systems. Explore physical properties of novel lubricants. Create new low-friction, long-life coatings and surface structures for terrestrial and space environments. Research novel three-dimensional surface nano-structures for sensor, optical, and power applications. Probe nano-scale surface structures with enhanced energy densities for better weapon system energy storage and delivery. Develop theoretical and predictive methods for surface and interfacial chemical processes.

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

(U)	$2,036	Research novel chemical synthesis and detection techniques, chemical theory, and modeling and simulation focused on revolutionary breakthroughs in new fuels and rocket propellants that are more energetic, are environmentally benign, have reduced signatures, and are less sensitive to accidental detonations. Identify and investigate applications of these potential fuels in flight vehicles so as to enhance the benefits of increasing mass of payloads put into space and increasing the lifetime of satellites on orbit. Study application of any potential fuels breakthroughs to the development of hydrocarbon-fueled scramjets and combined-cycle engines for space applications.
(U)	$28,810	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$11,885	Further molecular dynamics and theoretical chemistry research to identify and predict techniques to control molecular reactivity and energy flow. Results will enable the next generation of predictive tools for designing new materials and processes for advanced, super-energetic propellants and countermeasure techniques. Probe novel chemical synthesis and detection techniques, chemical theory, and modeling and simulation focused on fostering revolutionary breakthroughs leading to fuels and rocket propellants that are more energetic, environmentally benign, less sensitive to accidental detonations, and emit reduced signatures. Optimize properties of these potential fuels to increase the mass of payloads that can be put into space and to increase the lifetime of satellites on orbit. Study the fundamental behavior of these new fuels in hydrocarbon-fueled scramjets and combined-cycle engines for space applications. Explore uses of ion and plasma chemistry for combustion control applications. Model the chemical interactions between air and space systems and the space environment. Investigate concepts of reactive energetic nano-structures for enabling advances in munitions and propulsion systems leading to benefits such as safer penetrating munitions and enhanced spacecraft payload fractions. Develop and validate theoretical methods to predict and design the behavior and properties of nano-structures. Enhance models of chemically reacting flows associated with hypersonic vehicles. Research new chemical sources of electronic excited states needed to fuel chemical laser systems.
(U)	$9,286	Conduct polymer chemistry research to improve fundamental understanding of chemical structures, reactivity, and processing conditions to develop advanced polymeric materials aimed at significantly improving Air Force systems performance and life-spans to allow effective air and space persistence. Explore flexible structures that can provide functions such as sensing, power generation and storage, electronics and electronic memory for integration into multi-functional structures. Develop organic molecules with high optical nonlinearities for protection against laser threats. Improve electro-optic polymers for improved performance for photonic radar development. Research organic-based electronics for multi-functional integration.
(U)	$6,007	Critically examine the chemistry of surfaces and interfacial processes for the rapid and accurate detection of corrosion and degradation of air and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2303

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

space systems. Assemble novel multi-functional coatings for the corrosion protection of aging aircraft. Explore the chemical and physical properties of novel lubricants for terrestrial and space environments. Develop low-friction, long-life multi-functional surface structures and coatings for micro- and nano-electromechanical systems. Exploit chemically directed self-assembly to produce novel three-dimensional surface nano-structures for sensor, optical, and power applications. Probe nano-scale surface structures with enhanced energy-densities for better weapon system energy storage and delivery. Continue to improve theoretical and predictive methods for surface and interfacial chemical processes.

(U) $27,178 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602102F, Materials.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0602602F, Conventional Munitions.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2304

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2304 Mathematical and Computer Sciences	34,200	32,211	29,625	33,383	34,231	37,741	38,723	39,237	Continuing	TBD

(U) A. Mission Description

Mathematical and computer sciences research develops novel techniques for mathematical modeling and simulation, algorithm development, complex systems control, and innovative analytical and high performance computing methods for air and space systems. Basic research provides fundamental knowledge enabling improved performance and control of systems and subsystems through accurate models and computational tools, artificial intelligence, and improved programming techniques and theories. The primary areas of research investigated by this project are dynamics and control, complex systems software, physical mathematics and applied analysis, optimization and discreet mathematics, computational mathematics, and signals communication and surveillance.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,776 Performed dynamics and control research to develop new techniques for design and analysis of control systems to significantly enhance capabilities and performance of air and space vehicles. Expanded programs on cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, unmanned vehicles, and constellations of small satellites. Further developed novel techniques for the control of nonequilibrium behavior of complex, unsteady fluid systems (chemically reacting flows) with applications to combustion and materials processing.

(U) $6,776 Conducted research in complex systems and software, artificial intelligence, automatic knowledge acquisition; study high performance knowledge bases to allow rigorous construction of highly complex battlefield information systems. Identified advanced techniques in intelligent and mobile agents for next generation information systems. Conducted research in information operations, including support for language-based security, mobile code security, protected execution, and dynamic, adaptive intrusion detection for protection of future battlespace and infosphere systems and networks.

(U) $6,452 Conducted physical mathematics/applied analysis and electromagnetics research to devise accurate models of physical phenomena to enhance controls and signal processing techniques. Investigated the feasibility of coherently propagating short laser pulses through the air for superior accuracy in laser-guided munitions. Enhanced models to predict nonlinear optical effects within semiconductor lasers and through other nonlinear optical media for applications in laser beam control and stability. Expanded formulation of optimal electromagnetic wave propagation/scattering codes to provide accurate and timely target recognition. Evaluated methods to penetrate tree cover and recognize targets with wide band radar. Investigated feasibility of incorporating virtual time-reversal methodology onboard a formation of small satellites to enhance imaging of radar-acquired moving targets.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2304**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U)	$4,517	Studied optimization and discrete mathematics to devise advanced mathematical methods for solving complex problems in logistics, engineering design, and strategic planning for battlespace information management. Expanded algorithmic research which produces a feasible solution within the time constraint of military operations. Developed techniques for hierarchical model building to accommodate multiple levels of aggregation and complexity, to reflect time and computational constraints.
(U)	$3,549	Performed computational mathematics research to devise unique simulations and designs of advanced Air Force systems. Integrated new multi-disciplinary design optimization strategies with high-order, time-accurate solvers for superior design of jet engines, aircraft wings, munitions, along with other air and space components. Investigated efficient methods to quantify uncertainty in nonlinear multi-disciplinary design models. Continued devising methods to reduce computation time for chemical simulations from months to days. Improved algorithms for plasma dynamics simulations, munition penetration simulations, and ground-based image reconstruction.
(U)	$2,583	Studied signals communication and surveillance to expand quantitative methodologies that extend the capability of critical mobile, networked communications systems, and strengthen the performance of surveillance and targeting functions. Improved the efficiency of source-channel coding in wireless communication through technical advances such as optical transmission. Continued research in probabilistic and analytic theory to achieve higher information rates and greater reliability under stringent military covertness constraints. Further developed promising areas such as super-resolution imaging and trellis-coded modulation.
(U)	$1,933	Constructed quantum computer devices that enable atomic level computing a million times faster than silicon chip. Designed, implemented, and tested quantum computing algorithms and architectures enabling fast, accurate solutions of complex fluid dynamics problems eliminating the need for multiple design iterations and prototype testing. Developed scalable quantum computers for automatic target recognition and target characterization.
(U)	$1,614	Explored mathematical and computational methods of external aerodynamics associated with hypersonic weapon release. Expanded plasma aerodynamics algorithms to include magneto hydrodynamic augmentation of complete scramjet engines. Computationally investigated the effects of dynamic air and space structural tailoring during combat maneuvers on end-game targeting. Computationally explored hypersonic boundary layer transition on transatmospheric vehicles to reduce heat transfer and viscous drag to enable long-range, high-payload hypersonic vehicles.
(U)	$34,200	Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2304

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,480 Perform dynamics and control research to develop new techniques for design and analysis of control systems. Research findings will significantly enhance capabilities and performance of air and space vehicles. Focus of the research is on cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, unmanned aerial vehicles (UAVs), and constellations of small satellites. Explore means to improve control of nonequilibrium behavior of complex, unsteady fluid systems (chemically reacting flows) with applications to combustion and materials processing. Foster advances in image processing and sensor technology that can be utilized in controller design for UAVs, smart munitions, nondestructive testing of aging or stealth air and space vehicles. Design computational models to analyze biological processes for adaptation to air and space systems.

(U) $6,480 Conduct research in complex systems and software, artificial intelligence, automatic knowledge acquisition, and high performance knowledge bases to allow rigorous construction of highly complex battlefield information systems. Explore methods to enhance research in information operations, including support for language-based security, mobile code security, protected execution, and dynamic, adaptive intrusion detection for protection of future battlespace/infosphere systems and networks. Develop new computational techniques/software in extremely large (10,000,000+ axioms) knowledge bases to provide deep, adaptive, expert decision support to battlefield commanders.

(U) $6,922 Conduct research in physical mathematics and applied analysis and in electromagnetics to develop accurate models of physical phenomena to enhance the fidelity of simulations and predictability of devices. Investigate the properties of coherently propagating ultrashort laser pulses through the air and their exploitation in areas such as electronic warfare and laser-guided munitions. Develop algorithms to simulate nonlinear optical effects within semiconductor lasers and nonlinear optical media. Formulate optimal electromagnetic wave propagation/scattering codes to provide accurate and timely target recognition. Evaluate methods to penetrate tree cover with wide band radar to recognize and track targets. Study feasibility of designing reconfigurable warheads by suitable placement/timing of microdetonators. Pursue description of dynamics of internal stores released from transonic/supersonic platforms.

(U) $4,897 Conduct research in optimization and discrete mathematics to validate and further advance mathematical methods for solving complex problems in logistics, engineering design, and strategic/tactical planning for battlespace information management. Evaluate anytime algorithms -- those that produce a feasible, but not necessarily optimal, solution. Examine new modeling techniques and computer algorithms for various urgent Air Force problems such as target tracking, mobilization planning, and manufacturing.

(U) $4,560 Perform computational mathematics research to create unique simulations and designs of advanced Air Force systems. Devise means to integrate new multi-disciplinary design optimization strategies with high-order, time-accurate solvers in order to design superior jet engines, aircraft wings, munitions, and other aerospace components. Develop new algorithms for unsteady reactive flow, munition penetration and fragmentation, and plasmadynamics for directed energy weapons. Develop quantum computing algorithms, architectures, and implementations

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2304**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

to enable exponential improvements in speed, accuracy, and fidelity of fluid dynamics simulations, signal processing, and data mining.

(U) $2,872 Investigate signals communication and surveillance to expand the capability of critical mobile, networked communications, and surveillance/reconnaissance and targeting systems through examination of fundamental principles governing signal analysis. Areas of study include linear operator theory, generalized functions and probability, harmonic methods, and asymptotic expansions. Explore source-channel encoding methods for robust wireless communication using optical transmission phenomenology. Develop a rigorous basis for and delineate the domain of applicability of self learning, trial and error (heuristic) methods such as super-resolution imaging. Research technologies with higher information rates and higher reliability of communications.

(U) $32,211 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,603 Extend dynamics and control research to develop new techniques for design and analysis of control systems. Research findings will significantly enhance capabilities and performance of aerospace vehicles. Focus of the research is on cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, unmanned aerial vehicles (UAVs), and constellations of small satellites. Develop control methodology to improve nonequilibrium behavior of complex, unsteady fluid systems (chemically reacting flows) with applications to combustion, materials processing and agile autonomous flight. Foster advances in image processing and sensors applicable to advanced controllers for UAVs, smart munitions, and non-destructive testing of aging or stealth aerospace vehicles. Design computational models to analyze biological processes for adaptation to air and space systems. Adapt explorations in bio-inspired sensing systems to assess feasibilty for and applicability in use in controlling autonomous systems.

(U) $6,437 Investigate complex systems and software, artificial intelligence, automatic knowledge acquisition, and high performance knowledge bases to allow rigorous construction of highly complex, secure battlefield information systems. Continue research in information assurance, including support for language-based security, mobile code security, protected execution, steganography/steganalysis and dynamic, adaptive intrusion detection for protection of future battlespace/infosphere systems and networks. Develop new computational techniques/software for information fusion at the situation refinement and impact assessment levels to provide deep, adaptive, expert decision support to battlefield commanders. Construct quantum computer devices that enable atomic level computing a million times faster than state-of-the-art silicon chip to allow enhanced target tracking, command and control, and decisive awareness. Design, implement, and test quantum computing algorithms and architectures enabling fast, accurate solutions of complex fluid dynamics problems eliminating the need for multiple design iterations and prototype testing. Continue developing scalable quantum computers for automatic target recognition and target characterization.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2304

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U)	$6,257	Conduct research in physical mathematics and applied analysis, and electromagnetics to develop accurate models of physical phenomena that enhance the fidelity of simulations and predictability of equipment. Investigate the properties of coherently propagating ultrashort laser pulses through the air and their exploitation in areas such as electronic warfare, laser-guided munitions, and irradiation of chemical/biological clouds. Develop algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media to exploit in future weapons. Formulate optimal electromagnetic wave propagation/scattering codes to provide accurate and timely target recognition. Evaluate methods to penetrate tree cover with wide band radar to recognize and track targets. Study feasibility of designing reconfigurable warheads by suitable placement/timing of microdetonators. Pursue description of dynamics of internal stores released from transonic/supersonic platforms.
(U)	$4,382	Enhance research in optimization and discrete mathematics to validate, advance, and exploit mathematical methods for solving complex problems in system diagnostics/prognostics, air mobility contingencies, and strategic/tactical planning for battlespace information management. Continue evaluating anytime algorithms -- those that produce a feasible, but not necessarily optimal, solution. Examine new modeling techniques and computer algorithms for various Air Force present and long-term challenges, such as target allocation for unmanned air vehicles, special operations planning, and system health and maintenance.
(U)	$3,442	Perform computational mathematics research to develop unique modeling and simulation capabilities for improving design methods for future Air Force systems. Integrate new multi-disciplinary design optimization strategies with high-order, time-accurate solvers for superior design of jet engines, aircraft wings, munitions, as well as other air and space components. Efficiently compute the simulation uncertainty in nonlinear models of aerodynamic flows and structural failure predictions. Develop new algorithms for unsteady reactive flow, munitions penetration and fragmentation, and plasmadynamics for directed energy weapons.
(U)	$2,504	Conduct investigations to expand the capability of critical mobile, networked communications through mathematical innovations in signal processing. Examine the fundamental principles of stochastics and probabilistic analysis to actuate proof-of-concept surveillance/reconnaissance and targeting systems. Employ linear operator theory, generalized functions, differential equations, and quantum theory to facilitate flexible, high bandwidth reliable transmission of multi-source data. Explore hybrid radio-frequency and optical phenomenology to achieve robust wireless communication. Delineate the domain of applicability of self-learning, and heuristic methods such as super-resolution imaging. Examine revolutionary technologies that attain ultra-fast information exchange with superior dependability.
(U)	$29,625	Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2304

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

(U) Related Activities:
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602602F, Conventional Munitions.
(U) PE 0602702F, Command, Control, and Communications.
(U) PE 0603789F, C3I Advanced Development.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
01 - Basic Research	0601102F Defense Research Sciences	2305

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2305 Electronics	26,809	23,918	23,856	25,280	27,001	29,383	29,793	30,183	Continuing	TBD

(U) A. Mission Description

Electronics basic research enhances the fundamental understanding of electronic materials, devices, and systems to advance Air Force operational capabilities in directed energy weapons, stealth technologies, electronic countermeasures, information and signal processing, and communications. Research seeks to develop fundamental technologies to meet future Air Force challenges in the areas of target search, command and control, and aerospace dominance. The research enables the development of electronic processes to model and predict the performance of electronic materials, devices, and systems for power generation, optical signal processing, radiation effects, and high-speed signal processing. The goals are to firmly control the complexity and reliability of electronic systems, increase data transmission and information processing speeds, and to improve the security and reliability of electronic information. The primary areas of research investigated by this project are space electronics, optoelectronic materials, optoelectronic information processing, optoelectronic memory technologies, and quantum electronic solids.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $7,789 Performed space electronics research to examine military unique low-power and complementary electronic circuits to greatly reduce the size and weight of space platforms. Studied the effects of intense radio frequency (RF) pulses on electronic circuits and systems. Continued to devise means to prevent surface and interface states from degrading electronic device performance. Further explored wide bandgap semiconductor materials as promising candidates for RF power sources and high-temperature operations. Expanded identification of fundamental radiation effects on electronic and semiconductor materials and devise methods to prevent space system degradation or destruction.

(U) $7,567 Conducted optoelectronic materials research for detection and emission of optical radiation from far infrared to the ultraviolet spectral range to achieve spectral dominance of the battlespace. Investigated new nonlinear optical materials to protect critical optical systems from laser fire, and access laser wavelengths and power not available with solid state or semiconductor lasers. Studied basic mechanisms that limit the efficiency and uncooled operation of lasers and detectors. Expanded formulation of laser materials to degrade or blind an adversary's detection and tracking capabilities. Investigated fast multiband detectors for characterization of the battlespace, surveillance, target tracking, and target signatures. Studied unique properties available from nanoscale combinations of optoelectronic materials.

(U) $4,487 Studied optoelectronic information processing to explore development and application of electro-optical materials and devices to enhance critical communication system accuracy, speed, and data storage. Investigated high bandwidth, multi-wavelength modulators and detectors to develop and refine complex semiconductor structures for imaging and communication systems. Created optical materials for maximum high-bandwidth communication and parallel signal processing. Investigated the use of new optical materials for enabling secure satellite communications and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2305

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

increased data transfer speeds required for military operations.

(U) $3,778 Performed quantum electronic solids research to investigate superconducting, magnetic, and nanoscopic materials and devices for advanced sensing communications and signal processing, and superior data storage capabilities. Improved high-temperature, high-current superconducting tapes and cables for enhanced storage and power generation on Air Force space platforms and directed energy weapons. Developed new techniques to quantify active corrosion in aircraft structures to increase lifespan. Investigated new high-temperature magnetic materials with sufficient mechanical strength for utilization in aircraft with higher electric workloads.

(U) $1,932 Conducted research addressing the scientific barriers to miniaturization of components enabling much lighter, more compact, highly capable micro- and nano-satellites. Performed researched into nanopropulsion and power schemes, smart skins, radiation hardening and quantum effect electronics to reduce satellite cost, weight, and size each by a factor of ten. Investigated nano-satellite benefits for improving access to space, mission flexibility, ease of augmentation and upgrade, and graceful degradation during end of service life.

(U) $1,256 Established focused ion beam research associated with system optimization and characterization. Investigate properties for establishing and regulating the narrowest beam diameter at relatively high energy. Probed the effects and benefits derived from a wide range of isotopes provided by various liquid metal ion sources. Researched means to enable advancing computing, sensing, and image processing associated with ion beam research.

(U) $26,809 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $8,485 Conduct research on military space platform unique electronic circuits aimed at greatly reducing component part count, size, and weight, while increasing performance and reliability. Expand study of intense radio frequency (RF) pulse effects on electronic circuits and systems. Design, fabricate, and evaluate wide bandgap semiconductor materials to achieve an unique combination of high RF power output, high efficiency, low noise, robustness, and radiation hardness. Conduct research on the interaction of systems and sensors with the space environment. Develop models to predict the effects of terrestrial and space backgrounds and radiation on sensor performance in order to promote secure, wide bandwidth communication through the atmosphere and ionosphere as well as between satellites. Initiate studies of reconfigurable electronics.

(U) $7,469 Research optoelectronic materials for detection and emission of optical radiation from the far infrared to ultraviolet spectral range to achieve spectral dominance of the battlespace. Investigate unique nonlinear optical materials to protect critical optical systems from laser radiation. Assess basic electronic mechanisms to improve the efficiency and reduce the cooling requirements of lasers and detectors. Synthesize laser materials to degrade or disable an adversary’s detection and tracking capabilities. Create fast multiband detectors for characterization of the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2305**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

		battlespace, surveillance, target tracking, and target signatures. Develop nano-fabrication technology for unique optoelectronic material properties.
(U)	$2,376	Conduct research in optoelectronic information processing to explore the design, development, and application of novel optoelectronic materials and devices to enhance critical communication system accuracy and speed. Examine complex semiconductor structures and develop optical materials for use in high bandwidth, multi-wavelength modulators and detectors for secure satellite imaging and faster data transfer rate communication systems. Explore optoelectronic nanotechnologies: nanophotonics, nanoelectronics, and nanosensors and opportunities in terahertz technologies.
(U)	$4,001	Further investigate quantum electronic solids phenomena to explore superconducting, magnetic, and nanoscopic materials for advanced sensing, communications, and signal processing. Examine superconducting quantum systems for adaptation to quantum computing and encryption. Probe high-current, high-temperature superconducting cables and tapes for enhanced power generation and storage on Air Force directed energy weapons and space platforms. Develop new high-temperature magnetic materials with sufficient mechanical strength for use in aircraft with higher electric workloads.
(U)	$1,587	Perform research in optoelectronic memory technologies and persistent spectral hole-burning systems for data storage and processing. Investigate page-oriented or holographic memory configurations in two- or three-dimensions. Explore capabilities to buffer, store, and retrieve data at rates and quantities anticipated for multi-spectral devices. Develop new technogies to increase capabilities in high-speed image capture, data storage, and information processing for surveillance, target discrimination, and autonomous navigation.
(U)	$23,918	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$8,528	Expand research on military space platform unique electronic circuits aimed at greatly reducing component size and weight while increasing reliability. Research the scientific barriers to miniaturization of components enabling much lighter, more compact, highly capable microsatellites and nanosatellites. Explore nanopropulsion and power schemes, smart skins, radiation hardening, and quantum effect electronics to reduce satellite cost, weight, and size each by a factor of ten. Investigate nanosatellite benefits for improving access to space, battlefield awareness and control, mission flexibility, ease of augmentation and upgrade, and graceful degradation during end of service life. Further exploration of intense radio frequency (RF) pulse effects on electronic circuits and systems. Design, fabricate, and evaluate wide bandgap semiconductor materials to achieve a unique combination of high RF power output, high efficiency, low noise, robustness, and radiation hardness. Initiate efforts to identify electronic approaches to increasing spacecraft survivability. Enhance research into the fundamental interaction of systems and sensors with the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2305

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

		space environment. Develop models to predict the effects of terrestrial and space backdrops and radiation on sensor performance in order to promote secure, wide bandwidth communication through the atmosphere and ionosphere as well as between satellites to ensure superior strategic awareness.
(U)	$7,683	Further research into optoelectronic materials for detection and emission of optical radiation from the far infrared to ultraviolet spectral range to achieve spectral dominance of the battlespace. Investigate unique nonlinear optical materials to protect critical optical systems from laser radiation. Assess basic electronic mechanisms to improve the efficiency and reduce the cooling requirements of lasers and detectors. Synthesize laser materials to degrade or disable an adversary's detection and tracking capabilities. Create fast multiband detectors for characterization of the battlespace, surveillance, target tracking, and target signature identification. Develop nano-fabrication technology for unique optoelectronic materials. Probe new materials for high efficiency photovoltaic devices.
(U)	$2,281	Research optoelectronic information processing and relevant nano science to explore the design, development, and application of novel optoelectronic materials and devices in order to enhance the accuracy and speed of critical communications. Exploit guided wave and wireless communications networks with dense arrays for potential application to intelligent sensors, compact reconnaissance platforms, and revolutionary unmanned and manned Air Force assets. Initiate exploration of ultracompact microphotonic and nanophotonic structures and chip scale optical networks, with design and engineering of the electromagnetic properties of materials at the scales comparable to the wavelength of light. Investigate quantum computing device approaches for advanced computing and signal processing. Expand the science and technologies of the terahertz frequency spectrum through robust monolithic and miniature devices for security, remote sensing, optical communications, and optical signal processing.
(U)	$1,522	Examine optoelectronic memory and persistent spectral hole-burning approaches for enhanced data storage and processing to enable superior strategic awareness. Evaluate methods for constructing page-oriented or holographic memory configurations in two or three dimensions. Research methods of buffering, storing, and retrieving data at rates and quantities anticipated for multi-spectral devices. Evaluate techniques for enhancing capabilities in high-speed image capture, data storage, and information processing for surveillance, target discrimination, and autonomous navigation.
(U)	$3,842	Expand investigations into superconducting, magnetic, and nanoscopic materials for advanced sensing, communications, and signal processing. Examine superconducting quantum systems for adaptation to quantum computing and encryption. Probe high-current, high-temperature superconducting cables and tapes for enhanced power generation and storage on Air Force directed energy weapons and space platforms. Further the development of new high-temperature magnetic materials with sufficient mechanical strength for use in aircraft with higher electric workloads.
(U)	$23,856	Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2305**

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0602702F, Command, Control, and Communications.
(U) PE 0603203F, Advanced Aerospace Sensors.
(U) PE 0603789F, C3I Advanced Development.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2306

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2306 Materials	15,946	14,608	15,164	17,598	19,223	21,457	20,771	20,079	Continuing	TBD

(U) A. Mission Description

Materials research enables the development and implementation of structural materials that provide reliable performance in applications related to high-temperature strength, toughness, fatigue, and environmental conditions. The goal is to provide fundamental knowledge to make possible future systems that provide rapid global reach, on demand space surge, and measured global force projection. The research expands fundamental knowledge of material properties that leads to the development of novel materials for airframe, turbine engine, and spacecraft structures. The goals of this project are to develop materials for air and space vehicles that provide increased structural efficiency and reliability, increase the operating temperature of engine materials, and further increase thrust-to-weight ratio of engines. Basic research emphasis is on refractory alloys, intermetallics, shape memory alloys, polymer composites, metal and ceramic matrix composites, advanced ceramics, such as alumina, silicon carbide, silicon nitride, and carbon/carbon, and new material processing methods. The primary areas investigated by this project are ceramic and non-metallic materials, metallic materials, and organic matrix composites

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,624 Performed ceramic and non-metallic materials research to understand optimum strength of very high temperature, non-metallic materials for airbreathing and rocket engines, and space vehicle applications. Studied thermal and mechanical stability interaction of very-high temperature oxide and non-oxide composites for jet engine blade applications. Advanced fundamental materials knowledge to develop ultra-high temperature material systems based on carbides for rocket propulsion applications.

(U) $7,286 Conducted metallic materials research to develop affordable and durable metallic systems for advanced engines and aerospace structural applications. Investigations focused on mechanical and thermal stability of composites, metal refractory alloys, and intermetallics for very-high temperature aircraft applications. Developed functionally gradient structures for superior thermal barrier coatings. Created advanced metals for multi-functional space systems.

(U) $2,103 Performed organic matrix composites research to advance polymer matrix composite knowledge and increase the life-span and strength of aerospace structures. Studied thermal cycling effects of polymer matrix composites at cryogenic temperatures to improve material durability in liquid fuel tank environments. Researched novel fiber sizing techniques to minimize moisture degradation of mechanical and electromagnetic properties in glass fiber reinforced composite structures.

(U) $1,933 Developed new mathematical and computational strategies to reduce maturity time for new materials by ~50% and to minimize the costs of new structural materials for aerospace systems. Explored scientific basis for computational design to reduce amount of costly experimentation

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2306

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

required. Developed high performance materials more affordably through synchronization of material development and engineering system design.

(U)	$15,946	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$5,042	Perform ceramic materials research to develop new materials and composites for use at very high temperature and/or hostile environments. Investigation of the optimization of thermal and mechanical stability of oxide composites for aircraft and jet engine blade applications. Create ultra-high temperature materials systems based on non-oxide materials for space applications. Design and optimize multi-functional materials to enable the combination of structural and functional ceramics to enable enhanced fuel cells, sensors and actuators.
(U)	$7,275	Continue metallic materials research to develop affordable and durable metallic systems for advanced engines and aerospace structural applications. Investigations focus on the integration of computational materials science and materials design into the design of engineering components, mechanical and thermal stability of metal matrix composites, development and characterization of refractory metal alloys and intermetallics for very-high temperature aircraft applications. Develop functionally graded structures for superior thermal barrier coatings. Create advanced metals for multi-functional space systems.
(U)	$2,291	Perform organic matrix composites research to advance polymer matrix composites knowledge to increase the strength and life span of aerospace structural materials. Analyze effects of cyclic thermal loads on polymer matrix composites down to cryogenic temperatures to increase durability in liquid fuel tank materials. Develop new fiber sizing techniques in glass fiber reinforced structures to minimize degradation of mechanical and electromagnetic properties due to moisture.
(U)	$14,608	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$4,992	Explore ceramic and non-metallic materials research to design new materials and composites for future global reach and space access operations requiring very high temperature, hostile environments use materials. Expand studies optimizing the thermal and mechanical stability of oxide composites for aircraft and jet engine blade applications. Extend research on ultra-high temperature ceramic materials for space propulsion and structural systems. Maintain research focus on the design and optimization of multi-functional ceramic materials to enable structurally enhanced smart systems.
(U)	$7,902	Probe metallic materials integrating computational models of material behavior into engineering design applications to exploit advanced engines

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2306**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

as well as air and space structural applications. Expand experimental and modeling studies of mechanical strength, thermal stability, performance prediction, and lifetime assessment of composites, refractory metal alloys, and intermetallics for applications at moderate and very high temperatures. Develop advanced alloys for multi-functional space systems. Develop new mathematical and computational strategies to reduce maturity time for new materials by ~50% and to minimize the costs of new structural materials for air and space systems. Explore scientific bases for computational design to reduce the amount of costly experimentation required to develop new materials. Seek to develop high performance materials more affordably by integrating material development and engineering system design.

(U) $2,270 Investigate organic matrix composites to advance polymer matrix composites knowledge in order to increase the strength and life span of air and space structural materials. Analyze the effects of cyclic thermal loads down to cryogenic temperatures on polymer matrix composites in order to increase durability in liquid fuel tank materials. Develop new fiber sizing techniques in glass fiber reinforced structures to minimize the degradation of mechanical and electromagnetic properties due to moisture.

(U) $15,164 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602102F, Materials.
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0603211F, Aerospace Structures.
(U) PE 0708011F, Industrial Preparedness.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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

DATE February 2003

BUDGET ACTIVITY
01 - Basic Research

PE NUMBER AND TITLE
0601102F Defense Research Sciences

PROJECT
2307

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2307 Fluid Mechanics	9,705	10,320	10,985	11,901	12,024	12,241	12,437	12,623	Continuing	TBD

(U) A. Mission Description

Fluid Mechanics research advances fundamental knowledge, tools, data, concepts, and methods for improving the efficiency, effectiveness, and reliability of air and space vehicles that will provide rapid global reach and revolutionize access to space. The goals are to improve theoretical models for aerodynamic prediction and design as well as to originate flow control concepts and predictive methods used to expand current flight performance boundaries through enhanced understanding of key fluid flow; primarily high-speed air phenomena. Basic research emphasis is on turbulence prediction and control, unsteady and separated flows, super- and subsonic flows, and internal fluid dynamics. The primary approach is to formulate advanced computational methods to: simulate and study complex flows; predict real gas effects in high-speed flight; and control and predict turbulence in flight vehicles and propulsion systems. Primary areas of research investigated by this project are unsteady aerodynamics, hypersonic aerodynamics, turbulence and flow control, and rotating flows.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,427 Performed unsteady aerodynamics research to provide fundamental knowledge of high-speed airflows to optimize future Air Force air vehicle designs and enable revolutionary future weapon systems. Investigated unsteady, complex, three-dimensional flows to refine the control and flight performance of unmanned air vehicles. Completed the development of design tools for flow control to minimize flow separation and air vehicle drag. Completed the development of fluid/structural interaction design tools to predict vehicle failure modes in rapid maneuvers.

(U) $2,912 Conducted hypersonic aerodynamics research to investigate complex flowfield phenomena for enabling the design of future Air Force trans-atmospheric vehicles and their flight control systems. Researched advanced concepts for hypersonic flow control such as plasma or magneto-hydrodynamic techniques. Developed high-speed flow prediction codes to quantify thermal stresses. Investigated high temperature mitigation techniques for hypersonic flight vehicles.

(U) $2,424 Sought fundamental knowledge of turbulence in coordinated experimental and computational simulation efforts. Investigated flow control concepts to enhance the performance, controllability, and stability in air vehicles. Developed new predictive tools for the air vehicle design process. Evaluated promising flow control actuation concepts and investigate flow control coupling mechanisms in turbulent flows to enable agile flight vehicles with significantly reduced power requirements.

(U) $1,942 Studied complex rotating flow phenomena as they relate to turbomachinery and jet engine applications. Evaluated unsteady flow phenomena for enhancing the performance and reliability/maintainability of airbreathing propulsion systems. Continued development of Large Eddy Simulation methodology for affordable high fidelity predictions of gas turbine engine flow fields and heat transfer effects. Developed understanding of high

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2307

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

cycle fatigue aerodynamic forcing. Evaluated possible flow control applications in turbine engines.

(U) $9,705 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,595 Perform unsteady aerodynamics research to provide fundamental knowledge of high-speed airflows to optimize current Air Force air vehicle designs and enable revolutionary future weapon systems. Investigate unsteady, complex, three-dimensional flows to refine the control and flight performance of unmanned aerial vehicles (UAVs). Investigate rapid maneuver UAV aerodynamics. Investigate highly separated flow situations occurring in complex air vehicle and weapon systems.

(U) $3,073 Investigate complex phenomena in hypersonic flows to enable the design of future Air Force trans-atmospheric vehicles and flight control systems. Complete development of supersonic flow control concepts, including plasma and magneto-hydrodynamic techniques. Develop high-speed flow prediction codes to quantify thermal stresses and design mitigation techniques for hypersonic flight vehicles.

(U) $2,595 Explore fundamental knowledge of turbulence in coordinated experimental and computational simulation efforts. Investigate new areas and methods of flow control on aircraft wings and jet engines to enhance the performance, controllability, and stability in air vehicles. Develop reduced order models for turbulent flow control applications and affordable engineering predictive models for the air vehicle design process. Assess quality of promising flow control actuation concepts on realistic geometries. Continue investigating flow control coupling mechanisms in turbulent flows to enable agile flight vehicles.

(U) $2,057 Study complex rotating flow phenomena as they relate to turbomachinery and jet engine applications. Evaluate unsteady flow phenomena and develop understanding of forcing modes in turbomachinery to predict and avoid high cycle and thermal failures in jet engines. Investigate application of Large Eddy Simulation techniques to explore complex gas turbine engine flow fields and heat transfer effects. Evaluate flow control measurement and actuation devices for use in harsh environments such as turbine engines.

(U) $10,320 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,760 Characterize the critical phenomena in unsteady aerodynamic flows to allow optimization of current Air Force air vehicle designs that will make possible revolutionary future weapon systems. Develop the numerical tools and validating experimental database to determine the effect of unsteady, vortex-dominated flows on the control and flight performance of unmanned aerial vehicles (UAVs). Investigate aero/structure interactions associated with rapid maneuver UAVs. Develop tools for the accurate prediction of highly separated flow structure occurring in

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2307**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

flow over complex air vehicle and weapon systems.

(U) $3,256 Characterize critical aerothermal phenomena in super- and subsonic flows to enable the design of potential Air Force trans-atmospheric vehicles and flight control systems. Examine advanced flow control concepts for shock-dominated flows. Pursue aerothermal numerical simulation capabilities to quantify heat transfer and unsteadiness for flight vehicles.

(U) $2,760 Utilize experimental and computational simulations to develop more robust turbulence modeling approaches for complex flow phenomena. Develop approaches for modeling unsteady flow control inputs on aircraft wings and jet engines to enhance the performance, controllability, and stability in air vehicles. Utilize reduced order models for turbulent flow control applications and affordable engineering predictive models for the air vehicle design process. Test promising flow control actuation concepts on realistic geometries in wind tunnel tests. Continue investigating flow control coupling mechanisms in turbulent flows to enable agile flight vehicles.

(U) $2,209 Study complex rotating flow phenomena as they relate to turbomachinery and jet engine applications. Explore coupling mechanisms in multiple blade row interactions in order to develop understanding of forcing modes in turbomachinery and to predict high cycle fatigue failures in jet engines. Utilize Large Eddy Simulation techniques to explore heat transfer and fluid flow coupling in turbine engine flow fields. Develop flow control measurement and actuation devices for use in harsh environments such as turbine engines.

(U) $10,985 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602102F, Materials.
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0603211F, Aerospace Structures.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)										DATE February 2003
BUDGET ACTIVITY 01 - Basic Research				PE NUMBER AND TITLE 0601102F Defense Research Sciences						PROJECT 2308
COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2308 Propulsion	22,060	23,216	13,245	13,774	21,851	22,208	22,563	22,903	Continuing	TBD

Note: Funding in FY 2004 and 2005 decreased due to decreased emphasis in hypersonics basic research.

(U) A. Mission Description

Propulsion research expounds fundamental knowledge to enable and enhance efficient utilization of energy in airbreathing engines, chemical and non-chemical rockets, and combined cycle propulsion systems for future rapid global reach and on-demand space access. Basic research thrusts include airbreathing propulsion, space power and propulsion, high altitude signature characterization and contamination, propulsion diagnostics, and thermal management of space-based power and propulsion systems. Two key basic research areas include reacting flows and non-chemical energetics. Study of chemically reacting flows involves the complex coupling between energy release through chemical reaction and the flow processes that transport chemical reactants, products, and energy. Non-chemical energetics research includes plasma and beamed energy propulsion for orbit raising space missions, and efficient ultra-high energy techniques for space-based energy utilization. Primary areas of research investigated by this project are space power, propulsion, combustion, and diagnostics.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,934 Performed space power and propulsion research to investigate novel propulsion mechanisms to enable superior satellite propulsion performance. Undertook studies to enable clusters of cooperating autonomous micro-satellites by improving thrust and control of micro- and nano-satellite propulsion systems. Researched mechanical-electric energy conversion and self-consuming satellites to increase payload and thrust. Explored supercritical combustion for optimal rocket propulsion using hybrid rockets and/or combined cycle engines. Performed research on digital propulsion and pulsed detonation rocket engines. Investigated opportunities to exploit experimental university satellites to measure thrust and cross-contamination in micro-satellite constellations. Developed novel space diagnostic techniques and 100 gram class sensors for accurate measurements on micro- and nano-satellites.

(U) $6,604 Studied combustion to evaluate airbreathing propulsion systems for hypersonic, supersonic, and subsonic flight to enhance air warfare capabilities. Increased combustion efficiency and reduce fuel consumption through enhanced computer models that can predict unsteady behavior such as combustion instability. Advanced the state of turbulent combustion simulation methods by incorporating refined models for chemistry and fuel droplets. Investigated enhancements to ignition and flame stabilization by weakly ionized flows.

(U) $4,268 Investigated advanced diagnostics systems for data reduction and interpretation to create concepts for novel propulsion system applications. Applied picosecond spectroscopic techniques to characterize turbulent combustion statistical behavior and supercritical fuel properties.

(U) $1,891 Researched methods for improving aerodynamics for next generation aerospace vehicles for long-range strike. Expanded research to develop

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2308

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

sound scientific basis for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies enabling hypersonic vehicles by reducing drag and improving range by more than 10%. Performed demonstrations to prove plasma control effects and to determine how to engineer them into operational systems. Investigated plasma effects on lowering fuel consumption, improving propulsion system performance, providing on-board power generation, and alleviating sonic boom and engine noise.

(U) $2,363 Continued research in coal-derived jet fuels to investigate refinery-processing techniques for coal processing with petroleum, additives to suppress fuel system fouling, combustion characteristics of candidate fuels, and fuel-material interactions. Sought to produce small quantities (50 gallons) of coal-derived fuel for large-scale combustion, fuel system fouling, and ignition experiments. Investigated potential for coal-derived fuel production scale-up.

(U) $22,060 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $7,222 Explore space power and propulsion research to investigate novel propulsion mechanisms to enable superior satellite propulsion performance. Study means to improve thrust and control of propulsion systems to develop high-precision constellations of cooperating micro-satellites. Expand understanding of mechanical-electric energy conversion to increase payload and thrust. Study feasibility of excess silicon as a space propellant in developing concepts for self-consuming satellites. Continue researching new engine concepts such as pulsed detonation engines, hybrid rockets, and combined cycle engines. Create advanced supercritical combustion models and leverage computational capability to enhance the design of new engines. Research plasma turbulence and its effect on the transport coefficients to develop a new class of more versatile plasma thrusters.

(U) $6,933 Study combustion to evaluate airbreathing propulsion systems for hypersonic, supersonic, and subsonic flight to enhance air warfare capabilities. Develop enhanced computer models that predict unsteady behavior, such as combustion instability, to increase combustion efficiency and reduce fuel consumption. Advance the state of Large Eddy Simulation methods for turbulent combustion by incorporating upgraded subgrid-scale models for chemistry and fuel droplets.

(U) $4,491 Complete studies of advanced diagnostics systems for data reduction and interpretation to create concepts for novel propulsion system applications. Complete study of laser-induced fluorescence and absorption spectroscopic measurements in relation to infrared and ultraviolet excitation wavelength regimes.

(U) $2,022 Study methods for enabling and improving aerodynamics for next generation aerospace vehicles for long range strike. Further expand research studies to develop sound scientific basis for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies enabling

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2308

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

hypersonic vehicles by reducing drag and improving range by more than 10%. Demonstrate plasma control effects and evaluate means to engineer them into operational systems. Investigate plasma effects on lowering fuel consumption, improving propulsion system performance, providing on-board power generation, and alleviating sonic boom and engine noise.

(U) $2,548 Enhance research in coal-derived jet fuels to investigate refinery-processing techniques for coal processing with petroleum, additives to suppress fuel system fouling, combustion characteristics of candidate fuels, and fuel-material interactions. Produce limited quantities (50 gallons) of coal-derived fuel for large-scale combustion, fuel system fouling, and ignition experiments. Further investigations for coal-derived fuel production scale-up.

(U) $23,216 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,813 Study micro-chemical, plasma-based, and beamed-energy based thrusters to improve thrust, specific impulse, and control of propulsion systems for high-precision constellations of cooperating micro-satellites in order to enhance decisive awareness of threats and opportunities. Further research into new engine concepts such as pulsed detonation engines, hybrid rockets, and combined cycle engines. Create advanced supercritical combustion models and leverage computational capabilities that will enhance the design of new hydrocarbon, cryogenic, and monopropellant-fueled engines. Conduct research plasma turbulence and its effect on the transport coefficients in order to develop a new class of more versatile plasma thrusters. Examine magnetohydrodynamic (MHD) flow control to optimize propulsion system flow path performance in scramjets. Investigate lightweight super conducting magnet capability for onboard flight-rated systems needed to achieve MHD flow control of advanced engines. Investigate plasma ignition approaches to improve combustion efficiency and stability in scramjets and high altitude subsonic airbreathing propulsion systemz. Research high altitude signature characterization and spacecraft cross-contamination, especially in the presence of multiple thrusters and satellites.

(U) $6,432 Study combustion in airbreathing propulsion systems for supersonic and subsonic flight to enable new concepts and capabilities to deliver and sustain our in-theater forces. Develop detailed mechanisms for hydrocarbon fuel combustion at elevated pressures. Improve laser diagnostic measurement capabilities with expanded agility over limited wavelength ranges for time-resolved characterization of reacting flows.

(U) $13,245 Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2308

(U) **C. Other Program Funding Summary ($ in Thousands)**
(U) Related Activities:
(U) PE 0602102F, Materials.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0603211F, Aerospace Structures.

(U) **D. Acquisition Strategy**
Not Applicable.

(U) **E. Schedule Profile**
(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2311

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2311 Space Sciences	16,293	15,123	15,654	16,268	16,446	19,670	17,984	18,235	Continuing	TBD

(U) A. Mission Description

Space Sciences research provides fundamental understanding of the space environment for optimum design of Air Force systems operating in near-Earth orbit, geosynchronous orbit, and deep space. The goal is to enable greater, more cost-affordable, protection of space assets from space debris, solar wind, solar flares, cosmic rays, and geomagnetic storms. Basic research focuses on specifying the flow of mass, momentum, and energy through space to develop a global model that connects solar activity with the deposition of energy at the Earth. The objective is to develop methods to forecast the turbulent plasma phenomena that mediate the flow of energy through space in order to enhance the effectiveness of Air Force global dominance through space operations. The primary areas of research investigated by this project are solar physics and astrophysical observation techniques, solar wind transport and magnetospheric physics, ionospheric physics and scintillation, energization processes in the Earth's radiation belts, and innovative science for space-based communications.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,652 Analyzed, characterized, and modeled solar phenomena for much better prediction of large-scale solar disruptions in the space environment, and to advance development of protective spacecraft structures and defensive operational techniques. Began obtaining high-resolution observations of solar plasma arcades, solar flares, and coronal mass ejections to establish the physical basis for solar disturbance models. Continued investigating sunspots, solar oscillation modes, and solar magnetic field spin states to enable forecasting of solar eruptions and predict environmental risks to critical Air Force space operations. Developed solar vector magnetographs using adaptive optics.

(U) $3,636 Studied solar wind effects on the Earth's magnetospheric and radiation belt energization processes and morphology. Enhanced space systems performance degradation models. Developed models that provide realistic coupling of the magnetosphere - ionosphere system. Conceived magnetohydrodynamic models to develop a theoretical understanding of magnetic reconnection and self-organized criticality in the magnetosphere.

(U) $4,367 Probed ionospheric scintillation and turbulence to enhance global surveillance, geolocation, and communication. Observed atmospheric gravity wave interactions from high-latitude and tropical observation sites using light detection and ranging techniques. Conducted airglow and auroral emission observations and characterize the chemical and physical dynamics of the mesosphere, thermosphere, and ionosphere to develop comprehensive seasonal and climatic maps of high-altitude phenomena.

(U) $2,910 Characterized the populations of space debris particles derived from comets and asteroids to predict threats to Air Force spacecraft. Provided a test bed for advanced deep space surveillance techniques through new astronomical instrumentation and observational methods. Expanded laser

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2311

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		guide-star development and observations of space backgrounds and optical signatures of orbital targets over the tropics. Researched the variable energy deposited in near-Earth space by cosmic rays and energetic particles from deep space to identify risks to Air Force systems.
(U)	$741	Researched space weather phenomena through the investigation of several solar variables observed from thousands of sun-like stars. Explored models detailing the evolution of our sun. Research supported through the Center for Solar Geophysical Interactions at the Mt. Wilson Observatory.
(U)	$987	Supported basic research and educational outreach projects at the California Science Center to assure the Air Force access to superior scientific and engineering talent in future years. Efforts included research to increase the fundamental understanding of atmospheric conditions, weather phenomena, and expanded into biological sensory systems.
(U)	$16,293	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,824	Observe and analyze solar phenomena to characterize and model the physics of solar magnetic fields for enhanced prediction of large-scale, high-energy plasma ejections in the space environment, to develop protective spacecraft structures and more robust designs. Explore technology requirements to enable development of a new ground-based Advanced Technology Solar Telescope to exploit adaptive optics techniques in solar observations. Continue investigating solar dynamo physics, solar oscillation modes, solar flares, coronal mass ejections, magnetic reconnection in space plasmas, and solar magnetic field complexity to enable forecasting of solar eruptions and predict environmental risks to critical Air Force space operations.
(U)	$3,824	Develop mitigation techniques for ionospheric scintillation and plasma turbulence radio disruptions to enhance global surveillance, geolocation, and communication. Support scientific analysis of space-based and ground-based data assimilation techniques to modernize ionospheric and space weather forecasting. Continue to observe atmospheric gravity wave interactions from high and low geomagnetic latitudes, as well as tropical observation sites, using radars, advanced electro-optical instrumentation, and light detection and ranging techniques in order to develop seasonal and climatic models of ionospheric phenomena.
(U)	$4,327	Predict threats to Air Force space assets by cataloging and tracking the populations of Near Earth Objects (NEOs) and space debris particles derived from comets and asteroids. Develop advanced astronomical instrumentation and observational methods to include laser ranging and adaptive optics for deep space surveillance. Explore laser guide-star development for observations of NEOs as well as ballistic and orbital targets. Exploit developments in astronomical detection and tracking algorithms for enhancement of DoD surveillance capability, and support observational campaigns to characterize the aerodynamic drag, turbulence, and optical clutter in the lower ionosphere that degrade DoD

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2311

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

		targeting.
(U)	$3,148	Provide theoretical development, physics-based modeling, and space observation support to the Air Force's Communications/Navigation Outage Forecast System and Solar Mass Ejection Imager satellite missions. Investigate the theoretical underpinnings of robust antenna designs for the space environment and charged particle remediation techniques. Investigate the variable energy deposited in near-Earth space by energetic charged particles from deep space and by cosmic rays to quantify risks to Air Force systems.
(U)	$15,123	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,928	Exploit solar physics models to develop techniques for protecting Air Force assets against high-energy plasma ejections in the space environment. Investigate impacts of terrestial events, e.g., seismic activities. Support cutting-edge instrumentation development for the ground-based Advanced Technology Solar Telescope. Continue to investigate solar flares, coronal mass ejections, magnetic reconnection in space plasmas, and solar magnetic field complexity through support of ground-based optical and radio solar observatories, as well as university and government teams managing space-based instruments. Define best-practices and commonality of algorithms used to model and simulate the space environment, focused on plug-and-play capability within next-generation computational architectures.
(U)	$2,928	Expand deployment of research sensors to observe ionospheric scintillation and worldwide plasma turbulence radio disruptions. Support scientific analysis of space-based and ground-based data assimilation techniques to modernize ionospheric and space weather forecasting. Design and examine observational equipment globally to improve capability to observe atmospheric gravity wave interactions with radars, and advance electro-optical instrumentation, and light detection and ranging techniques. Exploit cutting-edge developments in all-sky imaging optics to obtain sensitive infrared observations of ionospheric plasma physics, gravity waves, dynamics, and optical clutter.
(U)	$3,709	Develop advanced multi-conjugate adaptive optics for unparalleled resolution of small, dim, deep-space targets. Continue to characterize threats to Air Force space assets by cataloging and tracking the populations of Near Space Objects and space debris particles derived from comets and asteroids. Exploit developments in astronomical detection and tracking algorithms to enhance Air Force space awareness and control capabilities. Expand development of future space radar surveillance systems using nanotechnology and advanced signal processing algorithms.
(U)	$2,254	Continue to investigate the theoretical underpinnings of active and passive space environment remediation techniques. Exploit data from the Air Force's Communications/Navigation Outage Forecasting System and Solar Mass Ejection Imager satellite missions to create new space environment models and enhance current theories. Stimulate novel efforts to advance design, study, and development new sensor technologies to observe cosmic rays and energetic charged particles from deep space in order to better quantify risks to Air Force space systems. Research

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2311**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

		simulation and visualization techniques to simplify complex data analysis and ensure future strategic awareness.
(U)	$3,835	Investigate innovative technologies for space-based communication capabilities to ensure continued Air Force space dominance. Research innovative methods for optical communications. Probe novel techniques for potential bandwidth efficient modulation to enhance satellite communications. Explore the basic mechanisms of dual polarization antennas for space applications.
(U)	$15,654	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0602702F, Command, Control, and Communications.
(U) PE 0603410F, Space System Environmental Interactions Technology.
(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2312

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2312 Biological Sciences	13,535	14,005	14,352	14,720	14,879	18,072	15,389	15,621	Continuing	TBD

(U) A. Mission Description

Biological Science research provides the fundamental knowledge necessary to understand and enable technologies associated with chemical and physical agent toxicity, electromagnetic sensors based on biomimicry, biomolecular materials, biochromatics, and luminescence, as well as neuroscience and chronobiology. The goal is to exploit biological properties to control and manipulate operational environments. Research topics in toxicology explore the interaction of Air Force chemicals and physical agents (lasers and microwaves) with human tissues and associated effects to enable safety assessment strategies to ensure the hazard-free development and use of future aerospace materials and directed energy systems. Research in biomimetic sensors strives to mimic the biological detection systems of organisms at the molecular level in developing novel man-made sensors. Basic research in biocatalysis characterizes cellular enzymes that will catalyze the synthesis of chemical feedstocks used in the safe production of space and air materials. Research in neuroscience and chronobiology provides new strategies to maintain decisive awareness by preventing impaired operational performance due to jet lag and shift-work, night operations, and the loss of life and/or aircraft due to stress, inattention, or lack of vigilance. The primary areas of research investigated by this project are bioenvironmental sciences, biocatalysis, chronobiology and neural adaptation, and biomimetic sensors.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,632 Studied bioenvironmental sciences to investigate the biological effects of exposure to military aerospace chemicals and directed energy systems used by the military to assure the safety, health, and high performance of personnel before, during, and after mission-directed activities. Explored the molecular and cellular effects of JP-8 jet fuel on the lung, brain, skin, and immune system and continue to identify specific molecular pathways involved in eliciting and blocking toxic responses. Continued to develop reliable in vitro simulators of in vivo toxic responses and learn to use them to rapidly acquire and predict toxic profiles at a sub-cellular level. Continued to identify and quantify subtle, gene-induced effects of directed energy (microwaves and lasers) on cellular targets and determine the approximate exposure levels at which these effects are significant.

(U) $3,385 Researched biocatalysis to discover and characterize enzymes from living cells for use as biocatalysts to reduce cost, increase efficiency, and assure safety in chemical feedstocks synthesis for aerospace materials. Discovered, isolated, cloned, and sequenced genes of novel enzymes of use to the military. Biochemically characterized the enzymes and investigate their mechanisms of reaction, kinetics, substrate range, and specificity.

(U) $1,893 Performed chronobiology and neural adaptation research to examine the biological mechanisms responsible for crew fatigue, adaptation to the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2312**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

environment, and individual performance capabilities to improve skilled human performance. Continued to analyze the mechanism by which serotonin regulates the circadian clock. Research the effect of modafinil on preventing adverse performance effects without disrupting sleep. Further optimization of the combination of fatigue countermeasures such as optimally-timed rest periods and alertness promoting compounds.

(U) $1,625 Conducted biomimetic research to enable the development of novel sensors, engineering processes, and mechanisms. Investigated fundamental biological properties and processes of infrared sensitive biosystems at the cellular, sub-cellular, and molecular levels to enable the development of novel infrared materials and devices with enhanced structural and functional capabilities. Identified, isolated, and modeled alternate mechanisms of near ambient infrared sensing in biosystems to enable and/or enhance compact, room-temperature infrared sensors. Probed the functionality of alternative sensors for time-response characteristics. Investigated biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for application to military sensors.

(U) $13,535 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,536 Study bioenvironmental sciences to investigate the biological effects produced by exposure to air and space chemicals and directed energy systems used by the military to assure the safety, health, and high performance of the warfighter before, during, and after mission-directed activities. Continue to identify organ-specific molecular pathways altered by JP-8 jet fuel exposures and evaluate various biomolecular indicators and mediators of the toxic response for use as potential biomarkers of human exposure and to enable the development of protective strategies. Explore mechanisms and develop novel molecular descriptors that will help integrate in vitro toxicity data into a mathematical format for use in the rapid computational prediction of toxicity of air and space chemicals and new forms of directed energies. Investigate the biological effects of chronic low level exposures to directed energy by profiling and modeling intracellular molecular responses and identifying potentially harmful extra-cellular mediators.

(U) $3,661 Research biocatalysis to discover and characterize enzymes from living cells that can be used as biocatalysts to reduce cost, increase efficiency, and assure safety in the process of synthesizing chemical feedstocks used in the manufacture of aerospace materials. Continue the essential and fundamental process of enzyme discovery and characterization. Genetically modify the natural biocatalytic potential of enzymes to meet various synthetic manufacturing requirements by extending substrate ranges and specificities or altering reaction rates. Explore alternative metabolic engineering techniques for maintaining or enhancing reaction rates during large-scale production.

(U) $2,051 Investigate the biophysical mechanisms responsible for crew fatigue in sustained operations or in non-standard duty cycles and in adapting to jet lag. Test mathematical models of sleep/wake dynamics, including the effects of wake-promoting countermeasures on the homeostatic and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2312**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

circadian systems, and extend these models to predict specific deficits in human performance under conditions of sleep loss. Begin new research to identify the phenotypic differences that enable some individuals to maintain highly accurate cognitive and psychmotor performance under sleep deprivation.

(U) $1,757 Continue to conduct biomimetic research to enable the development of novel sensors, engineering processes, and mechanisms. Model the fundamental principles, processes, and designs of infrared sensitive biosystems at the sub-cellular, molecular and genomic levels to enable the further development of infrared materials, devices, and systems with enhanced structural and functional capabilities. Identify, model, and construct alternative biomimetic, near ambient infrared sensing devices. Probe and manipulate the functionality of alternative sensors for time-response characteristics. Adapt biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for applications to military sensor systems.

(U) $14,005 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,992 Investigate the biological effects produced by exposure to air and space chemicals and directed energy systems used by the military to assure the safety, health, and high performance of the warfighter before, during, and after mission-directed activities. Initiate a biokinetics study of the uptake, biodistribution, metabolism, and elimination of JP-8 fuel in animals exposed through the inhalation and skin routes as a first step in assessing the human health risks of jet fuels. Extend research on molecular descriptors and mathematical expression of in vitro toxicity data to include data from genomics and proteomics profiles to rapidly predict computationally the toxicity of air and space chemicals. Extend sensitive genomics and proteomics profiling techniques to studies investigating the cellular and extra cellular effects of chronic and acute low-level exposures of animals to laser and microwave systems.

(U) $3,607 Research biocatalysis to characterize and modify enzymes from living cells to use as biocatalysts in the process of synthesizing chemical feedstocks used in the manufacture of air and space materials to reduce cost, increase efficiency, and assure safety. Improve reaction rates and specificity of microbial oxygen-based enzymes to economically biosynthesize normally expensive reactants needed to manufacture of polymeric air and space materials. Begin developing approaches to identify unique bioenergetic enzymatic components from photosynthetic and/or microbial reaction pathways that may facilitate the development of novel biofuel cells to ensure future space access and continued operations. Further explore alternative metabolic techniques for maintaining or enhancing reaction rates during large-scale production either in the presence or absence of non-aqueous solvents.

(U) $2,021 Research the biophysical and neural mechanisms that determine human cognitive performance under conditions of sleep loss, sustained

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2312

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

operations, and non-standard sleep/wake duty cycles to ensure effective air and space persistence. Refine mathematical models of the interaction of homeostatic and circadian mechanisms to account for, and predict the effects of wake-promoting countermeasures on human performance. Develop science-based estimates for the use of caffeine, modafinil, light exposure, and naps. Continue to study genetic differences that make some individuals highly resistant, and others highly susceptible to sleep loss to develop future operational flexibility and persistence.

(U) $1,732 Enhance biomimetic research to enable developing novel sensors, engineering processes, and mechanisms for improved Air Force operations. Continue studying biomaterials and biointerfacial sciences to synthesize novel materials, prepare new biosensors, and exploit bionanotechnology. Model the fundamental principles, processes, and designs of noncryogenic infrared sensitive biosystems at the sub-cellular, molecular and genomic levels to enable the future infrared materials, devices, and systems with enhanced structural and functional capabilities to identify, model, and construct near ambient infrared sensing devices. Adapt characteristics of microbial and protein-based biosystems for applications to military sensor systems. Explore mimicking natural materials, using organisms as factories of new materials, or taking existing biomaterials and processing them into Air Force useful materials. Study the fundamental science and nano surface structure of biomaterials for application to military sensor systems that will ensure reliable assessment and monitoring.

(U) $14,352 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602202F, Human Effectiveness Applied Research.
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0602602F, Conventional Munitions.
(U) PE 0602702F, Command, Control, and Communication.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
01 - Basic Research	0601102F Defense Research Sciences	2313

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2313 Human Performance	14,097	12,700	12,776	12,218	12,337	15,489	12,767	12,958	Continuing	TBD

(U) A. Mission Description

Human Performance research provides the fundamental knowledge necessary to examine and exploit all aspects of human information processing critical to Air Force operations. The goal is to develop useful quantitative models of the way warfighters perceive, navigate, and manipulate their environment; make decisions in complex tasks under stress or uncertainty; and adapt to extreme sensory, biophysical, or cognitive workloads. Sensory research emphasizes visual, auditory, equilibrium, and kinesthetic systems and their optimal integration. Basic research topics focus investigations on the scientific foundation for nascent Air Force technologies including specialized interactive displays, simulators, intelligent control systems, sensors and fused-image displays, and adaptive systems for operator and team training. The primary areas of research investigated by this project are sensory and perceptual systems, cognition, and team performance.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,807 Performed sensory and perceptual system research to investigate sensory and perceptual systems to enhance human-machine interaction in Air Force weapon systems. Further developed theories for models of human-machine interaction in Air Force weapon systems. Critically assessed theories of visual search and scene analysis, and control of attention using measures of performance identified in several task domains. Developed models for perceptual and cognitive requirements for accurate simulation and for effective design of informative displays. Designed laboratory apparatus to test theories of sensory integration for image understanding.

(U) $5,355 Conducted cognition research to measure and analyze cognitive dimensions of human performance in complex command and control tasks with multiple crewmember interactions. Developed models of enhanced human performance aided or augmented by intelligent systems. Discovered and evaluate theories of training for operator and team effectiveness under stress and sustained operation.

(U) $4,935 Studied cognitive workload to validate behavioral and physiological measures of cognitive workload, alertness, and vulnerability to sleep loss in several domains of operator performance. Modeled relationships between individual skill differences and interactions with new training methodologies. Studied behavioral and physiological measures to avert human error in conditions of information overload and fatigue.

(U) $14,097 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2313

(U) A. Mission Description Continued

(U)	FY 2003 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$3,485	Perform sensory and perceptual system research to investigate sensory and perceptual systems to enhance human-machine interaction in Air Force weapon systems. Critically test theories of sensory and perceptual systems for enhanced human-machine interaction and sensor processing in Air Force weapon systems. Investigate novel methods for evaluating design options for visual displays used in scene analysis and command and control in several task domains. Evaluate theories and models of perception and cognition for accurate simulation and fused sensor processing. Using performance metrics, critically test theories of sensory integration for image understanding.
(U)	$4,771	Conduct cognition research to measure and analyze cognitive dimensions of human performance in complex command and control tasks with multiple crewmember interactions. Extend models of cognitive dimensions of human performance in complex command and control tasks to inform studies of automated decision making. Test models of enhanced human performance aided or augmented by intelligent systems. Determine mechanisms affecting training effectiveness for operator and team performance under stress and sustained operation.
(U)	$4,444	Study cognitive workload by using developed metrics to critically test behavioral and physiological theories of cognitive workload, alertness, and vulnerability to sleep loss in several domains of operator performance. Develop theories for modeled relationships between individual skill differences and interactions with envisioned training pedagogies. Determine behavioral and physiological measures to avert human error in conditions of information overload and fatigue.
(U)	$12,700	Total
(U)	FY 2004 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$3,468	Investigate sensory and perceptual systems to enhance human-machine interaction in Air Force weapon systems and to enable the capturing and exploiting of pertinent environment information. Critically investigate and model theories of sensory and perceptual systems. Explore visual information processing techniques to improve methods for evaluating display designs and enhance capability for collaboration and movement and sharing of information. Evaluate theories and models of perception and cognition for more accurate simulation and improved fusion of sensor data. Using performance metrics, critically test theories of sensory integration to understand complex images.
(U)	$4,813	Conduct research to model and assess cognitive dimensions of warfighter performance in complex command and control tasks including those involving multiple crewmember interactions. Extend models of the cognitive dimensions of human performance in complex command and control tasks to enable studies of automated decision-making and enhanced risk assessment and measured response. Test models for enhanced human performance aided or augmented by intelligent systems. Continue studies to determine mechanisms affecting training effectiveness for ensuring operator and team performance under stress and sustained operations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **2313**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U) $4,495 Study cognitive workload by using developed metrics to critically test behavioral and physiological theories of cognitive workload, alertness, and vulnerability to sleep loss in several domains of operator performance. Develop theories for modeled relationships between individual skill differences and interactions with envisioned training techniques. Determine behavioral and physiological measures to avert human error in conditions of information overload and fatigue and maintain full spectrum air and space vigilance.

(U) $12,776 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602202F, Human Effectiveness Applied Research.

(U) PE 0602702F, Command, Control, and Communication.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
01 - Basic Research	0601102F Defense Research Sciences	4113

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4113 External Research Programs Interface	6,321	7,205	7,409	7,605	7,403	7,748	7,708	7,827	Continuing	TBD

(U) A. Mission Description

External research programs interface optimizes interactions between the international and domestic research communities and U.S. Air Force researchers. These professional interchanges and collaborations stimulate scientific and engineering education beneficial to the Air Force, increase the awareness of Air Force basic research priorities, and attract talented scientists and engineers to address Air Force needs. International interactions ensure future interoperability of coalition systems and foster relationships with future coalition partners. Projects also seek to enhance educational interactions with historically black colleges and universities, Hispanic serving institutions, and minority institutions. The primary elements of this effort are international strategy, international technology liaison, and scientist and engineer research interchange.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,084 Supported the Air Force Research Laboratory international strategy mission to provide centralized international expertise to assist in the formulation of optimal cooperation with, and leveraging of, foreign science programs to the benefit of the Air Force. Provided the primary interface with Office of the Secretary of Defense, the Office of the Secretary of the Air Force, and Air Force Materiel Command to coordinate international participation among appropriate U.S. Department of Defense organizations.

(U) $2,466 Supported international technology liaison missions to identify unique international research capabilities, and make them available to the U.S. Air Force. Used the European Office of Aerospace Research and Development and the Asian Office of Aerospace Research and Development to provide on-site coordination with international research organizations, and support international visits of high-level Department of Defense delegations. Sustained and funded Air Force commitment to NATO-affiliated research institutes, such as the Von Karman Institute.

(U) $1,771 Supported scientist and engineer exchange efforts to assure the Air Force of continuing availability of superior scientific and engineering talent by supporting exceptional individuals and forging relationships between premier scientists and the Air Force Research Laboratory. Improved awareness of Air Force research needs throughout the civilian scientific community while simultaneously identifying and recruiting the best scientific talent to participate in critical Air Force research.

(U) $6,321 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 4113

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,384	Support the Air Force Research Laboratory international strategy mission to provide centralized international expertise to assist formulation of optimal cooperation with, and leveraging of, foreign science programs to the benefit of the Air Force. Provide the primary interface with the Office of the Secretary of Defense, the Office of the Secretary of the Air Force, and the Air Force Materiel Command to coordinate international participation among appropriate U.S. Department of Defense organizations.
(U)	$2,813	Support international technology liaison missions to identify unique international research capabilities, and make them available to the U.S. Air Force. Through the European Office of Aerospace Research and Development and the Asian Office of Aerospace Research and Development provide on-site coordination with international research organizations and support international visits of high level Department of Defense delegations. Sustain and fund Air Force commitment to NATO-affiliated research institutes, such as the Von Karman Institute.
(U)	$2,008	Support scientist and engineer education at U.S. colleges and universities, including historically black colleges and universities and minority institutions, to assure the Air Force of continuing availability of superior scientific and engineering talent by supporting exceptional individuals and forging associateships between premier scientists and the Air Force Research Laboratory. Improve awareness of Air Force research needs throughout the civilian scientific community while simultaneously identifying and recruiting the best scientific talent to participate in critical Air Force research.
(U)	$7,205	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,458	Support the Air Force Research Laboratory international strategy mission. Provide centralized international expertise to assist formulation of optimal cooperation with, and leveraging of, foreign science programs to the benefit of the U.S. Air Force. Provide the primary interface with the Office of the Secretary of Defense, the Office of the Secretary of the Air Force, and the Air Force Materiel Command to coordinate international participation among appropriate U.S. Department of Defense organizations.
(U)	$2,866	Support international technology liaison missions. Identify unique international research capabilities making them accessible to the U.S. Air Force. Through the European Office of Aerospace Research and Development and the Asian Office of Aerospace Research and Development, provide on-site coordination with international research organizations and support international visits of high-level Department of Defense delegations. Sustain and fund Air Force commitment to NATO-affiliated research institutes, such as the Von Karman Institute.
(U)	$2,085	Support scientist and engineer education research programs at U.S. colleges and universities, including historically black colleges and universities, Hispanic serving institutions, and minority institutions. Assure the Air Force of continued superior scientific and engineering talent

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601102F Defense Research Sciences**	PROJECT **4113**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

by supporting exceptional individuals and forging associations between premier scientists and the Air Force Research Laboratory. Improve awareness of Air Force research needs throughout the civilian scientific community while simultaneously identifying and recruiting the best scientific talent to participate in critical Air Force research.

(U) $7,409 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0601103D, University Research Initiative.
(U) PE 0602102F, Materials.
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602202F, Human Effectiveness Applied Research.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602204F, Aerospace Avionics.
(U) PE 0602269F, Hypersonic Technology Program.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0602602F, Conventional Munitions.
(U) PE 0602702F, Command, Control and Communication.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
01 - Basic Research	0601103F University Research Initiatives	5094

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5094	University Research Initiatives	0	0	105,224	116,169	110,392	110,500	110,974	112,845	0	0
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

Note: In FY 2004, the Office of the Secretary of Defense transferred this program to the Air Force.

(U) **A. Mission Description**

This program supports defense-related basic research in a wide range of scientific and engineering disciplines pertinent to maintaining U.S. military technology superiority; enhances and promotes the education of U.S. scientists and engineers in disciplines critical to maintaining, advancing, and enabling future U.S. defense technologies; and assists universities in establishing superior instrumentation capabilities needed to improve the quality of defense-related research and education. A fundamental component of this program is the recognition that future technologies and technology exploitations require highly coordinated and concerted multi- and interdisciplinary efforts. Competitive awards are selected from universities nationwide and provided to students pursuing these ends. These efforts are subject to long-range planning and technical review by both Air Force and tri-Service planning groups, and the Office of the Director of Defense Research and Engineering provides oversight.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program.
(U) $0 No Activity; previously managed by OSD.
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program.
(U) $0 No Activity; previously managed by OSD.
(U) $0 Total

(U) FY 2004 ($ in Thousands)
(U) $0 Accomplishments/Planned Program.
(U) $53,954 Issue competitive awards to universities to promote inter- and multi-disciplinary, often multi-university, science and engineering projects focused on enabling Air Force-related technologies usually not achievable through typical single investigator awards. Topics for the FY 2004 multi-disciplinary research competition will be selected in strategic basic research areas related to transformational and high priority

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601103F University Research Initiatives	PROJECT 5094

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

technologies, such as nanotechnology, biomimetic sensor networks, intelligence information fusion, smart materials and structures, efficient energy and power conversion, high energy materials for propulsion and control, enhancing human performance, and improving research related to student training in instrumentation development. Multi-disciplinary programs begun in prior years under centralized Department of Defense funding will be continued.

(U) $35,705 Promote academic excellence in post-graduate, graduate, and undergraduate education in science and engineering disciplines necessary to enable and exploit technologies to ensure superiority of U.S. defense applications. Approximately 190 graduate fellowships will be awarded as part of the FY 2004 National Defense Science and Engineering Graduate Fellowship Program. These fellowships are awarded under a joint tri-Service and Office of the Director of Defense Research and Engineering competition. Support competitive awards for graduate and undergraduate research experiences including those established under the Awards to Stimulate and Support Undergraduate Research Education program. Promote and advance recognition of superior academic research under Federal programs such as the Presidential Early Career Award for Scientists and Engineers. Funding for awards made under prior year Department of Defense programs will be continued.

(U) $15,565 Stimulate, advance, and enhance U.S. defense-related research and research education at universities through competitive awards for high technology infrastructure and instrumentation. Conduct the FY 2004 competition for unique capability, high technology instrumentation assistance under the Defense University Research Instrumentation Program. A key element of these awards is the multi-functional utilization of the instrumentation for both educational as well as research applications.

(U) $105,224 Total

(U) B. Budget Activity Justification

This program is Budget Activity 1, Basic Research, because it funds scientific study and experimentation. Through this program, the Air Force invests in research directed towards increasing knowledge and understanding in those fields of science and engineering related to long-term national security needs.

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

	FY 2002	FY 2003	FY 2004	Total Cost
(U) Previous President's Budget				
(U) Appropriated Value				
(U) Adjustments to Appropriated Value				
a. Congressional/General Reductions				
b. Small Business Innovative Research				
c. Omnibus or Other Above Threshold Reprogram				

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

DATE
February 2003

BUDGET ACTIVITY
01 - Basic Research

PE NUMBER AND TITLE
0601103F University Research Initiatives

PROJECT
5094

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

	FY 2002	FY 2003	FY 2004	Total Cost
d. Below Threshold Reprogram				
e. Rescissions				
(U) Adjustments to Budget Years Since FY 2003 PBR			105,224	
(U) Current Budget Submit/FY 2004 PBR			105,224	

(U) Significant Program Changes:
This program is part of the Office of the Secretary of Defense program management divestiture. Air Force program management begins in FY 2004.

(U) D. Other Program Funding Summary ($ in Thousands)
(U) Related Activities:
PE 0601102F, Defense Research Sciences.

(U) E. Acquisition Strategy
Not Applicable.

(U) F. Schedule Profile
(U) Not Applicable.

THIS PAGE INTENTIONALLY LEFT BLANK

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003

BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601108F High Energy Laser Research Initiatives	PROJECT 5097

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5097	High Energy Laser Research Initiatves	0	0	12,063	12,363	12,501	12,742	12,878	13,076	0	0
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

Note: In FY 2004, this program was transferred to the Air Force by the Office of the Secretary of Defense. The Air Force plans to continue the tri-Service operation of the program under the High Energy Laser (HEL) Joint Technology Office (JTO).

(U) A. Mission Description

This program funds basic research aimed at developing fundamental scientific knowledge to support future DOD HEL systems. HEL weapon systems have many potential advantages, including speed-of-light velocity, high precision, nearly unlimited magazine depth, low-cost per kill, and reduced logistics requirements since there is no need for stocks of munitions or warheads. As a result, HELs have the potential to perform a wide variety of military missions, including some that are impossible, or nearly so, for conventional weapons. These include interception of ballistic missiles in boost phase; defeat of high-speed, maneuvering anti-ship and anti-aircraft missiles; and the ultra-precision negation of targets in urban environments with no collateral damage. This program is part of an overall DOD initiative in HEL science and technology being conducted by the HEL JTO. Efforts funded under this program element are chosen for their potential to have a major impact on multiple HEL systems and on multiple Service missions. A broad range of technology is addressed in key areas such as chemical lasers, solid state lasers, beam control, optics, propagation, and free electron lasers. Research is conducted principally by universities, but also by Government laboratories and industry. The program funds theoretical, computational, and experimental investigations.

(U) FY 2002 ($ in Thousands)
(U) $0 This activity was performed under PE 0601108D8Z, High Energy Laser Initiative. Funding was approximately $11.8 million.
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 This activity is performed under PE 0601108D8Z, High Energy Laser Initiative. Funding is approximately $12.1 million.
(U) $0 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601108F High Energy Laser Research Initiatives	PROJECT 5097

(U) A. Mission Description Continued

(U)	FY 2004 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$2,320	Conduct fundamental research in solid state lasers. Achieving the promise of simplified logistics and platform integration requires that cost, power, and efficiency barriers be breached. Research areas of interest include laser materials with large fluorescence lifetime and cross-section and the ability to operate at high temperatures, athermal laser gain media, modular and scalable architectures for laser power scaling, means of increasing efficiency in excess of 20%, operation in harsh environments, and corrections for thermally induced distortions in gain media. Pursuant to the nature of the university-led multidisciplinary research initiative program, all of the efforts to address the above research areas begun during FY 2002 will continue to receive funding.
(U)	$1,910	Conduct fundamental research in high-power, lightweight optics. This research focuses on technology development that addresses advanced technological elements and concepts relevant to the development of lightweight optics for high energy laser (HEL) systems. Areas of interest include basic materials and fabrication techniques, large optics lightweight structure and deployment concepts, HEL optical coatings, multipurpose materials (e.g., wavefront correction combined with aperture adjustment), and control mechanisms. Pursuant to the nature of the university-led multidisciplinary research initiative program, all of the efforts to address the above research areas begun during FY 2002 will continue to receive funding.
(U)	$3,313	Conduct research focused on the scientific concerns associated with atmospheric beam control including characterization efforts in aerial, battlefield, and maritime-like environments. These efforts could lead to substantial increases in the lethality of HEL systems without the need for ever-higher power levels. Areas of interest include improved theoretical and computer-based analysis of propagation effects, advanced wavefront sensing and reconstruction (especially in the presence of thermal blooming), and the effects of extended reference sources used for wavefront correction. Pursuant to the nature of the university-led multidisciplinary research initiative program, all of the efforts to address the above research areas that were begun during FY 2002 will continue to receive funding.
(U)	$1,210	Conduct fundamental research in chemical lasers. This research focuses on improving the understanding of the processes necessary for the realization of truly closed cycle, lightweight, high-power, continuously operating chemical lasers. Areas of interest include studies of chemical processes and reactions for a closed-cycle chemical laser system, new sources of the high-energy chemical species needed to produce the lasing event, and novel recovery systems for regeneration of the laser fuels. Pursuant to the nature of the university-led multidisciplinary research initiative program, all of the efforts to address the above research areas that were begun during FY 2002 will continue to receive funding.
(U)	$1,810	Conduct fundamental research in high-average-power ultra-short-pulse free electron lasers (FELs). This research will significantly advance the average power obtainable by ultra-short-pulse FELs, while decreasing relative size and cost. Areas of interest include high-current devices and control methods, higher damage threshold resonator optics, advanced optical cavity designs for high power and compact spaces, and design methods for scaling FELs to reach multi-megawatt class average power levels. Pursuant to the nature of the university-led multidisciplinary

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003	
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601108F High Energy Laser Research Initiatives**	PROJECT **5097**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

research initiative program, all of the efforts to address the above research areas that were begun during FY 2002 will continue to receive funding.

(U) $1,500 Conduct fundamental research in modeling and simulation for high energy lasers (HELs). The initial focus achieves a balance between ongoing high-fidelity technical analyses, engineering trade studies which allow analyses of a wide range of systems, and analyses of HEL systems' military utility in a broad range of missions. Pursuant to the nature of the university-led multidisciplinary research initiative program, all of the efforts to address the above research areas that were begun during FY 2002 will continue to receive funding.

(U) $12,063 Total

(U) B. Budget Activity Justification

This program is Budget Activity 1, Basic Research, because it funds scientific study and experimentation. Through this program, the Air Force invests in research directed toward increasing knowledge and understanding in those fields of science and engineering related to long-term national security needs.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	0	0	0	
(U)	Appropriated Value				
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions				
	b. Small Business Innovative Research				
	c. Omnibus or Other Above Threshold Reprogram				
	d. Below Threshold Reprogram				
	e. Rescissions				
(U)	Adjustments to Budget Years Since FY 2003 PBR			12,063	
(U)	Current Budget Submit/FY 2004 PBR			12,063	

(U) Significant Program Changes:

In FY 2004, this program was transferred to the Air Force by the Office of the Secretary of Defense. The Air Force plans to continue the tri-Service operation of the program under the HEL Joint Technology Office (JTO).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY **01 - Basic Research**	PE NUMBER AND TITLE **0601108F High Energy Laser Research Initiatives**	PROJECT **5097**

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

(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602890F, High Energy Laser Research.
(U) PE 0603444F, Maui Space Surveillance System.
(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.
(U) PE 0603605F, Advanced Weapons Technology.
(U) PE 0603924F, High Energy Laser Advanced Technology Program.
(U) PE 0603883C, Ballistic Missile Defense Boost Phase Segment.
(U) PE 0602605F, Directed Energy Technology.
(U) PE 0602307A, Advanced Weapons Technology.
(U) PE 0602114N, Power Projection Applied Research.
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) E. Acquisition Strategy

Not Applicable.

(U) F. Schedule Profile

(U) Not Applicable.

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

DATE **February 2003**

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602102F Materials

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	96,064	106,955	68,657	68,283	70,539	75,917	77,926	75,504	Continuing	TBD
4347	Materials for Structures, Propulsion, and Subsystems	60,490	66,493	38,879	37,461	39,409	44,026	45,133	41,954	Continuing	TBD
4348	Materials for Electronics, Optics, and Survivability	14,686	18,552	11,317	11,692	11,850	12,176	12,523	12,808	Continuing	TBD
4349	Materials Technology for Sustainment	19,501	17,212	16,343	16,725	16,823	17,200	17,691	18,099	Continuing	TBD
4915	Deployed Air Base Technology	1,387	3,422	2,118	2,405	2,457	2,515	2,579	2,643	Continuing	TBD
5015	Rocket Materials Technology	0	1,276	0	0	0	0	0	0	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

Note: In FY 2002, Project 4915, Deployed Air Base Technology, efforts were transferred from PE 0602201F, Project 4397. In FY 2003, space unique tasks in Projects 4347 and 4348 were transferred to PE 0602500F, Project 5025, Space Materials Development, as a result of the Space Commission recommendation to consolidate all space unique activities. In FY 2004, space unique tasks in Project 5015 will be transferred to PE 0602500F, Project 5025, as a result of the Space Commission recommendation to consolidate all space unique activities.

(U) **A. Mission Description**

The Materials program develops advanced materials and processing technologies to reduce life cycle costs and improve performance, affordability, supportability, reliability, and survivability of current and future Air Force systems. The program has four projects which: (1) develop structural, propulsion, and sub-systems materials and processes technologies; (2) develop electronic, optical, and survivability materials and processes technologies; (3) develop sustainment materials and processes technologies; and (4) develop air base operations technologies including power generation, deployable shelters, and fire fighting. Note: In FY 2003, Congress added $6.0 million for the Strategic Partnership for Nanotechnology Research, $5.3 million for the Metals Affordability Initiative, $4.4 million for titanium matrix composites, $3.25 million for nanostructured materials, $2.8 million for durable coatings for aircraft systems, $1.3 million for thermal management for military aircraft and space structures, $1.25 million for cost-effective composite materials for unmanned aerial vehicles, $1.0 million for closed cell foam material, $1.0 million

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602102F Materials

(U) A. Mission Description Continued

for environmentally sound aircraft coatings, $1.0 million for nanostructured protective coatings, $0.5 million for composite materials training program, $3.4 million for advanced wide bandgap materials technology, $2.1 million for free electron laser materials processing, $1.1 million for advanced materials deposition for semiconductor nanotechnology, and $1.2 million for Tyndall Air Force Research Laboratory. This explains the perceived overall decrease in FY 2004 and out.

(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 technologies.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	97,989	75,272	77,104	
(U)	Appropriated Value	98,564	110,872		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-575	-3,623		
	b. Small Business Innovative Research	-1,456			
	c. Omnibus or Other Above Threshold Reprogram		-294		
	d. Below Threshold Reprogram				
	e. Rescissions	-469			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-8,447	
(U)	Current Budget Submit/FY 2004 PBR	96,064	106,955	68,657	TBD

(U) Significant Program Changes:

In FY 2003, space unique efforts in Projects 4347 and 4348 were transferred to PE 0602500F, Project 5025, Space Materials Development, as a result of the Space Commission recommendation to consolidate all space unique activities. In FY 2004, space unique efforts in Project 5015 are transferred to PE 0602500F, Project 5025, as a result of the Space Commission recommendation to consolidate all space unique activities. In addition, in FY 2003, this program received Congressional Adds, which explains the perceived decrease in FY 2004.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602102F Materials	4347

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4347 Materials for Structures, Propulsion, and Subsystems	60,490	66,493	38,879	37,461	39,409	44,026	45,133	41,954	Continuing	TBD

Note: In FY 2003, space unique tasks in Project 4347 were transferred to PE 0602500F, Project 5025, as a result of the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

Develops materials and processing technology base for aircraft and missiles to improve affordability, maintainability, and performance of current and future Air Force systems. Advanced thermal protection materials are being developed that are affordable, lightweight, dimensionally stable, thermally conductive, and/or ablation and erosion resistant to meet aerospace and missile requirements. A family of affordable lightweight materials is being developed, including metals, polymers, ceramics, metallic composites, and nonmetallic composites to provide upgraded capabilities for existing aircraft, missile, and propulsion systems to meet the future system requirements. Develops high-temperature turbine engine materials that will enable engine designs to double the turbine engine thrust to weight ratio. Alternative or replacement materials are being developed to maintain the performance of aging operational systems. Friction and wear-resistant materials, paints, coatings, and other pervasive nonstructural materials technologies are being developed for propulsion and subsystems on aircraft, spacecraft, and missiles. Concurrently develops advanced processing methods to enable adaptive processing of aerospace materials. Note: In FY 2003, Congress added $6.0 million for the Strategic Partnership for Nanotechnology Research, $5.3 million for the Metals Affordability Initiative, $4.4 million for titanium matrix composites, $3.25 million for nanostructured materials, $2.8 million for durable coatings for aircraft systems, $1.3 million for thermal management for military aircraft and space structures, $1.25 million for cost-effective composite materials for unmanned aerial vehicles, $1.0 million for closed cell foam materials, $1.0 million for environmentally sound aircraft coatings, $1.0 million for nanostructured protective coatings, and $0.5 million for composite materials training program. These adds explain the perceived decrease in FY 2004 and out.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $8,110 Developed enabling polymeric materials for diverse aerospace structural applications including spacecraft mirror applications, enhanced aircraft canopies, micromechanical devices, and advanced wiring concepts. Evaluated toughened and nanostructured polymers as temperature resistant in Air Force aircraft and space applications. Demonstrated and verified new methods for rapid fabrication of micron three-dimensional structures for Air Force micromechanical devices. Demonstrated use of hybrid thin wires for aircraft and spacecraft applications. Investigated feasibility of flexible, higher efficiency polymeric fibers for photovoltaic advanced solar cells. Optimized light-absorbing polymeric materials for incorporation into paint formulations for corrosion characterization applications.

(U) $13,800 Developed affordable, advanced organic matrix composite structural materials and technologies for Air Force systems applications including

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4347**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

lightweight structures requiring thermal and/or structural management for environmental control. Scaled-up and published demonstrated processing and/or mechanics models which predict component dimensions improving low-observability and affordability for large integrated structures for future Air Force air platforms. Investigated specific composite material degradation mechanisms to improve life prediction for aircraft environmental control systems and hot, exhaust-washed structures and engine components. Evaluated next generation high temperature organic matrix composites for air and space platforms. Evaluated non-autoclave materials and processes for composite cryogenic tank structures for future space platforms. Processed and fabricated novel product foams such as nanomaterials, nanotubes, and carbon foams for lightweight, tough, and affordable structural materials.

(U) $10,570 Developed and transitioned nonstructural materials for fluids, lubricants, aircraft topcoat, and corrosion resistant coatings and specialty treatments to improve system performance and reduce life cycle costs. Tested optically tailorable thermal control coatings with controlled heat dissipation for spacecraft thermal control. Evaluated effects of the space environment on polymer and thermal control coatings. Explored electrically conductive elastomers for use in low-observable gap treatments. Established baseline analytical techniques to predict the optical properties of specialty coatings. Processed permanent corrosion resistant primer resins and environmentally safe corrosion protection with a 30-year life for aircraft surfaces. Identified nanostructured multifunctional coatings to control friction and wear in extreme operating environments. Evaluated surface treatments for friction, stiction, and wear control in micro-scale devices and micromechanical applications.

(U) $24,005 Developed and transitioned affordable lightweight metallic materials, behavior and life prediction technologies, higher temperature intermetallic alloys, and metals processing technology to enhance performance, lower acquisition costs, increase durability, and improve reliability for weapon systems. Demonstrated life prediction methodology and surface treatments needed to prevent High Cycle Fatigue damage in integrally bladed rotors. Characterized high temperature metallic alloys with the potential of achieving a 300°F temperature capability increase over current turbine blade materials. Refined damage-tolerant life prediction methodologies for high temperature resistant titanium alloy for their use in fracture-critical turbine engine applications. Developed advanced affordable process technologies to enable more affordable production of complex structural metal components for air and space vehicles. Developed processing methods for the metallic materials for lightweight, high-strength components in future space vehicles.

(U) $4,005 Developed ceramics and ceramic matrix composite technologies for enhanced performance and supportability improvements in advanced propulsion systems and high temperature aerospace structures. Evaluated ceramic composites for exhaust and hot section components under real and simulated service life conditions, with a focus toward life prediction and durability assessment. Developed highly durable thermal protection materials for aerospace vehicles with aircraft-like operability. Developed ceramic composites for lightweight space mirror applications. Identified best performing aircraft brake material and performed full-scale dynamometer tests. Optimized radar absorbing material coating repair for superalloy and/or titanium alloy substrates. Evaluated advanced oxidation-resistant interface coatings in severe applications. Initiated the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4347**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

development of more durable ceramic composites based on these new coatings.

(U) $60,490 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $9,560 Develop enabling polymeric materials for diverse aerospace structural applications including enhanced aircraft canopies, micromechanical devices, advanced wiring concepts, and improved low-observable platforms. Demonstrate feasibility of nanostructured materials for temperature-resistant applications and evaluate applicability for gas and fluid containment components for pervasive Air Force aerospace subcomponent applications. Demonstrate and transition new methods for rapid fabrication of micron-scale three-dimensional structures for Air Force micromechanical devices. Demonstrate and transition use of hybrid thin wires for Air Force aerospace component applications. Demonstrate light-absorbing polymeric materials for incorporation into paint formulations for corrosion characterization applications. Investigate new methods for room temperature cure of resins for advanced Air Force composite applications. Evaluate the use of conductive materials for low-observable gap sealants in Air Force aircraft applications.

(U) $13,912 Develop affordable, advanced organic matrix composite structural materials and technologies for Air Force systems applications including lightweight structures for aerospace subcomponents and other structures requiring thermal and/or structural management for environmental control. Develop composite material degradation mechanisms to improve life prediction for aircraft environmental control systems, hot exhaust-washed structures, and engine components. Develop next generation high temperature organic matrix composites for aerospace platforms. Continue processing and fabrication of novel product foams such as nanomaterials, nanotubes, and carbon foams for lightweight, tough, and affordable structural materials.

(U) $11,234 Develop and transition nonstructural materials for fluids, lubricants, aircraft topcoat and corrosion resistant coatings, and specialty treatments to improve system performance and reduce life-cycle costs. Develop electrically conductive elastomers for use in electrostatic discharge control gap treatments. Develop advanced analytical techniques to predict the optical properties of specialty coatings. Test permanent corrosion-resistant primer resins and environmentally safe corrosion protection with a 30-year life. Establish baseline for nanostructured multifunctional coatings to control friction and wear in extreme environments. Develop surface treatments for friction, stiction, and wear control in micro-devices.

(U) $26,493 Develop and transition affordable lightweight metallic materials, behavior and life prediction technologies, higher temperature intermetallic alloys, and metals processing technology to enable enhanced performance, lower acquisition costs, increased durability, and improved reliability for Air Force weapon systems. Transition life prediction methodology and surface treatments needed to prevent High Cycle Fatigue damage in

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602102F Materials	PROJECT 4347

(U) **A. Mission Description Continued**

(U) FY 2003 ($ in Thousands) Continued

integrally bladed rotors. Develop processing methods for second-generation alloys with the potential of achieving a 300°F temperature capability increase over current turbine blade materials. Develop computational methods for modeling the mechanical properties of specific metallic alloys. Optimize and transition advanced affordable process technologies to enable more affordable production of complex structural metal components for Air Force aerospace vehicles.

(U) $3,260 Develop ceramics and ceramic matrix composite technologies for revolutionary performance and supportability improvements in advanced propulsion systems and high temperature aerospace structures. Test advanced ceramic composites for exhaust and hot section components under real and simulated service life conditions, using the data for durability assessment and life prediction development. Demonstrate highly durable thermal protection materials for aerospace vehicles with aircraft-like operability through hot acoustic and other specialized testing. Demonstrate radar absorbing material coating repair for superalloy and/or titanium alloy substrates. Evaluate more durable ceramic composites based on emerging fibers and advanced interface coatings.

(U) $2,034 Develop and transition materials processing technologies involving process models, multi-objective optimization methods, and advanced non-invasive sensors. Investigate the feasibility of using evanescent microwave or inelastic photon (Raman) imaging of the surface and near-surface region as a process sensor. Evaluate new techniques for generating large-scale dynamic and phase behavior simulations for nanomaterial process design. Transition an interactive design-manufacturing environment which allows rapid design interaction between multiple sites over the Internet. Demonstrate high-power, tunable laser processing tool for micro-engineered aerospace components and subsystems.

(U) $66,493 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,608 Develop enabling polymeric materials for diverse aerospace structural applications including enhanced aircraft canopies, micromechanical devices, advanced wiring concepts, and improved low-observable platforms. Test clay infiltrated nanostructured polymeric materials for impermeability of gas and fluids. Develop rapid fabrication of nanoscale three-dimensional structures for Air Force electromechanical devices. Test hybrid thin wires under rigorous environmental conditions and extreme mechanical stresses. Transition light-absorbing polymer materials for corrosion characterization applications. Develop the curing process for and initiate testing of composites containing advanced resins. Demonstrate the use of nanostructured polymer materials for low-observable applications.

(U) $7,710 Develop affordable, advanced organic matrix composite structural materials and technologies for Air Force systems applications including lightweight structures for aerospace subcomponents and other structures requiring thermal and/or structural management for environmental

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4347**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

control. Continue to develop understanding of degradation mechanisms and life prediction capabilities for aircraft turbine engine and exhaust-washed structures as a function of their environments. Validate materials, processing, and fabrication scale-up of high-temperature organic matrix composites for turbine engine and aircraft applications. Evaluate nanomaterials technologies for multifunctional properties required by military aircraft. Evaluate innovative carbon materials, such as carbon foams, and processing techniques for aircraft thermal management applications.

(U) $7,105 Develop and transition nonstructural materials for fluids, lubricants, aircraft topcoat and corrosion-resistant coatings, and specialty treatments to improve system performance and reduce life-cycle costs. Formulate the most promising electrically conductive elastomers for specific electrostatic discharge control gap treatments. Continue to develop advanced analytical techniques to predict the optical properties of specialty coatings. Demonstrate non-chromate surface treatments with advanced performance coatings for aircraft corrosion protection systems. Develop environmentally friendly corrosion protection systems with a 30-year life expectancy. Evaluate nanostructured multifunctional coatings to control friction and wear in extreme environments. Refine candidate surface treatments for friction, stiction, and wear control in micro-devices. Investigate potential health monitoring techniques for hydraulic fluids and related subsystems to extend aircraft life and establish condition-based maintenance procedures. Identify materials technologies suitable for use in secure and/or tamper resistant electronics.

(U) $16,441 Develop and transition affordable lightweight metallic materials, behavior and life prediction technologies, higher temperature intermetallic alloys, and metals processing technology to enable enhanced performance, lower acquisition costs, increased durability, and improved reliability for Air Force weapon systems. Initiate development of new life prediction technologies for improving aircraft turbine engine rotor durability in thermal-mechanical fatigue design systems. Continue to develop and analyze second-generation high-temperature structural materials that are Nickel (Ni) and Molybdenum (Mo) based for turbine engine applications. Demonstrate computational methods for modeling mechanical properties of metals and alloys and validate these tools so that they can be used to reduce the amount of proof testing required to release metals for final component production. Identify processes and protocols for unitized manufacturing of aerospace components.

(U) $2,410 Develop ceramics and ceramic matrix composite technologies for revolutionary performance and supportability improvements in advanced propulsion systems and high-temperature aerospace structures. Design advanced ceramics and ceramic composites with improved durability and fracture resistance for aircraft applications. Develop advanced analytical techniques to predict the life of advanced ceramic composites containing stress concentration sites. Develop advanced analytical models to design integrally woven, actively cooled ceramic composite structures for advanced combustor applications. Design advanced ceramic composites for severe environments using the best available fiber-matrix interface technology.

(U) $2,605 Develop and transition materials processing technologies involving process models, multi-objective optimization methods, and advanced non-invasive sensors. Validate the use of evanescent microwave sensors for evaluating laser damage and subsurface corrosion. Establish

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4347**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

baseline parameters for selected techniques for generating large-scale dynamic and phase behavior simulations for nanomaterial process design. Investigate process control of optical deposition for scale-up and stress control of optical and multi-functional coatings.

(U) $38,879 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0603112F, Advanced Materials for Weapon Systems.
(U) PE 0603211F, Aerospace Technology Dev/Demo.
(U) PE 0603202F, Aerospace Propulsion Subsystems Integration.
(U) PE 0603216F, Aerospace Propulsion and Power Technology.
(U) PE 0602500F, Multi-Disciplinary Space 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 February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	**0602102F Materials**	**4348**

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4348 Materials for Electronics, Optics, and Survivability	14,686	18,552	11,317	11,692	11,850	12,176	12,523	12,808	Continuing	TBD

Note: In FY 2003, space unique tasks in Project 4348 were transferred to PE 0602500F, Project 5025, as a result of the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

Develops materials technologies for surveillance and terrestrial situational awareness systems and subsystems for aircraft and missile applications. Develops materials for protection of aircrews, sensors, and aircraft from laser and high-power microwave directed energy threats. Develops sensor modules, microwave devices, infrared detectors, and infrared countermeasures devices that are used in target detection, weapons targeting, electronic warfare, and active aircraft protection. Electronic and optical materials are being developed to enable surveillance and terrestrial situational awareness with faster operating speeds, greater tunability, higher power output, improved thermal management (including higher operating temperatures), greater sensitivity, and extended dynamic range. New materials are being developed to counter the most prominent laser threat wavelengths, to respond to emerging threat wavelengths, and to reject the directed energy of agile threat wavelengths without impairing mission effectiveness. Note: In FY 2003, Congress added $3.4 million for advanced wide bandgap materials technology, $2.1 million for free electron laser materials processing, and $1.1 million for advanced materials deposition for semiconductor nanotechnology, which explains the perceived decrease in FY 2004.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $8,009 Developed and demonstrated materials and process technologies for power generation, power control, and microwave components to provide improved performance, affordability, and operational capability for surveillance, tracking, targeting, situational awareness, and lethal and non-lethal weapon systems. Developed and demonstrated materials and materials processing technologies to enable increased power generation and power control components reliability and temperature capability while reducing power consumption, weight, cost, cooling, complexity, and size. Developed and demonstrated materials and materials processes to provide presently unattainable performance for power control systems, advanced radar, and electronic countermeasures systems. Developed materials and materials process technologies for ultra-lightweight, ultra-high-power aircraft electrical generators enabling airborne lethal and non-lethal directed energy weapons in fighter-sized aircraft.

(U) $2,402 Developed and demonstrated infrared (IR) detector materials and processing technologies to enable improved performance, affordability, and operational capability of surveillance, tracking, targeting, and situational awareness systems. Developed alternative IR detector materials for space applications capable of detecting very long wavelengths. Developed the process control required for growth of complex IR detector materials that are responsive to multiple wavelengths within and between spectral bands. Validated new processing techniques to improve IR detector materials yield and affordability in small lots.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4348**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U) $3,608 Developed and demonstrated materials technologies to enhance the safety and survivability of aircrews and related assets against heat seeking missiles and laser threats. Demonstrated improved growth and processing techniques for large nonlinear crystals for generating higher power far-infrared (IR) laser radiation for advanced infrared countermeasures. Developed and validated materials processing techniques and materials that will enable high performance optical control of phased array radar and satellite to satellite data links. Identified and characterized organic materials with large nonlinear absorption properties for the protection of personnel eyes, viewing systems, and night vision goggles.

(U) $667 Developed enabling materials technologies to enhance the survivability and mission effectiveness of aerospace sensors, viewing systems, and night vision goggles against laser threats. Developed liquid crystal materials for autonomous tunable filters to block agile laser wavelengths. Evaluated high optical density, multiple wavelength switchable filter stacks on curved substrates for agile laser wavelength eye protection.

(U) $14,686 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $9,346 Develop and demonstrate materials and process technologies for power generation, power control, and microwave components to provide improved performance, affordability, and operational capability for Air Force surveillance, tracking, targeting, situational awareness, and lethal and non-lethal weapon systems. Demonstrate and validate materials and materials processing technologies to enable increased Air Force systems reliability and temperature capability while reducing power consumption, weight, cost, cooling, complexity, and size. Develop and transition materials and materials processes to provide presently unattainable performance for power control systems, advanced radar, and electronic countermeasures. Scale-up and transition materials and materials process technologies for ultra-lightweight, ultra-high-power aircraft electrical generators enabling airborne lethal and non-lethal directed energy weapons in fighter-sized aircraft.

(U) $2,932 Develop, demonstrate, and transition IR detector materials and materials processing technologies to enable improved performance, affordability, and operational capability of Air Force surveillance, tracking, targeting, and situational awareness systems. Demonstrate the process control required for growth of complex IR detector materials that are responsive to multiple wavelengths within and between spectral bands. Transition new processing techniques to improve detector materials yield and affordability in small lots. Investigate IR detector materials that provide enhanced real-time tracking capability.

(U) $5,326 Develop, demonstrate, and transition materials technologies to enhance the safety and survivability of aircrews and related assets against heat seeking missiles and laser threats. Develop growth and processing techniques for large nonlinear crystals for generating higher power mid-IR laser radiation for future IR countermeasures. Incorporate promising nonlinear absorbing materials into candidate host materials and demonstrate their performance in the Air Force Optical Limiting Testbed for the protection of personnel eyes, viewing systems, and night vision

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602102F Materials	PROJECT 4348

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

goggles.

(U) $948 Develop and transition enabling materials technologies to enhance the survivability and mission effectiveness of Air Force sensors, viewing systems, and night vision goggles against laser threats. Demonstrate liquid crystal materials employed in autonomous tunable filters to block near-infrared (IR) wavelengths. Develop high optical density, multiple wavelength switchable filter stacks on curved substrates.

(U) $18,552 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,948 Develop and demonstrate materials and process technologies for power generation, power control, and microwave components to provide improved performance, affordability, and operational capability for Air Force surveillance, tracking, targeting, situational awareness, and lethal and non-lethal weapon systems. Validate and transition materials and materials processing technologies to enable increased Air Force systems reliability and temperature capability while reducing power consumption, weight, cost, cooling, complexity, and size. Continue development and transition of materials and processes to provide presently unattainable performance for power control systems, advanced radar, and electronic countermeasures. Complete scale-up of baseline materials and materials process technologies for ultra-lightweight, ultra-high-power aircraft electrical generators enabling airborne lethal and non-lethal directed energy weapons in fighter-sized aircraft.

(U) $448 Develop, demonstrate, and transition IR detector materials and materials processing technologies to enable improved performance, affordability, and operational capability of Air Force surveillance, reconnaissance, tracking, targeting, and situational awareness systems. Validate the military utility of complex IR detector materials that are responsive to multiple wavelengths within and between spectral bands. Exploit validated processing techniques to enhance detector materials performance and improve military utility. Demonstrate the process control required for growth of complex infrared detector materials that require control on an atomic level to structure their detection properties. Investigate potential materials solutions for detection of chemical and biological threats.

(U) $4,888 Develop, demonstrate, and transition materials technologies to enhance the safety and survivability of aircrews and related assets against heat seeking missiles and laser threats. Investigate growth and processing techniques for nonlinear optical crystals including surface coatings and nanostructuring for generating laser radiation with significantly higher energy per pulse for future infrared countermeasures. Optimize the performance of promising nonlinear absorbing materials in candidate host materials and demonstrate their improved performance in the Air Force Optical Limiting Testbed for the protection of personnel eyes, viewing systems, and night vision goggles.

(U) $2,033 Develop and transition enabling materials technologies to enhance the survivability and mission effectiveness of Air Force sensors, viewing systems, and night vision goggles against laser threats. Validate the performance of liquid crystal materials employed in autonomous tunable

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4348**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

filters to block near-infrared wavelengths. Fabricate laboratory samples of high optical density, multiple wavelength switchable filter stacks on curved substrates.

(U) $11,317 Total

(U) B. Project Change Summary

Not Applicable

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

(U) Related Activities:
(U) PE 0603112F, Advanced Materials for Weapon Systems.
(U) PE 0602202F, Human Effectiveness Applied Research.
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0603231F, Crew Systems and Personnel Protection Technology.
(U) PE 0603211F, Aerospace Technology Dev/Demo.
(U) PE 0602500F, Multi-Disciplinary Space 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 February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602102F Materials	PROJECT 4349

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4349 Materials Technology for Sustainment	19,501	17,212	16,343	16,725	16,823	17,200	17,691	18,099	Continuing	TBD

(U) **A. Mission Description**

Develops and transitions materials and materials processing technologies to support operational Air Force mission areas by providing the ability to inspect the quality of delivered systems, transitioning more reliable and maintainable materials, establishing a capability to detect and characterize performance threatening defects, characterizing materials processes and properties necessary for materials transition, and providing quick reaction support and failure analysis to the operational commands and repair centers. Develops repair techniques and nondestructive inspection/evaluation (NDI/E) methods that are needed for metallic and non-metallic structures, coatings, corrosion control processes, and to support integration of composite structures for aerospace systems. Various NDI/E methods are essential to ensure optimum quality in the design and production of aircraft, propulsion, and missile systems. These NDI/E methods are also essential to monitor and detect the onset of any service-initiated damage and/or deterioration due to aging of operational systems.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,445 Developed NDI/E technology to identify and characterize damage in complex, low-observable materials and structures. Developed inspection technology for aging aerospace structures and propulsion systems. Identified methods to rapidly detect and characterize multi-site damage and cracks in large area, aging structures. Identified computer simulations and models of NDI/E technique response which will enable the development of improved inspections in a virtual environment to permit the depots to rapidly assess the potential of new corrosion and crack detection NDI/E methods. Developed transition methods to measure residual stress to allow depots to safely extend the service life of turbine engine rotors. Identified and developed methods to detect and characterize the severity of fretting fatigue in engine components. Identified NDI/E methods to characterize the low-observable properties of paints and coatings during and after application.

(U) $3,148 Developed enabling technologies to reduce the Air Force maintenance burden due to low-observable requirements. Developed capability for NDI/E point inspection devices and verify repair quality. Evaluated an integrated low-observable repair kit. Validated high temperature and/or ultraviolet gap sealants and conductive elastomers. Demonstrated ultrasonically applied and/or removed thermoplastic radar absorbing material (RAM) repairs, high temperature RAM coating repairs, and radar absorbing structure field level repairs.

(U) $4,605 Developed and transitioned support capabilities, information, and processes to resolve problems in the use of materials and provide electronic and structural failure analysis of components. Performed failure analysis and materials investigations for field, acquisition, and depot organizations. Continued certification and transition of emerging electrostatic discharge protection materials technologies and techniques for space and low-observable applications. Continued experimental evaluation of testing techniques needed for analyzing structural failures of

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602102F Materials	PROJECT 4349

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		replacement materials for aging Air Force systems.
(U)	$7,303	Developed support capabilities, information, and processes to resolve problems in the use of materials in the repair of aircraft structures and to reduce aircraft corrosion. Validated residual stresses baseline criteria of high cycle fatigue foreign object damage in turbine engine blade materials. Demonstrated advanced composite materials compatibility with laser effluents as an alternative to metallic materials for high energy chemical oxygen-iodine laser devices. Evaluated improved gap-filler materials for low-observable platforms and test on-aircraft processed adhesive and patch repair of high-temperature composite aircraft structures. Demonstrated capabilities to evaluate corrosion and erosion resistance of new and emerging materials used in operationally fielded Air Force systems. Established a baseline for improved corrosion management procedures.
(U)	$19,501	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$4,848	Develop non-destructive inspection/evaluation (NDI/E) technology to identify and characterize damage in complex, low-observable (LO) materials and structures. Develop inspection for aging aerospace structures and propulsion systems. Evaluate methods to rapidly detect and characterize multi-site damage and cracks in large area, aging structures. Evaluate computer simulations and models of non-destructive evaluation (NDE) technique response which will enable the development of improved inspections in a virtual environment to permit the depots to rapidly assess the potential of new corrosion and crack detection NDE methods. Evaluate methods to detect and characterize the severity of fretting fatigue in engine components. Evaluate NDI/E methods to characterize the LO properties of paints and coatings during and after application.
(U)	$2,466	Develop and transition enabling technologies to reduce the Air Force maintenance burden due to LO requirements. Validate capability for NDE point inspection devices and verify repair quality. Demonstrate an integrated LO repair kit. Transition high temperature and/or ultraviolet gap sealants and conductive elastomers. Transition ultrasonically applied and/or removed thermoplastic radar absorbing material (RAM) repairs, high temperature RAM coating repairs, and radar absorbing structure field level repairs.
(U)	$3,896	Develop support capabilities, information, and processes to resolve problems in the use of materials and provide electronic and structural failure analysis of components. Perform failure analysis and materials investigations for field, acquisition, and depot organizations. Continue certification and transition of emerging electrostatic discharge protection materials technologies and techniques for LO applications. Continue experimental evaluation of testing techniques needed for analyzing structural failures of replacement materials for aging Air Force systems.
(U)	$6,002	Develop support capabilities, information, and processes to resolve problems in the use of materials in the repair of aircraft structures and to

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4349**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

reduce aircraft corrosion. Publish residual stresses baseline criteria of high cycle fatigue foreign object damage in turbine engine blade materials. Transition advanced composite materials compatibility with laser effluents as an alternative to metallic materials for high-energy chemical oxygen-iodine laser devices. Transition improved gap-filler materials for low-observable (LO) platforms and demonstrate on-aircraft processed adhesive and patch repair of high-temperature composite aircraft structures. Demonstrate capabilities to evaluate corrosion and erosion resistance of new and emerging materials used in operationally fielded Air Force systems. Publish baseline for improved corrosion management procedures.

(U) $17,212 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,551 Develop non-destructive inspection/evaluation (NDI/E) technology to identify and characterize damage in complex, LO materials and structures. Transition methods to inspect and maintain the integrity of aging aerospace structures and propulsion systems. Develop electromagnetic methods to rapidly detect and characterize multi-site damage and cracks in large-area, aging structures. Develop computer simulations and models of NDI/E technique response, which will enable the development of improved inspections in a virtual environment to permit the depots to rapidly assess the potential of new corrosion and crack detection NDI/E methods. Develop methods to detect and characterize the severity of fretting fatigue in engine components. Evaluate technology concepts for measuring complex electromagnetic material properties beneath dielectric tiles in LO applications.

(U) $3,647 Develop and transition enabling technologies to reduce the Air Force maintenance burden due to LO requirements. Transition NDI/E point inspection device capability to the Non-Destructive Inspection Office at Oklahoma City Air Logistics Center. Demonstrate a standardized LO repair kit for use on multiple aircraft systems which will result in standardization of aircraft repair processes.

(U) $4,183 Develop support capabilities, information, and processes to resolve problems in the use of materials and provide electronic and structural failure analysis of components. Perform failure analysis and materials investigations for field, acquisition, and depot organizations. Develop electrostatic discharge protection technologies for emerging avionics subsystems. Develop new test methodologies for analyzing structural failures of replacement materials for aging Air Force systems. Initiate materials technologies effort to replace aging wiring in Air Force aircraft subsystems.

(U) $4,962 Develop support capabilities, information, and processes to resolve problems in the use of materials in the repair of aircraft structures and to reduce aircraft corrosion. Develop and evaluate methodologies to determine corrosion and erosion resistance of new and emerging materials used in operationally fielded Air Force systems. Identify failure mechanisms in Micro-Electro-Mechanical Systems used in hybrid,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4349**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

multifunctional, or health monitoring structures and subsystems.

(U) $16,343 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0603112F, Advanced Materials for Weapons Systems.
(U) PE 0603211F, Aerospace Technology Dev/Demo.
(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 February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602102F Materials	PROJECT 4915

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4915 Deployed Air Base Technology	1,387	3,422	2,118	2,405	2,457	2,515	2,579	2,643	Continuing	TBD

Note: In FY 2002, Project 4915, Deployed Air Base Technology, efforts were transferred from PE 0602201F, Project 4397.

(U) A. Mission Description

Supports the Aerospace Expeditionary Forces (AEF) through development of new technologies for deployable airbase systems to reduce airlift and manpower requirements, setup times, and sustainment costs. Develops efficient and cost-effective technologies, including fire fighting and physical protection, to provide force protection and survivability to deployed AEF warfighters. Develops affordable, deployable technologies that ensure military readiness, maintain aerospace missions, support weapon systems sustainment, and ensure deployability. Note: In FY 2003, Congress added $1.2 million for Tyndall Air Force Research Laboratory.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $881 Developed new deployable airbase technologies to reduce airlift and manpower requirements, setup times, and sustainment costs in support of AEF operations. Developed lightweight, flexible solar cell technologies that improve operating efficiency and reduce sustainment costs of airmobile systems. Developed lightweight, rapidly assembled matting systems to enable rapid expansion of aircraft parking at deployment locations. Developed effective advanced fire fighting agents and equipment to protect deployed warfighters.

(U) $104 Developed affordable, deployable technologies that ensure military readiness, maintain aerospace missions, support weapon systems sustainment, and ensure deployablity. Developed safe, cost-effective disposal of problem AEF wastes for low-observable material waste treatment.

(U) $402 Developed efficient and cost-effective technologies to provide force protection and survivability to AEF deployed warfighters and materials. Developed atmospheric threat prediction models and deployable sensors systems to protect AEF forces from toxic industrial materials.

(U) $1,387 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,825 Develop new deployable airbase technologies to reduce airlift and manpower requirements, setup times, and sustainment costs in support of AEF operations. Develop deployable fuel cell, solar power, and heat pump technologies that increase performance, decrease maintenance and mean times between failure, increase operating efficiency, and reduce sustainment costs.

(U) $101 Develop affordable, deployable technologies that ensure military readiness, maintain aerospace missions, support weapon systems sustainment, and ensure deployablity. Continue development of safe, cost-effective disposal of problem AEF wastes for low-observable material waste

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4915**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

treatment.

(U) $1,496 Develop cost-effective technologies to provide force protection and survivability to Aerospace Expeditionary Force (AEF) deployed warfighters and materials. Continue development of atmospheric threat prediction models and deployable sensors systems to protect AEF personnel from toxic industrial materials. Develop effective advanced fire fighting agents and equipment and advanced blast protection materials to protect deployed warfighters.

(U) $3,422 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,280 Develop new deployable airbase technologies to reduce airlift and manpower requirements, setup times, and sustainment costs in support of AEF operations. Transition deployable fuel cell power system to advanced technology development. Demonstrate and transition high-efficiency solid state solar cell technology. Initiate development of an advanced, compact integrated shelter/utility system that will integrate fuel cell and solar power with heat pump technologies to provide highly efficient, individual systems for deployable shelters. Initiate research on polymer-clay stabilization technology for rapid airfield expansion that will reduce the time required to prepare aircraft operating surfaces at contingency bases. Initiate research on biocatalysis and biodegradation of Air Force materials that will provide cleaner and lower cost advanced materials.

(U) $838 Develop cost-effective technologies to provide force protection and survivability for deployed AEF materials and warfighters. Continue development of fire fighting foam agents in conjunction with combined fire supressant equipment and advanced blast protection materials to protect deployed warfighters. Develop and demonstrate polymer-based retrofit technologies for expeditionary and permanent structures to protect the warfighter.

(U) $2,118 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0603112F, Advanced Materials for Weapon Systems.

(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **4915**

(U) D. Acquisition Strategy
Not Applicable.

(U) E. Schedule Profile
(U) Not Applicable.

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

DATE **February 2003**

BUDGET ACTIVITY **02 - Applied Research**

PE NUMBER AND TITLE **0602102F Materials**

PROJECT **5015**

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5015 Rocket Materials Technology	0	1,276	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2003, civilian salaries associated with space unique tasks in PE 0602102 were transferred to Project 5015. In FY 2004, these salaries in Project 5015 will be transferred to PE 0602500F, Project 5025, as a result of the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

Develops advanced pervasive materials and processing technologies for aerospace propulsion technologies to dramatically improve affordability, performance, and reliability of current and future aerospace engine applications. The components of liquid-fuel engines that advanced materials can significantly impact include lightweight ducts, turbo pumps, injectors, and nozzles sub-systems. The material advancements in these aerospace systems will provide lighter weight, performance, and cost-reduction enhancements for overall aerospace engine applications. This project will develop material property databases and initiate the demonstration of suitability for new materials application using representative geometry and processing conditions for the intended aerospace engine components.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $1,276 Develop and demonstrate pervasive materials and processing technologies for aerospace engine components and sub-components to dramatically improve affordability, performance, and reliability of current and future Air Force aerospace systems. Evaluate chemistry/heat treatment combination for new compatible alloys for aerospace propulsion housing components. Identify and develop pervasive zero erosion materials for multiple aerospace engine and missile applications. Identify and evaluate pervasive high temperature catalyst materials that will enable the use of high performance monopropellants for aerospace propulsion systems.
(U) $1,276 Total

(U) FY 2004 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602102F Materials**	PROJECT **5015**

(U) B. Project Change Summary
Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)
(U) Related Activities:
(U) PE 0602203F, Aerospace Propulsion.
PE 0603112F, Advanced Materials for Weapon Systems.
PE 0602500F, Multi-Disciplinary Space 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.

THIS PAGE INTENTIONALLY LEFT BLANK

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602201F Aerospace Vehicle Technologies

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	97,543	76,347	65,662	77,571	106,600	114,444	108,071	110,383	Continuing	TBD
2401	Structures	32,007	24,995	28,925	34,734	44,465	47,415	42,596	43,511	Continuing	TBD
2403	Flight Controls and Pilot-Vehicle Interface	34,398	25,618	14,418	17,097	31,093	34,344	29,548	30,147	Continuing	TBD
2404	Aeromechanics and Integration	29,959	25,734	22,319	25,740	31,042	32,685	35,927	36,725	Continuing	TBD
4397	Air Base Technology	1,179	0	0	0	0	0	0	0	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2002, selected efforts from Project 2401 have transferred into Projects 2403 and 2404 within this PE. In FY 2002, Project 4397 efforts transferred to PE 0602102F, Project 4915. In FY 2003, only the space-unique efforts in Project 2403 transferred to PE 0602500F, Project 5030, in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) **A. Mission Description**

This program investigates, develops, and analyzes aerospace vehicle technologies in the three primary areas of structures, controls, and aeromechanics. First, advanced structures concepts are explored and developed to exploit new materials, fabrication processes, and design techniques. Second, flight control technologies are developed and simulated for both manned and unmanned aerospace vehicles. Third, the aeromechanics of advanced aerodynamic vehicle configurations are developed and analyzed through simulations, experiments, and multidisciplinary analysis. Resulting technologies reduce life cycle costs and improve the performance of existing and future manned and unmanned aerospace vehicles. Note: In FY 2003, Congress added $1.2 million for intelligent flight control simulation research laboratory.

(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 aerospace vehicle technologies.

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602201F Aerospace Vehicle Technologies

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	98,785	78,789	108,212	
(U)	Appropriated Value	99,415	79,989		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-630	-3,150		
	b. Small Business Innovative Research	-1,868			
	c. Omnibus or Other Above Threshold Reprogram		-492		
	d. Below Threshold Reprogram	1,100			
	e. Rescissions	-474			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-42,550	
(U)	Current Budget Submit/FY 2004 PBR	97,543	76,347	65,662	TBD

(U) Significant Program Changes:
Changes to this program since the previous President's Budget are due to increased funding for technologies with higher Air Force priorities.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	**0602201F Aerospace Vehicle Technologies**	**2401**

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2401 Structures	32,007	24,995	28,925	34,734	44,465	47,415	42,596	43,511	Continuing	TBD

(U) A. Mission Description

This project develops advanced structures concepts to exploit new materials and fabrication processes and investigates new structural concepts and design techniques. Resulting technologies strengthen and extend the life of current and future manned and unmanned aerospace vehicle structures. Payoffs to the warfighter include reduced weight and cost, as well as improved operability and maintainability of aerospace vehicles.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,859 Developed economic service life analysis for current and future aircraft, enhancing capability, component replacement, and technology direction. Continued development of unitized structural concepts and multidisciplinary optimization methodologies that enhance affordability and decrease vulnerability for current and future aerospace vehicles. Incorporated newly developed analysis tools into life prediction and failure analysis software.

(U) $5,080 Developed analytical certification methodologies for the incorporation of advanced methods, concepts, and manufacturing technologies into legacy aircraft components and future airframe designs. Improved the air-worthiness certification process for aircraft subjected to dynamic aeroelastic loads with high fidelity models.

(U) $6,941 Continued development of structural concepts, design, and analysis methods that enable the integration of structure with other airframe functions to reduce cost and increase the survivability of future systems. Concepts include adaptive structures for varying moldline, subsystems hardware, and antennae contained within the loadbearing structure.

(U) $17,127 Developed technologies that incorporate advanced materials as well as passive and active cooling to withstand extreme flight environments. Technologies will improve durability of existing and future aerospace vehicle structures resulting in reduced cost and increased life. Concepts included advanced, durable, all-weather thermal protection systems, attachment techniques, vehicle health monitoring and health management, integrated thermal protection systems, hot primary structures, hybrid structures, unitized structures, joining concepts, and cryogenic and non-cryogenic tank structures.

(U) $32,007 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602201F Aerospace Vehicle Technologies	PROJECT 2401

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$7,605	Develop economic service life analysis for current and future aircraft, enhancing capability, component replacement, and technology direction. Continue development of unitized structural concepts and multidisciplinary optimization methodologies that enhance affordability and decrease vulnerability for current and future aerospace vehicles. Incorporate newly developed analysis tools into life prediction and failure analysis software.
(U)	$4,020	Develop analytical certification methodologies for the incorporation of advanced methods, concepts, and manufacturing technologies into legacy aircraft components and future vehicle designs. Improve the air-worthiness certification process for aircraft subjected to dynamic aeroelastic loads with high fidelity models.
(U)	$1,842	Continue development of structural concepts, design, and analysis methods that enable the integration of structure with other airframe functions to reduce cost and increase survivability of future systems. Concepts include adaptive structures for varying moldlines, subsystems hardware, and antennae contained within loadbearing structures.
(U)	$11,528	Develop technologies that incorporate advanced materials as well as passive and active cooling to withstand extreme flight environments. Technologies will improve durability of existing and future aerospace vehicle structures resulting in reduced cost and increased life. Concepts include advanced, durable, all-weather primary structures, hybrid structures, unitized structures, joining concepts, and cryogenic/non-cryogenic tank structures.
(U)	$24,995	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$7,187	Develop economic service life analysis and structural design tools for current and future air vehicles, enhancing capabilities, component replacement, and technology direction. Continue development of unitized structural concepts and multidisciplinary optimization methodologies that enhance affordability and decrease vulnerability for current and future air vehicles. Continue to incorporate newly developed analysis tools into life prediction and failure analysis. Complete reliability-based design tools for advanced air vehicle components and concepts.
(U)	$7,780	Continue to develop analytical certification methodologies for the incorporation of advanced methods, concepts, diagnostic techniques, and manufacturing technologies into legacy aircraft components and future vehicle designs. Improve the air-worthiness certification process for air vehicles subject to dynamic loads and with high fidelity models. Complete the initial development of analytical certification concepts for the insertion of structural components.
(U)	$5,742	Continue to develop concepts, design, and analysis methods and components that enable the integration of structures with other airframe

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602201F Aerospace Vehicle Technologies**	PROJECT **2401**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

		functions to reduce cost and weight, as well as to increase the survivability of future systems. Continue the development of concepts that include adaptive structures, subsystem hardware, and antenna integration into load-bearing structures to create multifunction or ultra-lightweight concepts.
(U)	$8,216	Develop technologies that will incorporate advanced materials and design concepts for the creation of an integrated air vehicle structure that can withstand extreme flight environments. Technologies will improve durability of existing and future air vehicle structures resulting in reduced cost and increased life. Complete the development of assessment methodologies for air vehicle assessment.
(U)	$28,925	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602102F, Materials.
(U) PE 0603112F, Advanced Materials for Weapon Systems.
(U) PE 0603211F, Aerospace Technology Dev/Demo.
(U) PE 0603333F, Unmanned Air Vehicle Dev/Demo.
(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 February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602201F Aerospace Vehicle Technologies	2403

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2403 Flight Controls and Pilot-Vehicle Interface	34,398	25,618	14,418	17,097	31,093	34,344	29,548	30,147	Continuing	TBD

Note: Beginning in FY 2002, selected efforts from Project 2401 have been moved into Projects 2403 and 2404. In FY 2003, the space unique tasks in Project 2403 will be transferred to PE 0602500F, Project 5030, in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This project develops technology to enable maximum affordable capability from manned and unmanned aerospace vehicles. Advanced flight control technologies are developed for maximum vehicle performance throughout the flight envelope and simulated in virtual environments. Resulting technologies contribute significantly towards the development of reliable autonomous unmanned air vehicles, space access systems with aircraft-like operations, and extended-life legacy aircraft. Payoffs to the warfighter include enhanced mission effectiveness, optimized flight safety, increased survivability, improved maintenance, and decreased size, weight, and cost. Leverages a network of synthetic environments for evaluation of advanced concepts.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,982 Developed and assessed advanced control mechanization technologies to provide highly reliable operation for manned and unmanned systems at significantly reduced size, weight, and cost. Completed laboratory demonstrations of a fiber optic-based vehicle management system and optical air data system components. Developed validation and verification techniques for complex, adaptive, and autonomous control software. Assessed control mechanization technologies for extending the effective life of legacy aircraft.

(U) $8,400 Developed and assessed control automation techniques and algorithms to enable the safe and interoperable application for formations of manned and unmanned vehicle systems. Concepts will also provide mission responsiveness and adaptability for improved operational effectiveness of manned and unmanned systems. Continued development and test of intelligent-agent software providing package-level coordination and health monitoring and management for aerospace vehicles. Continued the simulation analysis of automated aerial refueling system technologies. Completed analysis and specification of an on-board sensor suite for safe operation of unmanned vehicles in proximity of other manned and unmanned air vehicles.

(U) $6,657 Developed new flight control design methods and criteria that provide air combat advantages by increasing performance and decreasing vulnerability and cost. Continued development of a new intelligent/learning reconfigurable controller to enable continued air vehicle operation in the event of damage or failure. Integrated with on-line route planner and systems diagnostics for unmanned vehicle fault tolerant, autonomous operations. Developed integrated adaptive guidance and control systems for high-and ultra-high-speed aerospace vehicles.

(U) $6,199 Developed advanced flight control technology to enable aircraft-like operations for affordable on-demand military access to space. Continued

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602201F Aerospace Vehicle Technologies	PROJECT 2403

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

development and analysis of affordable, lightweight vehicle/health monitoring and management systems, integrated with critical guidance and navigation algorithms for high and ultra-high-speed aerospace vehicles. Developed parameters for health monitoring and management data collection, and developed prognostic algorithms.

(U) $8,417 Assessed the value of air vehicle technologies to future aerospace systems through the development and utilization of in-house tools, systems, and processes for simulation-based research and development. Continued development of virtual simulations for unmanned air vehicles used in validating autonomous control algorithms for mixed manned and unmanned air vehicle operations. Enhanced simulation and analysis capabilities to project life cycle cost impacts. Developed the capability to virtually simulate mission utility of next generation aerospace vehicles for long-range strike.

(U) $743 Initiated Congressionally-directed effort for advanced comprehensive engineering simulator.

(U) $34,398 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,910 Develop and assess advanced control mechanization to provide highly reliable operation for manned and unmanned systems at significantly reduced size, weight, and cost. Demonstrate validation and verification techniques for complex, adaptive, and autonomous control software. Assess mirco-effector technologies for lightweight, long endurance air vehicle applications. Develop real-time fault compensation using an integrated prognostic health management system.

(U) $11,781 Develop and assess novel control automation techniques and algorithms to enable the safe and interoperable application of unmanned vehicle systems. Concepts will also provide mission responsiveness and adaptability for improved operational effectiveness of manned and unmanned systems as well as mixed air vehicle operations. Conduct feasibility assessments of an automated refueling systems concept. Develop reliability and performance analysis of self-organizing, distributed control of multi-unmanned vehicle packages.

(U) $2,531 Develop improved flight control design methods and criteria that provide air combat advantage by increasing performance and decreasing vulnerability and cost. Complete development of adaptive guidance and control architectures for high-speed vehicles. Develop a cooperative control theory to optimize multi-ship trajectories.

(U) $8,209 Assess the value of air vehicle technologies to future aerospace systems, through the development and utilization of in-house tools, systems, and processes for simulation-based research and development. Complete the development of virtual simulation for unmanned air vehicles used in validating autonomous control algorithms for mixed manned and unmanned air vehicle operations. Continue to enhance simulation and analysis capabilities through the incorporation of cost models to determine the affordability of new technologies. Continue development of capability to

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602201F Aerospace Vehicle Technologies**	PROJECT **2403**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

virtually simulate future strike aircraft.

(U) $1,187 Initiated Congressionally-directed effort for intelligent flight control simulation research laboratory.

(U) $25,618 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $5,735 Develop and assess advanced control mechanization to provide highly reliable operations for manned and unmanned air vehicles at significantly reduced size, weight, and cost. Continue to develop demonstrations of validation and verification techniques for complex, adaptive, and autonomous control software. Define the sensing requirements for unmanned systems situational awareness in air operations.

(U) $4,661 Continue to develop and assess novel control automation techniques and algorithms to enable the safe and interoperable application of manned and unmanned air vehicle systems. Concepts will also provide mission responsiveness and adaptability for improved operational effectiveness for manned and unmanned air vehicles as well as mixed air vehicle operations. Investigate feasibility of biology inspired control techniques to simplify unmanned air vehicle system autonomy implementations. Continue to enhance reliability and performance analysis of self-organizing, distributed control of multi-unmanned air vehicles. Develop intelligent situational awareness algorithms to implement autonomous airspace operations control for unmanned air vehicle systems.

(U) $4,022 Continue to assess the value of air vehicle technologies to future air and space systems, through the development and utilization of in-house tools, systems, and processes for simulation-based research and development. Conduct simulation assessments of advanced unmanned air vehicle concepts. Continue to enhance simulation and analysis capabilities through incorporation of cost models to determine the affordability of new technologies.

(U) $14,418 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602202F, Human Effectiveness Applied Research.

(U) PE 0602204F, Aerospace Sensors.

(U) PE 0603211F, Aerospace Technology Dev/Demo.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602201F Aerospace Vehicle Technologies	PROJECT 2403

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

(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 February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602201F Aerospace Vehicle Technologies	PROJECT 2404

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2404 Aeromechanics and Integration	29,959	25,734	22,319	25,740	31,042	32,685	35,927	36,725	Continuing	TBD

Note: Beginning in FY 2002, selected efforts from Project 2401 have moved into Projects 2403 and 2404.

(U) A. Mission Description

This project develops aerodynamic configurations of a broad range of revolutionary, affordable air vehicles. It matures and applies modeling and numerical simulation methods for fast and affordable aerodynamics prediction, and integrates and demonstrates multidisciplinary advances in airframe-propulsion, airframe-weapon, and air vehicle control integration. Technologies developed will greatly enhance warfighter capability in aircraft, missiles, and high-speed aerospace vehicles. The payoffs from these technology programs include lower vehicle costs (both production, and operations and support costs), increased payload and range capability, and improved supportability, safety, and survivability of aerospace vehicles.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $10,975 Developed and assessed aeronautical technologies that enable a broad use of unmanned air vehicles in future missions to reduce life cycle cost and decrease human risk. Completed development of tools and techniques for predicting and optimizing aerodynamic performance and survivability of long duration unmanned air vehicles. Continued preliminary development of conformal inlet designs that improve airflow to engines while providing low signature for increased survivability. Continued development of signature compatible, high lift wings for long duration surveillance missions.

(U) $4,042 Developed design tools that permit quicker and more affordable certification of aerodynamic enhancements to extend the operational life of the current fleet. Continued development of analysis tools to accelerate the aerodynamic integration of new and existing weapons with current aircraft to enhance their warfighting ability. Continued to enhance computer design and analysis code that reduces the need for expensive flight-testing.

(U) $10,045 Developed and assessed aerospace technologies that enable ultra-high-speed flight and low-cost access to orbit to permit global reach. Continued comparative analyses of aerospace vehicle configurations for next generation long-range strike to project global power from the continental United States bases. Explored integrated airframe concepts for high-speed aerospace vehicles. Continued investigation into techniques to generate and control a plasma flow field over high-speed vehicles to significantly reduce drag. Developed computational, multidisciplinary, experimental, and analytical tools to simulate and control the flow fields around advanced concepts for ultra-high-speed aerospace vehicles in extreme flight environments. Continued development of complex configurations that mitigate the extreme thermal environment under which high-speed aerospace vehicles operate. Developed techniques to carry and deploy weapons from high-speed aerospace vehicles.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602201F Aerospace Vehicle Technologies**	PROJECT **2404**

(U) A. Mission Description Continued

(U)	FY 2002 ($ in Thousands) Continued	
(U)	$4,897	Developed and evaluated critical aeronautical technologies that enable directed energy weapons to be carried on future air vehicles to improve combat effectiveness. Completed analyses of integration of directed energy weapons on the total air vehicle system identifying impacts to the flight control system, secondary power subsystem, and aerodynamic configuration. Completed development of tools that establish the military impact of directed energy weapons when installed on viable air platforms on future engagements. Developed aircraft techniques to enhance energy beam transmission through the complex, turbulent aerodynamic environment surrounding aircraft, enabling the use of directed energy weapons from high-speed, maneuvering aircraft.
(U)	$29,959	Total
(U)	FY 2003 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$5,451	Develop and assess aeronautical technologies that enable the broad use of unmanned air vehicles in future missions to reduce life cycle costs and decrease human risk. Continue preliminary development of conformal inlet designs that improve airflow to engines while providing low signature for increased survivability. Continue development of signature compatible, high lift wings for long duration surveillance missions.
(U)	$5,625	Develop design tools that permit quicker and more affordable certification of aerodynamic enhancements to extend the operational life of the current fleet. Continue development of analysis tools to accelerate the aerodynamic integration of new and existing weapons with the current aircraft to enhance their warfighting ability.
(U)	$13,218	Develop and assess aerospace technologies that enable high-speed flight to permit global reach. Develop experimental capability to generate and control plasma flows. Develop analytic methods for modeling the plasma flow field over high-speed vehicles to significantly reduce drag. Continue development of complex configurations that mitigate the extreme thermal environment under which high-speed aerospace vehicles operate. Continue development of techniques to carry and deploy weapons from aerospace vehicles operating at high speeds and high temperatures.
(U)	$1,440	Develop and evaluate critical aeronautical technologies that enable directed energy weapons to be carried on future air vehicles to improve combat effectiveness. Continue development of aircraft techniques to enhance energy beam transmissions through the complex, turbulent aerodynamic environment surrounding aircraft, enabling the use of directed energy weapons from high-speed, maneuvering aircraft.
(U)	$25,734	Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602201F Aerospace Vehicle Technologies**	PROJECT **2404**

(U) A. Mission Description Continued

(U)	FY 2004 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$4,168	Develop and assess aeronautical technologies that enable the broad use of unmanned air vehicles in future missions, including offensive missions, to reduce life cycle costs and decrease human risk. Complete development of signature compatible, high lift wings for long duration surveillance missions. Complete development of technology to improve engine nozzle design for increased survivability. Continue to perform mission assessment and develop low-cost unmanned air vehicle concepts to perform tactical surveillance. Apply flow control techniques to complex air vehicle designs to achieve reduced drag and improve performance.
(U)	$2,528	Develop design tools that permit quicker and more affordable certification of aerodynamic enhancements to extend the operational life of the current fleet of manned air vehicles. Continue enhancement of computer design and analysis code that reduces the need for expensive flight-testing, including completion of a robust unstructured mesh generation and adaption framework.
(U)	$5,658	Develop and assess aeronautical technologies that enable revolutionary re-fueling and transport aircraft designs for rapid global mobility. Develop technologies that enable multiple roles and missions for support aircraft. Complete innovative designs for re-fueling and transport aircraft to improve range and payload capacity. Complete investigation of an aerodynamic flow field behind refueling aircraft to improve modeling and simulation.
(U)	$9,965	Continue to develop and evaluate critical aeronautical technologies that enable directed energy weapons to be carried on future air vehicles to improve combat effectiveness. Complete development of air vehicle techniques to enhance energy beam transmissions through the complex, turbulent aerodynamic environment surrounding high-speed, maneuvering aircraft. Continue analysis of tactical utility of a high energy laser on fighter aircraft. Perform flight test measurements of the actual aero-optics effects encountered when employing a laser weapon on a fighter aircraft. Perform evaluation and demonstration of scalable technologies leading towards a high-energy laser weapon.
(U)	$22,319	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0603211F, Aerospace Technology Dev/Demo.

(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602201F Aerospace Vehicle Technologies**	PROJECT **2404**

(U) **D. Acquisition Strategy**
Not Applicable.

(U) **E. Schedule Profile**
(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602201F Aerospace Vehicle Technologies	PROJECT 4397

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4397 Air Base Technology	1,179	0	0	0	0	0	0	0	Continuing	TBD

In FY 2002, efforts were transferred to PE 0602102F, Project 4915.

(U) A. Mission Description

Prior to FY 2003, this project developed air base technologies for fixed and bare base operations, including airfield pavements, energy systems, air base survivability, air base recovery, protective shelter systems, airfield fire protection, and crash rescue.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $1,179 Continued Congressionally-directed effort for weapon systems logistics, deployed base systems technology, and force protection.
(U) $1,179 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishment/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2004 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(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 0603211F, Aerospace Technology Dev/Demo.
(U) This project was coordinated through the Reliance process to harmonize efforts and eliminate duplication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602201F Aerospace Vehicle Technologies**	PROJECT **4397**

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

THIS PAGE INTENTIONALLY LEFT BLANK

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

DATE **February 2003**

BUDGET ACTIVITY **02 - Applied Research**

PE NUMBER AND TITLE **0602202F Human Effectiveness Applied Research**

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	67,740	76,707	66,795	68,693	73,776	85,902	78,012	79,399	Continuing	TBD
1123	Warfighter Training	13,601	10,921	10,627	11,053	12,873	18,165	14,604	14,966	Continuing	TBD
1710	Deployment and Sustainment	8,814	9,752	7,680	7,692	8,859	8,717	9,637	9,855	Continuing	TBD
7184	Crew System Interface & Biodynamics	30,965	29,478	33,830	35,424	38,832	45,421	38,383	38,820	Continuing	TBD
7757	Bioeffects and Protection	14,360	26,556	14,658	14,524	13,212	13,599	15,388	15,758	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2003, the protection program at Brooks City-Base, TX, moves from Project 7184 to Project 7757 to align resources with the Air Force Research Laboratory organization. In FY 2003, space unique tasks in Project 7184 will be transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) **A. Mission Description**

This program establishes technical feasibility and develops the technology base for protecting and enhancing human effectiveness for Air Force weapon systems and for operational readiness. The program addresses warfighter training, deployment and sustainment of forces, crew system interface, biodynamic response, directed energy bioeffects, and crew protection. The Warfighter Training project focuses on the development and evaluation of new methods and technologies to enhance Air Force training and education. The Deployment and Sustainment project develops and evaluates technologies that will increase weapon systems and force supportability. The Crew System Interface and Biodynamics project develops and evaluates technologies that will improve the performance and combat effectiveness of humans. The Bioeffects and Protection project develops technologies to predict and mitigate the biological effects of aerospace stressors and directed energy on personnel and mission performance. Note: In FY 2003, Congress added $2.5 million for Biotechnology - Cellular Dynamics and Engineering, $1.0 million for Three-Dimensional (3-D) Audio Display Technology, $4.3 million for Rapid Detection of Biological Weapons of Mass Destruction, and $7.0 million for Solid Electrolyte Oxygen Separator.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602202F Human Effectiveness Applied Research**

(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 technologies.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	70,155	66,000	75,500	
(U)	Appropriated Value	70,480	80,800		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-325	-3,802		
	b. Small Business Innovative Research	-2,085			
	c. Omnibus or Other Above Threshold Reprogram		-291		
	d. Below Threshold Reprogram				
	e. Rescissions	-330			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-8,705	
(U)	Current Budget Submit/FY 2004 PBR	67,740	76,707	66,795	TBD

(U) Significant Program Changes:

Decrease in FY 2004 is to fund higher priority Air Force programs.

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

DATE February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602202F Human Effectiveness Applied Research

PROJECT
1123

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
1123 Warfighter Training	13,601	10,921	10,627	11,053	12,873	18,165	14,604	14,966	Continuing	TBD

(U) A. Mission Description

This project develops and evaluates new methods and technologies in support of Air Force training and education requirements. The efforts focus on aircrew training; technical training; logistics training; mission rehearsal; training in support of complex decision-making; information warfare training; and warfare readiness training. It investigates the spectrum of new and advanced training and education technologies to design and implement training, and to evaluate training effectiveness. It develops and evaluates desktop tutors, courseware development tools and technologies, assessment methodologies, and simulation-based systems to determine how to achieve maximum learning effectiveness for specific needs at minimum cost. Technologies developed in this project will increase operational readiness by providing more effective methods and approaches to train and assess personnel. This project will contribute to a more highly trained and flexible cadre of personnel at a reduced cost.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,686 Researched new computer representation technologies and perceptual issues confronting the development of new visual systems to enhance the integrated Distributed Mission Training (DMT) environment. Explored High-Level Architecture federation connectivity options for training systems operating at different levels of security classification. Developed behavioral models to simulate the threat operators in the command and control chain. Explored PC-based, high-resolution, real-time image generator and ultrahigh resolution laser projector concept for DMT simulators.

(U) $6,119 Developed tools and strategies for identifying and improving combat mission training, rehearsal, and operations for distributing training and performance support methods and technology exemplars to operational forces. Research produced the empirical and analytical basis for better training guidelines when warfighters train in DMT environments. Completed development of methods to identify and validate mission essential competencies for air superiority and global attack, and began extending methods to new domains of space operations, information warfare, information operations, and command and control. Developed and validated curriculum for Air Superiority DMT implementation at operational mission training centers and within large-scale exercises at command and control simulation facilities. Conducted usability assessments of enhanced instructor operator station tools to embed instructional principles in DMT simulations and completed a first look assessment of operational deployment impacts on retention and decay of mission essential competencies and potential contributions of specific curricula for refresher training in pre- and post-deployment applications at mission training centers.

(U) $2,796 Developed training technologies in command and control centers that support theater air operations centers. Technologies will enhance aerospace operations through the development of training principles, guidelines, and criteria. Developed tools that provide real-time

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		performance support with automated remediation leading to a reduction in training costs with no reduction in training effectiveness. Integrated command and control systems into the Distributed Mission Training (DMT) environment. Developed embedded training tools and simulations for command and control information systems.
(U)	$13,601	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$1,597	Research perceptual issues confronting the development of new visual systems to enhance the integrated DMT environment. Research identifies the visual cues necessary for realistic aircrew training and mission rehearsal, allowing Air Force warfighters to train as they intend to fight. Assess technical performance of advanced ultrahigh resolution image generation, ultrahigh resolution projector and collimating display screen technologies. Determine feasibility of these technology developments for the next generation DMT simulator.
(U)	$2,084	Research new computer representation technologies for the synthetic environment used in simulation-based training within a distributed mode to enhance the integrated DMT environment. Research includes representation of the visual, electronic, and sensor world, the weather, the behavior of computer-generated forces, threats, and larger wargaming models. Improve rate of learning by developing pilot performance diagnostics for end game tactical engagements for use in mission debrief. Determine feasibility of using large constructive wargaming model as a manager of all participating entities in distributed combat exercises. Assess existing high-fidelity weather models as weather servers for all players in a distributed training exercise. Analyze methods for eliminating undesirable artifacts from the satellite source data used to build visualization tools and databases.
(U)	$5,951	Develop tools and strategies for identifying and improving combat mission training, rehearsal, and operations for distributing training and performance support methods and technology exemplars to operational forces. Research provides the combat air forces with the empirical data and guidelines for improving the quality and effectiveness of both DMT and live flight training environments. Complete validation of tools to facilitate continuous learning for critical air combat skills and link these tools to skills in domains such as intelligence, surveillance, and reconnaissance, and information operations. Complete operational validation studies of metrics that identify and prioritize mission essential content that can be delivered in deployable, desktop training environments located in field settings. Identify mission essential competencies underlying air superiority and global attack skills. Begin development of DMT content and scenarios for expeditionary force spin-up training and rehearsal.
(U)	$1,289	Develop training technologies in command and control centers that support theater air operations centers. Technologies will enhance aerospace operations through the development of training principles, guidelines, and criteria. Validate mission essential competencies for selected air

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602202F Human Effectiveness Applied Research**	PROJECT **1123**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

operations center individuals and teams. Determine feasibility of using enhanced performance assessment tools in command and control training exercises.

(U) $10,921 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,685 Research perceptual issues confronting the development of new visual systems to enhance the integrated Distributed Mission Training (DMT) environment. Research identifies the visual cues necessary for realistic aircrew training and mission rehearsal, allowing Air Force warfighters to train as they intend to fight. Identify requirements for and evaluate the capabilities and performance of various visual system technologies. Define the visual requirements relevant to performing the DMT tasks, identify which visual system characteristics and parameters have significant perceptual effects, and determine how the visual system can be optimized to minimize artifacts and to maximize image quality. Identify functional requirements for deployable and helmet-mounted display technologies for fast jet visual simulation. Quantify the effect network time delays have on aircrew visual-task performance.

(U) $7,840 Develop tools, strategies, and performance support methods for improving combat mission training, rehearsal, and operations for aircrews and command and control forces. Research provides the combat air forces and global strike operations with the empirical data and guidelines for improving the quality and effectiveness of both air and command and control DMT and live flight training environments. Complete specifications of mission essential competencies for operators in major air operations center divisions and teams. Complete preliminary training effectiveness evaluations with the Air Force Weapons School and an operational mission training center. Develop study plan for dynamic aerospace control training incorporating command and control, air combat, and coalition entities.

(U) $1,102 Develop training technologies and methods that support aerospace operations. Technologies will enhance aerospace operations through the development of training principles, guidelines, and criteria. Utilize quantitative data collection techniques to analyze the overall functional process as well as individual component tasks. Devise techniques to overcome training process shortfalls or inefficiencies.

(U) $10,627 Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602202F Human Effectiveness Applied Research	PROJECT 1123

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

(U) Related Activities:

(U) PE 0602233N, Human Systems Technology.

(U) PE 0602716A, Human Factors Engineering Technology.

(U) PE 0602785A, Personnel Performance and Training Technologies.

(U) PE 0603231F, Crew Systems and Personnel Protection Technology.

(U) PE 0604227F, Distributed Mission Training (DMT).

(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
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602202F Human Effectiveness Applied Research

PROJECT
1710

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
1710	Deployment and Sustainment	8,814	9,752	7,680	7,692	8,859	8,717	9,637	9,855	Continuing	TBD

(U) **A. Mission Description**

This project develops technologies to support the enhancement of the deployment and sustainment capabilities critical to Agile Combat Support and Air Expeditionary Force (AEF) operations. The research focuses on technologies with the potential to reduce the time required for units to plan, pack up, and deploy, and to reduce airlift requirements while enhancing deployed capability. It investigates and evaluates technologies to enhance the sustainment of deployed forces in contingency operations and to improve logistics support for both combat and peacetime operations. It develops toxicological tools and technology to minimize the risks and mission impact to DoD personnel from exposure to hazardous chemicals, while also reducing weapon systems life cycle cost.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,187 Developed logistics sustainment technology options and performed feasibility studies to support large-scale advanced technology development programs. These technologies will lead to more supportable weapon systems at reduced logistics support costs. Developed software tools to automatically generate maintenance procedures from weapon system design descriptions. Defined functional requirements for theater sustainment and distribution decision support tools. Developed artificial intelligence software architectures for improved depot repair forecasting and more timely and efficient home-based support for the warfighter. Developed advanced computer models for representing human cognition in simulations.

(U) $2,337 Developed logistics readiness technology options and performed feasibility studies to support large-scale advanced technology development programs. These technologies will lead to more efficient utilization of logistics resources for AEF operations. Conducted feasibility studies and devised preliminary plans for presenting various types of information to maintenance and logistics personnel, such as aircraft status, supply status, and diagnostics data. The focus was on display techniques for the support of the logistics commanders and their staff. Investigated the feasibility of developing a distributed logistics training capability to support the logistics community.

(U) $4,290 Demonstrated and applied predictive human health assessment models to accurately characterize the human health risks associated with exposure to operational compounds and materials for force protection. Demonstrated and applied methods to quantify skin toxicity risks from fuels and solvents used in flight operations and maintenance processes. Developed a biologically-based model for validation of exposure standards for Air Force missile fuel oxidizer. Began to develop innovative biotechnology techniques.

(U) $8,814 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602202F Human Effectiveness Applied Research**	PROJECT **1710**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$1,864	Develop logistics sustainment technology options and perform feasibility studies to support large-scale advanced technology development programs. These technologies will lead to more supportable weapon systems at reduced logistics support costs. Develop transformation algorithms and interface requirements for virtual validation of maintenance technical order data. Develop artificial intelligence software components to realistically model team decision-making in synthetic environments.
(U)	$1,770	Develop logistics readiness technology options and perform feasibility studies to support large-scale advanced technology development programs. These technologies will lead to more efficient utilization of logistics resources for Air Expeditionary Force operations. Continue to conduct feasibility studies and devise preliminary plans for the presentation of various types of information to maintenance and logistics personnel to include both the information presented and the platforms to be used. Begin work to define the technology requirements and component research areas to support a completely automated maintenance environment.
(U)	$3,641	Develop, demonstrate, and apply predictive assessment models to accurately characterize the toxicological risks associated with exposure to operational compounds and materials for force protection. Establish biologically-based approach for predicting skin irritation from dermal contact with fuels, solvents, and other hazardous chemicals used in the DoD. Develop innovative biotechnology techniques employing genomics and proteomics to identify exposure of animals to toxic substances and begin to employ that information to develop human biologically-based toxicity models.
(U)	$2,477	Perform biotechnology cellular dynamics research through a not-for-profit collaboration with industry and affiliated universities within the facilities of the Air Force Research Laboratory. Research and develop principles of integrated cellular control systems for use in innovative, cell-based technologies for Air Force applications.
(U)	$9,752	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,183	Develop logistics sustainment technology options and perform feasibility studies to support large-scale advanced technology development programs. These technologies will lead to more supportable weapon systems at reduced logistics support costs. Continue to develop transformation algorithms and interface requirements for virtual validation of maintenance technical order data. Develop software components to realistically model human interaction with synthetic team members. Develop advanced human-computer interface technology for logistics and control systems.
(U)	$1,652	Develop logistics readiness technology options and perform feasibility studies to support large-scale advanced technology development

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602202F Human Effectiveness Applied Research**	PROJECT **1710**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

		programs. These technologies will lead to more efficient utilization of logistics resources for Air Expeditionary Force operations. Continue to conduct feasibility and usability studies for the presentation of various types of information to maintenance and logistics personnel to include both the information presented and the platforms to be used. Continue work to define the technology requirements and component research areas to support a completely automated maintenance environment. Identify advanced simulation requirements and technology options for Air Force units to select the best options for using limited logistics resources in crisis action circumstances.
(U)	$3,845	Develop, demonstrate, and apply predictive assessment models to accurately characterize the toxicological risks to warfighters associated with exposure to operational compounds and material for force protection. Investigate the use of genomics, proteomics, and metabonomics to predict toxic combinations of chemicals and to measure exposures of warfighters to toxic chemicals before any adverse health effects occur. Develop prototype simulation models to predict the effects upon the warfighter in different exposure situations.
(U)	$7,680	Total

(U) B. Project Change Summary
Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)
(U) Related Activities:
(U) PE 0602233N, Human Systems Technology.
(U) PE 0602716A, Human Factors Engineering Technology.
(U) PE 0603231F, Crew Systems and Personnel Protection 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 February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602202F Human Effectiveness Applied Research	7184

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
7184 Crew System Interface & Biodynamics	30,965	29,478	33,830	35,424	38,832	45,421	38,383	38,820	Continuing	TBD

Note: In FY 2003, the protection program at Brooks City-Base, TX, moves from Project 7184 to Project 7757 to align resources with the Air Force Research Laboratory organization. In FY 2003, space unique tasks in Project 7184 will be transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This project develops the technology required to improve human performance, biodynamic response, and survivability in operational environments. This is accomplished by defining the physical and cognitive parameters, capabilities, and limits of systems operators; determining human responses to operational stresses such as noise, impact, vibration, maneuvering acceleration, spatial disorientation, and workload; and optimizing the human-machine interface. The project produces human-centered design criteria, guidelines, and automated design tools for the development of effective crew-systems interface. It develops and assesses technologies for information display, human-centered information operations, team communications, and modeling and simulation. It conducts experiments and evaluations of control interfaces, crew station layout and functional integration, aircrew information processing, crash protection, and emergency escape technologies.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,763 Developed interface technologies for crew station and equipment accommodation, multi-sensory adaptive controls and displays, and performance metrics. Determined the feasibility of extending real-time workload classification technology into unmanned combat air vehicle operations, and evaluated reduced crew operation in a multi-sensory unmanned air vehicle control station. Completed databases for cockpit accommodation and NATO three-dimensional human population as core elements for an intelligent, on-line physical accommodation information system to optimize equipment fit. Performed laboratory experiments using a virtual air command station to determine human interface design requirements for airborne early warning and control.

(U) $5,248 Developed cognitive information technology and human speech processing and control solutions for time-critical command and control to achieve common understanding at all echelons of information operations and to improve decision-making. Continued to devise user-computer interface concepts for intelligence analysts, investigated a display interface for integrated asset management, analyzed decision-support aids for air operations centers, and provided a laboratory demonstration of a rapid shared display for command center situation awareness. Began analysis and definition of human-machine interfaces and decision support tools for global attack. Began development of operator interface concepts and descriptive performance metrics in support of the Targets Under Trees program. Continued research on speech signal processing and speech-based countermeasures for information operations, including a concept demonstration of an intelligent voice jammer.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602202F Human Effectiveness Applied Research	PROJECT 7184

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U) $3,483 Developed concepts for integrating human-computer interface technologies, models of human behavior, and real-time simulations to affordably quantify operational benefit from new interface technologies. Produced design guidelines for an integrated control interface for unmanned vehicles. Continued to develop operator-vehicle interface concepts for exploiting real-time, off-board data and to demonstrate payoffs for mobility/special operations missions in laboratory simulations. Completed a feasibility evaluation for validating a digital model of human decision-making behavior.

(U) $4,123 Developed visual display interface technologies, specifically helmet-mounted displays, night vision technologies, large flat-panel displays, and developed an understanding of the effects of vision through display optics, vehicle transparencies, and synthetic vision. Conducted study on replacing the heads-up display with a helmet-mounted display, established color contrast guidelines, and developed frames of reference and symbology for attitude displays. Established design guides for windscreens and night vision displays. Determined resolution and brightness requirements for large flat-panel displays.

(U) $2,703 Developed advanced audio displays including three-dimensional audio, active noise reduction, and related technologies that mitigate effects of noise and enhance performance in the operational environment. Planned system integration and laboratory test as initial implementation for an acoustic remote threat detection in perimeter defense. Conducted research on (50 dB) hearing protection technologies for improved performance in high performance aircraft. Developed human performance standards for helmet-mounted cueing systems in vibratory environments.

(U) $918 Developed integrated human-centered information warfare technologies to assess and predict human performance under information warfare conditions and to influence an adversary's decision-making function. This research provided information warriors with human perception management tools and the means to evaluate the effectiveness of information warfare strategies on the human target set. Cognitive modeling efforts modeled effects of cross-cultural communications on human decision-making behavior. Auditory and visual technologies were applied to develop perception management tools for offensive counter-information applications.

(U) $3,023 Developed human injury and protective systems design criteria for use against hazards encountered in crash environments and emergency escape. Research developed technologies to improve full aircrew population safety during all phases of aircraft and vehicle operations including crashes, emergency escape, and parachute opening shock. Began developing injury assessment toolbox to be used in conducting injury risk assessment on personal protection and life support equipment, and seat and cockpit systems. Developed analysis techniques for evaluating data from ejection seat recorder. Conducted laboratory studies on adaptable restraint system technologies for application across Air Force airlift aircraft.

(U) $7,704 Developed aviation safety technologies to alleviate/mitigate warfighter fatigue, counter spatial disorientation, and improve pilot performance at high altitude and under high gravitational forces. Results will extend and enhance cognitive performance during Air Expeditionary Force deployments and long-range global attack missions. This research will reduce mishaps due to spatial disorientation and minimize adverse impacts of acceleration stresses on combat effectiveness. Extended fatigue management technologies to provide operational commanders and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602202F Human Effectiveness Applied Research	PROJECT 7184

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

mission planners with a limited capability to evaluate effects of alternative schedules on crew performance and mission effectiveness. Conducted fatigue countermeasures research to evaluate the operational efficacy of emerging alertness enhancing medications such as modafinil. Conducted spatial disorientation countermeasures research efforts to improve primary flight displays and reduce pilot workload through development of more intuitive symbology and improve pilot training through development of ground-based and flight-based spatial orientation training practices. Focused acceleration protection research efforts on defining physiological and performance effects of thrust-vectored flight and assessing the effects of pharmaceutical fatigue countermeasures on flight safety and pilot effectiveness in the high performance/high demand cockpit of modern fighter aircraft.

(U) $30,965 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,372 Develop interface technologies for crew station and equipment accommodation, multi-sensory adaptive controls and displays, and performance metrics. Evaluate methods for employing real-time measurement of crew workload as it changes with mission events to adjust automation and decision support in multi-ship, unmanned air vehicle missions. Develop concept for intelligent, on-line physical accommodation tools to optimize equipment fit, enabling future crew stations and equipment to adapt to human variability. Complete laboratory experiments exploring crew interface concepts for airborne command and control, demonstrate an advanced crew station for airborne early warning, and explore interface technologies for supervision of multiple autonomous unmanned air vehicles.

(U) $4,411 Develop cognitive information technology and human speech processing and control solutions for time-critical command and control to achieve common understanding at all echelons of information operations and improve decision-making and predictive battlespace awareness. Explore conceptual design options for a cognitive interface and knowledge repository to support information operations in the future air operations center. Continue to support the Targets Under Trees program by improving the ability to fuse imagery and signals intelligence. Continue research on speech signal processing and speech-based countermeasures for information operations and commence a multi-year program to demonstrate a robust stressed-speech identification capability including foreign language speech recognition.

(U) $3,548 Develop concepts for integrating human-computer interface technologies, models of human behavior, and real-time simulations to affordably quantify operational benefits from new interface technologies. Continue simulation software for an integrated, unmanned air vehicle crew station. Continue to develop operator-vehicle interface concepts for mobility using real-time, off-board data to assure tactical information dominance with minimum crew size. Explore control-display technology options for unmanned reconnaissance vehicles and begin to explore human performance requirements and fusion of on-board and off-board sensor data with imagery in a single display. Aggregate models of

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602202F Human Effectiveness Applied Research**	PROJECT **7184**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

human perception, decision-making, and control in selected military combat scenarios.

(U) $4,324 Develop visual display interface technologies, specifically helmet-mounted displays, night vision technologies, large flat-panel displays, and develop an understanding of the effects of vision through display optics, vehicle transparencies, and synthetic vision. Demonstrate the ability to calibrate color displays in the field environment to permit evaluating operational system displays, and develop an approach to model image quality. Begin to quantify the effects of binocular disparity and distortion, which negatively affect vision through helmet transparencies and windscreens. Determine feasibility and technical approach for exploiting color night vision in helmet-mounted displays. Develop testing standards for large flat-panel displays.

(U) $992 Develop low-cost PC-based three-dimensional (3-D) audio display system for enhancing the safety of general aviation aircraft. Develop spatial audio symbology for increasing the situational awareness of general aviation pilots. Demonstrate benefits of 3-D audio cueing in general aviation flight operations using immersive flight simulations and/or tests.

(U) $3,282 Develop advanced audio displays including 3-D audio, active noise reduction, and related technologies that mitigate effects of noise and enhance performance in the operational environment. Demonstrate feasibility of 3-D audio for security forces to localize threats and speed acoustic remote threat detection in perimeter defense. Recommend technologies, assess technology risk, and plan to develop a high performance (50 dB) hearing protection system. Begin to develop a dynamic noise model that can be integrated with real-time visualization of the sound field, usable for environmental analysis to characterize the noise environment around airfields, and usable for developing in-flight tactics in vectored thrust aircraft to minimize acoustic detection by adversaries.

(U) $788 Develop integrated human-centered information operations technologies to assess and predict human performance under information operations conditions to provide improved displays for quicker, more intuitive access to information to enhance decision-making capabilities, to improve situational and predictive battlespace awareness, and to provide more effective training procedures and fatigue management techniques. This research will provide information operations warriors with human perception management tools and the means to evaluate the effectiveness of information operations strategies on the human target set. Human perception management tools will be refined for potential weaponization in offensive and defensive counter-information operations. Concepts of operation for effects-based planning, demonstrations of prototypes for next-generation planning, and decision aids and warfighter-tailored information visualizations that specifically focus on information operations will be developed.

(U) $5,691 Develop human injury criteria and protective system technologies for use against hazards encountered in crash and other hazardous environments. Research will develop technologies to ensure full aircrew population safety during all phases of aircraft and vehicle operations including maneuvering acceleration, crashes, emergency escape, extended missions, and parachute opening shock. Revise injury criteria based on data from actual mishaps with ejection seat data recorder. Develop adaptable restraint system technologies, ensuring safety and expedient

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602202F Human Effectiveness Applied Research	PROJECT 7184

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

accommodation of diverse warfighters in Air Force transportation platforms. Human performance research results from simulated dynamic flight environments will improve aircrew performance in the operational environment. Research will provide cognitive performance and human information processing models that can be incorporated in war games and simulation-based acquisition models to accurately reflect the effects of physical stressors on human performance and mission effectiveness.

(U) $2,070 Develop technologies to counter spatial disorientation and improve pilot performance. Research will explore the feasibility of integrating emerging technologies such as three-dimensional audio, tactile situation awareness suit, pathway-in-the-sky displays, and night vision devices to improve pilots' ability to maintain spatial orientation and to aid recognition and recovery from spatial disorientation if it should occur.

(U) $29,478 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,523 Develop interface technologies for crew station and equipment accommodation, multi-sensory adaptive controls and displays, and performance metrics. Demonstrate a real-time ability to use on-line estimates of crew workload and situation awareness to adjust automation during future unmanned combat air vehicle missions. Continue to develop intelligent, on-line decision aiding and prediction tools to optimize equipment fit, by developing metrics that relate the quality of equipment fit to warfighter effectiveness. Perform laboratory demonstration of multi-sensory display concepts and technology for virtual air command in airborne early warning missions, and continue to assess the impact of near-term and far-term autonomous vehicle capability on the remote interface and decision support requirements of intelligent unmanned air vehicles.

(U) $4,253 Develop cognitive information technology and human speech processing and control solutions for time-critical command and control to achieve common understanding at all echelons of information operations and improve decision-making and predictive battlespace awareness. Perform laboratory and field evaluations of a cognitive interface and knowledge repository to support information operations in the future air operations center. Commence exploration of information, display, and course-of-action aids by analyzing information needs and by developing a combat operations visualization concept. Continue to support the Targets Under Trees program by evaluating target nomination advances in a field exercise. Continue research on speech signal processing and speech-based countermeasures for information operations and explore the concept of a robust stressed-speaker identification capability.

(U) $3,482 Develop concepts for integrating human-computer interface technologies, models of human behavior, and real-time simulations to affordably quantify operational benefit from new interface technologies. Demonstrate an operator-vehicle interface for mobility using real-time, off-board data to assure tactical information dominance with minimum crew size. Demonstrate a control-display interface to reduce task load and channelized attention for single operator control of multiple unmanned combat air vehicles. Continue to evolve new models of human

(U) **A. Mission Description Continued**

(U) FY 2004 ($ in Thousands) Continued

perception, decision-making and control, and explore model validation strategies.

(U) $4,366 Develop visual display interface technologies, specifically Helmet-Mounted Displays (HMD), night vision technologies, and large flat-panel displays, and develop an understanding of the effects of vision through display optics, vehicle transparencies, and synthetic vision. Continue to quantify the effects of binocular disparity, lasers, and distortion through helmet visors and windscreens. Begin to develop target acquisition and location symbology for HMDs. Investigate helmet-mounted tracker technology requirements for HMDs to replace aircraft Head-Up Displays. Begin to assess visual performance measures suitable for predicting display requirements under realistic viewing conditions.

(U) $3,332 Develop advanced audio displays including three-dimensional audio, active noise reduction, and related technologies that mitigate effects of noise and enhance performance in the operational environment. Continue exploratory development for acoustic remote threat detection in perimeter defense and recommend auditory symbology for security forces. Characterize the expected acoustic noise reduction achievable with earplugs for a high performance (50 dB) hearing protection system. Continue to develop a dynamic noise model that can be integrated with real-time visualization of the sound field, usable for environmental analysis to characterize the noise environment around airfields, and usable for developing in-flight tactics in vectored thrust aircraft to minimize acoustic detection by adversaries.

(U) $5,999 Develop integrated human-centered information operations technologies to provide quicker and more intuitive access to information, enhanced decision-making capabilities, and more effective training procedures. Conduct research to develop, distribute, and synchronize knowledge, training, and decision-making among various team members, multiple support teams, and reachback locations via advanced collaboration technologies and environments in order to enhance predictive battlespace awareness within Information Operations. Determine feasibility and technical approach for developing adversary cultural decision models, and development of training techniques and tools for information warriors.

(U) $5,575 Develop human injury criteria and protective system technologies for use against hazards encountered in crash and other hazardous environments. Research will continue to develop technologies to ensure full aircrew population safety during all phases of aircraft and vehicle operations including maneuvering acceleration, crashes, emergency escape, extended missions, and parachute opening shock. Revise injury criteria to account for variations in biodynamic response based on aircrew size and gender. Develop initial helmet weight and center of mass limits for symmetric and asymmetric HMD systems based on crew performance in operational maneuvering environments. Human information processing in the dynamic environment will be quantified and applied to models that can be incorporated in wargaming and simulation-based acquisition models.

(U) $2,300 Develop technologies to counter Spatial Disorientation (SD) and improve pilot performance, resulting in increased mission effectiveness and decreased loss of aircraft and lives due to SD mishaps. Pathway-in-the-sky symbology will be transitioned from a Head-Up Display format to Helmet-Mounted Display (HMD) simulator trials, ground-based spatial disorientation training criteria will be developed to better define training devices that can be procured for training purposes, alternative HMD off-boresight flight symbology will be flight-tested, and three-dimensional

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602202F Human Effectiveness Applied Research**	PROJECT **7184**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

audio, tactile stimulation, and intuitive flight displays will be integrated in motion-based flight simulator testing.

(U) $33,830 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0602500F, Multi-disciplinary Space Technology.
(U) PE 0602702F, Command, Control, and Communications.
(U) PE 0603205F, Flight Vehicle Technology.
(U) PE 0603231F, Crew Systems and Personnel Protection Technology.
(U) PE 0603245F, Flight Vehicle Technology Integration.
(U) PE 0604706F, Life Support Systems.
(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 February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602202F Human Effectiveness Applied Research	7757

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
7757 Bioeffects and Protection	14,360	26,556	14,658	14,524	13,212	13,599	15,388	15,758	Continuing	TBD

Note: In FY 2003, the protection program at Brooks City-Base, TX, moves from Project 7184 to Project 7757 to align resources with the Air Force Research Laboratory organization.

(U) A. Mission Description

This project predicts and mitigates the effects of exposure to radio frequency energy, high power microwaves, ultra-wideband pulsed fields, lasers, warfighter fatigue, altitude, and high, rapid-onset gravitational forces. The project enables the safe operational use of Air Force aerospace systems through technology developments that ameliorate/counter/exploit the biological effects of aerospace stressors including directed energy. It addresses areas such as safety, risk assessment, mission planning, countermeasures, and aircrew protection. The project also assesses the bioeffects of non-lethal directed energy technologies for force protection, special operations, military operations other than war, and peacekeeping applications.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $5,802 Conducted laser optical bioeffects laboratory experiments and field research, enabling exploitation of laser technology while researching countermeasures for optical hazards/threats with and without laser eye protection. Assessed bioeffects of agile laser technologies. Provided guidance for non-lethal laser illuminator employment. Demonstrated technologies for safe, active lasing in aircrew simulators, supporting improved engagement tactics, countermeasures, and laser safety training requirements.

(U) $6,044 Conducted radio frequency bioeffects laboratory experiments to enable safe exploitation of electromagnetic energy for directed energy weapons, non-lethal weapons, communications, and radar. Evaluated cellular damage and behavioral/cognitive disruption from pulsed radio frequency emitters. Continued health and safety studies on millimeter waves. Improved technology and models for radio frequency exposure prediction, assessment, and hazard warning.

(U) $294 Concluded post-operative evaluation and issued interim recommendations on the study of Photorefractive Keratectomy as a surgical method to reduce aircrew need for glasses or contact lenses.

(U) $567 Developed safety design criteria for portable active denial technology in support of the Air Expeditionary Force/Agile Combat Support initiative, enabling safe exploitation of directed energy weapons. Researched human safety, control, and pointing and tracking issues of directed energy. Verified the non-harmful effects of the active denial technology. Developed safety design criteria for directed energy systems using validated computer model.

(U) $1,653 Designed and developed probe kits to rapidly detect and identify biological weapons of mass destruction.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602202F Human Effectiveness Applied Research	PROJECT 7757

(U) A. Mission Description Continued

(U)	FY 2002 ($ in Thousands) Continued	
(U)	$14,360	Total
(U)	FY 2003 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$5,312	Conduct laser optical bioeffects laboratory experiments and field research, enabling exploitation of laser technology while providing countermeasures for optical hazards/threats with and without laser eye protection. Begin evaluation of eye protection technologies to counter the agile laser threat. Investigate the safety and effectiveness of emerging compact, ultrashort pulse laser technologies for both anti-materiel and non-lethal weapons applications. Explore new methods of conducting threshold damage studies to reduce reliance on in vivo experimentation. Expand research in optical technology development for information warfare and perception management applications.
(U)	$5,625	Conduct radio frequency bioeffects laboratory experiments to enable safe exploitation of directed energy. Expand laboratory assessment of biological effects of high power microwave and nanosecond pulse emissions. Evaluate cellular effects of radio frequency energy. Complete updated laboratory and field Radio Frequency Radiation (RFR) dosimetry tools for assessment of RFR exposure dose assessments by bioenvironmental engineering and occupational health personnel. Develop radio frequency and optical radiosensitive biotechnology tools to counter the proliferation of biological weapons of mass destruction.
(U)	$1,102	Develop safety design criteria for portable active denial technology in support of the Air Expeditionary Force/Agile Combat Support initiative, enabling safe exploitation of directed energy weapons. Complete laboratory assessment of portable active denial technology. Assess cognitive and psychosocial effects of non-lethal applications while attending to needs of the intelligence community.
(U)	$3,312	Develop aviation safety enhancing technologies to alleviate warfighter fatigue, counter physiological effects of high altitude flight, and improve pilot performance under high, rapid-onset gravitational forces. Results will extend and enhance cognitive performance during Air Expeditionary Force deployments and long-range global attack missions, and minimize adverse impacts of altitude and acceleration stresses on combat effectiveness. Sustained operations research will continue development and validation of quantitative models describing the effects of fatigue on human performance and mission effectiveness to increase the accuracy and realism of current human behavior representations used in war games, simulations, training exercises, and information warfare planning activities.
(U)	$4,265	Design and develop improved probe kits to rapidly detect and identify an expanded category of biological warfare agents.
(U)	$6,940	Develop solid electrolyte oxygen separation technologies for aircraft and ground-based oxygen generating systems. Technologies will improve the reliability of oxygen generation, ensure an oxygen source free of chemical and biological agents, and reduce the deployment footprint associated with the current liquid oxygen infrastructure. Advance state-of-the-art capabilities in oxygen generation by improving performance characteristics of the ion-separating ceramic membranes, increasing the liters of oxygen per minute produced by existing breadboard devices, and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602202F Human Effectiveness Applied Research**	PROJECT **7757**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

reducing the size, weight, and power requirements of those devices.

(U) $26,556 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $5,414 Conduct laser optical bioeffects laboratory experiments and field research, enabling exploitation of laser technology while providing countermeasures for optical hazards/threats with and without laser eye protection. Continue evaluating eye protection technologies to counter the agile laser threat. Continue to investigate the safety and effectiveness of emerging compact, ultrashort pulse laser technologies for both anti-materiel and non-lethal weapons applications. Continue to explore new methods of conducting threshold damage studies to reduce reliance on in vivo experimentation. Develop bioeffects-based safety criteria for test, deployment, and use of high energy laser systems.

(U) $4,638 Conduct radio frequency bioeffects laboratory experiments to enable safe exploitation of directed energy. Extend radio frequency dosimetry model to millimeter range. Evaluate bioeffects of high peak power and ultra-wideband microwaves on neural processing and performance. Complete evaluation of radio frequency radiation personal recording device. Enhance and apply laboratory techniques and models to evaluate and optimize the safety and effectiveness of directed energy for non-lethal applications.

(U) $1,856 Develop simulants for biological weapons with internal tracing and tracking (biosensor) technologies for support of development and evaluation of technologies for counterforce and neutralization of biological agents. Self-tracking and tracing biological simulants will enable assessment of the efficacy of counterforce and neutralization concepts more accurately and affordably than current methods. Continue feasibility study, including scalability, of biological self-tracking and tracing simulants. Begin design of specific category simulants (i.e., bacterial, viral, and toxin), laboratory tests, and scale-up process.

(U) $2,750 Develop aviation safety enhancing technologies to alleviate warfighter fatigue, counter physiological effects of high altitude flight, and improve pilot performance under high, rapid-onset gravitational forces. Results will extend and enhance cognitive performance during Global Strike/Global Mobility operations and minimize adverse impacts of altitude and acceleration stresses on combat effectiveness. Continue development of model-based quantitative fatigue management capabilities for operational mission planning and performance assessment. Assess chemical contaminant penetration in aircrew breathing gases produced by an onboard oxygen generation system that has a partially deactivated molecular sieve. Continue investigation of effects of break in oxygen prebreathe time on altitude decompression sickness risk. Quantify acceleration induced degradation in pilot performance that can occur prior to reaching actual loss of consciousness.

(U) $14,658 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602202F Human Effectiveness Applied Research**	PROJECT **7757**

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602720A, Environmental Quality Technology.
(U) PE 0603231F, Crew Systems and Personnel Protection Technology.
(U) PE 0604703F, Aeromedical Systems Development.
(U) PE 0604706F, Life Support Systems.
(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-2 Exhibit)

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602203F Aerospace Propulsion

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	174,292	132,285	101,575	88,859	100,434	109,747	106,982	107,881	Continuing	TBD
3012	Advanced Propulsion Technology	18,435	3,454	13,907	8,009	15,354	20,529	18,829	18,003	Continuing	TBD
3048	Fuels and Lubrication	12,380	17,304	13,754	13,341	14,873	17,134	13,530	13,828	Continuing	TBD
3066	Turbine Engine Technology	46,144	41,496	36,846	32,983	33,189	32,857	35,644	36,438	Continuing	TBD
3145	Aerospace Power Technology	26,726	34,508	22,763	22,841	23,905	23,309	26,921	27,521	Continuing	TBD
4847	Rocket Propulsion Technology	70,607	35,523	14,305	11,685	13,113	15,918	12,058	12,091	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

Note: In FY 2002, the Hypersonic Technology Program work performed in PE 0602203F, Project 3066; PE 0603202F, Project 668A; and PE 0603216F, Project 681B was transferred to Project 3012 in this PE in order to align projects with the Air Force Research Laboratory organization. In FY 2003, only the space unique tasks in Projects 3012 and 4847 were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities. In Project 4847, space unique includes all Integrated High Payoff Rocket Propulsion Technology activities except Technology for the Sustainment of Strategic Systems and tactical missiles.

(U) **A. Mission Description**

This program develops propulsion and power technologies to achieve enabling and revolutionary aerospace technology capabilities. The program has five projects, each focusing on a technology area critical to the Air Force. The Turbine Engine Technology project develops enabling capabilities to enhance performance and affordability of existing weapon systems. Efforts in this project are part of the Integrated High Performance Turbine Engine Technology and the Versatile Affordable Advanced Turbine Engine programs. The Rocket Propulsion Technology project pursues advances in rocket technologies for space access, space maneuver, and tactical and strategic missiles. Efforts in this project are part of the Integrated High Payoff Rocket Propulsion Technology program to include Technology for the Sustainment Systems. The Aerospace Power project develops efficient energy storage, power generation, and thermal management techniques for ground, air, and space military applications. The Fuels and Lubrication project develops new concepts and technologies to power, cool, and lubricate new and existing engines and directly supports the Integrated High Performance Turbine Engine Technology and the Versatile Affordable Advanced Turbine Engine programs. Finally, the Advanced Propulsion

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602203F Aerospace Propulsion

(U) A. Mission Description Continued

Technology of the Hypersonics Pillar of DDR&E's National Aerospace Initiative (NAI) to include combined cycle, ramjet, and hypersonic scramjet technologies to enable revolutionary propulsion capability for the Air Force. Note: In FY 2003, Congress added $3.0 million for Pulse Detonation Engines; $1.5 million for High Power Advanced Low Mass; $4.0 million for Lithium-ion Battery Development; $2.5 million for PBO Membrane for Advanced/High Performance Fuel Cells; $1.0 million for Unmanned Combat Air Vehicles Integrated Starter Generator; $2.5 million for Advanced Vehicle and Propulsion Center; $7.7 million for Cryo Installation for Jet and Rocket Engine Test Site; $5.7 million for DERF-Sustainment of Strategic Systems; and $2.3 million for Reusable Launch Vehicle Technology.

(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 technologies.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	178,485	107,659	118,958	
(U)	Appropriated Value	179,811	137,859		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-1,326	-4,915		
	b. Small Business Innovative Research	-3,337			
	c. Omnibus or Other Above Threshold Reprogram		-659		
	d. Below Threshold Reprogram	-6			
	e. Rescissions	-850			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-17,383	
(U)	Current Budget Submit/FY 2004 PBR	174,292	132,285	101,575	TBD

(U) Significant Program Changes:

FY 2004 decreases are primarily due to civilian salaries for space-related activities that were transferred to the new space unique PE 0602500F. Outyear funding for the NAI hypersonic activity will be addressed in the FY05 President's Budget Development.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 3012

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
3012 Advanced Propulsion Technology	18,435	3,454	13,907	8,009	15,354	20,529	18,829	18,003	Continuing	TBD

Note: In FY 2002, the Hypersonic Technology Program work performed in PE 0602203F, Project 3066; PE 0603202F, Project 668A; and PE 0603216F, Project 681B was transferred to this project in order to align projects with the Air Force Research Laboratory organization. In FY 2003, space unique tasks in this project were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This project develops combined/advanced cycle airbreathing high-speed (up to Mach 4) and hypersonic (Mach 4 to 8+) propulsion technologies to enable revolutionary propulsion options for the Air Force. These new engine technologies will enable future high-speed/hypersonic weapons and aircraft concepts. The primary focus is on hydrocarbon fueled engines capable of operating over a broad range of flight Mach numbers. Technologies developed under this program enable capabilities of interest to both DoD and NASA. Efforts include modeling and simulation, proof of concept demonstrations of critical components, advanced component development, and ground-based demonstrations.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $11,785 Demonstrated advanced hydrocarbon scramjet engine technology to enable fuller dominance of space. Conducted detailed analysis for mating scramjet a flight ready engine with flight demonstrator vehicle. Performed trajectory optimization for flight test. Completed design and component development. Initiated fabrication of a flight-ready hydrocarbon fueled scramjet engine, including flight weight fuel cooled structures, flight weight fuel control valves, fuel pump, and engine controller. Evaluated options for scramjet start, including gas generator/heat exchanger system, barbotage fuel injection with plasma ignition, and silane injection with a mechanical throat or air throttle. Demonstrated flight weight scramjet start system through ground testing. Verified operation of engine control techniques, based on rapid shock train identification/characterization coupled with fuel control logic, to ensure stable scramjet operation.

(U) $1,200 Conducted assessments, system design trades, and simulations to integrate combined and advanced cycle airbreathing hypersonic propulsion technologies into future missiles, manned and unmanned air vehicles, and access to space concepts. The goal is to improve warfighting capabilities and to meet Air Force Global Reach/Power needs. Conducted system trade studies to determine military payoff and establish component technology goals. Defined component and engine performance objectives to enable development of affordable hypersonic flight demonstrators jointly with NASA and the Defense Advanced Research Projects Agency.

(U) $3,000 Conducted proof-of-concept demonstrations of critical components for advanced and combined cycle engines. Designed, fabricated, and tested sub-scale inlet/combustor/nozzle to identify coupling between engine operating modes and to investigate the transition between modes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 3012

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

Designed and fabricated components capable of withstanding severe temperature and acoustic environments, and demonstrated component structural integrity. Performed ground demonstration of flight-type scramjet engine operation and performance over a broad flight speed envelope.

(U) $2,000 Designed flowpath for advanced and combined cycle engines to demonstrate operation and performance over a broad flight speed envelope. Initiated design of advanced and combined cycle engine components for incorporation into advanced and combined cycle demonstrator engines.

(U) $450 Developed a plasma ignition system coupled with the necessary power source, power conditioning, and control system to eliminate the need to pre-heat fuel or use a silane combustion aid. Investigated magnetohydrodynamic power generation and extraction from a hydrocarbon fueled scramjet flow path to provide energy for directed energy weapons and plasma generation for hypersonic vehicle drag reduction and scramjet combustion enhancement.

(U) $18,435 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $3,454 This project previously included space unique funding, which will be transferred to PE 0602500F, Project 5027. These funds represent the civilian salaries and in-house support for the work effort transferred.

(U) $3,454 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $13,339 Develop advanced hydrocarbon scramjet engine technologies to enable the broad application of hypersonics to meet future warfighter needs and to support flight demonstration consistent with that defined in the High Speed - Hypersonics planning Pillar of the NAI. Develop flight weight engine components including flight weight fuel control valves, fuel pumps, and engine controllers. Fabricate a flight engine consisting of three scramjet engine modules for the joint Air Force and NASA X-43C flight experiment. Evaluate options for scramjet start, including a gas generator/heat exchanger system and coast heating. Verify operation of engine control techniques based on rapid shock train identification and characterization coupled with fuel control logic to ensure stable engine operation. Conduct detailed analysis for mating scramjet flight engines with demonstrator vehicles. Perform trajectory optimization for flight test. Complete preliminary engine design. Complete development of flight weight engine components including flight weight fuel control valves, fuel pump, and engine controller. Evaluate options for scramjet start, including gas generator/heat exchanger system barbotage fuel injection with plasma ignition, and silane injection with a mechanical throat or air throttle. Verify operation of engine control techniques, based on rapid shock train identification/characterization coupled with fuel control logic,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 3012

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

to ensure stable scramjet operation. Initiate ground testing of the X-43C flight clearance engine. Conduct detailed analysis for mating a scramjet flight engine with the flight demonstrator vehicle. Perform trajectory optimization for flight test.

(U) $568 Conduct assessments, system design trades, and simulations to integrate combined and advanced cycle airbreathing hypersonic propulsion technologies into future missiles, and manned and unmanned aerospace vehicle concepts. Conduct system trade studies to determine military payoff and establish component technology goals. Define component and engine performance objectives to enable development of affordable hypersonic flight demonstrators jointly with NASA and the Defense Advanced Research Projects Agency.

(U) $13,907 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0601102F, Defense Research Sciences.
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602602F, Conventional Munitions.
(U) PE 0602702E, Tactical Technology.
(U) PE 0603211F, Aerospace Structures.
(U) PE 0603216F, Aerospace Propulsion and Power Technology.
(U) PE 0603601F, Conventional Weapons Technology.
(U) Program is reported to/coordinated by the Joint Army/Navy/NASA/Air Force (JANNAF) Executive Committee.
(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 February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 3048

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
3048 Fuels and Lubrication	12,380	17,304	13,754	13,341	14,873	17,134	13,530	13,828	Continuing	TBD

(U) A. Mission Description

This project develops improved fuels, lubricants, and combustion concepts for advanced turbine engines, scramjets, pulse detonation, and combined cycle engines. Systems applications include missiles, aircraft, and hypersonic vehicles. Analytical and experimental areas of emphasis include fuels and fuels logistics, lubricants, bearings, electromagnetic rotor, oil-less engine technology, optical diagnostics, and fundamental combustion. Fuels and lubricants for these engines must be thermally stable, cost-effective, and operate over a broad range of conditions. Advanced combustion concepts must be cost effective, durable, and reduce pollutant emissions.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $1,880 Developed low-cost additive approaches to improve fuel properties needed for manned and unmanned systems. Approaches included flow improving additives for low temperature properties to enable replacement of specialty fuels with JP-8, thermal-oxidative and pyrolytic deposit-reducing additives to increase the temperature limit of JP-8 to 900 degrees Fahrenheit, and particulate reducing additives to reduce soot emissions and infrared signature from propulsion systems. Initiated development of a computer model based upon chemical structure-activity relationships for fuel additives design and performance modeling.

(U) $450 Studied low-cost approaches to reduce fuel logistics footprint. Screened candidate technologies for fuel field diagnostic techniques. Defined improvements in additive packages to reduce logistics footprint.

(U) $660 Examined hydrocarbon fuel behavior under conditions encountered in combined and advanced cycle engines for low-cost access to space. Determined fuel ignition and combustion property deficiencies. Studied high energy density fuels for combined cycle engine applications. Performed payoff analyses and configuration trade studies to define, focus, and evaluate research in common fuels for future military air and space vehicles. Developed modeling and simulation capability for thermal management systems for aerospace vehicles.

(U) $2,680 Developed and evaluated combustor and propulsion concepts for gas turbine, pulse detonation, and combined and advanced cycle engines for manned and unmanned systems. Completed optimization of the trapped vortex combustor for transition to demonstrator engines. Identified combustor designs to reduce emissions from gas turbine engines. Demonstrated a highly-swirled ultra-compact combustor for use as the main combustor of a gas turbine engine. Investigated non-traditional thermodynamic cycles and propulsion systems through modeling, simulation, and experimentation. Performed payoff analyses and configuration trade studies to define, focus, and evaluate propulsion technology research for revolutionary combustor and propulsion concepts. Continued the development of pulse detonation engine technology and evaluated the performance using hydrocarbon fuel.

(U) A. Mission Description Continued

(U)	FY 2002 ($ in Thousands) Continued	
(U)	$275	Developed advanced optical and electromechanical diagnostics techniques and devices for fuel systems. Developed revolutionary combustor and propulsion concepts. Investigated pollutant gaseous emissions and particulate formation mechanisms and mitigation techniques in combusting environments.
(U)	$1,484	Conducted research to provide the Air Force with reliable and economical advanced lubricants. Developed and explored advanced bearing and lubricants concepts, components, and materials for improved engine performance, affordability, and engine health monitoring. Performed payoff analyses and configuration trade studies to define, focus, and evaluate research in lubricants and mechanical systems for combined cycle engines.
(U)	$2,000	Developed and explored advanced bearing concepts for small- and intermediate-sized turbine and rocket engine applications. Developed electromagnetic rotor support and power generation concepts, components, and materials for advanced, oil-less engines.
(U)	$2,951	Developed the technology base to build an airbreathing Pulse Detonation Engine for use in an unmanned air vehicle. Pulse Detonation Engines offer potential for low-cost propulsion systems that can be applied to unmanned vehicles and eventually to high-speed combined cycle engines. Initiated the design of key components of the Pulse Detonation Engine including the inlet, intake valve, fuel injector, initiator, controller, and thrust tube. Initiated development of Pulse Detonation Engine performance predictive models using experimental data.
(U)	$12,380	Total
(U)	FY 2003 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Programs
(U)	$2,327	Develop low-cost additive approaches to improve fuel properties needed for manned and unmanned systems. Approaches include flow improving additives for low temperature properties to enable replacement of specialty fuels with JP-8, thermal-oxidative and pyrolytic deposit-reducing additives to increase the temperature limit of JP-8 to 900 degrees Fahrenheit, and particulate reducing additives to reduce soot emissions and infrared signatures from propulsion systems. Complete development of an initial computer model based upon chemical structure-activity relationships for fuel additives design and performance modeling.
(U)	$1,128	Study low-cost approaches to reduce fuel logistics footprint, including field additization of locally-available fuels to produce a JP-8-quality fuel. Define improvements in additive packages and fuel dispensing methods to reduce logistics footprint, including on-board fuel evaluation and additization. Screen candidate technologies for fuel field diagnostic techniques, including on-line quality assessments.
(U)	$1,467	Investigate hydrocarbon and other high energy density fuel behavior under conditions encountered in combined cycle engines for low-cost access to space. Continue analyses and configuration trade studies to define and evaluate common fuels for future aircraft and military vehicles. Assess additive approaches to improve thermal stability and ignition/combustion properties in reduced scale component testing.
(U)	$4,020	Continue development, testing, and evaluation of revolutionary combustor, and propulsion concepts for gas turbine, pulsed detonation, and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 3048

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

combined and advanced cycle engines for missiles, manned and unmanned systems, and access to space. Perform modeling and simulation along with experiments to identify fuel additives and combustor designs to reduce emissions from gas turbine engines. Demonstrate an ultra-compact combustor at design operating conditions for use as an inter-turbine burner. Investigate non-traditional thermodynamic cycles for military propulsion systems through simulation/modeling and experimentation. Continue to perform payoff analyses and configuration trade studies to define, focus, and evaluate propulsion technology research for revolutionary combustor and propulsion concepts. Investigate inlet and nozzle configurations for a pulsed detonation engine and investigate incorporating pulsed detonation propulsion technologies into gas turbine engines.

(U) $475 Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary combustor and propulsion systems. Investigate pollutant emissions formation pathways through computational and experimental methods. Evaluate methods to reduce gaseous and particulate pollutant emissions from legacy and future gas turbine engines. Initiate evaluation of high intensity laser light interaction with matter.

(U) $1,084 Develop reliable and economical advanced lubricants. Continue development, test, and qualification activities to provide the most reliable and economical advanced turbine engine lubricants for the Air Force. Develop and test advanced bearing and lubrication system concepts, components, and materials for improved engine performance, affordability, and engine health monitoring. Continue to perform payoff analyses and configuration trade studies to define, focus, and evaluate research in lubricants and mechanical systems for combined cycle engines. Perform field support activities for aviation lubrication technologies.

(U) $2,915 Develop advanced bearing concepts for small- and intermediate-sized turbine engine applications. Design, fabricate, and test electromagnetic rotor support and power generation concepts, components, and materials for advanced, oil-less engines, including demonstrators that are part of the Integrated High Performance Turbine Engine Technology program. Continue development and initiate testing of air and foil bearing technology for small- and intermediate-sized turbine engine applications. Initiate development of modeling and simulation capabilities to advance design, shorten development time, and reduce testing requirements for mechanical and electromagnetic rotor support and power generation systems. Commence advanced rotor support and power generation studies for Versatile Affordable Advanced Turbine Engine program requirements.

(U) $940 Develop thermal management concepts and analysis tools for long-range strike applications of varying speed classes. Conduct fuel trade studies to identify fuel options and capability shortfalls for long-range strike applications. Develop diagnostic approaches and sensors for control of fuel/thermal management systems across the flight envelope. Continue development of engine fuel system and thermal management components identified in the Versatile Affordable Advanced Turbine Engine program.

(U) $2,948 Establish a design database relevant to the aerothermal and structural design of pulse detonation engines . Continue the design of key

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

components to include the inlet, intake valve, fuel injector, detonation initiator, controller, and thrust tube for an airbreathing PDE for use in subsonic and supersonic unmanned air vehicles. Pulse Detonation Engines offer potential for low-cost propulsion systems that can be applied to unmanned vehicles and high-speed combined cycle engines. Perform ground demonstration testing of some of the key components and continue development of Pulse Detonation Engine performance predictive models using experimental data.

(U) $17,304 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $1,858 Continue to develop affordable additive and fuel system approaches to improve fuel properties and to expand the flight envelope for manned and unmanned aircraft systems. Develop approaches to increase JP-8 temperature capability to 900 degrees Fahrenheit, including thermal stability additives, fuel deoxygenation, and improved coatings. Complete development of additive packages to enable JP-8 to achieve jet propulsion thermally stable low temperature (high altitude) performance. Enhance existing fuel modeling and simulation capabilities by incorporation of more realistic additive performance models.

(U) $1,061 Continue to evaluate low-cost approaches to reduce fuel logistics footprints, including field and on-board additive injections. Continue to develop improvements to existing fuel additive packages to simplify logistics and reduce cost. Assess performance of fuels from alternative (non-petroleum) sources, including Fischer-Tropsch fuels. Test candidate technologies for field-fuel quality diagnostics and sensors. Continue investigation of biological contamination in fuels.

(U) $1,026 Develop advanced additive approaches to reduce engine emissions and signature, including biotechnology, molecular imprinting, and nano-scale reactivity enhancement. Verify additive performance in laboratory-scale combustion tests. Develop improved diagnostics for sub-micron scale particulate emissions from combustors.

(U) $482 Continue to assess suitability of fuels for advanced and combined cycle vehicle applications for high-speed aerospace vehicles. Develop fuel property and performance data for industry and Government use in selecting alternative hydrocarbon fuels, in support of Integrated High Payoff Rocket Propulsion Technology hydrocarbon booster engine development efforts. Investigate approaches to assess fuel thermal stability under high heat flux conditions relevant to advanced rockets and combined cycle engines.

(U) $900 Develop approaches to extend the life of endothermic fuels and fuel system components for reusable hypersonic applications. Develop approaches to improve fuel heat sink capability. Develop structural approaches to minimize regenerative cooling heat loads absorbed by endothermic fuel systems. Develop approaches to improve fuel combustion performance, especially during cold start and cycle transition. Improve fuel system modeling and simulation tools to better simulate endothermic fuel behavior.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 3048

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U)	$3,291	Develop, test, and evaluate revolutionary combustor and propulsion concepts for gas turbine, pulsed detonation, and combined-cycle engines for missiles, manned, and unmanned systems. Evaluate the inter-turbine burner combustor at conditions that simulate turbine-wake and turbine-inlet interactions. Perform experiments to validate the high-speed performance of a pure pulsed detonation engine. Investigate the performance of a rudimentary combined-cycle pulsed-detonation engine and evaluate the technical issues associated with incorporating pulsed detonation propulsion technology into gas turbine engines. Perform experiments to evaluate promising fuel additives used to reduce particulates and emissions from gas turbine engines.
(U)	$833	Develop and demonstrate optical, electromechanical, and laser diagnostic tools and sensors for application to revolutionary combustor and propulsion systems. Develop and demonstrate sensors for the control of combustor performance and extension of component life. Investigate pollutant emission formation pathways through computational and experimental methods and evaluate methods to reduce gaseous and particulate pollutant emission from legacy and future gas turbine engines. Continue investigation of high intensity laser light interaction with matter.
(U)	$1,799	Continue development, test, and qualification activities to provide the most reliable and affordable advanced turbine engine lubricants for Department of Defense (DoD) and commercial users. Continue development and testing of advanced bearing and lubrication system concepts, components, and materials for improved engine performance, affordability, and engine health monitoring. Perform payoff analyses and configuration trade studies to define, focus, and evaluate research in lubricants and mechanical systems for man-rated, expendable, and uninhabited air vehicle turbine engines. Perform field support activities for aviation lubrication technologies and to support DoD operational units.
(U)	$2,504	Continue development of advanced bearing concepts for small-and intermediate-sized turbine engine applications. Perform full-scale rig testing of electromagnetic rotor support and a power generation system for advanced, oil-less engines, including demonstrators that are part of the Integrated High Performance Turbine Engine Technology program. Continue development and testing of affordable rotor support technology for small- and intermediate-sized turbine engine applications. Continue development of modeling and simulation capabilities to advance design, shorten development time, and reduce testing requirements for mechanical and electromagnetic rotor support and power generation systems. Perform advanced rotor support and power generation studies and testing for Versatile Affordable Advanced Turbine Engine program requirements.
(U)	$13,754	Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602203F Aerospace Propulsion**	PROJECT **3048**

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

(U) Related Activities:

(U) PE 0601102F, Defense Research Sciences.

(U) PE 0602805F, Dual Use Science and Technology.

(U) PE 0603216F, Aerospace Propulsion and Power 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 February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 3066

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
3066 Turbine Engine Technology	46,144	41,496	36,846	32,983	33,189	32,857	35,644	36,438	Continuing	TBD

Note: In FY 2002, the Hypersonic Technology Program work in this project was transferred within this PE into Project 3012, in order to align projects with the Air Force Research Laboratory organization.

(U) A. Mission Description

The Turbine Engine Technology project develops technology to increase turbine engine operational reliability, durability, mission flexibility, and performance while reducing weight, fuel consumption, and cost of ownership. Analytical and experimental areas of emphasis are fans and compressors, high temperature combustors, turbines, internal flow systems, controls, augmentor and exhaust systems, thermal management systems, engine inlet integration, mechanical systems, and structural design. This project supports the Integrated High Performance Turbine Engine Technology and Versatile Affordable Advanced Turbine Engine programs, which are joint DoD, NASA and industry efforts to focus turbine propulsion technology on national needs. The FY04 program plan reflects the tech base support for the VAATE activity relative to the TBCC technology development in support of the NAI hypersonics activity.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $29,244 Developed core turbine engine components (compressors, combustors, and high-pressure turbines) for turbofan/turbojet engines for fighters, attack aircraft, bombers, and transports. These components enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycles costs. Designed and fabricated a high-pressure ratio compressor including an active stability control system for reduced fuel burn, and high reaction blading and engine stall avoidance techniques for reduced maintenance costs. Developed improved performance, reduced emissions combustor technologies. Conducted analytical and experimental evaluations of combustor aerodynamics, fuel-air mixing, and liner cooling techniques. Developed affordable, robust, lightweight, and compact combustors such as the Integrated Lightweight Combustor or the Trapped Vortex Combustor configurations. Conducted environmental and structural evaluation of the spar/shell turbine blade with enhanced internal convection, limited transpiration cooling technologies, and three-dimensional features to reduce cooling air at high design operating temperatures. Rig tested a non-contacting stress measurement system allowing durable measurement of vibratory response of rotating blades. This technology enables replacements for limited life strain gages, reducing core engine components development and maintenance costs.

(U) $7,000 Developed turbine engine components (fans, low pressure turbines, engine controls, exhaust nozzles, and integration technology) for turbofan/turbojet engines for fighters, attack aircraft, bombers, and transports. These components enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Validated the contoured ceramic composite exhaust

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 3066

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

nozzle hardware in a high temperature environment. Evaluated temperature, pressure, and vibration of integrated components in a demonstrator engine. Completed reliability testing of a variable displacement vane pump system to eliminate fuel recirculation to tanks, reduce thermal loading, and increase weapon system thermal capacity. Completed fabrication of the non-linear control system to simplify control logic development and provide component performance trend data.

(U) $3,750 Developed components for limited life engines for missile and unmanned air vehicle applications. These components enable engines with reduced cost, reduced fuel consumption, and increased specific thrust, thereby greatly expanding the operating envelopes of cruise missiles and unmanned vehicles. Rig tested a composite forward swept fan for reduced weight, improved efficiency, and lower cost. Rig tested low-cost ceramic turbine blades to reduce cooling air and enhance performance.

(U) $2,350 Developed components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. Completed rig testing the splittered, forward swept compressor rotor to validate a high efficiency, high stage loading design. The components enable engines with reduced fuel consumption and lower production and maintenance costs.

(U) $2,300 Upgraded jet engine compressor and turbine aerodynamic test cells to enable assessment of emerging Air Force jet engine technologies supporting fighter and bomber transformational requirements. Increased power capability to 6,000 horse power and developed counter-rotating capability for these facilities.

(U) $1,500 Developed modeling and simulation tools to analyze and predicted the performance of aerospace engines and their components. Improved analytical tools associated with aerospace engines, focusing primarily on high performance, long life, advanced cooling techniques, and combustion stability.

(U) $46,144 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $29,035 Develop core engine components (compressors, combustors, and high-pressure turbines) for turbofan/turbojet engines for fighters, attack aircraft, bombers, long-range strike/next generation bombers, and transports. These components enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Perform testing on a high-pressure ratio compressor including an active stability control system for reduced fuel burn, and high reaction blading and engine stall avoidance techniques for reduced maintenance cost. Conduct testing on an active combustion control high response fuel valve to reduce acoustically coupled fatigue and to enhance overall combustion efficiency resulting in fuel burn reduction. Complete the subscale rotational intentional mistuning experiment and initiate the application of methodology to transonic rig hardware. Modify the spar/shell turbine blade design system using component bench test results and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602203F Aerospace Propulsion**	PROJECT **3066**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

transition this technology to engine demonstrator testing.

(U) $7,293 Develop turbine engine components (fans, low pressure turbines, engine controls, exhaust nozzles, and integration technology) for turbofan/turbojet engines for fighters, attack aircraft, bombers, long-range strike/next generation bombers, and transports. These components enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Conduct testing of a non-linear control system to simplify control logic development and to provide the component performance trend data necessary for transitioning this technology to the demonstrator engine program.

(U) $3,477 Develop components for limited life engines for missile and unmanned air vehicle applications. These components enable engines with reduced cost, reduced fuel consumption, and increased specific thrust, thereby greatly expanding the operating envelopes of cruise missiles and unmanned vehicles. Conduct rig test of an enhanced fan flow control treatment for an all-composite, forward swept shrouded rotor. Design rub tolerant ceramics for an advanced turbine rotor blades.

(U) $1,691 Develop components for turboshaft/turboprop and small turbofan engines for trainers, rotorcraft, special operations aircraft, and theater transports. Conduct durability tests of Ceramic Matrix Composite materials under high temperature/high pressure/high moisture conditions to validate composite integrity and life models. Perform rig tests to demonstrate the feasibility of a very high fuel/air ratio combustor with a supercritical fuel delivery system.

(U) $41,496 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $28,250 Develop core turbofan/turbojet engine components (i.e., compressors, combustors, and high-pressure turbines) for fighters, bombers, sustained hypersonic cruise vehicles, and transports. These components, made with advanced materials like Titanium Matrix Composites, enable aircraft engines with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Complete testing on a high-pressure ratio compressor, including an active stability control system for reduced fuel burn, and high reaction blading and engine stall avoidance techniques for reduced maintenance cost. Conduct full annular aerothermal test of a trapped vortex combustor. Conduct design and begin fabrication of advanced high-pressure turbine rig hardware, employing advanced three-dimensional, low shock loss aerodynamics for increased performance and reduced fuel burn. Develop advanced intentional mistuning methodology and begin experimental verification on transonic rig hardware.

(U) $8,151 Develop turbine engine components (i.e. fans, low pressure turbines, engine controls, exhaust nozzles, and integration technology) for turbofan/turbojet engines for fighters, bombers, sustained hypersonic cruise vehicles, and transports. These components enable aircraft engines

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602203F Aerospace Propulsion**	PROJECT **3066**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

with higher performance, increased durability, reduced fuel consumption, and lower life cycle cost. Complete design and begin fabrication of an advanced tandem, forward swept fan incorporating hybrid blade construction and composite reinforced disks to achieve high efficiency and stage loading with reduced weight and cost. Conduct testing of advanced control system hardware using component life models to verify real-time computational capabilities for transitioning this technology to a demonstrator engine program. Begin analysis and testing of advanced, low-observable compatible augmentor designs, resulting in improved design rules and tools to improve augmentor operability and reduce screech.

(U) $294 Develop limited life engine components for missile and unmanned air vehicle applications. These components enable engines with reduced cost, reduced fuel consumption, and increased specific thrust, thereby greatly expanding the operating envelopes of cruise missiles and unmanned vehicles. Begin preliminary design of an advanced versatile and affordable high pressure compressor, combustor, and high pressure turbine configurations for expendable engines using rub tolerant ceramic blades to meet the small engine performance and cost reduction objectives of the Versatile Affordable Advanced Turbine Engine program.

(U) $151 Develop turboshaft/turboprop and small turbofan engine components for trainers, rotorcraft, special operations aircraft, and theater transports. Begin preliminary design of advanced versatile and affordable high pressure compressor, combustor, and high pressure turbine configurations for turboshaft/turboprop engines to meet the small engine performance and cost reduction objectives of the Versatile Affordable Advanced Turbine Engine program. Supports the technology base support of TBCC concepts responsive to the High Speed-Hypersonics Pillar of NAI and focused on the tubine engine combined cycle technology requirements for a reusable high speed air vehicle.

(U) $36,846 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Materials:
(U) PE 0601102F, Defense Research Sciences.
(U) PE 0602102F, Materials.
(U) PE 0603216F, Aerospace Propulsion and Power Technology.
(U) PE 0602122N, Aircraft Technology.
(U) PE 0603210N, Aircraft Propulsion.
(U) PE 0603003A, Aviation Advanced Technology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602203F Aerospace Propulsion**	PROJECT **3066**

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

(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 February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602203F Aerospace Propulsion	3145

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
3145	Aerospace Power Technology	26,726	34,508	22,763	22,841	23,905	23,309	26,921	27,521	Continuing	TBD

(U) **A. Mission Description**

This project develops techniques for efficient power generation, energy storage, and thermal management for military aerospace applications. Power component technologies are developed to increase reliability, maintainability, commonality, and supportability of aircraft and flight line equipment. Research in energy storage technologies enables the 10-20 year long term energy storage goals of Air Force unmanned vehicles. Electrical power generation and thermal management technologies are enabling for all future military directed energy weapon systems. This project supports development of very high output power systems suitable for applications to air moving target indication radar, and high power lasers for aerospace platforms. Lightweight power systems suitable for other aerospace applications are also developed.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $9,363 Developed power generation/conditioning/distribution, energy storage, and thermal management component and subsystem technologies for manned and unmanned aircraft systems. These technologies improve aircraft self-sufficiency, reliability, maintainability, and supportability while reducing life cycle costs and enabling new capabilities. Fabricated and began evaluation of advanced switched reluctance machine controllers. Initiated fabrication of Inverter Converter Controller to demonstrate power density improvements. Continued development of high energy density lithium-ion cell and maintenance free battery technologies by testing cells and batteries to load profiles specified in performance requirements for aircraft. Initiated development of lithium polymer cells. Completed design of low-cost, long duration fuel cells for unmanned air vehicle systems. Developed and tested magnetic materials for high temperature generator and magnetic bearing aircraft applications.

(U) $6,000 Developed thermal management, energy storage and power conditioning components, and subsystem technologies for space applications. Fabricated an integrated Power Management and Distribution system for space-based distributed power systems that are half the weight and volume of conventional approaches. Demonstrated a radiation-hardened power semiconductor device. Continued development of high energy density polycrystalline capacitors, high voltage/high power diamond switches, and distributed power for laser diodes to enable the use of high power lasers on air and space platforms. Tested cycle life of high energy density lithium-ion cells and batteries for long-term space applications. Evaluated mechanical pumped-loop for higher-powered spacecraft. Continued work on active two-phase thermal management technologies.

(U) $5,420 Developed cryogenic power generation, high rate batteries, energy storage and power conditioning components, and system technologies with low volume displacement. These technologies enable the delivery of high power for operation of directed energy weapons. Completed component design of high density power conditioning for directed energy weapon systems. Developed high rate (pulse power) lithium-ion batteries. Began development of a thermal management system for cryogenic generator applications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 3145

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U) $2,970 Developed and demonstrated magnetic bearings for cooling turbine/power generation systems. Magnetic bearings provide increased cooling package reliability and longer life cycles over conventional turbine systems with rolling element bearings or air bearings. This task optimizes the controls for an integrated cooling turbine-generator trim load and advanced magnetic bearing cooling turbine systems.

(U) $991 Developed Poly(p-phenylene-2, 6-benzobisoxazole) (PBO)-based membrane fuel cells. PBO membrane fuel cells offer a lower cost, lighter weight, higher performance, and more energy efficient fuel cell over existing proton exchange membrane fuel cells. Initiated design and fabrication for a model PBO-based membrane in a single cell configuration.

(U) $991 Developed large ampere-hour rechargeable lithium-ion cell battery technologies for future spacecraft and aircraft. Lithium-ion batteries offer advantages over conventional systems by storing the same amount of energy at one-fourth the weight. Potential applications for rechargeable lithium-ion batteries include satellite energy storage, manned and unmanned aircraft, planetary orbiters, and ground support equipment. Initiated development of large ampere-hour cells that address cycle life technical issues for aircraft and Low Earth Orbit space applications and also address calendar life technical issues paramount for Geosynchronous Earth Orbit applications.

(U) $991 Developed high pulse power rechargeable lithium-ion cell battery technology that maximizes current capacity under high discharge rates required for solid state lasers. Potential high power military applications could include pulse power weapons for spacecraft and aircraft. This effort will focus on proper design and fabrication techniques beginning with relatively small ampere-hour cells.

(U) $26,726 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $9,465 Develop power generation/conditioning/distribution, energy storage, and thermal management component and subsystem technologies for manned and unmanned aircraft systems. These technologies improve aircraft self-sufficiency, reliability, maintainability, and supportability while reducing life cycle costs and enabling new capabilities. Conduct testing of advanced switched reluctance machine controllers. Fabricate and conduct tests on full-scale lithium-ion batteries and fuel cells for manned and unmanned vehicles. Continue development of lithium polymer cells.

(U) $5,030 Develop thermal management, energy storage and power conditioning components, and subsystem technologies for aerospace applications. Test and demonstrate an integrated Power Management and Distribution system for space-based distributed power systems that are half the weight and volume of conventional approaches. Fabricate and test full-scale lithium-ion batteries for aerospace spacecraft applications.

(U) $9,380 Develop cryogenic power generation, high rate batteries, energy storage and power conditioning components, and system technologies with low volume displacement. These technologies enable delivery of high power for operation of directed energy weapons. Fabricate and test high

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

density power conditioning for directed energy weapon systems. Continue developing higher rate (pulse power) lithium-ion batteries. Initiate testing of a thermal management system with Yttrium Barium Copper Oxide coated wire and coils for cryogenic generator applications.

(U) $1,882 Develop high density electrical power system and thermal management technologies for a next generation aerospace long-range strike vehicle. Develop power and thermal requirements for a long-range strike aircraft incorporating advanced weapon systems and initiate compact high power conditioning, energy storage, and thermal management component designs that optimize secondary power system size, weight, and efficiency.

(U) $2,430 Develop Poly (p-phenylene-2, 6-benzobisoxazole) (PBO) based membrane fuel cells. PBO membrane fuel cells offer a lower cost, lighter weight, higher performance, and more energy efficient fuel cell over existing proton exchange membrane fuel cells. Using results from past single cell research, initiate design and fabrication for a model PBO-based membrane in multi-cell/stack configurations.

(U) $3,889 Initiate development of large ampere-hour cells for lithium-ion cell batteries that address cycle life technical issues for aircraft and Low Earth Orbit space applications and also address calendar life technical issues paramount for Geosynchronous Earth Orbit applications. Next generation, high energy density and high power density rechargeable lithium-ion cell batteries (for future light weight, less expensive advanced spacecraft and aircraft (manned and unmanned) and possibly for high power weapons and ground support equipment) offer advantages over conventional, rechargeable systems by storing the same amount of energy at one-fourth the weight.

(U) $1,459 Develop component and system technologies for the High-Power, Advanced Low-Mass solar thermionic power system, including inflatable concentrator materials and design, thermionic cell materials and advanced converter design, secondary concentrator design, thermal storage materials, and high temperature power conditioning. Potential High-Power, Advanced Low-Mass applications in space are high power (>50 kW) orbital transfer propulsion, communication, radar or direct energy platforms. Component development will be aimed at supporting a ground demonstration of a 5 kW solar-thermionic power system. Performance analyses will continue with an emphasis on studying unique mission capabilities and comparing High-Power, Advanced Low-Mass capabilities and launch characteristics (size, weight, and cost) to that of other space power systems.

(U) $973 Provide hardware and technology to support demonstrations, at an engine manufacturer, of integrated power extraction from an integral starter/generator for Unmanned Combat Air Vehicles. These demonstrations will focus on anticipated Navy and Air Force Unmanned Combat Air Vehicles power requirements. Power generation, conditioning, and distribution technologies for Unmanned Combat Air Vehicles engines will focus on delivering an integral starter/generator . The integral starter/generator allows the engine to be started electrically, provides electrical power to support aircraft operations, and fits internal to the case, thus requiring no aircraft volume. The technologies can also be expanded and applied to a dual-spool engine's low pressure spool resulting in higher levels of power extraction, particularly at high altitudes, and at improved cycle efficiency. Aircraft self-sufficiency, reliability, maintainability, and supportability are all improved while life cycle costs are

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602203F Aerospace Propulsion**	PROJECT **3145**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

reduced and new capabilities are enabled.

(U) $34,508 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $11,977 Develop power generation/conditioning/distribution, energy storage, and thermal management component and subsystem technologies for manned and unmanned aircraft systems. These technologies improve aircraft self-sufficiency, reliability, maintainability, and supportability while reducing life cycle costs and enabling new capabilities. Complete testing of advanced-switched reluctance machine controllers. Develop preliminary design of optically controlled power electronics. Perform a dynamometer test of a starter/generator applicable for mid-thrust class turbine engine high spool applications. Initiate development of lithium-based solid state electrolyte battery technology.

(U) $2,500 Develop thermal management, energy storage and power conditioning components, and subsystem technologies for aerospace applications. Study advanced packaging techniques for silicon carbide power electronics. Develop integrated aerospace vehicle health monitoring algorithms.

(U) $8,286 Develop power generation, high rate batteries, energy storage and power conditioning components, and system technologies with low volume displacement. These technologies enable the delivery of higher power for operation of directed energy weapons. Design and fabricate advanced capacitors for pulsed power applications. Fabricate and begin testing liquid dielectric high voltage switch. Optimize processing techniques for long length Yttrium Barium Copper Oxide high temperature superconducting components. Fabricate and test small-scale, high rate lithium-ion cells. .

(U) $22,763 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0601102F, Defense Research Sciences.

(U) PE 0602102F, Aerospace Flight Dynamics.

(U) PE 0602605F, Directed Energy Technology.

(U) PE 0602805F, Dual Use Science and Technology.

(U) PE 0603605F, Advanced Weapon Technology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602203F Aerospace Propulsion	3145

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

(U) PE 0603216F, Aerospace Propulsion and Power 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 February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 4847

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4847 Rocket Propulsion Technology	70,607	35,523	14,305	11,685	13,113	15,918	12,058	12,091	Continuing	TBD

Note: In FY 2003, space unique tasks in this project were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities. In this project, space unique includes all Integrated High Payoff Rocket Propulsion Technology activities except Technology for the Sustainment of Strategic Systems and tactical missiles.

(U) A. Mission Description

This project develops advances in rocket technologies for space access, space maneuver, and for tactical and strategic missiles. Analytical and experimental areas of emphasis are propellants, combustion, rocket materials, strategic sustainment, and novel space propulsion concepts. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of future space and missile launch sub-systems. Technologies are developed to reduce the weight and cost of components using new materials, and improved designs and manufacturing techniques. All efforts in this project are part of the Integrated High Payoff Rocket Propulsion Technology program with emphasis on the Technology for the Sustainment of Strategic Systems. Integrated High Payoff Rocket Propulsion Technology is a joint DoD, NASA, and industry effort to focus rocket propulsion technology on national needs.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Programs

(U) $5,122 Developed, characterized, and tested strained-ring, unsaturated hydrocarbons and energetic, reduced-toxicity monopropellants to increase space launch payload capabilities. Refined synthesis methods of new propellants to facilitate the transition from producing lab-scale quantities to producing sufficient material to meet operational requirements. Continued scale-up of selected propellants for laboratory and demonstrator engine evaluations. Developed and explored high-energy-density oxidizers and polymeric binders (i.e., linked heterocyclic compounds) and worked to optimize paths for incorporating these materials into propellants with significantly enhanced performance. Continued evaluating the potential of monopropellants comprised of reduced-toxicity ionic salts to reduce the cost of space access and space operations. The goal is to develop monopropellants that have performance equivalent to bipropellants. Continued to evaluate selected propellants in advanced combustion devices to determine materials compatibility and performance.

(U) $2,475 Developed advanced liquid engine combustion technology to improve performance while preserving chamber lifetime and reliability in heavy lift space vehicle engines. Continued to characterize, study, and evaluate injector performance to ensure chamber/injector compatibility and to prevent damage to test and operational combustion devices. Continued to develop, analyze, and model potential advanced combustion devices and injectors compatible with new energetic propellants. Continued to model and analyze advanced propulsion concepts with enhanced performance and reliability such as laser-propelled lightcraft and rocket-based combined cycle engines.

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U) $3,036 Developed advanced technologies and material property enhancements for lightweight components for use in launch and space systems. Developed advanced ablative components using hybrid polymers for use in current and future launch systems. Continued to characterize and develop new high temperature polymer formulations and carbon-carbon materials for use in advanced combustion devices and propulsion systems to meet lower weight and increased strength requirements. Continued to develop advanced materials for use with high-energy propellants. Completed and transitioned advanced high temperature materials to Air Force systems to reduce system weight and cost, and increase performance.

(U) $11,108 Developed propulsion component technology for reliable, safe, and low-cost boost and orbit transfer systems. Completed development of an advanced lightweight rocket engine nozzle for upper stage and space booster applications. Continued development of a low-cost, high discharge pressure turbopump for advanced cryogenic engines. Developed components for hybrid propulsion for space boosters and air-launched missiles. Continued to develop turbomachinery, combustion, and propellant management devices for solid and liquid rockets. Continued developing high temperature turbine materials for oxidizer rich applications. Continued developing advanced lightweight rocket engine nozzles for upper stage and space booster applications. Verified performance and weight improvements of a rapid densification nozzle technology using improved strategic propellants for future ballistic missiles. Continued to demonstrate low-cost, high temperature, non-erosive, lightweight coated carbon-carbon ceramic and hybrid polymer components for solid rocket motors. Developed new fuels and oxidizers for advanced solid propulsion.

(U) $7,038 Developed missile propulsion technology, aging and surveillance technology, and Post Boost Control Systems for sustainment of the current Intercontinental Ballistic Missile fleet. Continued to develop an advanced lightweight solid rocket motor. Completed development of the initial version of tools to enhance the capability of determining the service life of strategic systems and other solid rocket motors. Began full-scale testing of the advanced Post Boost Control Systems. Completed efforts for prediction of solid motor life and transition into damage assessment models.

(U) $7,375 Developed solar electric and thermal propulsion technologies for stationkeeping, repositioning, and orbit transfer for large communication satellites and satellite constellations. Continued Hall thruster development efforts to achieve Air Force orbit transfers using electric propulsion. Continued development of microsatellites (< 25 kg) propulsion systems (e.g., plasma thrusters) for advanced imaging missions. Continued developing solar thrusters and concentrators for future orbital transfer vehicles. Evaluated an electrically controlled solid propellant. Designed high power solar thermal components.

(U) $11,824 Developed materials and processes to dramatically improve performance, durability, and cost of rocket propulsion systems. Evaluated new candidate materials for rocket engines such as Metal Matrix Composites, Discontinually Reinforced Materials, Ceramics, Ceramic Metallics, and Advanced Composites for use in liquid oxygen, liquid hydrogen, high-temperature, and high-pressure environments. Identified and evaluated the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 4847

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		applications of these materials to turbopump housings, ducts, valves, solid rocket casings, insulation, and nozzle throats. Developed material property databases and initiated a demonstration of suitability for applications using representative geometry and processing conditions for the intended rocket engine components.
(U)	$5,000	Developed rocket components of a hydrocarbon fueled rocket based combined/combination cycle engine for rapid access to space. Initiated studies to establish the optimum propulsion cycle and operating conditions. Initiated detailed design of high pressure turbopumps for hydrocarbon propellants. Initiated hydrocarbon thrust chamber design, focusing on affordable, lightweight materials and propellants to provide optimal heat transfer. Evaluated rocket engine health management and prognostic systems. Initiated scale-up and testing of new high density strained-ring hydrocarbon propellants. Evaluated combustion and thermal stability properties of select new hydrocarbon propellants. Produced sufficient quantities of propellants for 100-200 lb. thrust level rocket engine demonstrations.
(U)	$7,032	Conducted risk reduction efforts on the Integrated High Payoff Rocket Propulsion Technology program. This included adding an alternate, high temperature material into the hot gas valve for development and testing of lower cost, higher performance Post Boost Control System propulsion materials, a key portion of the Technology for the Sustainment of Strategic Systems program. Conducted solid and liquid propellant synthesis and scale-up critical for meeting Integrated High Payoff Rocket Propulsion Technology goals to significantly reduce cost-per-pound of payload to orbit for space launch applications. Conducted interim demonstrations of subsystems (propellant, case, nozzle, and insulation) for missile propulsion demonstration programs. Conducted demonstration of new monopropellant solutions for spacecraft applications such as the TechSat 21 flight experiment.
(U)	$10,597	Completed refurbishment and modernization of a large liquid rocket engine test stand and a component test stand to meet increased demand for liquid rocket test capability at Edwards Air Force Base. Performed modifications necessary to accommodate multiple users and broader capability on Test Stand 1D. Provided increased capability on Test Stand 2A for high pressure fluid storage and more test configurations.
(U)	$70,607	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Programs
(U)	$17,826	This project previously included space unique funding, which has been transferred to PE 0602500F, Project 5026. These funds represent the civilian salaries for the work effort transferred.
(U)	$5,542	Develop missile propulsion technologies for ballistic missile and boost systems. Begin component development and risk reduction efforts for the next phase Technology for the Sustainment of Strategic Systems ballistic missile technology demonstration. Verify performance and weight improvements of rapid densification nozzle technology using improved strategic propellants for future ballistic missiles. Continue to demonstrate

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602203F Aerospace Propulsion	PROJECT 4847

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

		low-cost, high temperature, non-erosive, lightweight coated carbon-carbon ceramic and hybrid polymer components for solid rocket motors. Formulate and characterize new propellant formulations using new fuels and oxidizers developed the last couple years for the next phase of advanced solid propulsion.
(U)	$7,488	Upgrade the existing Jet Engine Test Cell, located on the former Norton Air Force Base in San Bernardino, to enable the development testing of larger rocket engines, including those needing cryogenic propellants. The capability being installed will enable medium-size rockets to be tested and is complimentary to component test facilities at Edwards Air Force Base.
(U)	$2,430	Perform the initial Analysis of Alternatives at the Advanced Vehicle and Propulsion Center that will enable the next stage of acquisition planning for the following key Air Force Space Command missions: prompt global strike capability, land-based strategic nuclear deterrent, and operationally-responsive space lift system.
(U)	$2,237	Upgrade space infrastructure facilities at Air Force Research Laboratory's Edwards Air Force Base research site to provide data on the responsiveness of candidate new Reusable Launch Vehicle system designs.
(U)	$35,523	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Programs
(U)	$2,337	Continue risk reduction and technology development for Post Boost Control systems and solid rocket motor development FY 2003 work being done in 62500F, BPAC 5026. This work is part of the Technology for the Sustainment of Strategic Systems Phase I. Continue Phase I full-scale risk reduction component developments and testing supporting the advanced Post Boost Control Systems demonstration. Continue risk reduction efforts supporting Phase I missile propulsion demonstration.
(U)	$9,668	Develop missile propulsion technologies for tactical, ballistic missile, and boost systems. Continue component development and risk reduction efforts for the next phase Technology for the Sustainment of Strategic Systems ballistic missile technology demonstration. Verify performance and weight improvements of rapid densification nozzle technology using improved strategic propellants for future ballistic missiles. Continue to demonstrate low-cost, high temperature, non-erosive, lightweight coated carbon-carbon ceramic and hybrid polymer components for solid rocket motors. Formulate and characterize new propellant formulations using new fuels and oxidizers developed the last couple years for the next phase of advanced solid propulsion. Continue development of advanced tactical propulsion components.
(U)	$2,300	Develop missile propulsion technologies and aging and surveillance technologies for strategic systems. Continue second phase Technology for the Sustainment of Strategic Systems aging and surveillance technology developments in analysis codes, tools, and inspection tools for improved assessment of ballistic missile aging characteristics and status.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602203F Aerospace Propulsion**	PROJECT **4847**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued
(U) $14,305 Total

(U) B. Project Change Summary
Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)
(U) Related Activities:
(U) PE 0601102F, Defense Research Sciences.
(U) PE 0602114N, Power Projection Applied Research.
(U) PE 0602303A, Missile Technology.
(U) PE 0602805F, Dual Use Science and Technology.
(U) PE 0603311F, Ballistic Missile Technology.
(U) PE 0603401F, Advanced Spacecraft 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-2 Exhibit)

DATE **February 2003**

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602204F Aerospace Sensors

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	79,389	76,743	75,577	84,110	96,231	99,107	98,548	100,945	Continuing	TBD
2002	Electronic Component Technology	19,675	14,592	11,874	12,780	16,355	16,586	16,961	17,335	Continuing	TBD
2003	EO Sensors & Countermeasures Tech	13,602	14,028	15,670	15,739	15,975	16,461	16,836	17,206	Continuing	TBD
4916	Electromagnetic Tech	8,807	7,940	9,255	9,737	10,075	10,475	10,898	11,334	Continuing	TBD
5016	Photonic Component Technology	0	2,242	2,914	3,334	2,405	2,436	2,506	2,576	Continuing	TBD
5017	RF Processing for ISR Sensors	0	9,078	6,700	7,911	7,886	7,482	7,674	7,867	Continuing	TBD
6095	Sensor Fusion Technology	12,568	12,407	12,235	14,071	15,948	16,590	16,961	17,328	Continuing	TBD
7622	RF Sensors & Countermeasures Tech	24,737	16,456	16,929	20,538	27,587	29,077	26,712	27,299	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2002, work performed under PE 0602702F, Project 4600, moved to this PE, Project 4916. Apparent project ramps are due to realignment of the projects within the Air Force Research Laboratory organization. Project realignment did not affect work planned for the overall program element or the budget topline. In FY 2003, space unique tasks in this PE, Projects 2002, 6095, and 7622, transferred to PE 0602500F, Projects 5028 and 5029, in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This program develops the technology base for Air Force aerospace sensors and electronic combat. 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 aerospace sensor technologies for a variety of offensive and defensive uses; 3) RF antennas and associated electronics for

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602204F Aerospace Sensors

(U) **A. Mission Description Continued**

airborne surveillance, together with active and passive electro-optical 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 sensors and electronic combat systems. Note: In FY 2003, Congress added $1.0 million for Wireless Surveillance of Hostile Threats, $1.0 million for Advanced Fourier Transform-Infrared Gas Analysis, $1.0 million for Phased Array Antenna and Control System, and $1.3 million for Air Force Research Laboratory Information and Sensors Directorate.

(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 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	80,847	75,799	80,380	
(U)	Appropriated Value	81,149	80,099		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-302	-3,181		
	b. Small Business Innovative Research	-1,070			
	c. Omnibus or Other Above Threshold Reprogram		-175		
	d. Below Threshold Reprogram				
	e. Rescissions	-388			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-4,803	
(U)	Current Budget Submit/FY 2004 PBR	79,389	76,743	75,577	TBD

(U) Significant Program Changes:

None.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)											DATE February 2003
BUDGET ACTIVITY 02 - Applied Research				PE NUMBER AND TITLE 0602204F Aerospace Sensors							PROJECT 2002

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2002	Electronic Component Technology	19,675	14,592	11,874	12,780	16,355	16,586	16,961	17,335	Continuing	TBD

Note: In FY 2003, efforts in photonic component technology moved from this project into this PE, Project 5016. Also in FY 2003, space unique tasks in this project transferred to PE 0602500F, Projects 5028 and 5029, in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) **A. Mission Description**

This project focuses on generating, controlling, receiving, and processing electronic signals for radio frequency (RF) sensor aerospace applications. The enabling technologies developed under this project will be used for intelligence, surveillance, reconnaissance (ISR), electronic warfare (EW), and precision engagement. The technologies developed include: solid state power devices and amplifiers; low noise and signal control components; high-temperature electronics; 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 Department of Defense weapon systems requirements in the areas of radar, communications, EW, navigation, and smart weapons.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,071 Developed compact, affordable, multi-function receiver and phased array components for radar, EW, and other ISR sensors. Demonstrated Gallium Arsenide (GaAs), Indium Phosphide (InP), and silicon-on-insulator RF components for bench-level evaluation of radar and EW digital receiver modules. Developed a brassboard low-power (< 1.0W) analog-to-digital converter and delivered the converter for testing in a space-qualified silicon package. Completed the study and design phase of a multi-mode/multi-function digital receiver prototype module, and completed a feasibility trade study on performing wideband direct digital synthesis from aerospace platforms.

(U) $3,192 Developed microwave technologies for advanced RF apertures and phased array antennas used in military ISR sensors. Developed and demonstrated robust components for L-band and X-band transmitters and receivers that operate with limited environmental controls. The components are greater than 60% efficient with no active cooling, provide 20 Watts of output power, and are designed for radiation tolerance to 1 Mrad and greater than 200 degrees Celsius operating temperature.

(U) $4,057 Developed packaging and integration technologies for high performance aerospace RF sensor components. Demonstrated ten-fold cost reduction in an aerospace 20 GHz transmitter and a Ku-to -X-Band down-converter using low-cost packaging techniques. Developed a novel, flexible

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
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

		membrane to enable an ultra lightweight transmit/receive subarray. Developed mixed signal multi-chip modules, and evaluated three-dimensional interconnects, chip coatings, and advanced design techniques to enable high density micro-electro-mechanical systems and flexible assemblies for aerospace applications.
(U)	$604	Developed signal control components and techniques to meet radio frequency (RF) loss levels required for future radar, electronic warfare (EW), and intelligence, surveillance, and reconnaissance (ISR) sensors. Fabricated and characterized micro-electro-mechanical systems phase shifters for 300% improvement in RF loss performance operating over a 3:1 bandwidth.
(U)	$4,070	Developed RF photonic technologies to demonstrate compact, affordable, wide bandwidth, high data rate aerospace sensors. Developed low-loss, low-voltage broadband modulators for compact digital receiver applications. Designed high-performance components for wideband phased array antennas. Investigated the integration of photonic solutions for long time delays with the micro-electro-mechanical phase shifters for short delays to increase bandwidth.
(U)	$2,502	Developed innovative transmitter and receiver concepts along with the associated component technology alternatives required for an affordable space-based RF surveillance sensor system. Designed architectures that maximize predicted transmitter and receiver technology payoffs, and identified long lead-time RF sub-components required for space-based moving target indication.
(U)	$991	Designed and developed Fourier Transform-Infrared spectrometric gas analysis techniques for applications in controlling reactant gases generated during the vapor phase epitaxial growth of semiconductor films on substrates. These techniques will also be used to monitor gas concentrations in nanostructure growths for electronic and optical devices, and in the development of new approaches to detecting chemical and biological agents.
(U)	$1,188	Developed and conducted a proof of concept demonstration of the integration of active aperture components into flexible RF-compatible substrates. Integrating these components will enable robust chip placement on flexible phased array subassemblies for radar, EW, and communications systems.
(U)	$19,675	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,047	Develop compact, affordable, multi-function receiver/exciter and phased array components for communications, Global Positioning System, radar, EW, and other ISR sensors. Test Gallium Arsenide and Indium Phosphide RF components (analog-to-digital converters, filters, mixers, etc.) inserted into radar and EW digital receiver modules against environment scenarios. Demonstrate a brassboard low-power (< 1.0W), silicon-on-sapphire based analog-to-digital converter and complete ground-level radiation testing in a space-qualified package. Laboratory test a

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602204F Aerospace Sensors**	PROJECT **2002**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

silicon-on-insulator mixed-signal (digital, radio frequency (RF), microwave, etc.) integrated circuit, for reconfigurable signal conversion.

(U) $2,545 Develop microwave technologies for advanced RF apertures and phased array antennas used in military intelligence, surveillance, and reconnaissance (ISR) sensors. Develop and demonstrate robust components for L-band and X-band transmitter and receiver channels that operate with limited environmental controls and under severe electromagnetic stress.

(U) $3,247 Develop integration and assembly technologies for high performance aerospace phased array sensors. Demonstrate X-band, flexible RF membrane-based sub-assemblies that enable integrating low-cost and low-mass transmitter and receiver channels at the subarray level.

(U) $2,171 Develop signal control and low-power consumption components and techniques to reduce both power loss and power consumption. These components will be required for future radar, electronic warfare (EW), and ISR sensors. Characterize and mature micro-electro-mechanical systems wideband phase shifters for extended switch lifetimes. Reduce the power consumption of low-noise amplifiers while maintaining high linearity over wide bandwidths.

(U) $1,624 Refine materials and processes for two-dimensional and three-dimensional device interconnects and component protection from the environment. Verify these interconnects and components perform on rigid, flexible, and conformal assemblies of high density mixed signal technologies (digital, analog, microwave and millimeter wave devices and components). Test interconnects and components in both packaged (non-hermetic multi-chip modules) and package-less (bare-die-chip on board) forms.

(U) $979 Develop low-temperature, high-efficiency, small-scale fuel cells to generate power for wireless micro-sensor systems that will provide 'anytime, anywhere' ISR capabilities against emerging hostile threats.

(U) $979 Demonstrate Fourier Transform-Infrared spectrometric gas analysis techniques for applications in controlling reactant gases generated during the vapor phase epitaxial growth of semiconductor films on substrates. These techniques will also be used to monitor gas concentrations in nanostructure growths for electronic and optical devices, and in the development of new approaches to detecting chemical and biological agents.

(U) $14,592 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,606 Develop compact, affordable, multi-function receiver/exciter and phased array components for communications, Global Positioning System, radar, EW, and other ISR sensors. Develop receiver architecture and components addressing issues specific to digital beamforming systems, such as multiple channel coherence of multi, digital true time delay support, channel equalization, and array calibration. Evaluate in an operational environment affordable Gallium Arsenide (GaAs) RF components (analog-to-digital converters, filters, mixers, etc.), together with the technology upgrade plan for Indium Phosphide (InP) RF components into radar and EW digital receiver modules.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602204F Aerospace Sensors**	PROJECT **2002**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U)	$2,298	Develop and integrate microwave technologies for advanced radio frequency (RF) apertures and phased array antennas used in military intelligence, surveillance, and reconnaissance (ISR) sensors. Develop and demonstrate the proof of concept of transmit and receive (T/R) channels that are able to withstand strong undesired electromagnetic signals.
(U)	$2,039	Continue developing integration and assembly technologies for high performance phased array sensors. Demonstrate large area (>0.5 m2) active apertures based on flexible RF membranes that lower the assembly costs and mass over conventional phased arrays by an order of magnitude.
(U)	$2,738	Develop low-power consumption components and techniques to reduce the aperture power consumption required for future radar, electronic warfare, and ISR sensors suitable for use on small, air-launched, unmanned aerial vehicles. Fabricate subarrays with T/R channels that feature a five-fold power consumption reduction while maintaining high linearity over wide bandwidths.
(U)	$1,300	Demonstrate mixed-signal receiver/processor multi-functionality on flexible arrays using advanced two-dimensional and three-dimensional interconnects, and package-less protection schemes. Verify the electrical performance of these mixed signal assemblies and validate their hermetic-like protective qualities.
(U)	$893	Evaluate the integrated tool suite in the modeling, simulation, design, and characterization environment for mixed-signal (digital, RF, microwave, etc.) component development in both advanced and emerging electronic component technologies. Laboratory test breadboard silicon-on-insulator and silicon-on-sapphire signal conversion components designed for precise positioning, navigation, and other aerospace applications.
(U)	$11,874	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602500F, Multi-disciplinary Space Technology.

(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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 2002

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)										DATE February 2003
BUDGET ACTIVITY 02 - Applied Research				PE NUMBER AND TITLE 0602204F Aerospace Sensors						PROJECT 2003
COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2003 EO Sensors & Countermeasures Tech	13,602	14,028	15,670	15,739	15,975	16,461	16,836	17,206	Continuing	TBD

(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 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 aerospace surveillance and targeting. Other project goals include advanced EO threat warning and countermeasures.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,790 Developed technology for non-cooperative identification of airborne and ground-based platforms. Conducted ground-to-air demonstration of long-range combat identification (CID) sensors. Tested coherent image processing/extraction algorithms including three-dimensional (3-D) block registration algorithms. Conducted measurements and evaluated advanced 3-D focal planes for CID application. Continued passive hyperspectral model development, validation, and performance predictions. Continued analyzing and evaluating multi-function ladar flight demonstration data for CID.

(U) $2,509 Developed optical transmitter technology capable of sensing multiple target characteristics for robust non-cooperative target identification. Continued developing a pulsed vibration/imaging sensing system for long-range combat identification. Investigated and demonstrated critical components of a monolithic, solid state coherent ladar architecture.

(U) $3,175 Developed innovative techniques and components to target difficult objects in degraded atmospheric conditions. Began utility analysis of high altitude active sensors. Tested components for active multi-spectral imaging. Demonstrated EO imaging through weather and obscurants. Designed and demonstrated targeting concepts based on high precision pointing, range gating, and image processing. Evaluated non-mechanical EO beam steering devices. Investigated component designs for ladar apertures.

(U) $1,808 Developed countermeasure technologies for use against IR- and EO-guided missiles. Continued to design components and refine techniques to defeat imaging missile seekers. Continued exploiting advanced infrared missile technology.

(U) $1,539 Developed aerospace missile and laser warning technologies to accurately cue countermeasures. Laboratory tested temporal and spectral tracking algorithms focused on multi-spectral imaging techniques. Evaluated advanced laser warning sensor component hardware for application

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602204F Aerospace Sensors**	PROJECT **2003**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		in a space environment.
(U)	$1,781	Investigated the feasibility of designing and fabricating a three-dimensional (3-D) Adverse Weather Ballistic Imaging and Targeting System imaging laser radar sensor for unmannned aerial vehicles. This laser radar would be capable of making one-foot resolution 3-D images of targets and areas of interest through moderate cloud cover.
(U)	$13,602	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$4,253	Develop technology for non-cooperative identification of airborne and ground-based platforms. Conduct air-to-air and air-to-ground demonstrations of long-range combat identification (CID) sensors. Test range-resolved coherent image processing and extraction algorithms, including 3-D block registration algorithms. Conduct long-range experiments using advanced 3-D sensors for CID applications. Continue passive hyperspectral model development, validation, and performance predictions, and assess signature-based data processing performance based on ground demonstration data. Continue flights, analysis, and evaluation of multi-function ladar for identification of ground targets.
(U)	$3,149	Develop optical transmitter technology capable of sensing multiple target characteristics for robust non-cooperative target identification. Develop pulsed vibration sensing system for long-range CID. Begin developing flight-capable, multi-function architectures. Integrate platform compensation techniques into new architectures. Develop breadboard multi-spectral transmitter, and predict performance for different types of targets.
(U)	$4,029	Develop innovative techniques and components to target difficult objects in degraded atmospheric conditions. Continue utility analysis of high altitude active sensors, including platform trades. Perform tower tests of an active multi-spectral imaging system. Demonstrate imaging through weather and obscurants through flight test of active imaging sensors. Design and demonstrate concepts based on high precision pointing, range gating, and image processing. Develop concepts for airborne application of non-mechanical beam steering devices, including mitigating aero-optical effects. Investigate concepts for combined radio frequency and electro-optical (EO) apertures.
(U)	$1,948	Develop countermeasure technologies for use against infrared (IR) guided missiles and EO threats. Continue to design components and refine techniques to defeat imaging missile seekers. Continue the exploitation of advanced IR missile technology.
(U)	$649	Develop aerospace missile and laser warning technologies to accurately cue countermeasures. Laboratory test temporal and spectral tracking algorithms focused on multi-spectral imaging techniques. Initiate the testing of an advanced laser warning receiver for application in a space environment.
(U)	$14,028	Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602204F Aerospace Sensors	2003

(U) A. Mission Description Continued

(U)	FY 2004 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$4,004	Develop technology for non-cooperative identification of airborne and ground-based platforms. Conduct ground- and air-based testing and demonstration of an advanced Combat Identification (CID) system with multi-spectral detection and cueing, and active electro-optical (EO) target long-range combat identification sensors. Integrate advanced, three-dimensional (3-D) focal planes and algorithms in a concept design of a high altitude system to detect targets in relevant environments. Continue passive hyper-spectral model development, validation, and performance predictions specifically supporting the flying testbed. Define technologies suited to layered sensing approaches for deep penetration and continuous target area coverage.
(U)	$2,010	Develop optical transmitter technology capable of sensing multiple target characteristics for robust non-cooperative target identification. Demonstrate multi-function, pulsed vibration imaging sensing system for long-range CID. Test and evaluate sensors utilizing 3-D focal planes. Continue development of flight capable multi-function architectures. Continue fabricating a breadboard multi-spectral transmitter and evaluate performance for different types of targets.
(U)	$7,510	Develop innovative techniques and components to target objects in degraded atmospheric conditions. Develop high altitude active sensor performance specifications and concept design. Integrate weather and obscurant penetration concepts. Evaluate non-mechanical beam steering concepts for high altitude sensor applications including precision pointing, focusing, and wavefront correction. Perform an initial demonstration of a combined EO and radio frequency aperture. Perform tests, analyses, and evaluations of a specialized multi-function ladar for the detection and characterization of difficult targets.
(U)	$1,149	Develop countermeasure technologies for use against infrared (IR) guided missiles and EO threats. Complete an IR scene projector to assess imaging sensor capabilities. Begin evaluating onboard and offboard techniques to defeat imaging missile seekers. Continue exploiting advanced IR missiles and IR sensor technologies.
(U)	$997	Develop aerospace missile and laser warning technologies to accurately cue countermeasures. Laboratory test temporal and spectral tracking algorithms focused on multi-color imaging techniques. Initiate developing an advanced laser warning receiver for space and airborne applications.
(U)	$15,670	Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 2003

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

(U) Related Activities:

(U) PE 0602500F, Multi-disciplinary Space Technology.

(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.

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602204F Aerospace Sensors

PROJECT
4916

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4916 Electromagnetic Tech	8,807	7,940	9,255	9,737	10,075	10,475	10,898	11,334	Continuing	TBD

Note: In FY 2002, this work transferred to this project 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 (EO) 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 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,173 Developed 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) $2,307 Designed and developed antennas for airborne and space-based surveillance. Designed, analyzed, and built advanced large, lightweight antenna arrays. Developed new algorithms for digital beam-formed multi-beam antennas. Developed high-speed electronics for antenna front ends.

(U) $2,053 Designed and developed next generation EO techniques and advanced components for use in detection and identification of concealed targets. Designed and fabricated multi-function sensor arrays and innovative materials and device technologies for optical beamsteering. Designed and developed active components and advanced integration techniques for autonomous ladar-guided munitions and other imaging applications. Developed optical processing techniques for optical aberration in aircraft-generated turbulence.

(U) $2,274 Developed hardware and software for passive multi-dimensional sensing in the thermal infrared spectral wavelength range at high frame rates. Established the viability of tomographic hyperspectral sensing techniques for missions that have not been able to capitalize on the power of spectral target identification tools. Evaluated 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) $8,807 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 4916

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$1,832	Investigate detecting difficult airborne and ground-based targets in clutter from airborne or space-based surveillance platforms. Develop models and experimental techniques for characterizing radio frequency (RF) scatter from targets, ground clutter, and foliage.
(U)	$1,749	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 forming and limited-scan phased array antennas. Develop high-speed electronics for antenna front end applications and micro-electro-mechanical systems technology for delayed line switching in phased arrays.
(U)	$1,580	Design and develop new electro-optical (EO) techniques and components for detecting and identifying concealed targets. Design and fabricate multi-function sensor arrays and the associated materials and device technologies for optical beam steering. Design and develop active components and integration techniques for autonomous three-dimensional ladar-guided munitions and other imaging applications. Develop optical processing techniques that compensate for optical aberration in aircraft-generated turbulence.
(U)	$1,800	Develop hardware and software for passive multi-dimensional sensing in the thermal infrared spectral wavelength range at high frame rates. Establish viability of tomographic hyperspectral sensing techniques for aerospace applications. Demonstrate the applicability of tomographic hyperspectral sensor concepts to characterizing explosions and missile launches, and to developing techniques for real-time bomb-damage assessment.
(U)	$979	Continue developing a phased array antenna control system by implementing computer algorithms that control the antenna's beam pointing, and by developing the computer hardware necessary to enable system operators to monitor the health and status of the antenna and monitor antenna operations.
(U)	$7,940	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,269	Investigate the detection of difficult airborne and ground-based targets in clutter from surveillance platforms. Develop models and experimental techniques for the characterization of RF frequency scattering from targets, ground clutter, and foliage.
(U)	$2,429	Design and develop antennas for aerospace surveillance. Design, analyze, and build advanced large, lightweight antenna arrays. Develop new algorithms for digital beam forming and limited-scan phased array antennas. Develop high-speed electronics antenna front end applications and micro-electro-mechanical systems technology for delayed line switching in phased arrays.
(U)	$2,179	Design and develop new EO techniques and components for detecting and identifying concealed targets. Design and fabricate multi-function sensor arrays and the associated materials and device technologies for optical beam steering. Design and develop active components and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 4916

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

integration techniques for autonomous three-dimensional ladar-guided munitions and other imaging applications. Develop optical processing techniques that compensate for optical aberrations in aircraft-generated turbulence.

(U) $2,378 Develop hardware and software for passive multi-dimensional sensing in the thermal infrared spectral wavelength range at high frame rates. Establish viability of tomographic hyperspectral sensing techniques for aerospace applications. Demonstrate the applicability of tomographic hyperspectral sensor concepts to characterizing explosions and missile launches, and to developing techniques for real-time bomb-damage assessment.

(U) $9,255 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602500F, Multi-disciplinary Space Technology.

(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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 5016

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5016 Photonic Component Technology	0	2,242	2,914	3,334	2,405	2,436	2,506	2,576	Continuing	TBD

Note: In FY 2003, photonic component technology work previously performed in this PE, Project 2002, transferred to this project.

(U) A. Mission Description

This project focuses on designing and developing methods to generate, control, receive, transmit, and process opto-electronic (mixed) signals for radio frequency (RF) sensor aerospace applications. Enabling technologies developed under this project for intelligence, surveillance, reconnaissance, electronic warfare (EW), and precision engagement sensors include: low noise, aerospace environmentally-qualified signal control components (e.g., electro-optical (EO) switches, micro-opto-electronic mixed signals; electro-optical components for RF links; photonic signal control, distribution, and signal processing; multi-function, aerospace-qualified, opto-electronic integrated circuits; wide band photonic-based high-speed EO analog-to-digital and digital-to-analog converters; and opto-electronic intraconnects and interconnects. This project designs, develops, fabricates, and evaluates techniques for integrating various combinations of photonic and electronic technologies. The main purpose is to demonstrate significantly improved military sensors of smaller size, lower weight, lower cost, lower prime power, higher reliability, and improved performance -- as compared to current systems. The device, component, and subsystem technology developments under this project are military unique and based on Air Force and other Department of Defense weapon systems requirements in the areas of radar, sensors, communications, EW, navigation, and smart weapons.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $1,575 Develop high performance integrated photonic technology link, interconnect, and switching components and subsystems for wideband RF phased array antenna beamforming and control, and for high data rate aerospace sensors and communication systems.
(U) $667 Develop ultrafast, wideband photonic analog-to-digital mixed signal conversion component technology.
(U) $2,242 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602204F Aerospace Sensors**	PROJECT **5016**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,248	Continue developing high performance integrated photonic technology link, interconnect, and switching components and subsystems for wideband radio frequency phased array antenna beamforming and control, and for high data rate aerospace sensors and communication systems.
(U)	$666	Continue developing ultrafast, wideband photonic analog-to-digital mixed signal conversion component technology.
(U)	$2,914	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602500F, Multi-disciplinary Space Technology.
(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

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 5017

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5017 RF Processing for ISR Sensors	0	9,078	6,700	7,911	7,886	7,482	7,674	7,867	Continuing	TBD

Note: In FY 2003, efforts in radio frequency (RF) processing for intelligence, surveillance, and reconnaissance (ISR) sensors previously performed in this PE, Project 7622, transferred to this project.

(U) A. Mission Description

This project develops and assesses radar technology for affordable, reliable, all weather aerospace ISR systems. Emphasis is on detecting and tracking surface and airborne targets that have difficult to detect signatures due to reduced cross sections, concealment and camouflage measures, severe clutter, or heavy jamming. Techniques exploited include the use of multiple RF phenomenologies, multi-dimensional adaptive processing, advanced waveforms, and knowledge-aided processing techniques.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $0 No Activity

(U) $0 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,460 Investigate techniques for implementing distributed airborne sensor systems to increase sensitivity and improve location accuracy. These techniques include sparse arrays with maneuvering platforms and improved location accuracy using interfermetric methods combined with knowledge-based responsive mode selections.

(U) $1,987 Investigate techniques for multi-intelligence data acquisition from a single platform. Investigate common waveform techniques, knowledge-based scheduling, and advanced target detection for both unconcealed and concealed targets. Determine the electromagnetic compatibility issues associated with simultaneously hosting and operating multiple radars, electronic support measure receivers, integrated communications, and electronic attack components on a single platform. Investigate methods to mitigate unintentional interference sources to multi-intelligence platforms from the ground and in the air, such as commercial broadcast assets, civilian radar assets, and commercial communications systems.

(U) $3,828 Develop multi-mission aerospace microwave processing algorithms to detect and locate advanced cruise missiles, slowly moving ground targets, and stationary targets in severe clutter and jamming environments. Study multi-mission adaptive radar algorithms to support various operational modes, including air and ground target detection, ground target imaging, electronic protection, and passive RF emission detection. Study

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602204F Aerospace Sensors**	PROJECT **5017**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

advanced waveforms for achieving transmitter adaptivity and simultaneous multi-mode operation to improve interference rejection, self-protection, and target identification by exploiting diversities in frequencies, delays, polarizations, modulations, and codings. Develop knowledge-aided radar signal processing techniques for improved detection and false alarm control performance in ground moving target indication sensors.

(U) $530 — Study and analyze technology for detecting and precisely locating concealed targets using standoff aerospace platforms. Initiate an investigation of emerging adaptive processing techniques for knowledge-aided multi-mission processing and resource management. Initiate the study of adaptive processing techniques for multi-mission conformal arrays. Initiate the study of wideband and polarization adaptive processing techniques for multi-function radar.

(U) $1,273 — Test and evaluate Global Positioning System receivers to assess potential problems from spectrum encroachment by ultra-wideband devices.

(U) $9,078 — Total

(U) FY 2004 ($ in Thousands)

(U) $0 — Accomplishments/Planned Program

(U) $498 — Demonstrate, through computer simulation and emulation, the techniques for the implementation of distributed airborne sensing techniques for detecting, locating, and engaging airborne and ground targets.

(U) $2,312 — Continue to investigate techniques for multi-intelligence data acquisition from a single platform. Validate multi-function radar sensing through computer simulations and emulations. Continue investigating the electromagnetic compatibility issues associated with hosting multiple radars, electronic support measure receivers, integrated communications equipment, and electronic attack components on a single platform capable of operating simultaneously. Continue investigating methods to mitigate unintentional interferers on the ground and in the air such as commercial broadcast assets, civilian radar assets, and commercial communications systems on multi-intelligence platforms. Initiate investigating electronic counter-countermeasure techniques that will enable maintaining a surveillance capability in various advanced jamming scenarios based upon multi-intelligence single platform sensing.

(U) $3,109 — Evaluate and refine multi-mission aerospace microwave processing algorithms for detecting and locating advanced cruise missiles, slowly moving ground targets, and stationary 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, and electronic protection. Develop advanced waveforms for achieving transmit adaptivity and simultaneous multi-mode operations to improve interference rejection, self-protection, and target identification by exploiting diversity in frequency, delay, polarization and modulation, and coding. Evaluate and refine knowledge-aided radar signal processing techniques for improved detection and false alarm control performance in ground moving target

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 5017

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

indication sensors.

(U) $781 Develop emerging adaptive processing techniques for knowledge-aided multi-mission processing and resource management. Study and analyze adaptive processing techniques for multi-mission conformal arrays. Study and analyze wideband and polarization adaptive processing techniques for multi-function radar. Initiate investigating distributed processing technology for next generation, deep-reach target detection and tracking.

(U) $6,700 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602500F, Multi-disciplinary Space Technology.

(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

(U) Not Applicable.

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

DATE February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602204F Aerospace Sensors

PROJECT
6095

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
6095 Sensor Fusion Technology	12,568	12,407	12,235	14,071	15,948	16,590	16,961	17,328	Continuing	TBD

Note: In FY 2003, space unique tasks in this project transferred to PE 0602500F, Project 5029, in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This project develops the technologies required to perform management and fusion of 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 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,838 Developed and evaluated single and multi-sensor ATR lethality algorithms to dramatically improve capability to rapidly find, track, and target time-critical mobile targets. Performed laboratory demonstrations of adaptive resource allocation methods for ATR. On embedded high-performance computing systems, developed real-time ATR algorithms for time-critical targets. Developed and evaluated algorithms and concepts for detecting and targeting targets under trees.

(U) $2,431 Developed and evaluated single and multi-sensor radar target signature models to support ATR in strike operations. Developed target signature models for multi-sensor fusion of synthetic aperture radar, electro-optical 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) $1,673 Developed precision time, position, and velocity sensors capable of operating in jamming environments enabling multiple platform sensor-to-shooter operations. Continued developing Global Positioning System specific jamming mitigation techniques for operations in hostile radio frequency environments.

(U) $4,833 Developed and demonstrated enabling ATR technologies for intelligence, surveillance, and reconnaissance applications. Continued evaluating physics-based and adaptive learning techniques.

(U) $1,793 Developed ATR and sensor fusion performance assessment technology. Conducted ATR performance evaluation theory research.

(U) $12,568 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 6095

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,789	Continue integrating, evaluating, and demonstrating single and multi-sensor automatic target recognition (ATR) and sensor fusion algorithms for rapidly finding, tracking, and targeting mobile targets. Continue integrating real-time ATR algorithms, for time-critical targets, on embedded high-performance computing systems. Complete laboratory demonstration of adaptive resource allocation methods. Continue integrating and evaluating algorithms and concepts for detecting and targeting targets under trees. Complete developing single sensor ATR performance assessment technology, and multi-sensor and sensor fusion assessment technology. Continue ATR performance evaluation theory research. Complete the first single sensor ATR performance prediction model.
(U)	$3,666	Develop, evaluate, and demonstrate target signature models to support ATR and sensor fusion algorithm development and testing for reconnaissance and strike mission applications. Develop target signature models for signature exploitation of synthetic aperture radar, electro-optical multi-spectral systems, and signals intelligence sensors. Demonstrate the ability to generate synthetic air and ground target signatures with sufficient fidelity to support automatic recognition of targets in operationally realistic mission environments. Develop modeling and simulation tools that can estimate warfighter effectiveness enhancements due to inserting ATR and sensor fusion aids into the reconnaissance and strike components of the time-critical targeting kill chain.
(U)	$4,321	Develop and demonstrate enabling ATR, sensor management, and sensor fusion technologies for target detection, tracking, and identification in intelligence, surveillance, and reconnaissance (ISR) and combat identification (CID) applications. Complete the evaluation of adaptive learning techniques for target identification. Initiate laboratory demonstration of adaptive sensor management algorithms for target detection, tracking, and identification. Continue evaluating physics-based techniques for target detection and identification for ISR and CID applications.
(U)	$631	Develop precision time, position, and velocity sensors capable of operating in jamming environments. These sensors will enable multiple platform sensor-to-shooter operations. Continue developing Global Positioning System-specific jamming mitigation techniques for operation in hostile radio frequency environments, with an emphasis on synergistically integrating anti-jam technologies. Develop virtual flight test technology for improved assessment of reference sensors.
(U)	$12,407	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,709	Continue evaluating and integrating multi-sensor ATR and sensor fusion algorithms to provide a dramatic improvement in capability to rapidly find, track, and target mobile targets. Improve image formation development and processing of Synthetic Aperture Radar data from Research and Development (R&D) data collections. Automate image analysis and truthing tools. Improve the ATR R&D computer and networking

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602204F Aerospace Sensors**	PROJECT **6095**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

infrastructure via software, hardware, and network integration enhancements. Assess the effectiveness of real-time automatic target recognition (ATR) algorithms for time-critical targets on embedded high-performance computing systems. Develop challenge problem sets to standardize ATR evaluation across the ATR community. Continue integrating and evaluating algorithms and concepts for detecting and engaging targets under trees. Begin integrating detection and identification algorithms for targets under trees into high-performance computing systems. Complete developing multi-sensor and sensor fusion assessment technologies. Continue ATR performance evaluation theory research. Continue developing the first multi-sensor ATR performance prediction model.

(U) $3,891 Continue developing, evaluating, and demonstrating target signature models to support ATR and sensor fusion algorithm development and testing for reconnaissance and strike mission applications. Continue maturing target signature models for signature exploitation of radio frequency sensors, electro-optical multispectral systems, and signals intelligence sensors. Continue generating synthetic air and ground target signatures with sufficient fidelity to support automatic recognition of targets in operationally realistic mission environments. Develop synthetic scene data generation capability to augment and enhance existing Research and Development and operational data sets. Continue developing modeling and simulation tools for estimating warfighter effectiveness enhancements enabled by inserting ATR and sensor fusion aids to the reconnaissance and strike components of the time-critical targeting kill chain.

(U) $4,635 Develop and demonstrate enabling ATR, sensor management, and sensor fusion technologies for target detection, tracking, and identification in intelligence, surveillance, and reconnaissance (ISR) and combat identification (CID) applications. Continue exploiting adaptive learning techniques for target identification using three-dimensional sensors. Continue studying exploitable radar features for target detection, tracking, and identification. Continue evaluating physics-based techniques for target detection and identification for ISR and CID applications. Initiate laboratory demonstration of advanced algorithms for detection and identification of targets under trees in the presence of heavy camouflage, concealment, and deception.

(U) $12,235 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602500F, Multi-disciplinary Space Technology.

(U) PE 0603203F, Advanced Aerospace Sensors.

(U) PE 0602602F, Conventional Munitions.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 6095

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

(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 February 2003

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

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
7622 RF Sensors & Countermeasures Tech	24,737	16,456	16,929	20,538	27,587	29,077	26,712	27,299	Continuing	TBD

Note: In FY 2003, efforts in radio frequency (RF) processing for intelligence, surveillance, and reconnaissance (ISR) sensors transferred from this project to this PE, Project 5017. Also in FY 2003, space unique tasks in this project transferred to PE 0602500F, Project 5029, in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This project develops and assesses RF sensing concepts for aerospace applications through modeling and simulation. This project also develops and evaluates technology for fire control radar, electronic combat (EC), and integrated radar and EC systems. It emphasizes the detecting and tracking of surface and airborne targets with RF signatures that are difficult to detect due to reduced radar cross sections, concealment and camouflage measures, severe clutter, or heavy jamming. This project also develops the RF warning and countermeasure technology for advanced EC applications. Specifically, it develops techniques and technologies to detect and counter the links and sensors of threat air defense systems and hostile 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 EC, and electronic intelligence applications.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,131 Developed aerospace microwave sensor technologies for detecting, locating, and engaging airborne and ground targets. Conducted airborne radar target and clutter phenomenology data collections used to evaluate, validate, and improve engineering tools supporting ISR and multi-intelligence sensor concept studies and system analyses. Demonstrated sensor performance through in-flight experiments and simulations.

(U) $3,483 Developed 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. Developed multi-mission adaptive radar algorithms to support various operational modes including air and ground target detection, ground target imaging, electronic protection, and passive RF emission detection. Developed advanced waveforms to achieve transmit adaptivity and simultaneous multi-mode operation. Improved interference rejection, self-protection, and target identification by exploiting diversity in frequency, delay, polarization, modulation, and coding.

(U) $1,208 Developed technology for detecting and precisely locating concealed targets using standoff aerospace platforms. Developed and evaluated technology for airborne ground-penetrating radar. Developed and evaluated signal processing algorithms for improving detection and false alarm performance in foliage-penetrating radar.

(U) $1,671 Developed affordable RF jamming technology and concepts that enhance aerospace vehicle survivability by degrading enemy radar, missile, and command and control systems. Developed multi-function electronic warfare technique waveforms. Evaluated exploitations of advanced radio

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602204F Aerospace Sensors	PROJECT 7622

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

frequency (RF) threats. Developed optimized electronic warfare (EW) techniques to degrade modern radar, communications, and missile threat systems.

(U) $2,730 Developed technology to enable low-cost upgrades to RF signal receivers. Modeled threat identification algorithms for next-generation threat warning receivers. Evaluated state-of-the-art digital receiver subsystems. Designed advanced very-high frequency receiver improvements for detecting targets under trees. Designed novel RF photonic analog-to-digital converter circuitry for order-of-magnitude gains in performance accuracy versus current state-of-the-art.

(U) $3,638 Developed affordable antenna technology for use in operational and future aerospace platform electronic receivers and apertures. Evaluated wideband, high precision, interferometric, multi-mode, direction-finding antennas in the laboratory. Developed design tools to predict antenna performance installed on host platform models. Developed robust ultra-wideband front end electronics to handle large signals.

(U) $2,723 Developed and validated, via a global infosphere experiment, the radar architectures, aperture technology, and signal processing to support a space-based moving target indication sensor. Used the collaborative engineering environment to model and assess RF architectures and signal processing techniques. Analyzed the utility of a space-based sensor architecture.

(U) $1,915 Designed and validated multi-intelligence sensor technologies for total battlefield awareness. Evaluated single platform technologies for common waveform utilization, knowledge-based function scheduling, and superior difficult target detection for both in-the-clear and concealed targets. Developed and evaluated hybrid sensor systems, including space/air/ground combinations delivering improved location accuracies and tracking strategies.

(U) $5,238 Developed and analyzed concepts for a multi-mission unmanned aerial vehicle based sensor suite capable of detecting and tracking advanced aerial targets and both exposed and concealed ground targets. Determined enabling technologies required for full target surveillance capability.

(U) $24,737 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,696 Develop affordable RF jamming technology and concepts that enhance aerospace vehicle survivability by degrading enemy radar, missile, and command and control systems. Develop multi-function EW technique waveforms. Continue exploitation evaluations against new, advanced RF threats. Develop optimized EW techniques to degrade modern radar, communications, and missile threat systems. Initiated phase calibration development.

(U) $5,098 Develop technology to enable affordable upgrades to RF signal receivers. Model threat identification algorithms for next generation threat warning receivers. Evaluate state-of-the-art radar and EW digital receiver subsystems with Gallium Arsenide and Indium Phosphide radio

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602204F Aerospace Sensors**	PROJECT **7622**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

		frequency (RF) components (analog-to-digital converters, filters, mixers, etc.) for laboratory environment scenario testing. Design advanced very high frequency (VHF) receiver improvements for detecting targets under trees.
(U)	$3,783	Develop robust, ultra wide bandwidth antenna technology for use in operational and future aerospace platform electronic apertures. Demonstrate prototype wideband, high precision interferometric multi-mode direction finding antennas. Develop design tools to predict antenna performance installed on host platform models. Demonstrate components and techniques that increase five-fold the signal handling capability of an aperture.
(U)	$879	Develop and evaluate innovative multi-function RF sensing concepts for aerospace applications through modeling and simulation with an emphasis on system engineering.
(U)	$16,456	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$5,036	Continue developing affordable RF jamming technology and concepts that enhance aerospace vehicle survivability by degrading enemy radar, missile, and command and control systems. Continue developing multi-function electronic warfare (EW) technique waveforms. Continue exploitation evaluations against new, advanced RF threats. Continue to develop optimized EW techniques to degrade modern radar, communications, and missile threat systems. Perform laboratory demonstration of phase calibration system for a monopulse countermeasure technique to protect all Air Force platforms.
(U)	$2,064	Continue developing technology to enable affordable upgrades to RF signal receivers. Continue modeling threat identification algorithms for next generation threat warning receivers. Continue designing advanced VHF receiver improvements for detecting targets under trees. Evaluate the integrated tool suite in the modeling, simulation, design, and characterization environment for mixed-signal (digital, RF, microwave, etc.) component development in advanced and emerging technologies. Demonstrate breadboard electronic/photonic wideband digital receiver for multi-mode/multi-function applications.
(U)	$918	Continue developing robust, ultra-wide bandwidth antenna technology for use in operational and future aerospace platform electronic apertures. Continue demonstrating breadboard wideband, high precision interferometric multi-mode direction finding antennas. Continue developing design tools to predict antenna performance installed on host platform models. Develop techniques that provide low-cost, lightweight phased arrays for low band applications.
(U)	$6,704	Continue developing and evaluating innovative multi-function RF sensing concepts for air and space applications through modeling and simulation with an emphasis on system engineering. Develop and evaluate advanced multi-function and multi-intelligence RF sensors for intelligence, surveillance, and reconnaissance and targeting of time-critical targets. Develop testbed integration techniques for advanced

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602204F Aerospace Sensors**	PROJECT **7622**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

multi-intelligence sensor hardware and algorithms. Develop and evaluate multi-platform sensor coordination and synchronization techniques.

(U) $2,207 Develop digital radio frequency receiver/exciter technology to support digital beamforming (DBF). Analyze and develop approaches to address DBF specific issues such as such as coherence of multiple channels, digital true time delay, channel equalization, distributed waveform generation, and array calibration. Develop techniques for integrating multi-intelligence radio frequency receiver/exciter subsystems into aperture and signal processing testbeds.

(U) $16,929 Total

(U) B. Project Change Summary

None.

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

(U) Related Activities:
(U) PE 0602500F, Multi-disciplinary Space Technology.
(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.

THIS PAGE INTENTIONALLY LEFT BLANK

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

DATE: February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602500F MULTI-DISCIPLINARY SPACE TECH

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	0	98,929	90,526	91,185	87,613	105,733	126,760	124,746	Continuing	TBD
5023	Laser & Imaging Space Tech	0	1,246	5,110	5,133	5,381	5,395	5,423	4,718	Continuing	TBD
5024	Human Centered Applied Space Tech	0	484	0	0	0	0	0	0	Continuing	TBD
5025	Space Materials Development	0	18,204	19,614	23,389	21,612	27,376	37,236	36,737	Continuing	TBD
5026	Rocket Propulsion Component Tech	0	23,143	40,653	43,664	45,551	47,949	48,969	50,017	Continuing	TBD
5027	High Speed Airbreathing Prop Tech	0	4,146	4,588	4,861	5,018	5,121	5,200	5,278	Continuing	TBD
5028	Space Sensors, Photonics & RF Proc	0	43,549	1,690	2,162	1,957	4,217	4,267	4,317	Continuing	TBD
5029	Space Sensor & CM Tech	0	6,884	12,690	5,631	1,675	5,248	7,306	6,282	Continuing	TBD
5030	Applied Space Access Vehicle Tech	0	1,273	0	0	0	3,913	8,249	7,312	Continuing	TBD
5081	Space Antennas Tech	0	0	1,065	1,177	1,273	1,371	4,976	4,960	Continuing	TBD
5082	Optical Networking Tech	0	0	5,116	5,168	5,146	5,143	5,134	5,125	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

Note: In FY 2003, this is a new PE, but not a New Start, resulting from the Space Commission recommendation to consolidate all space unique activities. In FY 2003, space unique efforts in the following PEs/Projects transferred to this PE in conjunction with the Space Commission recommendation: PE 0602102F, Projects 4347, 4348, 4349, and 5015, to Project 5025; PE 0602201F, Project 2403, to Project 5030; PE 0602202F, Project 7184, to Project 5024; PE 0602203F, Project 4847, to Project 5026; PE 0602203F,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**

Project 3012, to Project 5027; PE 0602204F, Project 2002, to Project 5028; Projects 2002, 6095, and 7622, to Project 5029; PE 0602605F, Project 4866, to Project 5023. In FY 2004, efforts in Projects 5024 were terminated and efforts in Project 5030 were delayed until FY 2007 due to higher Air Force priorities. Also in FY 2004, space antenna efforts in PE 0602204F, Project 4916, were transferred to this PE, Project 5081 and the Air Force increased emphasis on developing optical networks for space-based applications in Project 5082.

(U) A. Mission Description

This program advances the technology base in multiple disciplines for future space applications in eight projects, each focusing on a separate technology area. 1) Laser and imaging space technologies develop concepts for advanced, very long-range optical systems and assess the vulnerability of satellites to the effects of high energy laser weapon systems. 2) Human centered applied space technologies focus on the human interface concepts that improve satellite operations during routine and on-demand space missions. 3) Space materials concentrate on the materials technology base for spacecraft and launch systems to improve affordability, maintainability, and performance. 4) Rocket propulsion component technologies advance technology in liquid propulsion rocket engines, solid rocket motors, spacecraft and upperstage propulsion, ballistic missiles, and application of advanced materials for rockets to achieve revolutionary launch capabilities. 5) High-speed airbreathing propulsion technologies develop advanced and combined cycle engine technologies for revolutionary low-cost access to space. 6) Photonics and radio frequency processes develop technologies to generate, control, process, receive, and transmit opto-electronic signals for space sensor applications. 7) Space sensors and countermeasures technologies focus on generation, control, reception and processing of electronic and electromagnetic signals for space sensor applications in intelligence, surveillance, reconnaissance, warning, electronic combat, and countermeasures. 8) Applied space access vehicle technologies develop advanced concepts for affordable on-demand access to space. 9) Lightweight satellite antenna technology and affordable antenna terminal technology for communications and surveillance. 10) Optical networking technology focuses on the technology base for space-based laser communications to provide the warfighter with unlimited communications to any place at any time. Note: In FY 2003, Congress added $47.0 million ($43.0 million for Ground Moving Target Indication/Air Moving Target Indication, $2.0 million for Engineering Tool Improvement Program, and $2.0 million for Integrated High Payoff Rocket Propulsion Technology).

(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 technologies.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	0	53,592	70,020	
(U)	Appropriated Value	0	100,592		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions		-1,063		
	b. Small Business Innovative Research				

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH

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

		FY 2002	FY 2003	FY 2004	Total Cost
	c. Omnibus or Other Above Threshold Reprogram		-600		
	d. Below Threshold Reprogram				
	e. Rescissions				
(U)	Adjustments to Budget Years Since FY 2003 PBR		0	20,506	
(U)	Current Budget Submit/FY 2004 PBR	0	98,929	90,526	TBD

(U) Significant Program Changes:

This is a new PE, but not a New Start, resulting from the Space Commission recommendation to consolidate all space unique activities. In FY 2004, the increase is primarily due to the transfer of civilian salaries related to space unique activities into this PE.

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602500F MULTI-DISCIPLINARY SPACE TECH

PROJECT
5023

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5023 Laser & Imaging Space Tech	0	1,246	5,110	5,133	5,381	5,395	5,423	4,718	Continuing	TBD

Note: In FY 2003, space unique efforts transferred from PE 0602605F, Project 4866, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, increase is primarily due to the transfer of civilian salaries related to space unique activities into this project.

(U) A. Mission Description

This project examines the technical feasibility of space-oriented laser and imaging technologies/concepts including advanced, very long-range optical system concepts for both imaging and beam projection applications. It also supports the modeling and analysis of satellite objects to assess vulnerability to laser radiation and to support the space situational awareness mission.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $622 Develop advanced long-range optical technologies such as space-based relay mirrors to support beam projection and imaging applications. Develop technologies such as beam control; beam acquisition, tracking, and pointing; dual line of sight pointing; and beam stabilization. Develop a roadmap for relay mirror technology development. Develop lightweight, low power optics for space-based relay mirrors. Produce and test one-meter class membrane mirror with near final curvature and demonstrate holographic correction of the mirror surface.
(U) $624 Assess the vulnerability of satellites to the effects of high-energy laser weapons. Update previously completed assessments on catalogued satellites. Incorporate improved algorithms and hardware for rapidly characterizing new launches into current data fusion workstations for the space situational awareness mission.
(U) $1,246 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5023

(U) A. Mission Description Continued

(U)	FY 2004 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$2,970	Develop advanced long-range optical technologies such as advanced beam control; beam acquisition, tracking, and pointing; adaptive optics; dual line of sight pointing; large, lightweight optics; and optical coatings (low energy and high energy) that support relay mirrors. Relay mirrors can greatly extend the range of high power laser weapons as well as low power imaging systems. Develop technologies for lightweight primary mirrors applicable to bifocal relay mirrors. Investigate different solutions for spacecraft and optical control dynamics.
(U)	$2,140	Assess the vulnerability of satellites to the effects of high energy laser weapons. Update previously completed assessments on catalogued satellites. Develop finite state models for space systems that will enable rapid characterization of new launches and provide a better estimate of on orbit space systems capabilities for improved space situational awareness.
(U)	$5,110	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602605F, Directed Energy Technology.
(U) PE 0603444F, Maui Space Surveillance Systems.
(U) PE 0603500F, Multi-Disciplinary Adv Dev Space Technology.
(U) PE 0603605F, Advanced Weapons 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 February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602500F MULTI-DISCIPLINARY SPACE TECH	5024

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5024 Human Centered Applied Space Tech	0	484	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2003, space unique efforts transferred from PE 0602202F, Project 7184, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, efforts in this project were terminated due to higher Air Force priorities within the Science and Technology Program..

(U) A. Mission Description

This project identifies and develops human and crew interface concepts and technologies that improve satellite operations, satellite attack reporting, and crew situational awareness during routine and on-demand space missions. Payoffs include faster satellite reconfiguration for time-critical targeting, improved situational awareness of the space battlespace, and lower cost for operations, training, and modernization due to reduced manning and control station standardization.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $0 No Activity

(U) $0 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $484 Develop and evaluate new crew interface concepts for satellite attack reporting, having the optimal mix of human interface technologies that maximize crew situational awareness. Identify new human roles for on-orbit servicing, prepare a satellite control station simulator as an evaluation testbed, and begin to develop a multi-sensory control station interface usable across systems.

(U) $484 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $0 No Activity

(U) $0 Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5024

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

(U) Related Activities:

(U) PE 0602202F, Human Effectiveness Applied Research.

(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 February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5025

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5025 Space Materials Development	0	18,204	19,614	23,389	21,612	27,376	37,236	36,737	Continuing	TBD

Note: In FY 2003, space unique efforts were transferred from PE 0602102F, Projects 4347, 4348, 4349, and 5015, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, the increase is primarily due to the transfer of civilian salaries related to space unique activities into this project. In FY 2008, increases are due to higher priorities within the Science and Technology Program.

(U) A. Mission Description

This project develops the materials and processing technology base for spacecraft and launch systems to improve affordability, maintainability, and performance of current and future Air Force space systems. Families of affordable lightweight materials are being developed, including metals, polymers, ceramics, metallic composites, and nonmetallic composites, to provide new capabilities for spacecraft, ballistic missile, and propulsion systems to meet the future space requirements. Rocket propulsion materials development in this project support the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Program. Advanced thermal protection materials are being developed that are affordable, lightweight, dimensionally stable, thermally conductive, and/or ablation and erosion resistant to meet space and ballistic missile requirements. Develops materials technologies for surveillance and terrestrial situational awareness systems and subsystems for space and ballistic missile applications.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $11,234 Develop materials and processes to dramatically improve performance, durability, and cost of rocket propulsion systems. Evaluate new candidate materials for rocket engines such as metal matrix composites, ceramics, and advanced organic composites for use in liquid oxygen, liquid hydrogen, high-temperature, and high-pressure environments. Identify and evaluate the applications of these materials to turbopump housings, ducts, valves, solid rocket casings, insulation, nozzle throats, and spacecraft propulsion. Develop material property databases and initiate demonstration of suitability for application using representative geometry and processing conditions for the intended rocket engine components.
(U) $5,560 Develop affordable, advanced structural and non-structural materials and technologies for Air Force space applications. Demonstrate optically tailorable thermal control coatings with controlled heat dissipation for spacecraft thermal control. Establish baseline effects of the space

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

environment on polymer and thermal control coatings. Optimize processing methods for the metallic materials which are expected to be used for lightweight, high-strength components in future space vehicles. Test non-autoclave materials and processes for composite cryogenic tank structures for future Air Force space platforms.

(U)	$1,410	Develop and demonstrate materials and materials processing technologies to enable improved performance, affordability, and performance of surveillance, tracking, targeting, and situational awareness systems. Refine improved thin film processing techniques to optimize efficiency in solar cells. Validate and transition materials processing techniques and materials that will enable high performance optical control of phased array radar and satellite-to-satellite data links. Demonstrate alternative infrared detector materials for space applications capable of detecting very long wavelengths.
(U)	$18,204	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$10,389	Develop materials and processes to dramatically improve performance, durability, and cost of rocket propulsion systems. Develop candidate materials and improve processing capabilities to ensure consistent material characteristics to meet Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Phase II program goals for high-speed turbopump housings, ducts, valves, solid rocket casings, insulation, nozzle throats, and spacecraft propulsion. Evaluate identified high temperature metals, ceramics, and composite materials by fabricating test articles with representative geometry to provide validation of material characteristics and processing capabilities to meet IHPRPT Phase II program goals for solid rocket nozzles, throats, and spacecraft propulsion. Establish materials database and provide predictive modeling capability to anticipate materials performance and model life cycle behavior of materials in a rocket propulsion environment. Identify new candidate materials for spacecraft and rocket propulsion environment, such as thrust chambers, nozzles, and propellant catalysts to meet IHPRPT Phase III goals.
(U)	$2,311	Develop nanostructured materials technology for application to aerospace structures, propulsion, and subsystems to enable lighter weights, higher performance, and lower costs. Evaluate and assess nanoparticle and nanostructured fabrication, characterization, processing techniques, and models for the efficient, low-cost assembly of nanomaterials for system integration and nanomaterials insertion into space subsystems technologies such as rocket engine components and cryogenic structures/components.
(U)	$4,364	Develop affordable, advanced structural and non-structural materials and technologies for Air Force space applications. Fabricate laboratory-level demonstrations of optically tailorable active thermal control coatings with controlled heat dissipation for spacecraft thermal control and three-fold increase in service life. Establish baseline effects of the space environment on thermal control coatings, space lubricants, and other organic/inorganic space materials. Transition processing methods for the metallic materials that are expected to be used for

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5025

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

lightweight, high-strength components in future space vehicles. Develop and fabricate high temperature metallic gamma-titanium-aluminide technologies for reusable access to space vehicles. Develop advanced and reproducible joining processes for large metallic cryotanks. Publish results of non-autoclave materials and processes testing for composite cryotank structures. Evaluate composite materials, process, and materials evaluation techniques for cryogenic tank structures utilized on future Air Force space platforms. Develop hybrid thermal protection materials for reusable systems and demonstrate thermal protection concepts for single use applications. Develop lightweight, highly conductive, all-composite heat-pipe radiators for spacecraft thermal management. Identify next-generation high-temperature organic matrix composites for space launch vehicle and satellite structures.

(U) $2,550 Develop and demonstrate materials and materials processing technologies to enable improved performance, affordability, and performance of surveillance, tracking, targeting, and situational awareness systems. Identify higher performance, including optical nanocomposites, photonic band gap materials and exotic ferroelectronics, for advanced optical architecture in phased array radar and satellite-to-satellite data links. Scale-up very long wavelength, alternative infrared detector materials to areas suitable for the fabrication of staring focal plane arrays.

(U) $19,614 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602102F, Materials.

(U) PE 0603112F, Advanced Materials for Weapon Systems.

(U) PE 0603500F, Multi-Disciplinary Advanced Development Space 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 February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602500F MULTI-DISCIPLINARY SPACE TECH	5026

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5026 Rocket Propulsion Component Tech	0	23,143	40,653	43,664	45,551	47,949	48,969	50,017	Continuing	TBD

Note: In FY 2003, space unique efforts transferred from PE 0602203F, Project 4847, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, civilian salaries transferred from PE 0602203F, Project 4847, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2005, ballistic missile Technology for Sustainment of Strategic Systems (TSSS), Phase 1 will end.

(U) A. Mission Description

This project develops advances in rocket propulsion technologies for space access, space maneuver, and ballistic missiles. Analytical and experimental areas of emphasis are propellants, propellant management, combustion, rocket material applications, TSSS Phase 1, and novel space propulsion concepts. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of future space and missile launch subsystems. Technologies are developed to reduce the weight and cost of components using new materials and improved designs and manufacturing techniques. All efforts in this project are part of the Integrated High Payoff Rocket Propulsion Technology program, a joint Department of Defense, National Aeronautics and Space Administration, and industry effort to focus rocket propulsion technology on national needs.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $1,995 Develop, characterize, and test advanced hydrocarbons and energetic, reduced-toxicity monopropellants to increase space launch payload capability. Refine synthesis methods of new propellants to facilitate the transition from producing lab-scale quantities to producing sufficient material to meet operational requirements. Continue scale-up of selected propellants for laboratory and demonstrator engine evaluations. Develop high-energy-density oxidizers, nano-materials, and polymeric binders and optimize paths for incorporating these materials into propellants with significantly enhanced performance. Continue evaluating the potential of monopropellants comprised of reduced-toxicity ionic salts to reduce the cost of space access and space operations. The goal is monopropellants with performance equivalent to bipropellants. Continue to evaluate selected propellants in advanced combustion devices to determine materials compatibility and performance. Continue to model and analyze advanced propulsion concepts with enhanced performance and reliability such as laser-propelled lightcraft.
(U) $975 Develop advanced liquid engine combustion technology for improved performance while preserving chamber lifetime and reliability needs for

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5026

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

engine uses in heavy lift space vehicles. Continue to characterize, study, and evaluate injector performance to ensure chamber/injector compatibility and prevent damage to test and operational combustion devices. Continue to develop, analyze, and model advanced combustion devices and injectors compatible with new energetic propellants. Continue to model and analyze advanced propulsion concepts with enhanced performance and reliability such as rocket-based combined cycle engines and pulsed detonation engines.

(U) $2,681 Continue to develop advanced material applications for lightweight components and material property enhancements for use in launch and space systems. Develop advanced ablative components using hybrid polymers for use in current and future launch systems. Continue to characterize and develop new high temperature polymer components and carbon-carbon components for use in advanced combustion devices and propulsion systems to meet lower weight, increased strength, and lower cost requirements. Continue to develop advanced motor casings and propellant system components for high-energy propellants.

(U) $5,281 Continue to develop propulsion component technology for reliable, safe, and low-cost boost systems. Complete development and begin testing single stage hydrogen turbopump for advanced cryogenic engines. Continue development of components for hybrid propulsion technologies for space boosters and air-launched missiles. Initiate testing of injector for hydrocarbon or cryogenic fuel applications.

(U) $3,214 Continue development of lightweight combustion chamber and nozzle technology. Continue development of advanced lightweight rocket engine nozzle for upper stage and space booster applications. Initiate design study for high pressure turbopumps for use in advanced upper stage engines.

(U) $2,478 Continue demonstration of missile propulsion technology and Post Boost Control Systems (PBCS) and integrate results of aging models and test database for aging and surveillance technology for sustainment of current Intercontinental Ballistic Missile fleet. Continue demonstration of an advanced lightweight solid rocket motor. Continue demonstration of tools to increase the capability to determine the service life of strategic systems and other solid rocket motors. Continue demonstration of advanced full-scale, flight-like PBCS.

(U) $2,561 Develop solar electric and solar thermal propulsion technologies for stationkeeping, repositioning, and orbit transfer for large communication satellites and satellite constellations. Complete small-scale Hall thruster development efforts to achieve Air Force orbit transfers using electric propulsion. Continue development of microsatellites (<25 kg) propulsion systems (e.g., plasma thrusters) for advanced imaging missions. Continue developing solar thrusters and concentrators for future orbital transfer vehicles. Continue testing of an electrically controlled solid propellant. Continue development of high power solar thermal components.

(U) $1,979 Assess and verify tool performance for additional data requirements for the modeling and simulation tool against available data. Make recommendations for future modeling and data acquisition. These efforts will contribute to the ongoing development of modeling and simulation tools as part of the Engineering Tool Improvement Program to analyze and predict the performance of aerospace engines and their components. Improve analytical tools associated with aerospace engines with the main focus on high performance, long life, advanced cooling

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5026

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

techniques, and combustion stability.

(U) $1,979 Develop components and propellants that will meet the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Phase II goals. Design, fabricate, and evaluate an advanced throttleable propulsion system for energy management of tactical missile systems. Design and evaluate a new attitude control system to increase maneuverability of tactical missile systems. Develop an improve reduced/minimum smoke propellant system to reduce/change the plume signature of tactical systems.

(U) $23,143 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,060 Develop, characterize, and test advanced hydrocarbons and energetic, reduced-toxicity monopropellants to increase space launch payload capability. Refine synthesis methods of new propellants to facilitate the transition from producing lab-scale quantities to producing sufficient material to meet operational requirements. Continue scale-up of selected propellants for laboratory and demonstrator engine evaluations. Develop high-energy-density oxidizers, nano-materials, and polymeric binders and optimize paths for incorporating these materials into propellants with significantly enhanced performance. Continue evaluating advanced monopropellants to reduce the cost of space access, space operations, and other Air Force applications. Begin development of advanced catalysts for new monopropellant formulations. Begin scale-up of promising high energy-density materials candidates. Continue to evaluate selected propellants in advanced combustion devices to determine materials compatibility and performance. Continue to model and explore advanced propulsion concepts with enhanced performance and reliability such as laser-propelled lightcraft and rocket-based combined cycle engines. Complete formulation of propellant ingredients for IHPRPT Phase III solid propellant developments and transition to propellant formulation.

(U) $5,680 Develop advanced liquid engine combustion technology to improve performance while preserving chamber lifetime and reliability in heavy lift space vehicle engines. Continue to characterize, study, and evaluate injector performance to ensure chamber/injector compatibility and prevent damage to test and operational combustion devices. Continue to develop, analyze, and model advanced combustion devices and injectors compatible with new energetic propellants. Conduct analysis and testing to characterize causes and issues that lead to combustion instability in hydrocarbon fueled liquid rocket engines reducing the need for conducting large numbers of costly full-scale component and engine tests. Complete advanced hydrocarbon fuels development and transition to scale-up and testing.

(U) $4,954 Develop advanced technologies and material property enhancements for lightweight components for use in rocket propulsion systems. Develop advanced ablative components using hybrid polymers for use in current and future launch systems. Continue to characterize and develop new processes for high temperature polymers and carbon-carbon materials for use in advanced combustion devices and propulsion systems to meet

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT **5026**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

		lower weight and increased strength requirements. Continue to develop advanced material components for use with high-energy propellants. Complete and transition advanced high temperature material components to Air Force systems to reduce system weight and cost and increase performance. Initiate exploration of the use of nanocomposites for liquid rocket engine tanks.
(U)	$1,950	Continue to develop propulsion component technology for reliable, safe, and low-cost boost systems. Complete development of components for hybrid propulsion technologies for space boosters and air launched missiles. Complete testing of single stage hydrogen turbopump for advanced cryogenic engines. Continue hydrocarbon fuel characterization test rig development and evaluation of potential hydrocarbon fuels.
(U)	$11,673	Continue development of lightweight nozzle technologies for liquid rocket engines. Begin development of an advanced lightweight altitude compensating nozzle, advanced liquid oxygen and liquid hydrogen (LOX/H2) turbopumps for the next phase of advanced reusable LOX/H2 engines.
(U)	$5,151	Develop missile propulsion, aging, and surveillance technology for solid rocket systems. Complete initial tool developments to enhance the capability to determine the service life of strategic systems and other solid rocket motors. Continue risk reduction efforts supporting missile propulsion demonstration. Complete efforts for prediction of solid motor life and transition into damage assessment models.
(U)	$5,185	Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for stationkeeping, repositioning, and orbit transfer for large communication satellites and satellite constellations. Develop monopropellant thruster component technologies for chemical-based space propulsion. Continue Hall thruster development efforts evaluating 100-200 kilowatt and clustered thrusters to achieve Air Force orbit transfers using electric propulsion. Continue development of microsatellites (<25 kg) propulsion systems (e.g., plasma thrusters) for advanced imaging missions. Continue developing solar thrusters and concentrators for future orbital transfer vehicles. Continue testing of an electrically controlled solid propellant. Continue development of high power solar thermal components. Begin electro dynamic tether developments.
(U)	$40,653	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0601102F, Defense Research Sciences.

(U) PE 0602114N, Power Projection Applied Research.

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0602303A, Missile Technology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT **5026**

(U) <u>C. Other Program Funding Summary ($ in Thousands)</u>

(U) PE 0602805F, Dual Use Science and Technology.

(U) PE 0603216F, Aerospace Propulsion and Power Technology.

(U) PE 0603500F, Multi-Disciplinary Adv Dev Space Technology.

(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) <u>D. Acquisition Strategy</u>

Not Applicable.

(U) <u>E. Schedule Profile</u>

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)											DATE February 2003
BUDGET ACTIVITY 02 - Applied Research				PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH							PROJECT 5027
COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5027	High Speed Airbreathing Prop Tech	0	4,146	4,588	4,861	5,018	5,121	5,200	5,278	Continuing	TBD

Note: In FY 2003, space unique efforts transferred from PE 0602203F, Project 3012, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This project develops revolutionary, airbreathing, hypersonic propulsion technology options to enable affordable, on demand access to space for the Air Force. The short-term focus is on hydrocarbon fueled engines capable of operating over a broad range of flight Mach numbers and longer term focus will be on hydrogen fueled scramjet powered engines that can enable the higher Mach numbers of achieving access to space. Technologies developed under this program enable capabilities of interest to both Department of Defense and National Aeronautical and Space Administration. Efforts include modeling and simulation, proof of concept demonstrations of critical components, advanced component development, and ground-based demonstrations.

(U) FY 2002 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$0	No Activity
(U)	$0	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$223	Initiate development of flight demonstrator vehicle concepts. Conduct vehicle design trades for integration of hydrocarbon fueled scramjet engine.
(U)	$946	Increase scramjet operating range (Mach 3 to >Mach 8) to provide robust options for combined cycle engines. Conduct initial feasibility assessment of variable geometry devices. Investigate variable geometry through collaborative effort with France and Russia.
(U)	$288	Conduct assessment of advanced airbreathing engines/Combined Cycle Engines (CCEs) to establish and extend operability limits. Enables development of low internal drag scramjet flowpath for reusable applications. This supports the development of affordable, on-demand access to space vehicles.
(U)	$2,689	Initiate development of critical components for advanced airbreathing engines and CCEs for robust performance over extended Mach range. Initiate development of high performance/low internal drag devices. This provides robust scramjet components applicable to affordable, on-demand access to space vehicles.
(U)	$4,146	Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5027

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands)

(U) $0	Accomplishments/Planned Program	
(U) $4,020	Develop robust hydrocarbon fueled scramjet engine components and technologies and integrate into advanced combined cycle engine designs. Develop and demonstrate low internal drag flame stabilization devices. Demonstrate advanced ignition systems for scramjets. Conduct feasibility assessments of variable geometry devices to increase scramjet operating range from Mach 3 to Mach 8 to provide robust options for combined cycle engines. Develop advanced engine components to improve structural durability for reusable applications. Conduct assessment of current structural concepts and identify life limiting factors and initiate development of multi-use components. Support development of flight test engine components.	
(U) $568	Conduct assessment of advanced air breathing engines/Combined Cycle Engines to establish and extend engine operability limits. Conduct system trade studies to determine military payoff and establish component technology goals. Define component and engine performance objectives to enable development of affordable hypersonic combined cycles engines to meet future war fighter needs.	
(U) $4,588	Total	

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0601102F, Defense Research Sciences.
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602602F, Conventional Munitions.
(U) PE 0602702E, Tactical Technology.
(U) PE 0603111F, Aerospace Structures.
(U) PE 0603216F, Aerospace Propulsion and Power Technology.
(U) PE 0603601F, Conventional Weapons Technology.
(U) Program is reported to/coordinated by the Joint Army/Navy/NASA/Air Force (JANNAF) Executive Committee.
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT **5027**

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602500F MULTI-DISCIPLINARY SPACE TECH	5028

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5028	Space Sensors, Photonics & RF Proc	0	43,549	1,690	2,162	1,957	4,217	4,267	4,317	Continuing	TBD

Note: In FY 2003, space unique efforts transferred from PE 0602204F, Project 2002, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This project focuses on developing methods of generating, controlling, receiving, transmitting, and processing photonic, optical, and opto-electronic (mixed) signals for radio frequency (RF) space sensor applications. The enabling technologies will be used for intelligence, surveillance, reconnaissance, electronic warfare, and precision engagement sensors based in space. The project aims to demonstrate significantly improved military space sensors of smaller size, lower weight, lower cost, lower power dissipation, higher reliability, and improved performance. This project also develops and assesses multi-dimensional adaptive techniques in radar technology for affordable and reliable space surveillance and reconnaissance systems.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $367 Design and develop high performance integrated photonic technology link, interconnect, and switching components and subsystems for wideband RF phased array antenna beamforming/control, and for high data rate space sensors and communication systems.
(U) $191 Design and develop efficient, high coefficient chip-scale optical waveguide technology for mixed signal component subsystems.
(U) $349 Perform independent modeling, test, and evaluation for space-qualified photonic components and integrated electro-optical devices for space-based sensors.
(U) $96 Initiate the study of adaptive processing techniques for large, multi-mission, space-based conformal arrays.
(U) $42,546 Develop a system brassboard of the Active Electronic Scanned Antenna and On-Board Processor (AESA/OBP) to demonstrate the technology readiness of the most critical element of an affordable Space-Based Radar. Develop the processing architecture, adaptive signal processing algorithms, and fault tolerant, radiation resistant processing for OBP in a space environment. Develop Battle-Management Command, Control and Communications techniques for multiple satellite tasking, target tracking, and moving target exploitation. Refine and validate Space-Based Radar and Moving Target Exploitation simulation capabilities to serve as a development tool for both short term acquisition and longer term

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5028

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

capability enhancement. Develop and validate both Ground Moving Target Indication and Airborne Moving Target Indication processing algorithms for environments with clutter and interference.

(U)	$43,549	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$586	Fabricate and evaluate high performance integrated photonic technology link, interconnect, and switching components and subsystems for wideband radio frequency phased array antenna beamforming and control, and for high data rate space sensors and communication systems.
(U)	$242	Test and evaluate efficient, high coefficient chip-scale optical waveguide technology for mixed signal component subsystems.
(U)	$244	Apply the results of modeling, test, and evaluation for space-qualified photonic components and integrated electro-optical devices for space-based sensors.
(U)	$618	Study and analyze adaptive processing techniques for large, multi-mission, space-based, adaptive conformal arrays.
(U)	$1,690	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Funding:
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0603203F, Advanced Aerospace Sensors.
(U) PE 0603500F, Multi-Disciplinary Adv Dev Space 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 February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602500F MULTI-DISCIPLINARY SPACE TECH	5029

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5029 Space Sensor & CM Tech	0	6,884	12,690	5,631	1,675	5,248	7,306	6,282	Continuing	TBD

Note: In FY 2003, space unique efforts transferred from PE 0602204F, Projects 2002, 6095, and 7622, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, increases are due to the transfer of civilian salaries related to space unique activities into this project and increased emphasis on National Aerospace Initiative technologies.

(U) A. Mission Description

This project focuses on developing processes and techniques for electronic and electromagnetic signal processing for intelligence, surveillance, and reconnaissance (ISR) space sensor applications. This project develops the baseline technologies required to manage and perform on-board space sensor information fusion for timely and comprehensive communications and situational awareness. Through modeling and simulation, this project develops and evaluates innovative electromagnetic and electronic countermeasures for space applications.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $0 No Activity

(U) $0 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,709 Develop compact, affordable, multi-function receiver/exciter and phased array components for communications, Global Positioning System, radar, electronic warfare, and other ISR space sensors. Fabricate critical components consisting of gallium arsenide, indium phosphide, silicon, and/or wide bandgap devices for use in multi-mode/multi-function digital receiver prototype modules, and demonstrate a feasible architecture for performing wideband direct digital synthesis from space platforms.

(U) $87 Develop microwave technologies for advanced radio frequency (RF) apertures and phased array antennas used in military ISR space sensors. Develop and demonstrate robust components for L-band and X-band transmitter and receiver (T/R) channels that operate with limited environmental controls and under severe electromagnetic signals.

(U) $514 Demonstrate X-band sub-assemblies based on flexible RF membranes that enable low-cost and low-mass T/R channels integrated at the subarray level for space applications.

(U) $101 Characterize and mature space-qualified micro-electro-mechanical systems phase shifters for extended switch lifetimes and able to operate over a ten-to-one bandwidth.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5029

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

(U)	$514	Refine materials and processes for two-dimensional and three-dimensional interconnects for space applications.
(U)	$639	Continue to refine the accuracy of predictions of the scattering phenomenology associated with electromagnetic radiation returned from objects or backgrounds when viewed from space.
(U)	$1,630	Develop space-qualified precision time, position, and velocity sensors capable of operating in jamming environments enabling multiple platform sensor-to-shooter operations. Continue developing Global Positioning System (GPS) specific jamming mitigation techniques for operation in hostile radio frequency (RF) environments with emphasis on synergistic integration of anti-jam technologies. Develop virtual flight test technology for improved assessment of reference sensors for space applications.
(U)	$1,690	Develop technology to enable affordable upgrades to space-qualified RF signal receivers. Model threat identification algorithms for next generation threat warning receivers. Evaluate state-of-the-art radar and electronic warfare (EW) digital receiver subsystems with Gallium Arsenide and Indium Phosphide RF components (Analog-to-Digital Convertors, filters, mixers, etc.) for laboratory environment scenario testing.
(U)	$6,884	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$6,316	Fabricate and test compact, affordable, multi-function receiver/exciter and phased array components for communications, GPS, radar, EW, and other Intelligence, Surveillance, and Reconnaissance (ISR) space sensors. Evaluate integrating these components into operational radar and EW digital receiver/exciter modules. Demonstrate a feasible architecture for performing wideband direct digital synthesis from aerospace platforms. Perform a component evaluation of an electronic/photonic digital receiver for Moving Target Indication and Synthetic Aperture Radar applications.
(U)	$1,206	Develop and integrate microwave technologies for advanced RF apertures and phased array antennas used in military ISR space sensors. Develop and demonstrate the proof of concept of transmitter and receiver channels that are able to withstand radiation, limited or no active cooling, and strong undesired electromagnetic signals.
(U)	$540	Demonstrate a large area (>0.5 m2) active aperture based on flexible RF membranes that lowers the assembly costs and mass over conventional phased arrays by an order of magnitude.
(U)	$433	Demonstrate mixed signal receiver/processor multi-functionality on flexible RF membranes using advanced two-dimensional and three-dimensional interconnects.
(U)	$559	Continue to refine the accuracy of exploitation of the scattering phenomenology associated with electromagnetic radiation returned from objects or backgrounds when viewed from space.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5029

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U)	$3,294	Design robust precision time, position, and velocity sensor technologies for multi-platform sensor-to-shooter network-centric engagement. Develop synergistic global positioning system jamming mitigation techniques for operation in hostile radio frequency (RF) environments.
(U)	$342	Continue developing technology to enable affordable upgrades to space-qualified RF signal receivers. Continue modeling threat identification algorithms for next generation threat warning receivers. Continue evaluating state-of-the-art digital and software receiver techniques for radar, electronic warfare, and narrowband space applications.
(U)	$12,690	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0603203F, Advanced Aerospace Sensors.
(U) PE 0603500F, Multi-Disciplinary Adv Dev Space 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
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602500F MULTI-DISCIPLINARY SPACE TECH

PROJECT
5030

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5030 Applied Space Access Vehicle Tech	0	1,273	0	0	0	3,913	8,249	7,312	Continuing	TBD

Note: In FY 2003, space unique efforts transferred from PE 0602201F, Project 2403, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, efforts in this project were delayed until FY 2007 due to higher Air Force priorities.

(U) A. Mission Description

This project develops technologies in areas of advanced structures, flight controls, and aerodynamics to enable affordable on-demand military access to space. Resulting technologies contribute significantly towards the development of reliable, responsive space access systems with aircraft-like operations. Payoffs to the warfighter include enhanced mission effectiveness, improved flight safety, improved maintenance, and decreased size, weight, and cost. Leverages a network of virtual environments for evaluation of advanced concepts.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $1,273 Develop advanced structure, flight control, and aerodynamic technologies to enable aircraft-like operations for affordable on-demand military access to space. Define and develop integrated guidance and control laws to expand launch vehicle performance envelope. Develop capability to simulate space access operability in a virtual environment.
(U) $1,273 Total

(U) FY 2004 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5030

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

(U) Related Funding:

(U) PE 0602201F, Aerospace Flight Dynamics.

(U) PE 0602202F, Human Effectiveness Applied Research.

(U) PE 0602204F, Aerospace Sensors.

(U) PE 0603211F, Aerospace Technology Dev/Demo.

(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 February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5081

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5081 Space Antennas Tech	0	0	1,065	1,177	1,273	1,371	4,976	4,960	Continuing	TBD

Note: In FY 2004, space antenna efforts in PE 0602204F, Project 4916 transfer to this project.

(U) **<u>A. Mission Description</u>**

This project develops the technology base for lightweight satellite antenna technology and affordable antenna terminal technology for communications and surveillance. Enabling antenna technologies developed under this project for satellite terminals and satellite tracking will focus on significantly lowering the life cycle cost of sensors and communications system ownership, while increasing performance. Novel antenna architectures based on emerging technologies such as Micro-Electro-Mechanical Systems, nanostructures, metamaterials, rigidizable systems, and adaptive polymers will be developed. The project will include new approaches to multi-layer microstrip and stripline feed networks for limited scan, and planar and conformal architectures using overlapped subarrays. Digital Beamforming (DBF) on transmit and receive will be implemented in order to achieve simultaneous multiple-beams, conformal array beamforming, array pattern synthesis, and neural beamforming.

(U) <u>FY 2002 ($ in Thousands)</u>
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) <u>FY 2003 ($ in Thousands)</u>
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) <u>FY 2004 ($ in Thousands)</u>
(U) $0 Accomplishments/Planned Program
(U) $336 Develop lightweight antenna technologies concepts that enable affordable deployment of space sensors for low life cycle cost communications, detection of air and ground moving targets, and remote sensing.
(U) $316 Develop new lightweight radiators, transmission mechanisms, and control components and concepts for advanced wideband phased array antenna architectures.
(U) $413 Develop concepts for Digital Beamforming on both transmit and receive cycles in order to implement simultaneous multiple-beams, conformal array beamforming, array pattern synthesis, and neural beamforming.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT **5081**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued
(U) $1,065 Total

(U) B. Project Change Summary
Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0603203F, Advanced Aerospace Sensors.
(U) PE 0603500F, Multi-Disciplinary Adv Dev Space 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 February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH** — PROJECT **5082**

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5082 Optical Networking Tech	0	0	5,116	5,168	5,146	5,143	5,134	5,125	Continuing	TBD

Note: In FY 2004, in Project 5082, the Air Force increased emphasis on developing optical networks for space-based applications.

(U) A. Mission Description

This project develops the technology base for the next generation of ultra-wide- bandwidth, multi-channeled, space-based communications networks on and between platforms. As the application of laser-based, point-to-point communications between satellites emerges, space-based optical networks, whose communications capacities are thousands of times greater than current communications satellites, become a realistic possibility. A major thrust of this project is to assess and adapt the emerging communication and information technologies, being developed for next-generation Internet, for applications in space. This project will explore technologies for implementing photonic chip scale optical Code Division Multiple Access (CDMA) and Wavelength Division Multiplexed (WDM) transceivers and prototype networks, built to demonstrate the benefits associated with the advanced fiber optic, wireless, and satellite networks that can be built from them. This technology has potential applications in specific military systems including reliable, high bandwidth, jam-resistant communications at the theater level, and multiplexing of multiple DoD users onto a common networking infrastructure for reduced manning and logistics.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2004 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $2,009 Develop, demonstrate, and assess optical network technologies for application in the space environment. Assess, explore, and adapt the emerging communication and information technologies being developed for next-generation Internet, for applications in space.
(U) $2,082 Develop, demonstrate, and assess existing and emerging Optical CDMA and WDM schemes and protocols for use in space-based optical networks. In conjunction with industry and academia, develop or adapt appropriate standards to ensure the evolution of an open systems

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT 5082

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

		architecture for space based-optical networks.
(U)	$1,025	Further develop photonic chip scale optically implemented Code Division Multiple Access and Wavelength Division Multiplexed transceivers and prototype network into a capability to characterize, evaluate, and optimize optical network components and technologies for space applications.
(U)	$5,116	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) PE 0602702F, Command, Control, and Communications.

(U) PE 0603789F, C3I Advanced Development.

(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.

THIS PAGE INTENTIONALLY LEFT BLANK

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602601F Space Technology

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	79,330	76,239	83,240	90,810	92,771	100,742	122,044	129,729	Continuing	TBD
1010	Space Survivability & Surveillance	31,287	23,797	36,348	38,206	38,549	41,192	39,798	40,362	Continuing	TBD
4846	Spacecraft Payload Technologies	14,473	11,384	15,282	19,328	20,157	20,896	36,090	40,120	Continuing	TBD
5018	Spacecraft Protection Technology	0	4,346	4,045	2,831	2,653	2,500	2,567	2,635	Continuing	TBD
8809	Spacecraft Vehicle Technologies	33,570	36,712	27,565	30,445	31,412	36,154	43,589	46,612	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2003, Project 1010 is split, with efforts focused on protecting spacecraft from manmade threats being transferred into Project 5018.

(U) A. Mission Description

This PE focuses on four major areas. First, space systems protection develops technologies to understand, mitigate, and exploit effects of weather and geophysics environments on the design and operation of Air Force systems. Second, spacecraft payload technologies improve satellite payload operations by investigating advanced component and subsystem capabilities. Third, spacecraft protection, develops technologies for protecting U.S. space assets in potential hostile environments. The last major area, spacecraft vehicles focuses on spacecraft platform, payload, and control technologies, and their interactions. Note: In FY 2003, Congress added $21.4 million ($5.1 million for the High-frequency Active Auroral Research Program (HAARP) Space Technology, $2.6 million for HAARP Incoherent Scatter Radar, $2.0 million for Electromagnetic Gradiometer Research, $3.0M for Seismic Monitoring Research, $1.4 million for Mixed Signal Very Large Scale Integrated (Circuits) for Space Vehicle Communication Subsystems, $3.0 million for TechSat 21, $1.4 million for Substrates for Solar Cells, $1.4 million for Integrated Control for Autonomous Space Systems, $1.0 million for Lightweight and Novel Structures for Space, and $0.5 million for Carbon Foam for Aircraft and Spacecraft).

(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 space technologies.

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602601F Space Technology

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	81,344	58,582	68,437	
(U)	Appropriated Value	81,686	79,942		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-342	-3,589		
	b. Small Business Innovative Research	-1,626			
	c. Omnibus or Other Above Threshold Reprogram		-114		
	d. Below Threshold Reprogram				
	e. Rescissions	-388			
(U)	Adjustments to Budget Years Since FY 2003 PBR		0	14,803	
(U)	Current Budget Submit/FY 2004 PBR	79,330	76,239	83,240	TBD

(U) Significant Program Changes:

Changes to this PE since the previous President's Budget are due primarily to higher priorities within the Science and Technology Program.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602601F Space Technology	1010

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
1010 Space Survivability & Surveillance	31,287	23,797	36,348	38,206	38,549	41,192	39,798	40,362	Continuing	TBD

Note: In FY 2003, Project 1010 is split, with efforts focused on protecting spacecraft from manmade threats being transferred into Project 5018.

(U) A. Mission Description

This project develops the technologies to exploit the space environment for the warfighter's benefit. The project focuses on characterizing and forecasting the battlespace environment for realistic space system design, modeling, and simulation, as well as the battlespace environment's effect on space systems' performance. It includes technologies to specify and forecast the environment from 'mud to sun' for planning operations and ensuring uninterrupted system performance, optimize space-based surveillance operations, and allow the opportunity to mitigate or exploit the space environment for both offensive and defensive operations. Finally, this project includes the seismic research program that supports national requirements for monitoring nuclear explosions.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,490 Developed technologies for monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense operational space systems. These technologies lead to improved space system design, lifetime operational capabilities, and aid in anomaly resolution. Used simulations to assess technologies that control hazardous space particle populations in extreme environments resulting from natural or adversarial actions. Used simulations and test data from space-based detector system to develop advanced algorithms for tracking system-impacting solar eruptions en route to Earth. Developed algorithms for short-term forecasting of solar flares based on observations of plasma flow in solar active regions. Validated time-dose probability codes for space system design using data from compact environment anomaly sensors. Completed design of space particle control experiment. Constructed dynamic radiation belt data assimilation and forecasted models to predict energetic electron spacecraft hazards.

(U) $8,070 Developed real-time infrared backgrounds clutter code, spectral signature libraries, target detection techniques, and decision aids for application to space-based surveillance, laser weapons, and countermeasure systems, including detection of low-observable targets. Technologies lead to increased surveillance capability and to more effective operation of laser weapons and countermeasures systems. Developed global clutter specification model and dim-target detection techniques for advanced space-based surveillance systems. Incorporated global clutter model into all-altitude background prediction code and validated model with space-based data. Conducted field measurements to validate candidate concepts for earliest detection of theater ballistic missiles in boost phase. Tested and validated decision aids and performance prediction tools for turbulence effects on laser weapon system performance. Validated global spectral signature libraries created from collected hyperspectral imaging data, and developed a modeling and simulation capability to predict the performance of surveillance functions under specified scene and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 1010

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

atmospheric conditions.

(U) $7,010 Developed artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including communications/navigation outage forecasting and space-based geolocation demonstrations. This forecasting capability will support the warfighter through situational awareness, allowing operators to use alternate links or systems in times of outages. Integrated and validated the suite of ionospheric specification and forecast models for the Communications/Navigation Outage Forecast System (C/NOFS) Advanced Concept Technology Demonstration. Assembled the models with data-handling systems to construct the C/NOFS data center. Provided navigation reliability maps for geolocation requirements. Expanded the ground-based network of ultra high frequency and L-band satellite links to provide worldwide outage specification and enhance the ground-based component of C/NOFS. Established high latitude sites to monitor formation and motion of polar ionospheric patches.

(U) $1,356 Developed key satellite threat warning technologies and tools for on-board satellite use that detect, geolocate, and characterize acquired intentional and unintentional ground-based radio frequency and laser signals. Satellite threat warning technologies enable the warfighter to increase knowledge of possible hostile acts directed at mission critical satellites and aid in satellite anomaly resolution. Completed miniaturization of radio frequency attack reporting receiver. Investigated integrated attack reporting approaches.

(U) $8,209 Continued development of the High Frequency Active Auroral Research Program (HAARP) site transmitting and diagnostic instrument infrastructure. Installed a permanent aircraft alert radar, a Very High Frequency ionosphere radio diagnostic, high frequency transmitter enhancements, and diesel power-plant reliability improvements. Provided facility management and environmental oversight. Conducted research programs to assess the viability of exploiting Extremely Low Frequency/Very Low Frequency waves generated in the ionosphere for detecting and characterizing underground structures and for reducing charged particle populations in the radiation belts, which disrupt satellite systems and operations.

(U) $2,511 Developed a modular design and phased approach for an Incoherent Scatter Radar diagnostic capability for the HAARP facility. Prepared the site infrastructure, including a gravel pad, access road, and power and optical fiber distribution networks. Acquired and installed Incoherent Scatter Radar transmitting modules for engineering test purposes to validate the overall concept and design.

(U) $1,641 Investigated, enhanced, and tested electromagnetic radiometry technologies for the detection of underground structures using the HAARP facility. Developed a miniature, rugged man-portable hardware system and an experimental airborne system, including improved detection algorithms, frequency agility, and remote data access. Conducted a study for a ground-based, unmanned random array detection system to exploit emerging technology.

(U) $31,287 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **1010**

(U) A. Mission Description Continued

(U)	FY 2003 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$1,283	Develop technologies for monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense (DoD) operational space systems. Validate algorithms for tracking solar plasma clouds to Earth and predicting onsets of adverse effects on DoD systems. Develop models and algorithms for propagation of solar/geomagnetic activity for spacecraft susceptibility to single event upsets. Complete initial dynamic radiation belt model with real-time data assimilation for spacecraft hazard forecasting.
(U)	$4,435	Develop real-time infrared backgrounds clutter code, spectral signature libraries, target detection techniques, and decision aids for application to space-based surveillance, laser weapons, and countermeasure systems, including detection of low-observable targets. Validate background models with new experimental data and apply to surveillance system design trades and performance analyses. From field measurements determine trade space for space system for earliest detection of theater ballistic missiles in boost phase. Upgrade models of atmospheric turbulence sources and improve laser weapon performance prediction model of airborne and space-based systems. Develop advanced techniques to exploit hyperspectral data and validate hyperspectral performance modeling and simulation codes. Develop design requirements for space-based sensor to obtain sub-pixel, high spectral resolution measurements of optical/infrared backgrounds for next-generation operational surveillance, target identification, and damage assessment systems.
(U)	$5,509	Develop artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including communications/navigation outage forecasting and space-based geolocation demonstrations. Develop data processing software and hardware architecture for collecting and analyzing ground and space data to provide near-real-time nowcasts and forecasts of ionospheric hazards. Validate nowcast and forecast predictions using ground and space-based experimental databases and incorporate results into forecast tool risk reduction. Improve techniques to track the motion of the highly structured plasma in the polar region, to enhance the reliability of ionospheric specification in high latitude theaters. Develop multi-scale algorithms to increase reliability of global ionospheric forecasts.
(U)	$5,048	Continue development of the High-frequency Active Auroral Research Program (HAARP) site transmitting and diagnostic instrument infrastructure. Provide facility management and environmental oversight. Continue research programs to assess the viability of exploiting Extremely Low Frequency/Very Low Frequency waves generated in the ionosphere for military applications. Begin research programs to characterize high power radio wave interactions in the ionosphere and space, including the generation of irregularities and optical emissions and to exploit the HAARP diagnostic instruments for space weather specification. Develop real-time diagnostic and data analysis software and web displays.
(U)	$2,573	Develop a modular approach for installation of an Incoherent Scatter Radar (ISR) diagnostic at the HAARP facility. Complete site infrastructure for the ISR and preliminary support structure. Acquire and install a modular, 8-panel, ISR transmit/receive sub-array. Conduct a research program to characterize radio-wave interactions and processes in the ionosphere using the sub-array as a powerful radar diagnostic instrument in

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **1010**

(U) **A. Mission Description Continued**

(U) FY 2003 ($ in Thousands) Continued

conjunction with the High-frequency Active Auroral Research Program high power high frequency transmitting array.

(U)	$1,979	Investigate, enhance, and test electromagnetic radiometry technologies for the detection of underground structures. Conduct field demonstrations of a miniature and rugged man-portable hardware system using Very Low Frequency waves to detect underground structures. Design a system with improved detection algorithms, frequency agility, and remote data access for unmanned aero vehicle/airborne applications. Develop techniques to enhance the operational viability of both the man-portable and airborne systems.
(U)	$2,970	Develop seismic technologies to support national requirements for monitoring nuclear explosions. Enhance United States capabilities in seismic monitoring of nuclear explosions, with special focus on monitoring regional events located at distances less than 2,000 km from the sensors. Perform theoretical and experimental seismology studies to detect, locate, and characterize nuclear explosions.
(U)	$23,797	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,226	Develop technologies for specifying, monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense (DoD) operational space systems in order to improve performance, reduce cost, and increase operational lifetimes. Develop advanced space weather forecasting models combining remote sensing of interplanetary clouds with in situ plasma and fields data. Validate dynamic radiation belt model for satellite hazard forecasts with newly acquired data sets from operational DoD satellites. Develop advanced technology solar telescope for detecting and forecasting explosive solar events which generate spacecraft-damaging energetic particle events and initiate plasma clouds responsible for adverse communication and navigation effects. Develop capability to test sub-micron and nano-scale technology concepts for extremely small space hazard detectors.
(U)	$9,965	Develop real-time infrared backgrounds clutter code, spectral signature libraries, target detection techniques, and decision aids for application to space-based surveillance, laser weapons, and countermeasure systems, including detection of low-observable targets. Develop all-altitude, sub-pixel infrared background radiance model for atmospheric transmission of extended radiance sources such as missile hard bodies and plumes. Test and validate decision aids and turbulence performance prediction tools, including theater ballistic missile boost phase negation, on airborne laser platform. Expand models for other high energy laser systems and explore a forecasting capability for high altitude turbulence effects on aircraft platforms. Develop sensors, algorithms, and clutter removal techniques for space-based hypertemporal imaging sensor. Incorporate spectral signature variability into simulation codes to improve performance predictions. Collect high quality spectral data from existing systems and evaluate system requirements for theater surveillance and area search missions.
(U)	$6,765	Develop artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **1010**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

communications/navigation outage forecasting, space-based geolocation demonstrations, and determination and prediction of radar degradation. Develop nowcasting and forecasting validation algorithms for the Communication/Navigation Outage Forecasting System (C/NOFS) Advanced Concept Technology Demonstration. Integrate validation algorithms into ionospheric specification and forecast modeling architecture. Validate communication and navigation outage forecasts with C/NOFS satellite and ground-based data to demonstrate utility of outage warning due to scintillation. Integrate polar region plasma tracking models into global models of scintillation to provide seamless equator-to-pole outage specification. Validate multi-scale algorithms and data assimilation techniques to increase reliability of global ionospheric electron profile specifications and forecasts to improve radar and geolocation performance. Begin concept development of scintillation mitigation techniques to overcome satellite-to-ground link degradation in real-time.

(U) $9,767 Continue development of the High Frequency Active Auroral Research Program site transmitting and diagnostic instrument infrastructure. Provide facility management and environmental oversight. Initiate the completion of the high frequency transmitter array to its full capacity of 180 array elements and 3.6 megawatt radiated output power.

(U) $6,625 Develop basic seismic technologies to support national requirements for monitoring nuclear explosions. Enhance United States capabilities in seismic monitoring of nuclear explosions, with special focus on monitoring regional events located at distances less than 2,000 km from the sensors. Conduct seismic research such as seismic energy partitions for local and regional events, magnitudes and source physics; seismic calibration and ground truth collection; and seismic detection, location, and discrimination technologies. Perform observational studies of seismic wave propagation and collect seismic propagation characteristics of the Eurasian land-mass.

(U) $36,348 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0305160F, Defense Meteorological Satellite Program.

(U) PE 0601102F, Defense Research Sciences.

(U) PE 0602204F, Aerospace Sensors.

(U) PE 0305111F, Weather Systems.

(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **1010**

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602601F Space Technology

PROJECT
4846

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4846	Spacecraft Payload Technologies	14,473	11,384	15,282	19,328	20,157	20,896	36,090	40,120	Continuing	TBD

(U) A. Mission Description

This project develops advanced technologies that enhance spacecraft payload operations by improving component and subsystem capabilities. The project focuses on four primary areas: (1) development of advanced, space-qualified, survivable electronics, and electronics packaging technologies; (2) development of advanced space data generation and exploitation technologies, including infrared, Fourier Transform hyperspectral imaging, polarimetric sensing, and satellite antenna subsystem technologies; (3) development of high-fidelity space simulation models that support space-based surveillance and space asset protection research and development for the warfighter; and (4) development of advanced networking, radio frequency, and laser communications technologies to support next generation satellite communication systems.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,290 Developed advanced infrared device technologies for space applications that support hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of targets such as decoys, satellites, and warheads, throughout their trajectory. Developed cryogenic detector and read-out devices that will perform for extended periods of time under adverse natural and enhanced space environments. Developed and evaluated both broadband and narrow band detector devices and the appropriate low-noise, cryogenic read-out device and device architectures necessary for multi-band (two- and three-color) detection. Enhanced device architectures for future space sensor concepts that included the need for radiation-hardness, radiation tolerance, longer wavelengths, higher operating temperatures, and higher frame rates. Studied next generation detection requirements for space, and explored and exploited potential infrared device solutions.

(U) $993 Developed hyperspectral imaging data exploitation methodologies for military imaging and remote sensing applications. Fourier Transform HyperSpectral Imager (FTHSI) and polarimetric sensing technologies will provide enhanced surveillance capability for future space-based sensor systems by improving the ability of the systems to discriminate military targets in various scenarios. Completed evaluation of the hyperspectral imaging system performance based on data received from the FTHSI payload. Developed technology and modeling for understanding the electro-optical/infrared polarimetric phenomenology.

(U) $4,292 Developed technologies for space-based payload components such as low power, high performance, radiation-hardened electronic devices, micro-electro-mechanical devices, and advanced electronics packaging for next generation high performance space electronics. Goals are decreased feature size, improved scalability, decreased size/weight/power, and radiation-hardness. Expanded microelectronic material characterization to silicon-on-insulator and chalcogenide materials and apply radiation research and material defect analysis to improve device

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 4846

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

design. Fabricated and tested monolithically integrated low power, silicon-based quantum-sized devices. Characterized new radiation-hardened nonvolatile digital memories, Fast Fourier Transform (FFT) processors, and optical sensors. Investigated design enhancements for ten-fold performance improvement for the memories and FFT processors. Fabricated nonvolatile analog memories. Established a micro-electro-mechanical (MEMS) reliability test device for ground and space experiments. Investigated a chip-scale packaging system with optimized confinement features and coating for MEMS devices. Established a non-volatile analog reconfigurable packaging architecture.

(U) $942 Developed modeling, simulation, and analysis (MS&A) tools for space-based surveillance systems, rendezvous and proximity operations, optical/infrared imaging space systems, large deployable space optics, and distributed satellite architecture payloads. MS&A tools provide data to validate research and development systems engineering level technology trade off decisions for space-based missions/campaign level assessments and for intelligent satellite system test beds. Completed connection of satellite toolkit and spacecraft simulation toolkit. Extended simulation architecture to support flight software development and definition and conduct near-term flight test experiment.

(U) $963 Developed advanced satellite antenna architectures and performance characterization tools for large, lightweight, modular space antennas. The advanced antenna architectures will improve the affordability and capability of antennas for space-based payload subsystems for Air Force surveillance and navigation efforts. Developed algorithms for performance characterization of modular phased-array antenna tiles. Built and tested engineering models to simulate performance of phased-array antenna tiles and integrated antenna modules. Characterized performance of antenna tiles and modules and correlate results to model predictions; updated models based on actual performance. Extended engineering models to simulate performance of the antenna tiles and integrated modules in a space environment in preparation for demonstration on a multi-microsatellite constellation space flight experiment.

(U) $1,255 Developed core infrastructure components for a robust satellite simulation toolkit. The toolkit will enable cost-effective risk reduction for space technology programs via modeling and simulation of all phases from concept design through flight experiment and technology transition. Designed and built software components for different user interfaces, connection to external hardware/software environments and simulations, and installation on inexpensive computer platforms. Added models and simulations of such space-based payload systems as radar, hyperspectral, and remote inspection sensors. Developed requirements for and initial designs of high-level models of space capability protection and counterspace technologies to be used for concept studies.

(U) $1,738 Developed radiation-hard analog circuit elements for mixed signal, Very Large Scale Integrated circuits for secure high-bandwidth intra-satellite and satellite-ground station communications. Radiation tested and characterized state-of-the-art commercial mixed signal systems and elements to determine feasibility of adapting commercial technologies for military application. Designed new radiation-hard analog elements.

(U) $14,473 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **4846**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,582	Develop advanced infrared device technologies for space applications that support hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of targets such as decoys, satellites, and warheads throughout their trajectory. Evaluate two- and three-color detector and continue development of multi-color detectors and tunable and broadband gratings. Design and fabricate selected concepts for future longer wavelength infrared detectors and infrared detectors with optimal background-limited performance for stressing, low photon noise, and space backgrounds. Complete design study of next generation long and very long wavelength infrared detector concepts, including quantum wells and strained layer superlattices, as lower cost, higher performance alternatives to mercury cadmium telluride. Evaluate delivered radiation-hardened cryogenic multiplexers for lower background, space infrared detector arrays.
(U)	$847	Develop spectral sensing and data exploitation methodologies for military imaging and remote sensing applications. Continue development of technology and modeling for understanding the electro-optical/infrared polarimetric phenomenology. Evaluate initial polarimetric signature model capability and validate with measured data. Develop capability to integrate polarimetric models into modeling, simulation, and analysis (MS&A) for space-based surveillance applications.
(U)	$3,511	Develop technologies for space-based payload components such as low power, high performance, radiation-hardened electronic devices, micro-electro-mechanical system (MEMS) devices, and advanced electronics packaging for next generation high performance space electronics. Continue silicon-on-insulator radiation research and enhance the switching speed and durability of the chalcogenide material by ten times for improved devices. Extend the design of the monolithically integrated low power, silicon-based quantum-sized devices to include non-traditional electronic materials. Continue to improve the speed of the radiation-hardened nonvolatile digital memories. Characterize the analog memories and enhance resolution to an eight-bit equivalent. Build space-qualified MEMS reliability test devices and chip-scale packages for ground and flight insertion. Build reconfigurable analog array packaging structures.
(U)	$1,118	Develop MS&A tools for space-based surveillance systems, rendezvous and proximity operations, optical/infrared imaging space systems, and distributed satellite architecture payloads. Extend simulation architecture to support flight experiment ground-to-space segment simulation, post-experiment distributed signal processing, and post-experiment data validation. The architecture can then be used for objective system-of-systems assessment.
(U)	$941	Develop advanced satellite antenna architectures and performance characterization tools for large, lightweight, modular space antennas. Extend antenna architecture and algorithms developed for performance characterization of modular phased array antenna tiles to multi-beam, wider-bandwidth, multi-mode operation to support development of advanced low-power, low-noise amplifiers, integrated wide-bandwidth radiators, and active radio frequency manifold control technologies. Build a testbed to simulate performance of multi-beam, wide-bandwidth phased array antenna tiles and integrated antenna models.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **4846**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

(U) $1,385 Develop radiation-hard analog circuit elements for mixed signal, Very Large Scale Integrated circuits for secure high-bandwidth intra-satellite and satellite-ground station communications. Continue radiation testing and characterization of commercial state-of-the-art mixed signal components to determine the feasibility of employing commercial foundry technologies for space applications. Design and fabricate innovative circuit configurations and test devices using new radiation-hard analog elements and circuit architectures. Mixed signal designs will include analog to digital converters, frequency synthesizers, and phase locked loops.

(U) $11,384 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,865 Develop advanced infrared device technologies for space applications that support hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of targets such as decoys, satellites, and warheads throughout their trajectory. Fabricate and characterize strained-layer superlattice detectors and use results to modify designs to improve absorption efficiency and eliminate manufacturing or operationally induced defects. Complete the two-dimensional focal plane array development effort by identifying, designing, and fabricating the appropriate cryogenic detector multiplexors required for transitioning the technology. Begin development of infrared detector and detector read-out circuit technologies for next generation surveillance systems with projected requirements for adaptive, re-configurable, and polarimetric capabilities.

(U) $759 Develop spectral sensing and data exploitation methodologies for military imaging and remote sensing applications. Complete initial assessment of technology and modeling for understanding the electro-optical/infrared spectral polarimetric phenomenology. Demonstrate partially validated polarimetric signature model capability and continue validation with measured data from ongoing field collects. Integrate initial polarimetric models into modeling, simulation, and analysis architecture for space-based surveillance applications.

(U) $3,763 Develop technologies for space-based payload components such as low power, high performance, radiation-hardened electronic devices, micro-electro-mechanical system devices, and advanced electronics packaging for next generation high performance space electronics. Research radiation effects in electronics components based on emerging silicon-on-insulator, sapphire, or other radio frequency and analog technology compatible substrates. Design new chalcogenide-based reconfigurable electronics providing ten-fold performance improvement based on adaptability. Demonstrate monolithically integrated low power, silicon-based quantum-sized devices for system-on-a-chip applications. Develop radiation hardening design techniques to enable fabrication of electronics on commercial lines. Demonstrate architecture and components supporting analog memory. Build micro-electro-mechanical system based switches supporting complex switching harnesses in support of self-adaptable spacecraft hardware. Develop architectures and packaging approaches in support of reconfigurable space systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **4846**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U) $1,266 Develop modeling, simulation, and analysis tools for space-based surveillance systems, rendezvous and proximity operations, optical/infrared imaging space systems, and distributed satellite architecture payloads. Continue to extend simulation architecture to support flight experiment ground-to-space segment simulation, post-experiment distributed signal processing, and post-experiment data validation. Extend the architecture for use in objective system-of-systems assessment. Begin to develop extensions to the simulation architecture to address missions associated with space capability protection and counterspace. Begin to develop enhancements to optical/infrared imaging system simulation to include polarimetric effects.

(U) $965 Develop advanced satellite antenna architectures and performance characterization tools for future large, lightweight, modular space antennas. Refine transmit/receive testbed, enhancing the performance of the phased-array antenna subsystems and integrated antenna modules using miniaturized active radio frequency components and planar wide-bandwidth radiators. Characterize performance of new wide-bandwidth antenna subsystems and correlate results to model predictions; update models based on actual performance. Develop algorithms for performance characterization of sparse cooperating apertures and for advanced antenna array calibration.

(U) $1,888 Begin to develop bandwidth efficient modulation and high bandwidth communications technologies to support next generation satellite communication systems. Initiate architecture studies and guide technology investment in support of satellite communications roadmap. Begin development of technology standards and system designs for integrating multiple Airborne Intelligence, Surveillance, and Reconnaissance (AISR) assets into single space platforms.

(U) $3,776 Develop technologies for multi-access laser communications terminals. Assess the maturity of single access terminal components and their applicability to a multi-access terminal design. Begin development of standards for combining multiple AISR and space asset feeds into a single optical data path. Begin design of a laboratory multi-access terminal testbed.

(U) $15,282 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0603401F, Advanced Spacecraft Technology.

(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **4846**

(U) **D. Acquisition Strategy**
Not Applicable.

(U) **E. Schedule Profile**
(U) Not Applicable.

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602601F Space Technology

PROJECT
5018

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5018 Spacecraft Protection Technology	0	4,346	4,045	2,831	2,653	2,500	2,567	2,635	Continuing	TBD

Note: In FY 2003, Project 1010, is split with efforts focused on protecting spacecraft from manmade threats being transferred into Project 5018.

(U) A. Mission Description

This project develops the technologies for protecting U.S. space assets in potential hostile environments to assure continued space system operation without performance loss in support of warfighter requirements. The project focuses on identifying and assessing spacecraft system vulnerabilities, developing threat warning technologies, and developing technologies to mitigate the effects of both intentional and unintentional threats.

(U) FY 2002 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/Planned Program
(U) $941 Develop key satellite threat warning technologies and tools for on-board satellite use to detect, geolocate, and characterize intentional and unintentional ground-based radio frequency (RF) and laser signals. Begin development of a high performance multiple threat sensors satellite protection system, improving technical performance of the sensor suite while still minimizing cost, power, and weight. Investigate integration of the miniature RF receiver, laser detector, and ionospheric specification system with advanced reconfigurable processor electronics for the first generation system. Assess feasibility of using a single antenna for performing RF geolocation from a low-earth-orbit satellite. Investigate laser and RF false alarm rejection/mitigation and anomaly resolution and management techniques.
(U) $1,312 Develop miniaturized RF attack receiver. Conduct risk reduction space shuttle experiment and perform post-test data and system performance analysis.
(U) $346 Develop techniques to exploit existing on-board satellite resources as first-line threat detection systems. Investigate use of systems on currently fielded or launch ready satellites for preliminary determination of RF/laser illumination or kinetic impact. Assess the use of telemetry, state-of-health data, and other appropriate data for event determination. Prepare for laboratory proof of concept demonstrations.
(U) $1,747 Develop techniques for monitoring and assessing electromagnetic interference and compatibility between ultra-sensitive payload sensors for space systems which support space weather forecasting. Begin payload integration for the Communications/Navigation Outage Forecast System Advanced Concept Technology Demonstration. Design, develop, and test serial communications hardware and software for command and data

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 5018

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

handling spacecraft sub-system risk reduction for real-time space weather forecasting. Validate data compression techniques with payload sensor data and apply to space flight software for demonstrating space weather forecasting.

(U) $4,346 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,296 Develop key satellite threat warning technologies and tools for on-board satellite use to detect, geolocate, and characterize intentional and unintentional ground-based radio frequency (RF) and laser signals. Develop and bench-test high performance multi-threat warning on-board sensors. Explore reconfigurable processor electronics capability and build testbed in support of multi-threat warning sensors. Analyze light, adaptable single antenna performance for threat detection and geolocation applications. Complete false alarm research for relevant threats. Select antenna technology for wide-band and narrow-band threat detectors for multi-threat capability space experiment.

(U) $854 Develop miniaturized RF attack receiver. Design and begin fabrication of miniaturized narrowband RF attack reporting receiver with of goal of five times reduction in power and size.

(U) $838 Develop techniques to exploit existing on-board satellite resources as first-line threat detection systems. Develop technology for currently fielded or launch-ready satellites to detect anomalies that result from RF/laser illumination or kinetic impact. Exploit on board resources such as telemetry or state-of-health data for anomaly determination as a zero added power/weight solution and assess the limits of this technique. Conduct laboratory proof of concept for selected subsystems.

(U) $1,057 Develop techniques for monitoring and assessing electromagnetic interference and compatibility between ultra-sensitive payload sensors for space systems which support space weather forecasting. Conduct space experiment demonstration of the Communication/Navigation Outage Forecasting System. Perform measurements of key ionospheric and scintillation parameters needed for input to ionospheric specification and forecast models. Assess data for electromagnetic interference effects on ultra-sensitive payload sensors. Assess payload performance in measuring ionospheric and scintillation parameters needed for space weather support in theater and for mission planners and other users.

(U) $4,045 Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **5018**

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

(U) PE 0603401F, Advanced Spacecraft 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 February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 8809

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
8809 Spacecraft Vehicle Technologies	33,570	36,712	27,565	30,445	31,412	36,154	43,589	46,612	Continuing	TBD

(U) A. Mission Description

This project focuses on seven major space technology areas: spacecraft platforms (e.g., structures, controls, power, and thermal management); space-based payloads (e.g., survivable electronics); satellite control (e.g., software for autonomous distributed satellite formation flying, signal processing, and control); modeling and simulation of space-based systems; satellite protection technologies (e.g., space environment effects, debris prediction, and threat warning/attack reporting); microsatellite technologies; and integrated experiments of advanced technologies for transition to planned systems (e.g., payload/platform/launch vehicle merging).

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,265 Developed technologies for advanced space platform subsystems, such as cryocoolers, compact, high-efficiency solar power cells and arrays, and innovative power generation concepts. Advance space platform subsystems will have more available power, longer operational lifetimes and increased operational range, and will be lighter and more affordable than current subsystems. Continued identification of mechanical mechanisms for assessing cryocooler reliability. Developed improved models for low-temperature cryocooler regenerator performance. Completed a 32% efficient solar cell and a 10% efficient thin-film solar cell.

(U) $8,632 Developed technologies for advanced space platform structures such as structural controls for vibration suppression, multifunctional structures, deployable large aperture optical arrays, and lightweight composite satellite and launch vehicle structures. Whole spacecraft launch vibration suppression will enable precision pointing and sensing systems. Multifunctional and composite structures, with a higher level of integration and standardized interfaces, will be reusable, lighter, and more affordable. Ground tested payload vibration suppression systems. Fabricated and characterized performance of multifunctional structure designs. Continued integration and ground test of component subsystems of deployable large aperture optical arrays. Started development of multifunctional bus structure for small spacecraft.

(U) $146 Completed development of ground support and small satellite integration technologies for spaceborne platforms with advanced bus components and standardized interfaces for testing and demonstrating revolutionary high payoff mission hardware and mission-enabling technologies for space and near-space experiments. Completed final analyses and reports on the MightySat II.1 platform and stand-alone experiment options.

(U) $15,988 Developed microsatellite (10-100kg) technologies and integrated microsatellite technology concepts. Integrated and tested microsatellite engineering model, and began component fabrication of a three-unit flight constellation to demonstrate on-orbit formation flying, inter-satellite communications, distributed processing, and sparse aperture sensing.

(U) $2,898 Developed low-cost, lightweight, leak-proof, linerless, non-metallic composite cryogenic tanks for reusable and small expendable launch vehicle

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602601F Space Technology**	PROJECT **8809**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

applications. Investigated novel composite material systems and processes, focusing on manufacturability and scaling. Developed liquid oxygen (LOX) compatible material system, addressing both oxidation and ignition phenomena. Designed, fabricated, and tested full-scale tanks to determine the effectiveness of microcrack mitigation and LOX compatibility techniques on flight-representative articles.

(U) $1,641 Developed and evaluated the world's first optically implemented Code Division Multiple Access wide-band network within the context of the Next Generation Internet. Continued to assess and demonstrate the inherent security capabilities of different coding schema as a means of enhancing information assurance at the transmission level.

(U) $33,570 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,409 Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts. Continue to improve accuracy of cryocooler modeling tools and the identification of mechanisms that limit operational life and degrade cryocooler subsystem performance. Demonstrate a 32% efficient solar cell. Demonstrate production capacity for a 10% efficient thin-film solar cell.

(U) $10,311 Develop technologies for advanced space platform structures such as structural controls for vibration suppression, multifunctional structures, deployable large aperture optical arrays, and lightweight composite satellite and launch vehicle structures. Flight test payload vibration suppression systems. Continue performance characterization of multifunctional bus structure for small spacecraft.

(U) $14,805 Develop microsatellite (10-100kg) technologies and integrated microsatellite technology concepts. The innovative microsatellite architectures and advanced satellite bus technologies could enable applications such as space protection, counterspace capabilities, sparse aperture sensing, on-orbit formation flying, inter-satellite communications, distributed processing, and responsive payloads. Complete fabrication and qualification testing of microsatellite subsystem hardware for future flight demonstration of bus technologies, including advanced avionics, thin-film solar arrays, Hall Effect micro-thrusters, high density memories, and Lithium-polymer batteries.

(U) $2,970 Develop key microsatellite subsystem technologies to support mission applications that range from distributed aperture formations to space surveillance, threat warning, and protection. Build and functionally test flight hardware for the following advanced technology subsystems: high power density lithium polymer batteries, low power integrated Global Positioning System positioning and communications, lightweight thin-film solar arrays, and lightweight 160-Gbyte non-volatile mass memory.

(U) $1,385 Develop high temperature polymer substrates for thin film solar cells for next generation flexible, thin film solar arrays. These thin film arrays will be 3 to 5 times lighter, cost 5 times less, require 5 times less stowed volume, and be more radiation resistant than state-of-the-art rigid panel

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

		arrays. Current polymer substrates for Copper-Indium-Gallium-DiSelenide (CIGS) thin film solar cells do not survive the high temperature processing necessary for fabricating the highest efficiency solar cells. Develop, fabricate, and test high temperature silicone resin films suitable for CIGS thin film solar cell substrates. Demonstrate the deposition of CIGS solar cells on the high temperature polymers.
(U)	$1,385	Develop advanced attitude and dynamic control technologies for next generation spacecraft. These technologies will provide unprecedented levels of control over dynamic subsystem response, precision pointing and target tracking. Design an integrated controls architecture which includes flight computer, an advanced suite of dynamic sensors, and real-time system identification software which can characterize the capability enhancements for operational space platforms.
(U)	$991	Develop technologies for advanced mirror systems and space structures, including improved advanced mirror fabrication techniques and methods for enhancing performance of the associated structural systems required to support sensors in space. Current fabrication methods are labor and time intensive, and the product is heavy, expensive, and falls short of achieving technical requirements. Investigate non-traditional and innovative composite fabrication techniques, focusing on accelerated fabrication techniques and dimensionally stable materials.
(U)	$456	Develop carbon foam-based structures for aircraft and spacecraft. Carbon foam based-structures will afford a critical 20% weight reduction without sacrificing structural performance. Investigate the performance requirements of structures for currently planned airborne and space-based systems and assess carbon foam blends and types for use in optical backing structures and the optical mounts for those systems. Downselect to the optimal carbon foam formulation and complete preliminary designs of an optical backing structure and optical mount.
(U)	$36,712	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,920	Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts. Complete identification of mechanical and long-term failure mechanisms for assessing cryocooler performance and reliability. Build first generation analytical performance prediction models, empirical measurements, and thermophysical fluid flow and heat transfer models for low-temperature cryocooler regenerator performance. Investigate technology development to improve cryocooler capability and performance for regenerative and recuperative cycle cryocoolers. Continue to demonstrate 32% efficient solar cells on reduced-mass wafers. Demonstrate 10% efficient thin-film solar cells on polymer substrate.
(U)	$9,620	Develop technologies for advanced space platform structures such as structural controls for vibration suppression, multifunctional structures, deployable large aperture optical arrays, and lightweight composite satellite and launch vehicle structures. Complete characterization of multifunctional small spacecraft bus. Initiate development of tunable nanotechnology-enhanced lightweight space structures. Begin

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 8809

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

development of lightweight structures and precision structural controls for large-aperture space optics. Begin development of low-shock and precision deployment mechanisms.

(U) $14,025 Develop microsatellite (10-100kg) technologies and integrated microsatellite technology concepts. The innovative microsatellite architectures and advanced satellite bus technologies could enable applications such as space protection, counterspace capabilities, sparse aperture sensing, on-orbit formation flying, inter-satellite communications, distributed processing, and responsive payloads. Integrate and functionally test microsatellite for future flight demonstration of bus technologies, including advanced avionics, thin-film solar arrays, Hall Effect micro-thrusters, high density memories, and Lithium-polymer batteries. .

(U) $27,565 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602102F, Materials.
(U) PE 0603311F, Ballistic Missile Technology.
(U) PE 0603401F, Advanced Spacecraft Technology.
(U) PE 0603500F, Multi-Disciplinary Advanced Development Space 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.

THIS PAGE INTENTIONALLY LEFT BLANK

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

DATE: February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602602F Conventional Munitions

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	48,051	58,802	46,455	50,351	51,310	55,768	53,718	54,991	Continuing	TBD
2068	Advanced Guidance Technology	14,534	17,175	16,731	17,305	17,633	18,199	18,651	19,094	Continuing	TBD
2502	Ordnance Technology	33,517	41,627	29,724	33,046	33,677	37,569	35,067	35,897	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

(U) A. Mission Description

This program investigates, develops, and establishes the technical feasibility and military utility of advanced guidance and ordnance technologies for conventional air-launched munitions. The program includes two projects: (1) development of advanced guidance technologies, including seekers, navigation and control, target detection and identification algorithms, and simulation assessments; and (2) development of conventional ordnance technologies, including warheads, fuzes, explosives, munitions integration, and weapon lethality and vulnerability assessments. Note: In FY 2003, Congress added $1.1 million for the Defense Against Weapons of Mass Destruction (WMD).

(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 technologies.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	49,029	60,343	52,709	
(U)	Appropriated Value	49,270	61,443		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-241	-2,283		
	b. Small Business Innovative Research	-743			
	c. Omnibus or Other Above Threshold Reprogram		-358		
	d. Below Threshold Reprogram				

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602602F Conventional Munitions

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

		FY 2002	FY 2003	FY 2004	Total Cost
	e. Rescissions	-235			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-6,254	
(U)	Current Budget Submit/FY 2004 PBR	48,051	58,802	46,455	TBD

(U) Significant Program Changes:

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602602F Conventional Munitions	2068

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2068	Advanced Guidance Technology	14,534	17,175	16,731	17,305	17,633	18,199	18,651	19,094	Continuing	

(U) A. Mission Description

This project investigates, develops, and evaluates conventional munitions advanced guidance technologies to establish technical feasibility and military utility. This project includes development of advanced guidance including terminal seekers, navigation and control, signal and processing algorithms, and guidance and control simulations. Project payoffs include: adverse-weather and autonomous precision guidance capability; increased number of kills per sortie; increased aerospace vehicle survivability; improved reliability and affordability; and, improved survivability and effectiveness of conventional weapons.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $5,133 Investigated and developed advanced guidance component technologies such as laser sources, detectors and detector arrays, receiver electronics, signal pre-processing, target recognition, spatial target characteristics, optics, and beam scanning and shaping technology for lower cost, enhanced precision, adverse weather, and autonomous seekers for air-delivered munitions. These technologies enabled the development of next generation seekers that will increase a weapon's kill probability, reduce pilot workload, and enhance sortie effectiveness. Developed software tools for the development of laser radar algorithms and created a database for both measured and synthetic laser radar information. Initiated development and ground test of a scanner-less laser radar system with simultaneous, multi-wavelength capabilities. In conjunction with the Defense Advance Research Project Agency, investigated and developed focal plane array architecture that is capable of flash (one shot) range imaging for application in laser radar seekers.

(U) $4,282 Investigated and developed advanced navigation and control technologies, including nonlinear controllers, biomimetic guidance, clutter rejection modules, detection and segmentation modules, and micro-electromechanical gyros for air-delivered munitions. These technologies allowed a more efficient flight path to the target, increased stand off ranges, and enhanced strike aircraft effectiveness and survivability. Designed and fabricated a reliable, accurate, miniaturized, and low-cost anti-jam weapon guidance system capable of operating in highly dynamic flight environments in the presence of Global Positioning System (GPS) jamming systems. Completed applied research of a miniature navigation device, based on micro-electromechanical system technology, which couples the GPS signal with an inertial navigation system to provide ultra-high GPS jamming resistance and accuracy without the need for an anti-jam antenna.

(U) $2,484 Investigated and developed advanced optical and digital processors and target detection, classification, and identification algorithms for improved seeker performance to allow greater air-delivered weapon autonomy. These seekers deny an enemy the ability to hide or camouflage a target while also decreasing the pilot's workload. Developed an in-house, state-of-the-art signal and imaging processing capability used to assess

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

current and future, single-mode, ultra-spectral, and multi-mode seeker concepts. Investigated and transitioned biomimetic principles of variable resolution sensors, which emulate biological or human characteristics, into advanced seeker components for moving target scenarios. Continued in-house activities including algorithms and simulation development and validation, statistical analysis of fixed, mobile targets and background data, and independent evaluation of target classification software, pattern recognition concepts, and seeker processing techniques to support design of autonomous munitions.

(U) $2,635 Investigated and developed detailed six-degree-of-freedom and hardware-in-the-loop simulations including synthetic aperture radar, automatic target recognition, and biomimetic processing. Simulations also included trajectory optimization algorithm and polarization sensing and models to analyze guided munitions and their components that enabled requirement studies, design iteration and evaluation, and experiment risk reduction. These simulations shortened development time, reduced development cost, and provided more effective munitions. Continued analysis efforts and multi-sensor modeling to improve target signature prediction models, expedite development, and reduce the acquisition cycle expense for state-of-the-art seekers. Developed hardware-in-the-loop, laser radar, and scene projector instrumentation. The instrumentation combined optical signals to produce a complex laser radar return signal capable of providing real-time scene generation capabilities to test seeker components. Developed six-degree-of-freedom simulations to provide detailed performance estimates of guidance-related component technology for guided weapon systems. Developed modular system level analysis tools to provide comprehensive comparisons amongst inventory, and conceptualized munitions to identify high payoff technologies and weapon attributes.

(U) $14,534 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,779 Investigate and develop advanced guidance component technologies for adverse weather, and autonomous seekers for air-delivered munitions, such as laser sources, detectors and detector arrays, receiver electronics, signal pre-processing, target recognition, spatial target characteristics, optics, and low-cost beam scanning and shaping technologies. These technologies will enable the development of next generation seekers that will increase a weapon's kill probability, reduce pilot workload, and enhance sortie effectiveness. Demonstrate in-house, high-throughput, parallel processing target acquisition algorithms. Evaluate laser radar components to quantify operational range, target detection and identification, aim-point selection, and weather penetration effectiveness. Develop a low-cost, synthetic aperture radar seeker to assess future advanced guidance applications.

(U) $4,921 Investigate and develop advanced navigation and control technologies for air-delivered munitions; for example, nonlinear controllers, biomimetic guidance, clutter rejection modules, detection and segmentation modules, and micro-electromechanical gyros. These technologies

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602602F Conventional Munitions**	PROJECT **2068**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

will allow a more efficient flight path to the target, increase stand off ranges, and enhance strike aircraft effectiveness and survivability. Complete laboratory field testing of a reliable, accurate, miniaturized, and low-cost anti-jam weapon guidance system. This guidance system will be capable of operating in highly dynamic flight environments in the presence of Global Positioning System jamming devices. Develop new design technologies for tactical munitions flight control systems. Develop novel ways to enhance weapon system effectiveness through higher levels of integration of guidance, navigation, control, and estimation algorithms. Investigate the neuro-physiology of insects for applications to guidance. Investigate clutter and multi-discriminate rejection to defeat camouflage, concealment, and deception.

(U) $2,112 Investigate and develop advanced optical and digital processors and target detection, classification, and identification algorithms for improved seeker performance to allow greater air-delivered weapon autonomy. These seekers will deny an enemy the ability to hide or camouflage a target, while also decreasing the pilot's workload. Develop highly innovative concepts and approaches in guidance and control. Continue investigating and transitioning biomimetic principles of variable resolution sensors, which emulate biological or human characteristics, into advanced seeker components for moving target scenarios. Investigate algorithms to perform flight trajectory shaping that reduces manning effects.

(U) $3,363 Investigate and develop detailed six-degree-of-freedom and hardware-in-the-loop simulations including synthetic aperture radar, automatic target recognition, and biomimetic processing. Technologies also include trajectory optimization algorithm, and polarization sensing and models to analyze guided munitions and their components that will enable requirement studies, design iteration and evaluation, and experiment risk reduction. These simulations will shorten development time, reduce development cost, and provide more effective munitions. Continue analysis efforts and multi-sensor modeling to improve target signature prediction models, expedite development, and reduce the acquisition cycle expense for state-of-the-art seekers. Investigate the long-term technology and strategy for developing an advanced laser radar scene projector. Develop two-dimensional laser arrays for laser radar scene projectors. Provide detailed performance estimates of guidance-related component technology, using six-degree-of-freedom simulations, for guided weapon systems. Continue to develop modular, system-level, analysis tools to provide comprehensive comparisons among inventory, planned, and conceptual munitions to identify high payoff technologies and weapon attributes.

(U) $17,175 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,471 Investigate and develop advanced guidance component technologies for adverse weather, and autonomous seekers for air-delivered munitions, such as laser sources, detectors and detector arrays, receiver electronics, signal pre-processing, target recognition, spatial target characteristics, optics, and low-cost beam scanning and shaping technologies. These technologies will enable the development of next generation seekers that

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602602F Conventional Munitions**	PROJECT **2068**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

will increase a weapon's kill probability, reduce the pilot's workload, and enhance sortie effectiveness. Demonstrate a laser ranging and detection seeker with the capability to perform 'single-shot' imaging technology. Begin design of a dual-mode seeker that uses both long and short-range electromagnetic wave energy to improve adverse weather performance with clearer resolution. Develop a low-cost, synthetic aperture radar seeker to assess future advanced guidance applications.

(U) $4,787 Investigate and develop advanced navigation and control technologies for air-delivered munitions. Example technologies include nonlinear controllers, biomimetic guidance, clutter rejection modules, detection and segmentation modules, and micro-electromechanical gyros. These technologies will allow a more efficient flight path to target, increase stand off ranges, and enhance strike aircraft effectiveness and survivability. Investigate concepts for penetrator guidance below the surface. Develop new design technologies for tactical munitions flight control systems using the results of basic research. Develop novel ways to enhance weapon system effectiveness through higher levels of integration of guidance, navigation, control, and estimation algorithms. Continue to investigate the neuro-physiology of insects for applications to guidance.

(U) $1,747 Investigate and develop advanced optical and digital processors and target detection, classification, and identification algorithms for improved seeker performance to allow greater air-delivered weapon autonomy. These seekers will deny an enemy the ability to hide or camouflage a target while also decreasing the pilot's workload. Develop highly innovative concepts and approaches in guidance and control for use in advanced seekers for moving target scenarios. Continue investigating and transitioning biomimetic principles of variable resolution sensors, which emulate biological or human characteristics, into advanced seeker components for moving target scenarios. Investigate algorithms to perform flight trajectory shaping that reduces human error design effects. Investigate polarization measurement to differentiate the properties of manmade materials from natural backgrounds.

(U) $3,726 Investigate and develop detailed six-degree-of-freedom and hardware-in-the-loop simulations including synthetic aperture radar, automatic target recognition, and biomimetic processing. Technologies also include trajectory optimization algorithm and polarization sensing and models to analyze guided munitions and their components that will enable requirement studies, design iteration and evaluation, and experiment risk reduction. These simulations will shorten development time, reduce development costs, and provide more effective munitions. Continue analysis efforts and multi-sensor modeling to improve target signature prediction models, expedite development, and reduce the acquisition cycle expense for state-of-the-art seekers. Investigate the long-term technology and strategy for developing an advanced laser ranging and detection scene projector capability. Develop two-dimensional laser arrays for laser ranging and detection scene projectors. Provide detailed performance estimates of guidance-related component technology, using six-degree-of-freedom simulations, for guided weapon systems. To identify high payoff technologies and weapon attributes, continue to develop modular, system-level, analysis tools to provide comprehensive comparisons among inventory, planned, and conceptual munitions.

(U) $16,731 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602602F Conventional Munitions	2068

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0603601F, Conventional Weapons 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 February 2003
BUDGET ACTIVITY 02 - Applied Research					PE NUMBER AND TITLE 0602602F Conventional Munitions						PROJECT 2502
COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2502	Ordnance Technology	33,517	41,627	29,724	33,046	33,677	37,569	35,067	35,897	Continuing	

(U) A. Mission Description

This project investigates, develops, and evaluates conventional ordnance technologies to establish technical feasibility and military utility. Included in this project are technologies for advanced conventional weapon dispensers, submunitions, safe and arm devices, fuzes, explosives, warheads, and weapon airframe and carriage technology. The project also assesses the lethality and effectiveness of current and planned conventional weapons technology programs and assesses target vulnerability. The payoffs include: improved storage capability and transportation safety of fully assembled weapons; improved warhead and fuze effectiveness; improved submunition dispensing; low-cost airframe/subsystem components and structures; and reduced aerospace vehicle/weapon's drag.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,006 Investigated and developed high fidelity analytical tools such as computational mechanics models for predicting weapons effects and assessing target vulnerability. These analysis tools will reduce air-delivered munitions development costs by providing weapons that can generate maximum lethality against a given target class. Developed new hydro-code to improve predictive warhead performance capabilities by adding metal cutting, detonation waves, shear banding, and phase transitions. Developed a high fidelity model that predicts the dispersion of chemical and biological neutralizing agents from warheads. Upgraded and refined basic models describing fragmentation effects against various target facilities, including weapons of mass destruction (WMD). Performed phenomenology tests to provide data for the development of lethality and vulnerability codes for ground-fixed WMD targets.

(U) $3,155 Investigated and developed more efficient, affordable explosives, including inert dense metal additives, tungsten-laden explosives, cast and cure high energy composite explosives, and nano-scale metal fuels that provide both higher blast performance and lower ignition sensitivity for air-delivered munitions. These technologies enable safer, less expensive explosive fills for inventory and future weapons. Continued developing micro-scale and nano-scale fuel and oxidizer particles to create new, intermolecular energetic materials. In collaboration with the Department of Energy labs, completed efforts to develop a new class of materials for use in fragments, shaped charges, and explosively formed projectiles. Developed insensitive explosive formulations for use in penetrator warheads capable of Mach 4 impact velocities. Initiated development of a highly energetic material with twice the power density of conventional explosives, but exhibiting insensitive munition attributes. Evaluated intermolecular energetic material to measure mixing and fabrication techniques, material properties, and performance augmentations for specific applications. Initiated dense reactive metal explosive research to investigate cost-effective methods to improve current explosives.

(U) $6,258 Investigated and developed advanced fuze technologies for air-delivered munitions, such as commercially available micro-mechanical systems,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602602F Conventional Munitions	PROJECT 2502

(U) **A. Mission Description Continued**

(U) FY 2002 ($ in Thousands) Continued

shock-hardened fuzes, low energy detonators, light-activated and modular firing systems for advanced single point initiation, switches, capacitors, power sources, and safe-arming concepts. The advanced fuze techniques will enhance lethality through precise selection of burst-height at, above, or below the surface to increase weapon safety and tactical performance while simultaneously decreasing procurement costs and system supportability requirements. Developed test methodology to analyze hardened-influence-fuze components, and bench-level and field-shock testing of fuze components. Initiated critical component design and fabrication of the next generation burst-height fuze with discrimination against foliage, rain, chaff, electronic countermeasures, and electromagnetic interference. Developed technologies that communicate battle damage assessment through hardened mediums.

(U) $8,912 Investigated and developed control and carriage technologies for ordnance packages for advanced air-delivered munitions in order to enhance weapon lethality. Examples of these technologies include high energy explosives, mass focus fragmentation, and multi-sensor fuzing. These technologies will increase weapon system effectiveness by contributing to increased weapon load-out on strike aircraft and enhanced sortie effectiveness. Developed advanced munition dispenser electronics and software, and investigated reduction of platform integration cost for the advanced carriage technology. Investigated alternate technologies, such as microbots and nano-encapsulation, to disrupt, deny, destroy, or damage facilities involved with chemical and biological weapons. Continued investigating technologies for defeating hard and deeply buried targets.

(U) $9,186 Investigated and developed advanced warhead kill mechanisms, such as the adaptable warhead, directional control and fragmenting ordnance, and application of reactive metals. The investigation included characterization of the dynamic response of metals and geologic materials, adjustable yield ordnance packages, and distributed multi-point fire set to enhance air-delivered munition lethality. This enhanced lethality supports the development of smaller munitions with effectiveness similar to current inventory weapons and with a corresponding increase in strike aircraft load-out and sortie effectiveness. Designed, fabricated, and evaluated initiation-based, adaptable, and multi-mode warheads using enhanced lethality materials and miniaturization technologies for the advanced warhead kill mechanism. Fabricated and tested a chemical and biological agent defeat warhead design to determine its ability to deny an adversary access to storage and production facilities containing chemical or biological weapons. Analyzed improvements to multi-mode warheads using heavy metal liners to enhance lethality. Performed in-house experiments to characterize the interaction of munitions with chemical and biological containers.

(U) $33,517 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602602F Conventional Munitions**	PROJECT **2502**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,507 Investigate and develop high fidelity analytical tools such as computational mechanics models for predicting weapons effects and assessing target vulnerability. These analysis tools will reduce air-delivered munitions development costs providing weapons that can generate maximum lethality against a given target class. Develop new hydro-code to improve predictive warhead performance capabilities by adding metal cutting, detonation waves, shear banding, and phase transitions. Upgrade and refine basic models describing fragmentation effects against various target facilities, including weapons of mass destruction (WMD). Perform phenomenology tests to provide data for the development of lethality and vulnerability codes for ground-fixed WMD targets. Apply campaign analysis tools to compare inventory, budgeted, and conceptual munitions to identify high payoff technologies.

(U) $5,206 Investigate and develop more efficient, affordable explosives including inert dense metal additives, tungsten-laden explosives, cast and cure high energy composite explosives, and nano-scale metal fuels that provide both higher blast performance and lower ignition sensitivity for air-delivered munitions. These technologies will enable safer, less expensive explosive fills for inventory and future weapons. Utilize micro-scale and nano-scale fuel and oxidizer particles to create new, advanced, intermolecular energetic materials. Complete efforts to develop a new class of materials for use in fragments, shaped charges, and explosively formed projectiles. Continue development of a highly energetic material that has twice the power density of conventional explosives, while exhibiting insensitive munition attributes. Develop an explosive capable of surviving Mach 4 impacts that still functions as desired when initiated by the fuze. Continue research of dense reactive metal explosives and investigate cost-effective methods to improve current explosives.

(U) $7,116 Investigate and develop advanced fuze technologies for air-delivered munitions, such as commercially available micro-mechanical systems, shock-hardened fuzes, low energy detonators, light activated and modular firing systems for advanced single-point initiation, switches, capacitors, power sources, and safe-arming concepts. The advanced fuze technologies will enhance lethality through precise selection of burst-height at, above, or below the surface to increase weapon safety and tactical performance while simultaneously decreasing procurement costs and system supportability requirements. Develop a high resolution, electromagnetic countermeasure-hardened, active imaging fuze that calculates warhead burst direction and detonation time. Determine the benefits of developing a high-speed, hard target fuze using sensors such as micro-electromechanical system gyroscopes. Investigate technologies that can communicate battle damage assessment information through hardened mediums.

(U) $9,976 Investigate and develop control and carriage technologies for ordnance packages for advanced air-delivered munitions in order to enhance weapon lethality. Examples of these technologies include high-energy explosives, mass-focus fragmentation, and multi-sensor fuzing. These technologies will increase weapon systems effectiveness by contributing to increased weapon load-out on strike aircraft and enhanced sortie effectiveness. Investigate and compare the subsystem technologies necessary to develop an optimum kill missile against low-observable, aerial

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602602F Conventional Munitions	PROJECT 2502

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

targets. Investigate technologies, such as microbots and nano-encapsulation, to disrupt, deny, destroy, or damage facilities containing chemical and biological weapons. Investigate technologies that can defeat hard and deeply buried targets by simultaneously placing multiple, precise, time-of-arrival guided munitions on target.

(U) $12,822 Investigate and develop advanced warhead kill mechanisms, such as the adaptable warhead, directional control and fragmenting ordnance, and application of reactive metals. The investigation includes characterization of the dynamic response of metals and geologic materials, adjustable yield ordnance packages, and distributed multi-point fire set to enhance air-delivered munition lethality. This enhanced lethality supports the development of smaller munitions with effectiveness similar to current inventory weapons and with a corresponding increase in strike aircraft load-out and sortie effectiveness. Continue to evaluate initiation-based, adaptable, and multi-mode warheads using enhanced lethality materials and miniaturization technologies for the advanced warhead kill mechanism. Begin evaluation of an ordnance package designed for low collateral damage with high near-field and minimum far-field lethality. Complete assessment of multi-mode warheads using heavy metal liners to enhance lethality. Complete in-house experiments to characterize the interaction of munitions with chemical and biological weapon and storage containers. Begin an effort to improve the attributes of penetrating munitions by focusing on improving warhead case survivability, control of depth of burial, trajectory control methodologies while penetrating hardened material, and decreasing case thickness to allow a greater amount of energetic material to be carried to the required depth of target.

(U) $41,627 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,321 Investigate and develop high fidelity analytical tools such as computational mechanics models for predicting weapons effects and assessing target vulnerability. These analysis tools will reduce air-delivered munitions development costs and provide weapons that can generate maximum lethality against a given target class. Upgrade and refine basic models describing fragmentation effects against various target facilities, including weapons of mass destruction. Apply campaign analysis tools to compare inventory, budgeted, and conceptual munitions to identify high payoff technologies. Complete development of improved engineering level predictive methods for blast effects, combined effects environment, and target structural response. Improve methodologies for predicting the penetration performance of unitary penetrating materials into complex target structures.

(U) $3,028 Investigate and develop more efficient, affordable explosives including inert dense metal additives, tungsten-laden explosives, cast and cure high energy composite explosives, and nano-scale metal fuels that provide both higher blast performance and lower ignition sensitivity for air-delivered munitions. These technologies will enable safer, less expensive explosive fills for inventory and future weapons. Continue

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602602F Conventional Munitions	PROJECT 2502

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

development of a highly energetic material that has twice the power density of conventional explosives, while still exhibiting insensitive munition attributes. Continue developing an explosive capable of surviving Mach 4 impacts that still functions as desired when initiated by the fuze. Develop characterization and evaluation methodologies to test the munition application performance of high energy density materials developed in other laboratories. Increase the energy output while maintaining the producible capability of cast and cure composite explosives by using advanced energetic materials, plasticizers techniques, and formulation techniques.

(U) $6,592 Investigate and develop advanced fuze technologies for air-delivered munitions, such as commercially available micro-mechanical systems, shock-hardened fuzes, low energy detonators, light activated and modular firing systems for advanced single-point initiation, switches, capacitors, power sources, and safe-arming components. These advanced fuze technologies will enhance lethality through precise selection of burst-height at, above, or below the surface to increase weapon safety and tactical performance while simultaneously decreasing procurement costs and system supportability requirements. Develop a high resolution, electromagnetic countermeasure-hardened, active imaging fuze that calculates warhead burst direction and detonation time. Investigate technologies that can communicate battle damage assessment information through hardened mediums. Develop miniaturized fuze to effectively control the release of anti-agent and submunition for defeating weapons of mass destruction.

(U) $6,267 Investigate and develop control and carriage technologies for ordnance packages for advanced air-delivered munitions in order to enhance weapon lethality. Examples of these technologies include high energy explosives, mass-focus fragmentation, and multi-sensor fuzing. These technologies will increase weapon systems effectiveness by contributing to increased weapon load-out on strike aircraft and enhanced sortie effectiveness. Continue investigating the subsystem technologies necessary to develop an optimum kill missile against low-observable, aerial targets. Investigate technologies that can defeat hard and deeply buried targets by simultaneously placing multiple, precise, time-of-arrival guided munitions on target. Perform concept trade studies to determine the technologies necessary to deny adversary operations over long, stand off ranges.

(U) $7,516 Investigate and develop advanced warhead kill mechanisms, such as adaptable warhead, directional control and fragmenting ordnance, and application of reactive metals. The investigation includes characterization of the dynamic response of metals and geologic materials, adjustable yield ordnance packages, and distributed multi-point fire set to enhance air-delivered munition lethality. This enhanced lethality supports the development of smaller munitions with effectiveness similar to current inventory weapons and with a corresponding increase in aircraft load-out and sortie effectiveness. Continue to evaluate initiation-based, adaptable, and multi-mode warheads using enhanced lethality materials and miniaturization technologies for the advanced warhead kill mechanism. Continue evaluation of an ordnance package designed for low collateral damage with high near-field and minimum far-field lethality. Develop the design constraints to provide adaptable warhead technologies to better attack mobile ground targets. Begin evaluating tungsten to be used for high-speed, penetrating-warhead case material. Continue an effort to

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602602F Conventional Munitions**	PROJECT **2502**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

improve the attributes of penetrating munitions by focusing on improving warhead case survivability, control of depth of burial, trajectory control methodologies while penetrating hardened material, and decreasing case thickness to allow a greater amount of energetic material to be carried to the required depth of target. Complete an effort to develop experimental data analysis techniques to characterize the dynamic response of metals used for warhead cases. Investigate effectiveness of large blast explosive mechanisms.

(U) $29,724 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0603601F, Conventional Weapons 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.

THIS PAGE INTENTIONALLY LEFT BLANK

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

DATE
February 2003

BUDGET ACTIVITY
02 - Applied Research

PE NUMBER AND TITLE
0602605F DIRECTED ENERGY TECHNOLOGY

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	33,557	37,547	35,359	36,239	39,551	45,174	43,760	43,556	Continuing	TBD
4866	Lasers & Imaging Technology	18,840	21,777	20,635	20,854	23,881	27,218	26,510	26,283	Continuing	TBD
4867	Advanced Weapons & Survivability Technology	14,717	15,770	14,724	15,385	15,670	17,956	17,250	17,273	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

Note: In FY 2003, space unique tasks in Project 4866 were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This program covers research in directed energy technologies, primarily lasers and high power microwaves, that are not space unique. In lasers, this includes moderate to high power lasers (solid state and chemical) and associated optical components and techniques. In advanced weapons, this program examines technologies such as narrowband and wideband high power microwave devices and antennas. Both areas also provide vulnerability/lethality assessments of representative systems.

(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 technologies.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	34,616	39,936	40,251	
(U)	Appropriated Value	34,678	39,936		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-62	-2,325		
	b. Small Business Innovative Research	-893			
	c. Omnibus or Other Above Threshold Reprogram		-64		
	d. Below Threshold Reprogram	-2			

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**

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

		FY 2002	FY 2003	FY 2004	Total Cost
	e. Rescissions	-164			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-4,892	
(U)	Current Budget Submit/FY 2004 PBR	33,557	37,547	35,359	TBD

(U) Significant Program Changes:

The adjustment in FY 2004 is due to the delayed transfer of the civilian salaries associated with the space unique efforts previously transferred to PE 0602500F, Multi-disciplinary Space Technology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT 4866

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4866 Lasers & Imaging Technology	18,840	21,777	20,635	20,854	23,881	27,218	26,510	26,283	Continuing	TBD

Note: In FY 2003, space unique tasks in Project 4866 were transferred to PE 0602500F in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description

This project examines the technical feasibility of moderate to high power lasers and associated optical components required for Air Force missions including long- and short-range weapons, weapon support such as aimpoint selection, and force protection. The technologies developed in this project are not uniquely space-oriented. Technologies applicable for a wide range of vehicles including unmanned combat air vehicles and fighters are being developed. High power solid state and chemical laser devices, optical components, advanced beam control and atmospheric compensation technologies, laser target vulnerability assessment techniques, and advanced optical processes and techniques are developed. Advanced, short-wavelength laser devices for applications such as illuminators and imaging sources for target identification and assessment are developed.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,504 Developed and tested advanced long-range optical technologies to support beam projection and imaging applications. Developed novel, advanced optical devices for faster corrections, increased resolution, and larger apertures. Tested and characterized these devices in a laboratory environment. Emphasized extending the wavelength coverage and decreasing number of system components to increase payoff to space-based optical systems. Produced one-meter class membrane mirror with near final curvature and demonstrated holographic correction of the mirror surface.

(U) $4,521 Developed high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications. Investigated high pressure ejector nozzle performance and iodine atom generation for potential long-range technology insertion into applications such as airborne lasers. Continued development of a subsonic all gas-phase iodine laser. Began design of a combustor-driven one kilowatt supersonic all gas-phase iodine laser. Conducted a study of the radio frequency-pumped overtone carbon monoxide laser in various spectral bands of interest for infrared countermeasures and remote sensing applications.

(U) $3,518 Developed and demonstrated high energy laser technologies for airborne tactical applications, including air-to-air and surface-to-air scenarios. Technologies addressed included lasers for long-range detection of targets in clutter and advanced beam control techniques to minimize platform vibration, atmospheric jitter, and aero-optic effects. Developed and demonstrated multifunctional laser components capable of detecting, identifying, tracking, and defeating electro-optic targets. Investigated packaging issues for advanced tactical applications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT **4866**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U)	$5,540	Developed low-cost, scalable, high power solid state laser architectures for directed energy applications such as unmanned aerial vehicle designators/imagers and next generation weapon applications including tactical airborne lasers. Began developing promising solid state laser technologies that provide benefits such as low-cost, high efficiency (approaching 30%), compactness, and scalability. Developed integration technologies necessary for combining multiple fiber laser modules including coherent, spectral, and nonlinear optical beam combining technologies.
(U)	$528	Developed advanced laser remote optical sensing technology to support standoff detection of chemical/biological aerosols for signature intelligence on weapons of mass destruction; bomb damage assessment; target characterization; and theater intelligence, surveillance, and reconnaissance. Completed phase II experiments for frequency agile heterodyne receiver development for improved sensitivity.
(U)	$2,238	Assessed the vulnerability of six satellites (U.S. and foreign) to the effects of directed energy weapons, primarily high energy lasers. Updated previously completed assessments on catalogued satellites. Started development of finite state models for satellites to be used with observables to produce a more complete space situational awareness posture.
(U)	$991	Developed the Tactical Operations System Simulator to model, evaluate, trade, and optimize directed energy concepts and tactical employment. Developed software/hardware simulation tools to assess performance, demonstrate military utility to the warfighter, and identify requirements and technology shortfalls. Integrated tools to provide a government systems engineering, simulation, and operational research capability.
(U)	$18,840	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,484	This project previously included space unique tasks which have been transferred to PE 0602500F, Multi-disciplinary Space Technology. These funds represent the civilian salaries for the transferred work efforts.
(U)	$365	Develop and demonstrate generic technologies to support future tactical or strategic relay mirrors systems. These technologies include beam control; beam acquisition, tracking, and pointing; dual line of sight pointing; lightweight optics; and beam stabilization. Develop light, low power optics for relay mirrors.
(U)	$4,310	Develop high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications. Improve high pressure ejector nozzle performance and iodine atom generation for potential long-range technology insertion into applications such as airborne lasers. Investigate low-flow rate basic hydrogen peroxide and zero-gravity singlet delta oxygen generators for airborne applications. Begin construction of a combustor-driven one kilowatt supersonic all gas-phase iodine laser. Improve the efficiency of the radio frequency-pumped overtone carbon monoxide laser in various spectral bands of interest for infrared countermeasure and remote sensing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT 4866

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

applications.

(U)	$4,978	Develop and demonstrate high energy laser technologies for airborne tactical applications, including air-to-air and surface-to-air scenarios. Technologies being addressed include lasers for long-range detection of targets in clutter; high power, high-brightness, multi-wavelength compact lasers; and advanced beam control techniques to minimize platform vibration, atmospheric jitter, and aero-optical effects. Continue developing laser sources and supporting technology for detecting, identifying, tracking, and defeating electro-optic targets. Demonstrate 30-watt, near-diffraction-limited, 1.5 micron eye-safe laser. Address packaging issues for advanced tactical applications.
(U)	$6,504	Develop scalable, high power solid state laser architectures for directed energy applications such as unmanned aerial vehicle designators/imagers and next generation weapon applications including tactical airborne lasers. Develop promising solid state laser technologies for a FY 2004 demonstration of attributes such as low-cost, high efficiency, compactness, and scalability. Demonstrate technologies necessary for scaling solid state laser powers to 10 kilowatts.
(U)	$1,749	Develop advanced laser remote optical sensing technology to support standoff detection of chemical/biological aerosols for signature intelligence on weapons of mass destruction; bomb damage assessment; target characterization; and theater intelligence, surveillance, and reconnaissance. Continue design and development of hardware for differential absorption laser radar applications. Investigate issues for an airborne system.
(U)	$1,387	Perform vulnerability assessments on potential high energy laser targets to provide critical design data for laser systems to defeat these targets. Continue to update lethality assessment methodology by anchoring modeling tools to empirical data. Perform finite state modeling of laser targets to better understand vulnerabilities and identify indicators for battle damage assessment.
(U)	$21,777	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$1,100	Develop and demonstrate generic technologies to support future tactical or strategic relay mirrors systems. These technologies include beam control; beam acquisition, tracking, and pointing; dual line of sight pointing; lightweight optics; and beam stabilization. Select the best lightweight, low power optics candidate technologies for airborne relay mirrors and start development of these optics for potential demonstration on a small-scale (with 50-cm primary optics) bifocal relay testbed.
(U)	$4,594	Develop high power chemical laser technologies for applications such as directed energy weapons, illuminators, and wavelength specific applications. Perform sub-scaled demonstration of optimized high pressure ejector nozzles and integrated iodine atom generation for airborne applications. Demonstrate low-flow rate basic hydrogen peroxide and zero-gravity singlet delta oxygen generator concepts for airborne applications. Demonstrate the feasibility of electrical regeneration of laser consumables to reduce chemical laser logistics tail.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT **4866**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U) $4,252 Develop and demonstrate high energy laser technologies for airborne tactical applications, including air-to-air and surface-to-air scenarios. Technologies being addressed include lasers for long-range detection of targets in clutter; high power, high brightness, multi-wavelength compact lasers; and advanced beam control techniques to minimize platform vibration, atmospheric jitter, and aero-optical effects. Collect aero-optical data from tactical aircraft to anchor computer models. Address thermal management issues and packaging/integration/test issues for tactical laser weapon applications on airborne platforms. Demonstrate improvements in semiconductor laser efficiency and operating temperatures for tactical systems and combat identification systems.

(U) $7,367 Develop scalable, high power solid state laser architectures for directed energy applications such as unmanned aerial vehicle designators/imagers and next generation weapon applications such as tactical airborne lasers. Demonstrate laboratory operation of a solid state laser with a power level of 10 kilowatts or more. Investigate system-level issues such as weight and volume.

(U) $552 Perform vulnerability assessments on potential high energy laser targets to provide critical design data for laser systems to defeat these targets. Develop models and tools for tactical aircraft self-protection using high power solid state lasers against surface-to-air missiles. Identify system constraints and performance in degraded situations, including battlefield conditions and weather.

(U) $2,770 Develop and evaluate beam control/compensation techniques for atmospheric attenuation and distortion on laser beam propagation from airborne platforms. These efforts enhance high energy laser delivery from future airborne laser weapon systems to missile targets. Evaluate the performance of various wavefront sensors to maximize the ability to correct for atmospheric disturbances through laboratory demonstration. Initiate demonstration and evaluation of the compensated beacon illumination technique. Anchor wave optics propagation code to the demonstrated beam control performance.

(U) $20,635 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0601108F, High Energy Laser Research Initiatives.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602890F, High Energy Laser Research.
(U) PE 0603444F, Maui Space Surveillance System.
(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT **4866**

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

(U) PE 0603605F, Advanced Weapons Technology.

(U) PE 0603924F, High Energy Laser Advanced Technology Program.

(U) PE 0603883C, Ballistic Missile Defense Boost Phase Segment.

(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 February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT **4867**

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4867 Advanced Weapons & Survivability Technology	14,717	15,770	14,724	15,385	15,670	17,956	17,250	17,273	Continuing	TBD

(U) A. Mission Description

This project explores high power microwave (HPM) and other unconventional weapon concepts using innovative technologies. Technologies are developed that support a wide range of Air Force missions such as the potential disruption and degradation of an adversary's electronic infrastructure and military capability. This effect can often be applied covertly with no collateral structural or human damage. Targeted capabilities include local computer and communication systems as well as large and small air defense and command and control systems. This project also provides for vulnerability assessments of representative U.S. strategic and tactical systems to HPM weapons, HPM weapon technology assessment for specific Air Force missions, and HPM weapon lethality assessments against foreign targets.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,136 Investigated and developed technologies for narrowband and wideband HPM components to support multiple Air Force applications such as the disruption of electronic systems and subsystems. Continued to improve the electrical efficiency of wideband HPM sources in order to achieve greater range, longer lifetime, and smaller packaging. Integrated pulsed power and HPM source to show capability for single shot technologies. Selected a repetitively pulsed gigawatt technology for HPM breadboard munitions and airborne electronic attack proof-of-concept. Continued development of component technologies – pulsed power, sources, and antennas – for repetitively pulsed airborne and munitions systems. Developed and patented cathode and anode components for repetitively pulsed HPM experiments. Designed high efficiency repetitively pulsed HPM source. Conducted laboratory test of frequency agile HPM source. Continued development of compact repetitively operated sources. Continued pulsed atmospheric breakdown experiments. Continued explosive generator development experiments to support compact single-shot HPM sources.

(U) $2,869 Developed and used the ability to assess effects/lethality of HPM weapon technologies against representative air and ground military systems. Continued to conduct susceptibility tests on representative command and control warfare targets. Conducted susceptibility tests of high repetitively pulsed effects on targets. Implemented effects data and results into narrowband and wideband HPM experiments and demonstrations. Continued validation of computer codes' ability to predict the wideband electromagnetic coupling to increasingly complex structures. Continued to expand range of predictability of HPM narrowband effects models to damage or disrupt military electronic targets of interest. Continued validation of predictability of models. Continued developing better HPM source modeling techniques to incorporate HPM technologies into warfighting/wargaming activities.

(U) $3,917 Investigated HPM technologies that support advanced airborne tactical applications made possible by the increased power available on future

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT 4867

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

aircraft. Began study to determine feasibility and cost of construction for a novel effects experiment test chamber while upgrading existing test facility. Continued development of high power microwave (HPM) effects database including modeling and simulation of HPM illumination verses target effects. Initiated study of enhanced source components of promising concepts identified by the trade off studies to include an HPM repetitively pulsed source on an aerial platform. Studied aircraft integration issues.

(U) $1,795 Further developed active denial technologies to support airborne agile combat support applications. Began engineering design of improved millimeter wave sources for airborne active denial. Enhanced in-house capabilities for airborne system development including source modeling using computer simulations and upgrading of research equipment.

(U) $14,717 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $7,031 Investigate and develop technologies for narrowband and wideband HPM components to support multiple Air Force applications such as the disruption of electronic systems and subsystems. Continue development of compact repetitively operated sources. Continue to improve the electrical efficiency of wideband HPM sources in order to achieve greater range, longer lifetime, and smaller packaging. Continue pulsed atmospheric breakdown experiments. Continue explosive generator development experiments to support compact single-shot HPM sources. Conduct a subscale (laboratory) repetitively pulsed gigawatt class experiment. Develop conformal phased array antenna for HPM systems. Select a repetitively pulsed multi-gigawatt technology for HPM breadboard munitions and airborne electronic attack proof-of-concept. Utilize nanotechnology components (nanotubes) to continue development of cathodes and anodes for repetitively pulsed HPM experiments. Develop target identification concept using wideband technology.

(U) $2,600 Develop and use the ability to assess effects/lethality of HPM directed energy weapon technologies against representative air and ground targets. Continue to conduct susceptibility tests of representative command and control warfare targets. Continue to conduct susceptibility tests to determine relative importance of source parameters in causing the desired effects on targets. Continue to implement effects data and results into narrowband and wideband HPM experiments and demonstrations. Refine codes for better prediction of probability of effect on experimental targets and to guide program direction. Continue development of better modeling techniques to incorporate HPM technologies into warfighting/wargaming activities. Continue validation of computer codes' ability to adequately predict the electromagnetic coupling to, and probability of effect on, experimental targets within complex structures. Support implementation of predictive models into existing engagement models.

(U) $760 Develop and apply theory of advanced computation to enhance the development of HPM and related technologies. Investigate numerical

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602605F DIRECTED ENERGY TECHNOLOGY	PROJECT 4867

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

dispersions and enhance plasma models and physics algorithms for high power microwave (HPM) technologies. Perform virtual prototyping for HPM component technologies.

(U) $4,503 Investigate HPM technologies that support advanced airborne tactical applications made possible by the increased power available on future aircraft. Continue studying enhanced source components of promise and begin modeling and simulation of a complete source. Determine effect of air breakdown on transmitted HPM pulse over time. Continue aircraft integration issue studies of interest to determine effectual lethality of each concept.

(U) $876 Further develop active denial technologies to support airborne agile combat support applications. Continue development of computational physics algorithms for next-generation airborne millimeter wave sources by modeling subscale pieces of existing active denial sources to verify validity of computational approach. Begin design of a ground-based megawatt-class airborne source demonstrator. This work will transfer to PE 0603605F in FY 2004 for a ground-based demonstration of airborne applicable technologies.

(U) $15,770 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,741 Investigate and develop technologies for narrowband and wideband HPM components to support multiple Air Force applications such as the disruption of electronic systems and subsystems. Continue development of compact repetitively operated sources. Continue pulsed atmospheric breakdown experiments. Integrate explosive generator development experiments with compact single-shot HPM sources. Continue development of conformal phased array antenna for HPM systems. Develop subscale (laboratory) repetitively pulsed multi-gigawatt technology for HPM breadboard munitions and airborne electronic attack proof-of-concept. Conduct laboratory test of nanotechnology developed cathodes and anodes for repetitively pulsed HPM experiments. Utilize nanotechnology and other technologies to reduce the HPM source weight. Conduct a subscale (laboratory) wideband technology target identification experiment.

(U) $758 Develop and apply theory of advanced computation to enhance the development of HPM and related technologies. Continue the investigation of plasma models and develop physics algorithms for HPM technologies. Develop improved algorithms for higher frequency wideband HPM modeling. Continue to perform virtual prototyping for HPM component technologies.

(U) $2,810 Develop and use the ability to assess the effects/lethality of HPM directed energy weapon technologies against representative air and ground systems. Conduct susceptibility tests to determine relative importance of source parameters in causing the desired effects on targets. Implement effects data and results into narrowband and wideband HPM experiments and demonstrations. Refine HPM codes to predict probability of effect on target equipment and to guide experiment direction. Develop better modeling techniques to incorporate HPM technologies into

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602605F DIRECTED ENERGY TECHNOLOGY**	PROJECT **4867**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

warfighting/wargaming activities. Continue validation of computer codes' ability to adequately predict the electromagnetic coupling to, and probability of effect on, target equipment within complex structures.

(U) $4,415 Investigate high power microwave (HPM) technologies that support offensive advanced airborne tactical applications made possible by the increased power available on future aircraft. Continue studying enhanced source components of promise especially plastic-laminate pulse forming lines with integrated Marx pulser. Continue modeling and simulation of the complete source. Complete determination of effect of air breakdown on transmitted HPM pulse over time. Finish initial aircraft integration report on source effects on the aircraft and command and control between the HPM source and the aircraft.

(U) $14,724 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602202F, Human Systems Technology.

(U) PE 0603605F, Advanced Weapons 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.

THIS PAGE INTENTIONALLY LEFT BLANK

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602702F Command Control and Communications**

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	63,572	78,204	71,674	82,764	86,338	94,434	92,679	94,359	Continuing	TBD
4519	Communications Technology	15,605	15,380	15,473	17,062	17,508	17,980	18,502	19,031	Continuing	TBD
4594	Information Technology	16,750	24,286	24,845	25,441	26,116	28,793	29,173	29,036	Continuing	TBD
4917	Collaborative Information Tech	8,916	12,620	5,412	5,619	5,728	5,846	6,018	6,191	Continuing	TBD
5581	Command and Control (C2) Technology	22,301	25,918	25,944	34,642	36,986	41,815	38,986	40,101	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2002, portions of efforts in Projects 4519, 4594, and 5581 moved into Project 4917 within this PE.

(U) A. Mission Description

This program develops the technology base for Air Force Command, Control, and Communications (C3). Advances in C3 are required to increase warfighter readiness by providing the right information, at the right time, anywhere in the world. The program has four projects. The Communication Technology project develops assured and secure communications technology. The Information Technology project develops improved and automated capabilities to generate, process, fuse, exploit, interpret, and disseminate timely and accurate information. The Collaborative Information Technology project develops high payoff emerging technologies for the next generation of distributed, collaborative command and control systems. The Command and Control Technology project investigates and develops planning, assessment, and knowledge base technologies to allow the warfighter to plan, assess, execute, monitor, and re-plan on the compressed time scales required for tomorrow's conflicts. Note: In FY 2003, Congress added $3.5 million for Agile Research and Development/Science and Technology Center of Excellence; $1.5 million for Information Protection and Authentication; $3.5 million for Secure Knowledge Management; and $3.0 million for Information Management for Crisis Response.

(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 technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602702F Command Control and Communications**

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	66,561	70,951	80,767	
(U)	Appropriated Value	66,659	82,451		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-98	-4,182		
	b. Small Business Innovative Research	-731			
	c. Omnibus or Other Above Threshold Reprogram		-65		
	d. Below Threshold Reprogram	-1,947			
	e. Rescissions	-311			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-9,093	
(U)	Current Budget Submit/FY 2004 PBR	63,572	78,204	71,674	TBD

(U) Significant Program Changes:

The decrease in FY04 from the previous President's Budget is due to higher Air Force priorities.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602702F Command Control and Communications	4519

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4519 Communications Technology	15,605	15,380	15,473	17,062	17,508	17,980	18,502	19,031	Continuing	TBD

Note: In FY 2002, a portion of the effort accomplished in Project 4519 moved into Project 4917.

(U) A. Mission Description

The Air Force requires technologies that enable assured, worldwide communications for an agile Expeditionary Aerospace Force (EAF). These communication technologies will provide en route and deployed reachback communications for distributed collaborative command and control (C2). A rapidly deployed EAF requires assured connectivity with reliable, responsive, affordable information exchange via all available communications media. This project provides the technologies for: multi-level, secure, seamless networks; advanced communications processors; anti-jam and low probability of intercept techniques; lightweight, phased array antennas; and modular, programmable, low-cost software radios. It includes technologies for advanced processors and devices, advanced network protocols and services, intelligent communications management and control, advanced communications algorithms, and enabling communication signal processing techniques.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/ Planned Program

(U) $7,442 Developed assured and survivable information and networking technologies that enable the capability for worldwide command, control, and communication operations for an EAF. Continued to develop technologies to improve quality of service for globally distributed information systems. Continued to develop assured networking and information systems technologies to improve survivability to critical infrastructure attacks. Completed development of technologies for assured wireless networking algorithms. Developed assured communication technology that will focus on techniques for tactical wireless networking, wireless information assurance, and the management of these capabilities within the global information enterprise.

(U) $3,297 Developed critical assured communications and signal processing technologies to provide adaptive, covert, anti-jam, and assured global battlespace connectivity to aerospace forces and to greatly reduce equipment footprint. Investigated and developed techniques to improve information assurance capabilities for mobile wireless networks that would preclude information attacks aimed at denial of service and quality of service degradation. Continued to develop mobile communication technologies for wide-band data and video services to beyond-line-of-sight airborne C2, and sensor platforms.

(U) $4,866 Developed Defensive Information Warfare tools and technologies to ensure information protection and security of sensitive and encrypted Air Force communications and information systems. Continued to develop automated capability for damage assessment and recovery of information systems. Developed computer and network forensics tools. Developed data mining tools for coordinated information warfare attack assessment. Investigated techniques to perform analysis on detection and eradication of malicious software.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602702F Command Control and Communications	PROJECT 4519

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued
(U) $15,605 Total

(U) FY 2003 ($ in Thousands)
(U) $0 Accomplishments/ Planned Program
(U) $5,664 Develop assured and survivable information and networking technologies that will enable worldwide command, control, and communications (C3) operations for the Global Strike Task Force. Continue to develop technologies to improve quality of service for globally distributed information systems. Complete development of assured networking and information systems technologies that will improve survivability against critical infrastructure attacks. Initiate development of securely managed enterprise network technology to develop assured network services across multiple network security domains. Initiate development of programmable networking algorithms that enable the dynamic creation of advanced information delivery services, independent of the underlying physical infrastructure devices.
(U) $4,458 Develop critical assured communications and signal processing technologies to provide adaptive, covert, anti-jam, and assured global battlespace connectivity to aerospace forces and to greatly reduce equipment footprint. Continue to develop techniques to improve information assurance capabilities for mobile wireless networks by precluding information attacks aimed at denial of service and quality of service degradation. Develop assured communication technologies that will enable a full spectrum of information superiority capabilities in wireless networks in a joint/coalition environment. Investigate high performance wireless device and waveform technologies for improving affordability of critical Air Force command and control networks.
(U) $5,258 Develop Defensive Information Warfare tools and technologies to ensure information protection and security of sensitive and encrypted Air Force communication and information systems. Continue to develop automated capabilities for damage assessment and recovery techniques. Continue to develop computer and network forensics tools and data mining tools to assess coordinated information warfare (IW) attacks. Continue to develop detection and eradication techniques for malicious software. Initiate investigations in active response technologies, detection of hidden data, and early assessment of complex IW attacks.
(U) $15,380 Total

(U) FY 2004 ($ in Thousands)
(U) $0 Accomplishments/ Planned Program
(U) $5,631 Develop assured and survivable information and networking technologies enabling worldwide C3 operations for the Air Force Task Forces. Continue to develop technologies to improve quality of service for globally distributed information systems (e.g., Joint Battlespace Infosphere). Continue development of assured networking and information systems technologies that will improve survivability against critical infrastructure attacks. Continue development of securely managed enterprise network technology to develop assured network services across multiple network

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602702F Command Control and Communications	PROJECT 4519

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

security domains and coalitions. Continue development of programmable networking algorithms that enable wide area dynamic creation of advanced information delivery services that are independent of the underlying physical infrastructure devices.

(U) $4,465 Develop improved, higher bandwidth communications and signal processing technologies to provide secure, adaptive, covert, anti-jam, and assured global battlespace connectivity to highly mobile aerospace forces while reducing the equipment footprint. Continue development of information assurance technologies that will improve the robustness of the Global Information Grid in both wired and wireless networks for ground, air, and joint/coalition environments to preclude information systems attacks, such as denial of service and degradation of device quality. Continue to develop high performance, adaptable, and re-configurable wireless devices to implement new waveform technologies for improved robustness, security, and affordability of critical Air Force command and control networks. Initiate development of higher performance video compression and modulation techniques that enable critical objectives for high bandwidth information transmission and exploitation capabilities over wireless channels.

(U) $5,377 Develop information assurance technologies for enabling worldwide command, control, communications, and intelligence (C4I). Continue to develop automated capabilities for damage assessment and recovery techniques. Continue development of network forensics and data mining tools for detecting adversary information warfare attacks and to provide early warning notification. Continue to develop detection and eradication techniques for malicious code. Continue development of active response technologies and detection of hidden data. Initiate the development of new tools and techniques to protect C4I and information systems, and allow for integration of coalition information elements. Initiate investigation of effects-based information operations.

(U) $15,473 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0603789F, C3I Advanced Development.

(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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602702F Command Control and Communications**	PROJECT **4519**

(U) E. Schedule Profile Continued

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602702F Command Control and Communications	4594

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4594 Information Technology	16,750	24,286	24,845	25,441	26,116	28,793	29,173	29,036	Continuing	TBD

Note: In FY 2002, a portion of the effort accomplished in Project 4594 moved into Project 4917.

(U) A. Mission Description

The Air Force requires technologies that improve and automate their capability to generate, process, manage, fuse, exploit, interpret, and disseminate timely and accurate information. This project improves global awareness at all levels, enabling warfighters to understand relevant military situations on a consistent basis, with the timeliness and precision needed to accomplish their missions. Global awareness is achieved by exploiting information provided by the Air Force and other government agencies. The information is fused to support the dynamic planning and execution cycle via the global information enterprise. Knowledge, information, and data are all archived in the global information base for continued use and historical analysis. The information technologies required to achieve this capability are developed under this project in an affordable manner and include appropriate access mechanisms for our coalition partners.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/ Planned Program

(U) $3,969 Developed information exploitation technologies for imagery and electronic signals to increase global awareness. Developed advanced multi-sensor open systems techniques and tools for production of imagery (including hyperspectral), electronic signals, and speech intelligence products to achieve situational awareness. Developed advanced information dissemination techniques for seamless integration into global information databases.

(U) $4,042 Developed and evaluated innovative multi-sensor collaborative fusion technologies in a fully distributed aerospace environment. Developed techniques to quantitatively evaluate fusion algorithms. Developed and evaluated fusion technologies for multi-platform cross-cueing of sensors for the location and identification of military targets, addressing surface, airborne, and spaceborne systems in a fully distributed environment.

(U) $4,375 Developed global information base technologies to achieve situational awareness at all command levels for the dynamic planning and execution process. Investigated information extraction techniques to automatically populate very large knowledge base systems. Developed approaches for synthesizing a common data representation from multiple sources for improved situational awareness. Investigated methods of content-based retrieval techniques for improved sensor data exploitation and faster data base access.

(U) $1,945 Developed affordable, scalable, teraflop processing technologies for real-time information fusion and exploitation. Developed processor-in-memory, content-addressable architecture for rapid extraction of information from globally distributed knowledge bases. Developed architectures to support real-time requirements for dominant battlespace awareness.

(U) $1,114 Developed modeling and simulation technologies to support next generation planning, execution, and assessment environments. Evaluated,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602702F Command Control and Communications	PROJECT 4594

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

exploited, and developed model abstraction and multi-resolution modeling techniques to reduce the complexity of existing high-resolution models and simulations, supporting the National Air and Space Model.

(U) $1,305 Developed information hiding, steganography, and digital watermarking techniques to protect and authenticate data within Air Force and DoD information systems. Developed and evaluated steganography detecting and decoding techniques for data embedding, tamper detection and proofing, image and video content authentication, and secure information dissemination.

(U) $16,750 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/ Planned Program

(U) $6,078 Develop information exploitation technologies for imagery and electronic signals to increase global awareness. Continue to develop advanced multi-sensor open systems techniques and automated analyst tools for exploiting hyperspectral imagery, on-board video processing, new electronic signals, and speech intelligence products to achieve improved situational awareness.

(U) $5,838 Develop and evaluate innovative multi-sensor collaborative fusion technologies in a fully distributed aerospace environment. Continue to develop techniques to quantitatively evaluate fusion algorithms. Develop multi-source fusion techniques for continuous tracking of militarily significant vehicles in the battlespace. Develop and evaluate fusion technologies for enemy threat prediction based on multi-source fusion.

(U) $4,862 Develop global information base technologies to achieve situational awareness at all command levels for the dynamic planning and execution process. Develop intermediate information extraction techniques that will reduce data overload and increase time allocated to analysis and decision-making, that will enable the ability to populate knowledge base systems. Continue to develop techniques for a self-organizing, data repository, and content-based extraction. Develop advanced web-based search techniques and information aggregation methods required for rapid situational understanding.

(U) $3,043 Develop affordable, scalable, petaflop processing technologies for real-time information fusion and exploitation. Complete the processor-in-memory, content-addressable architecture for rapid extraction of information from globally distributed knowledge bases. Evaluate architecture to support real-time requirements for dominant battlespace awareness.

(U) $3,066 Develop modeling and simulation technologies to support next generation planning, execution, and assessment environments. Continue to evaluate, exploit, and develop model abstraction and multi-resolution modeling techniques to reduce the complexity of existing high-resolution models and simulations for next generation distributed collaborative decision support environments such as the Joint Synthetic Battlespace.

(U) $1,399 Continue development of information hiding, steganography, and digital watermarking to protect and authenticate data within Air Force and DoD information systems. Continue development and evaluation of steganographic detection, decoding, and countermeasure techniques for data

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602702F Command Control and Communications**	PROJECT **4594**

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

embedding, tamper detection and proofing, image and video content authentication, and secure information dissemination.

(U) $24,286 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/ Planned Program

(U) $7,003 Develop information exploitation technologies for imagery and electronic signals to increase the information value to the decision maker. Continue development of advanced multi-sensor open systems techniques and automated analyst tools for exploiting measurement and signature intelligence, hyperspectral imagery, on-board video processing, new electronic signals, moving target indicator, and speech intelligence products for improved situational awareness, indication and warning, and reporting capabilities. Research techniques in steganography, steganalysis, and watermarking of imagery, video and speech for information protection and authentication, intelligence exploitation, and analysis tool aids.

(U) $6,694 Develop innovative multi-sensor collaborative fusion technologies in a fully distributed air and space environment. Continue to develop techniques to quantitatively evaluate fusion algorithms that support the analysis of a new emerging information era. Continue development of optimized multi-source fusion techniques for continuous tracking of militarily significant vehicles in the battlespace. Continue development and evaluation of fusion technologies for enemy threat prediction through the use of multi-source fusion.

(U) $5,578 Develop higher-level fusion technologies to achieve situational awareness at all command levels for the dynamic planning and execution process. Continue development of intermediate information extraction techniques to reduce data overload and increase time allocated to analysis and decision-making, enabling the ability to populate knowledge base systems. Continue development of data mining techniques for a self-organizing data repository and content-based extraction to support prediction of potential events in the world. Continue development of advanced web-based search techniques, data filtering techniques, and information aggregation methods required for rapid situational understanding.

(U) $3,637 Develop automatic and dynamically reconfigurable, affordable, scalable, distributed petaflop processing technologies that adapt/reallocate resources to changes in environment and application requirements, for real-time command and control (C2) global information systems. Develop and demonstrate architectures for rapid extraction of information from globally distributed knowledge bases. Continue evaluation of architectures to support real-time requirements for dominant battlespace awareness. Initiate study of next generation information technologies (e.g., quantum computing and bio-molecular computing) for C2 systems.

(U) $1,933 Develop modeling and simulation technologies for the next generation of planning, execution, and assessment environments. Complete model abstraction and multi-resolution modeling techniques to reduce the complexity of existing high-resolution models and simulations for next generation distributed collaborative decision support environments. Initiate development of decision support technologies, and their theoretical

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602702F Command Control and Communications**	PROJECT **4594**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

foundation, to support high-profile system concepts such as the Joint Synthetic Battlespace and the Global Strike Task Force.

(U) $24,845 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0603789F, C3I Advanced Development.

(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 February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602702F Command Control and Communications	PROJECT 4917

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4917 Collaborative Information Tech	8,916	12,620	5,412	5,619	5,728	5,846	6,018	6,191	Continuing	TBD

Note: In FY 2002, a portion of efforts in Projects 4519, 4594, and 5581 moved into this project.

(U) A. Mission Description

To implement the Global Strike Task Force and other task force concepts, the Air Force requires a distributed, collaborative command and control (C2) system, allowing the majority of the C2 center to remain in the continential United States, while only a small command element is deployed forward. This project accomplishes the initial exploration of high payoff emerging technologies for the next generation of distributed collaborative C2 systems. This program develops technologies for platform connectivity, distributed collaboration, and embedded information systems. Platform connectivity technologies focus on advanced modulation waveforms for bandwidth efficiency, assured aerospace platform connectivity for C2, and conceptual design approaches for seamless integration of aerospace weapon systems into the information grid. Distributed collaboration technologies advance collaboration science, virtual environments, and predictive simulation tools to facilitate the development and fielding of next generation operational collaborative decision support systems. Embedded information systems technologies explore high payoff technologies for the next generation of distributed information integration architectures, which will provide cross disciplinary products/capability to a decision maker when, where, and how it is needed. It also provides embedded information system technologies for affordable and adaptable design and development of complex C2 systems, facilitated by an open system architecture approach.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/ Planned Program

(U) $1,238 Developed critical information transmission technologies to permit the seamless integration of aerospace weapon systems C2, intelligence, surveillance, and reconnaissance data/information. Continued to develop assured, secure communications technology, leveraging the commercial infrastructure, for positive C2 of aerospace assets in civilian airspace. Continued to develop secure, wide-band wireless information transfer technology for assured communications by multiple weapon systems.

(U) $2,235 Developed advanced information technologies for collaborative decision support, knowledge management, and rapid adaptation/re-allocation of assets in response to the continually changing threat environment. Developed technologies to support distributed decision making and collaborative planning for Expeditionary Aerospace Forces in a battlespace information environment. Developed technology to support a sensor-to-shooter scenario stressing the time-critical target requirement, resulting in denying the enemy the sanctuary of time.

(U) $1,667 Developed processes, methods, and techniques to provide assured performance, integrity, and security of real-time embedded information systems. Developed dynamically reconfigurable aerospace systems using adaptive computing techniques. Continued to develop concepts, designs, and models for the next generation C2 global information systems, which will allow affordable design and development of highly

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602702F Command Control and Communications	PROJECT 4917

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

complex aerospace systems, and autonomous unmanned airborne/spaceborne platforms for deployment against time-critical targets.

(U) $3,776 Developed and assessed Simulation-Based Acquisition (SBA) technologies for application to integrated aerospace systems design and analysis. Conducted experiments using challenge problems to define the boundaries of SBA capabilities. Developed an enhanced collaborative technology architecture that supports the tenants of SBA.

(U) $8,916 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/ Planned Program

(U) $1,372 Develop critical information transmission technologies to permit the seamless integration of aerospace weapon systems' command and control (C2), intelligence, surveillance, and reconnaissance data/information. Complete the development of assured secure communications technology, leveraging the commercial infrastructure, for positive C2 of aerospace assets in civilian airspace. Continue the development of secure, wide-band wireless information transfer technology for assured communications between munitions and aircraft.

(U) $5,865 Develop advanced information technologies for collaborative decision support, knowledge management, and rapid adaptation/re-allocation of assets in response to the continually changing threat environment. Investigate techniques to perform the collaborative planning for the Global Strike Task Force. Continue development of distributed decision making technology for joint battlespace information environment. Continue to develop technology to support a sensor-to-shooter scenario stressing the time-critical target requirement, which will result in denying the enemy the sanctuary of time.

(U) $1,922 Develop processes, methods, and techniques to provide assured performance, integrity, and security of real-time embedded information systems. Continue to develop dynamically reconfigurable aerospace systems using adaptive computing techniques. Continue to develop concepts, designs, and models for the next generation C2 global information systems, which will allow affordable design and development of highly complex aerospace systems. Develop methods and processes for determining the suitability of Java and Real-Time Java to support open system architectures for real-time, embedded information systems.

(U) $3,461 Continue to develop SBA technologies for application to integrated aerospace systems design and analysis. Continue development of an enhanced collaborative technology architecture supporting the tenets of SBA. Demonstrate the enhanced architecture in an experiment for collaborative spiral requirements and capability based planning.

(U) $12,620 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602702F Command Control and Communications	PROJECT 4917

(U) A. Mission Description Continued

(U)	FY 2004 ($ in Thousands)	
(U)	$0	Accomplishments/ Planned Program
(U)	$2,006	Develop critical information transmission technologies to permit the seamless integration of aerospace weapon systems command, control (C2), intelligence, surveillance and reconnaissance data/information. Continue the development of assured communications technology, leveraging commercial infrastructure, for positive C2 of aerospace assets in commercial airspace. Continue the development of secure, wide-band wireless miniaturized transceiver information transfer technology for assured communications between munitions and aircraft.
(U)	$2,006	Develop advanced information technologies for collaborative decision support, knowledge management, and rapid adaptation/re-allocation of assets in response to the continually changing threat environment. Develop techniques to assist in performing the collaborative planning for the Global Strike Task Force. Initiate development of distributed collaborative environment technology for effects-based operations and predictive battlespace awareness. Continue to develop technology to support a sensor-to-shooter scenario stressing time-critical target requirement, which will deny the enemy sanctuary of time.
(U)	$1,400	Develop processes, methods, and techniques to provide assured performance, integrity, and security of real-time embedded information systems. Continue to develop dynamically reconfigurable aerospace systems using adaptive computing techniques. Define and develop algorithms, methods, and processes to support real-time, adaptive resource management of system resources across multiple tactical platforms.
(U)	$5,412	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0603789F, C3I Advanced Development.

(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 February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602702F Command Control and Communications	5581

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5581 Command and Control (C2) Technology	22,301	25,918	25,944	34,642	36,986	41,815	38,986	40,101	Continuing	TBD

Note: In FY 2002, a portion of the effort accomplished in Project 5581 moved into Project 4917.

(U) **A. Mission Description**

The Air Force requires command and control (C2) technologies, that will provide the next generation of weapon systems with improved processing and presentation of information for real-time, distributed battle management. Technologies being developed in this project will increase capability and quality, while reducing the cost of C2 systems and infrastructure. Technology development in this project focuses on planning and assessing techniques, knowledge bases, distributed information systems, and information management and distribution services. Advances in planning and assessment technologies will vastly improve the military decision making process within C2 systems. Advances in the ability to detect, classify, identify, and track objects and events will improve the understanding and prediction of enemy intentions, allowing the development of various courses of action to counter their intentions. Advances in the development of very large comprehensive knowledge bases to rapidly formulate and create new knowledge are needed by the Expeditionary Aerospace Force. Advances in distributed intelligent information systems will allow automatic rapid reconfiguration of C2 centers to respond to varying crisis levels, as required, by the Expeditionary Aerospace Force. Advances in robust information management and distribution technologies will ensure the delivery of high quality, timely, secure information to the warfighter.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/ Planned Program

(U) $6,911 Developed the next generation of planning and assessment technologies and tools enabling aerospace commanders to determine and create the desired operational effects at the right place at the right time. Continued to develop technologies to dynamically assess the battlespace, determine measures to create the desired effects, and provide near-real-time command of forces to execute those measures. Developed tools to visualize the probability of success of qualitatively different courses of action. Continued to develop technologies to provide alternative courses of action and feasibility assessment in uncertain environments. Investigated intelligent agent technologies capable of supporting C2 systems for various missions, from humanitarian relief to major theater warfare. Developed techniques to enable the rapid insertion of new forces and their C2 information management systems into a battlespace infosphere.

(U) $5,828 Investigated and developed technologies for the rapid development and application of next generation knowledge bases for aerospace C2 systems. Developed tools that allow users to enter, validate, and manipulate knowledge using natural language, sketching, and templating approaches. Developed knowledge representation techniques to enable the structured common representation required for a battlespace infosphere. Developed capabilities that learn to extract, correlate, and classify link patterns. Investigated enhanced reasoning techniques and algorithms for more complex inferencing and performance.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602702F Command Control and Communications	PROJECT 5581

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U)	$9,562	Investigated, analyzed, and developed technologies for automatic rapid reconfiguration of distributed intelligent information systems to varying crisis levels faced by Expeditionary Aerospace Forces. Developed dynamic and adaptable interface technologies that allow commanders to create a mission-tailored view of the configuration and status of the currently executing Air Operations Center command and control (C2) process. Developed advanced interactive displays suitable for deployment with C2 applications and command centers. Developed techniques and applications for information visualization for use in conjunction with multiple, heterogeneous data sets. Developed techniques for integrating legacy client-server C2 systems into the next generation of agile, web-enabled information management environments. Investigated approaches to enable C2 systems to smoothly scale to over 1,000 clients exchanging information using a publish-subscribe paradigm as required for a battlespace infosphere.
(U)	$22,301	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/ Planned Program
(U)	$6,845	Develop the next generation of planning and assessment technologies and tools enabling aerospace commanders to determine and create the desired operational effects at the right place and at the right time. Continue to develop technologies to dynamically assess the battlespace, determine measures to create the desired effects, and provide near-real-time command of forces to execute those measures. Continue to develop tools to visualize the probability of success of qualitatively different courses of action. Continue to develop intelligent agent technologies capable of supporting joint/coalition C2 systems for various missions. Develop and assess active template technologies for use in dynamic mobile C2 applications. Develop tools to increase situational awareness through intelligent information push and pull in dynamic environments.
(U)	$5,167	Investigate and develop technologies for the rapid development and application of next generation knowledge bases for aerospace C2 systems. Continue to develop tools that will automate intelligent extraction, correlation, and classification of link patterns for discovering relevant linkages between entities. Develop enhanced reasoning techniques for complex inferencing and performance of C2 systems.
(U)	$7,369	Investigate, analyze, and develop technologies for automatic rapid reconfiguration of distributed intelligent information systems to varying crisis levels faced by Expeditionary Aerospace Forces. Continue to develop a dynamic and adaptable interface technology that allows commanders to create a mission-tailored view of the configuration and status of the currently executing Air Operation Center C2 process. Continue to develop advanced interactive displays suitable for deployment with C2 applications and command centers. Continue to develop techniques and applications for information visualization for use in conjunction with multiple, heterogeneous data sets.
(U)	$6,537	Investigate and develop technologies to implement flexible, secure, and survivable information management and distribution services to enable a Joint Battlespace Infosphere. Continue to develop techniques for integrating legacy client-server C2 systems into the next generation of agile,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003	
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602702F Command Control and Communications	PROJECT 5581

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

web-enabled information management environments. Continue to investigate approaches to enable a Joint Battlespace Infosphere to service thousands of participating command and control (C2) and intelligence, surveillance, and reconnaissance clients exchanging millions of information objects. Investigate and develop technologies that will ensure availability, integrity, and survivability of information within a JBI.

(U) $25,918 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/ Planned Program

(U) $9,170 Develop the next generation of monitoring, planning, execution, and assessment technologies and tools enabling aerospace commanders to efficiently and collaboratively develop effects-based campaigns. Continue to develop technologies to dynamically and rapidly assess the battlespace, and provide near-real-time command of manned and unmanned forces to execute the required missions. Investigate developments in decision support science for incorporation into C2 tools. Continue to develop tools to visualize the probability of success of qualitatively different courses of action. Continue to develop intelligent information systems capable of supporting joint/coalition C2 for various missions. Develop and assess active template and semantic ontology technologies for use in mobile C2 applications. Continue to develop tools to increase situational awareness through intelligent information push and pull in dynamic environments.

(U) $6,632 Investigate and develop technologies for the rapid development and application of next generation knowledge bases for aerospace C2 systems. Continue to develop tools that will automate the intelligent extraction, correlation, and classification of link patterns for discovering relevant linkages between entities. Investigate and develop ultra-large, all-source information repositories and associated privacy protection technologies. Complete development of enhanced reasoning techniques for complex inferencing and performance of C2 systems.

(U) $7,448 Investigate, analyze, and develop technologies for automatic rapid reconfiguration of distributed intelligent information systems to respond to varying crisis levels faced by Expeditionary Aerospace Forces. Continue to develop a dynamic and adaptable interface technology that allows commanders to create a mission-tailored view of the configuration and status of the currently executing Air Operation Center C2 process. Continue to develop advanced interactive displays suitable for deployment with C2 applications and command centers. Complete the development of techniques and applications for visualization of multiple, heterogeneous data sets. Develop technologies to improve the fidelity, accuracy, and interconnection of computer-based wargames used to prepare contingency plans and response strategies.

(U) $2,694 Investigate and develop technologies to implement flexible, secure, and survivable information management and distribution services to enable a JBI. Continue to develop techniques and tools for integrating legacy client-server C2 systems into a publish, subscribe, and query infosphere.

(U) $25,944 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602702F Command Control and Communications**	PROJECT **5581**

(U) B. Project Change Summary
Not Applicable.

(U) C. Other Program Funding Summary ($ in Thousands)
(U) Related Activities:
(U) PE 0603617F, C3 Applications.
(U) PE 0303401F, Communications-Computer Systems (C-CS) Security RDT&E.
(U) PE 0603789F, C3I Advanced Development.
(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.

THIS PAGE INTENTIONALLY LEFT BLANK

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602805F Dual Use Science & Technology	4770

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4770	Dual Use Science and Technology (S&T)	9,945	10,395	10,586	8,864	8,969	11,158	11,319	11,471	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

(U) A. Mission Description

This program seeks to leverage industry investments with interests in advanced technologies of mutual advantage to the Air Force and the commercial sector. A key objective of this program is for the Air Force to stimulate the development of dual use technologies so as to provide greater access to commercially developed technologies and to promote more affordable defense systems that maintain battlefield superiority. A critical component of the program is the cost-sharing requirement from industry and the Air Force. The cooperative funding assures joint commitment to the transition and dual use development efforts of successful demonstrated technologies. Specific projects are determined through annual competitive solicitation(s). Technology areas considered include advanced materials and manufacturing; sensors; advanced propulsion, power, and fuel efficiency; information and communications technologies; and weapon systems sustainment.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,579 Developed information technologies to help ensure the collection, dissemination, security, accuracy, and presentation of information to U.S. military decision-makers and corresponding commercial industry sectors. Technology areas considered included the gathering of pertinent information; providing for the fusion, accuracy, security, and transmission of information; and presenting the information in a consistent and easily understood manner to a decision maker.

(U) $2,039 Initiated development of innovative techniques and processes for non-destructive inspection, evaluation, and maintenance of Air Force and commercial aircraft assets. These techniques and processes are relevant to enable critical maintenance and repair decisions by depot and flight line maintenance personnel. The focus was on refinement and optimization of inspection, evaluation, and prediction techniques for maintenance and troubleshooting. Technology areas included inspection, evaluation, and maintenance of avionics, propulsion, structures, flight controls, and expendables such as fuels, lubricants, and hydraulic fluid; application of these new techniques to in-flight monitoring and early warning indicators; and automated and/or autonomous operation of inspection and evaluation techniques.

(U) $1,952 Continued to develop affordable, robust manufacturing processing and fabrication techniques for metals and special materials critical to defense weapon system applications. The technology also supported commercial applications with the potential to significantly impact the cost and performance of future aircraft, missiles, space systems, or other defense-related applications. Technology areas considered included more efficient and affordable manufacturing processes/components, part count reduction techniques, improved yields, improved process/dimensional

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602805F Dual Use Science & Technology**	PROJECT **4770**

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

control, reduced lead times, improved inspection techniques, and advanced prototyping techniques.

(U) $1,778 Sought to develop and demonstrate advanced power generation, power conditioning, energy conversion, energy storage, thermal management and power distribution component and system technologies for space applications. Military and commercial applications included satellites, energy storage, power distribution and conditioning, and thermal management systems. The focus was on enabling power generation improvements in efficiency, volume, mass, life, and reliability. The goal was to demonstrate significant improvements in size, weight, and reliability over state-of-the-art systems and/or enable new concepts.

(U) $1,597 Advanced development and demonstration of advanced power generation, power conditioning, energy conversion, energy storage, thermal management, and power distribution technologies for More Electric Aircraft military and civilian use. Applications included commercial aircraft, inhabited and uninhabited aircraft, and airborne directed energy weapons. Technologies of interest included aircraft power components and systems that demonstrated significant improvements in size, weight, and reliability over state-of-the-art systems and/or enable new concepts. The focus was on improvements in reliability, maintainability, commonality, and supportability. Technology areas considered included concepts to replace hydraulic, mechanical, and pneumatic power subsystems and their costly logistics support; compact high power generation and conditioning; and high rate energy storage.

(U) $9,945 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,079 Advance materials and manufacturing technologies that will reduce the life cycle cost while enhancing the capabilities of both Air Force, as well as commercial, air and space vehicles and launch systems. Technology areas of interest include: non-destructive/non-intrusive evaluation techniques; smart and adaptive skins; corrosion resistant coatings; micro- and nano-scale electronics; durable, lightweight materials for space launch; and agile materials for use in force protection.

(U) $2,079 Enable affordable advanced sensors technologies that have application to commercial and military air and space platforms. Technology areas of interest include: timely, high quality, precision imaging; sensitive, ambient environment electromagnetic (i.e., infrared) detection; and high-speed, precision temporal, spatial, and attitude sensors and controllers.

(U) $2,079 Develop advanced propulsion, power, and fuel efficiency technologies to improve the performance, increase the life, and reduce the cost of military and commercial air and space operations. Technology areas of interest include: performance and emissions of airbreathing and rocket propulsion systems; advanced gas turbine combustion and blades; electric propulsion alternatives; energy processing, storage, and conversion; lasers; and smart engine health monitoring techniques.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602805F Dual Use Science & Technology	PROJECT 4770

(U) A. Mission Description Continued

(U)	FY 2003 ($ in Thousands) Continued	
(U)	$2,079	Further advanced information and communication technologies to enhance the collection, processing, dissemination, security, accuracy, and presentation of information to U.S. and coalition military decision-makers and corresponding commercial industry sectors. Technology areas of interest include: collecting, synthesizing, and encoding pertinent information; securing the high-speed and reliable fusion, accuracy, security, and transmission of information; and presenting the appropriate information in an efficient, timely, consistent, and easily understood manner.
(U)	$2,079	Enhance weapon systems sustainment technologies that extend the life and improve the performance, efficiency, reliability, and maintainability of both Air Force and commercial air and space systems. Technology areas of interest include: avionics; materials fatigue and fracture; corrosion; cost-effective techniques for non-invasive, real-time monitoring of system health/performance; and associated environmental impacts.
(U)	$10,395	Total
(U)	FY 2004 ($ in Thousands)	
(U)	$0	Accomplishments/Planned Program
(U)	$1,762	Continue development of advanced information and communication technologies to enhance the collection, processing, dissemination, security, accuracy, and presentation capabilities of military and commercial information systems. Technology areas of interest include: collecting, synthesizing, and encoding pertinent information; securing high-speed and reliable fusion, accuracy, security, and transmission of information; and presenting relevant information in an efficient, timely, consistent, and easily understood manner.
(U)	$1,728	Further the design and development of affordable advanced sensors technologies aimed at enhancing the capabilities of military and commercial air and space platforms. Technology areas of interest include: real-time, high-resolution, precision imaging; sensitive, ambient environment electromagnetic (e.g., infrared) detection; and high-speed, precision temporal, spatial, and attitude sensors and controllers.
(U)	$2,708	Further develop advance materials and manufacturing technologies that will enhance the capability, performance, and durability of Air Force, as well as commercial, air and space systems while reducing the life cycle cost. Technology areas of interest include: smart and adaptive skins; corrosion resistant and genetically designed coatings; non-destructive/non-intrusive evaluation techniques; nano-scale electronics; specialized materials for space launch; and agile materials for use in force protection.
(U)	$2,659	Advance novel propulsion, power, and fuel efficiency technologies development to improve the capability, increase the life, and reduce the cost of military and commercial air and space operations. Technology areas of interest include: performance and emissions of airbreathing and rocket propulsion systems; advanced gas turbine combustion and blades; electric propulsion alternatives; energy processing, storage, and conversion; lasers; and smart engine health monitoring techniques.
(U)	$1,729	Prolong development of weapon systems sustainment technologies that enhance the performance capabilities, reliability, and maintainability while extending the life of both Air Force and commercial air and space systems. Technology areas of interest include: avionics; materials

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602805F Dual Use Science & Technology**	PROJECT **4770**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

fatigue and fracture; corrosion; cost-effective techniques for non-invasive, real-time monitoring of system health/performance; and associated environmental impacts.

(U) $10,586 Total

(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 technologies.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	10,316	10,626	10,820	
(U)	Appropriated Value	10,417	10,626		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-101	-112		
	b. Small Business Innovative Research	-322			
	c. Omnibus or Other Above Threshold Reprogram		-119		
	d. Below Threshold Reprogram				
	e. Rescissions	-49			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-234	
(U)	Current Budget Submit/FY 2004 PBR	9,945	10,395	10,586	TBD

(U) Significant Program Changes:

Not Applicable.

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

(U) Related Activities:

(U) PE 0601102F, Defense Research Sciences.

(U) PE 0602102F, Materials.

(U) PE 0602201F, Aerospace Flight Dynamics.

(U) PE 0602202F, Human Effectiveness.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602805F Dual Use Science & Technology	PROJECT 4770

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

(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0602602F, Conventional Munitions.
(U) PE 0602605F, Directed Energy Technology.
(U) PE 0602702F, Command Control and Communications.
(U) PE 0603112F, Advanced Materials for Weapon Systems.
(U) PE 0603203F, Advanced Aerospace Sensors.
(U) PE 0603211F, Aerospace Structures.
(U) PE 0603216F, Aerospace Propulsion and Power Technology.
(U) PE 0603231F, Crew Systems and Personnel Protection Technology.
(U) PE 0603270F, Electronic Combat Technology.
(U) PE 0603401F, Advanced Spacecraft Technology.
(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.
(U) PE 0603601F, Conventional Weapons Technology.
(U) PE 0603605F, Advanced Weapons Technology.
(U) PE 0603789F, C3I Advanced Development.
(U) This program has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) E. Acquisition Strategy

Not Applicable.

(U) F. Schedule Profile

(U) Not Applicable.

THIS PAGE INTENTIONALLY LEFT BLANK

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
02 - Applied Research	0602890F High Energy Laser Research	5096

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5096	High Energy Laser Research	0	0	41,854	45,452	48,448	51,805	52,167	52,971	0	0
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

Note: In FY 2004, this program was transferred to the Air Force by the Office of the Secretary of Defense. The Air Force plans to continue the tri-Service operation of the program under the High Energy Laser (HEL) Joint Technology Office (JTO).

(U) A. Mission Description

This program funds DOD HEL applied research aimed at translating fundamental scientific knowledge into proof-of-concept solutions relevant to HEL systems. HEL weapon systems have many potential advantages, including speed-of-light velocity, high precision, nearly unlimited magazine depth, low-cost per kill, and reduced logistics requirements since there is no need for stocks of munitions or warheads. As a result, HELs have the potential to perform a wide variety of military missions, including some that are impossible, or nearly so, for conventional weapons. These include interception of ballistic missiles in boost phase; defeat of high-speed, maneuvering anti-ship and anti-aircraft missiles; and the ultra-precision negation of targets in urban environments with no collateral damage. This program is part of an overall DOD initiative in HEL science and technology being conducted by the HEL JTO. In general, efforts funded under this program are chosen for their potential to have major impact on multiple HEL systems and on multiple Service missions. As a result of this focus and of close coordination with the Military Departments and Defense Agencies, this program complements other DOD HEL programs that are directed at more specific Service needs. A broad range of technology is addressed in key areas such as chemical lasers, solid state lasers, beam control, optics, propagation, and free electron lasers.

(U) FY 2002 ($ in Thousands)
(U) $0 This activity was performed under PE 0602890D8Z, High Energy Laser Research. Funding was $35.2 million.
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $0 This activity is performed under PE 0602890D8Z, High Energy Laser Research. Current funding is $45.9 million.
(U) $0 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602890F High Energy Laser Research	PROJECT 5096

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$17,000	Explore solid state lasers that have potential in future high energy laser (HEL) weapons because they require only electrical energy in order to run, thereby greatly simplifying systems engineering and supportability. A major focus for the HEL Joint Technology Office (JTO) will be the Joint High Power Solid State Laser (HPSSL) project. The objective of the Joint HPSSL project is to accelerate the demonstration of solid state lasers at initial weapon grade power levels. The power scaling will be 25 kilowatts in two years leading to a 100 kilowatt design.
(U)	$8,107	Develop beam-control technologies that are directly applicable to surface, air, and space mission areas. Results of these activities will be transitioned to near-term HEL systems and will also serve to enhance the HEL-related technology base and industrial capability. Beam control component technology will be developed to improve HEL system performance and to help protect and enhance the fragile manufacturing base in this critical area. Tactical beam control technology development efforts will seek to provide critical technology options for use in tactical scenarios on tactical platforms such as aircraft, ground vehicles, and maritime platforms, thus enabling the advantages of HELs to be applied in a wide variety of military operations.
(U)	$2,500	Develop chemical laser technologies concentrating on developing improved predictive and design capabilities and laser concepts that provide higher performance and better supportability. Despite the fact that chemical lasers are the most mature of the HEL laser device technologies, further technology development has the potential to greatly enhance their viability as weapon systems. Results of these activities will result in chemical lasers that are lighter and more affordable. Chemical laser research will include efforts to develop and demonstrate closed-cycle chemical lasers, especially chemical oxygen iodine laser-derived devices, appropriate for space-based and tactical applications. The anticipated payoffs are tactically-suited chemical lasers of high power that are supportable on the battlefield.
(U)	$3,300	Conduct mission and system analysis studies to examine potential military missions for which HELs present unique solutions because of their inherent characteristics (i.e., speed-of-light, possibility of graduated effects, precise target selectability, nearly unlimited magazine size, reduced logistics requirements, etc.) as compared to today's conventional weapons. Use the studies to focus the investment strategy for technology development.
(U)	$2,167	Development atmospheric characterization technologies and techniques aimed at making precise absorption measurements in interesting atmospheric windows, measuring and assimilating information on turbulence at locations relevant to tactical HEL systems, and developing and testing real-time characterization tools to assist the HEL operator. Characterization for tactical scenarios will concentrate on understanding atmospheric limitations in low-altitude tactical scenarios. The payoff will be increased lethal range in these optically stressing scenarios.
(U)	$3,780	Develop lethality technologies that concentrate on developing a strong scientifically-based understanding of laser kill mechanisms so that HEL systems can be optimized to produce the maximum kill probability for the minimum system size and cost. Develop a firm, physics-based understanding of the mechanisms involved in the interaction between HEL beams and the targets they strike. The expected payoffs from these

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602890F High Energy Laser Research**	PROJECT **5096**

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

		efforts are databases accepted by the high energy laser (HEL) community and validated models that are available to systems designers.
(U)	$3,700	Develop free electron laser (FEL) technologies to make the FELs more lethal, smaller, and lighter. Focus on technologies to scale to high power and technologies to permit FELs to be fielded on military platforms. The expected payoff is the demonstration of critical FEL technology.
(U)	$300	Develop advanced optics technologies that focus on large, lightweight deployable optics to reduce system weight while increasing laser intensity on target for space-based and other HEL systems. Advanced optics technology development will extend the state-of-the-art in lighter weight, nonconventional approaches to adaptive optics systems. The potential payoffs are large reductions in overall HEL system weight and significant improvement in the ability to correct for stressing atmospheric aberrations, particularly for space-related applications.
(U)	$1,000	Develop a fully realistic model of end-to-end HEL system performance, from birth of photons in the laser to their death at the target, thereby improving the design of HEL systems and reducing the need for expensive field testing. Continue development of a fully realistic model of end-to-end system performance, from birth of photons in the laser to their death at the target, thereby improving the design of HEL systems and reducing the need for expensive field testing.
(U)	$41,854	Total

(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 technologies.

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	0	0	0	
(U)	Appropriated Value				
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions				
	b. Small Business Innovative Research				
	c. Omnibus or Other Above Threshold Reprogram				
	d. Below Threshold Reprogram				
	e. Rescissions				
(U)	Adjustments to Budget Years Since FY 2003 PBR			41,854	
(U)	Current Budget Submit/FY 2004 PBR			41,854	

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
BUDGET ACTIVITY **02 - Applied Research**	PE NUMBER AND TITLE **0602890F High Energy Laser Research**	PROJECT **5096**

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

(U) Significant Program Changes:
In FY 2004, this program was transferred to the Air Force by the Office of the Secretary of Defense. The Air Force plans to continue the tri-Service operation of the program under the High Energy Laser (HEL) Joint Technology Office (JTO).

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

(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0601108F, High Energy Laser Research Initiatives.
(U) PE 0603444F, Maui Space Surveillance System.
(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.
(U) PE 0603605F, Advanced Weapons Technology.
(U) PE 0603924F, High Energy Laser Advanced Technology Program.
(U) PE 0603883C, Ballistic Missile Defense Boost Phase Segment.
(U) PE 0602605F, Directed Energy Technology.
(U) PE 0602307A, Advanced Weapons Technology.
(U) PE 0602114N, Power Projection Applied Research.
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) E. Acquisition Strategy
Not Applicable.

(U) F. Schedule Profile
(U) Not Applicable.