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<td>02 - Applied Research</td>
<td>0602500F MULTI-DISCIPLINARY SPACE TECH</td>
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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,
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).

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.

C. Program Change Summary ($ in Thousands)

<table>
<thead>
<tr>
<th>FY 2002</th>
<th>FY 2003</th>
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<th>Total Cost</th>
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<td>Adjustments to Appropriated Value</td>
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<td>Small Business Innovative Research</td>
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Page 2 of 29 Pages

Exhibit R-2 (PE 0602500F)
### C. Program Change Summary ($ in Thousands) Continued

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<thead>
<tr>
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<th>FY 2002</th>
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<th>FY 2004</th>
<th>Total Cost</th>
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<tr>
<td>d. Below Threshold Reprogram</td>
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<tr>
<td>e. Rescissions</td>
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**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.
<table>
<thead>
<tr>
<th>BUDGET ACTIVITY</th>
<th>PE NUMBER AND TITLE</th>
<th>PROJECT</th>
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<tr>
<td>02 - Applied Research</td>
<td>0602500F MULTI-DISCIPLINARY SPACE TECH</td>
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<tbody>
<tr>
<td>5023 Laser &amp; Imaging Space Tech</td>
<td>0</td>
<td>1,246</td>
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<td>5,423</td>
<td>4,718</td>
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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
### A. Mission Description Continued

**FY 2004 ($ in Thousands)**

- **$0** Accomplishments/Planned Program
- **$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.
- **$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.
- **$5,110** Total

### B. Project Change Summary

Not Applicable.

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

- Related Activities:
  - PE 0602605F, Directed Energy Technology.
  - PE 0603444F, Maui Space Surveillance Systems.
  - PE 0603605F, Advanced Weapons Technology.

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

### D. Acquisition Strategy

Not Applicable.

### E. Schedule Profile

Not Applicable.
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.

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.

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

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

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

B. Project Change Summary
Not Applicable.
C. Other Program Funding Summary ($ in Thousands)

Related Activities:
PE 0602202F, Human Effectiveness Applied Research.
This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

D. Acquisition Strategy
Not Applicable.

E. Schedule Profile
Not Applicable.
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 (IHPRT) 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.

FY 2002 ($ in Thousands)

0 Accomplishments/Planned Program
0 No Activity
0 Total

FY 2003 ($ in Thousands)

$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.

$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
A. Mission Description Continued

**FY 2003 ($ in Thousands) Continued**

- 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.

- 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.

**Total**

**FY 2004 ($ in Thousands)**

- 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 (IHRPPT) 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 IHRPPT 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 IHRPPT Phase III goals.

- 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 systems technologies such as rocket engine components and cryogenic structures/components.

- 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...
A. Mission Description 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.

$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.

$19,614 Total

B. Project Change Summary

Not Applicable.

C. Other Program Funding Summary ($ in Thousands)

Related Activities:
PE 0602102F, Materials.
PE 0603112F, Advanced Materials for Weapon Systems.
PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.
This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

D. Acquisition Strategy

Not Applicable.

E. Schedule Profile

Not Applicable.
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.

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.

FY 2002 ($ in Thousands)

$0 Accomplishments/Planned Program

FY 2003 ($ in Thousands)

$0 Accomplishments/Planned Program

$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.

$975 Develop advanced liquid engine combustion technology for improved performance while preserving chamber lifetime and reliability needs for
A. Mission Description Continued

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.

$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.

$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.

$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.

$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 life service of strategic systems and other solid rocket motors. Continue demonstration of advanced full-scale, flight-like PBCS.

$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.

$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
<table>
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<th>PE Number and Title</th>
<th>Project</th>
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<td>02 - Applied Research</td>
<td>0602500F MULTI-DISCIPLINARY SPACE TECH</td>
<td>5026</td>
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</tbody>
</table>

### A. Mission Description Continued

#### FY 2003 ($ in Thousands) Continued

1. 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. ($1,979)

2. Total ($23,143)

#### FY 2004 ($ in Thousands)

1. 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. ($5,680)

2. 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. ($4,954)

3. 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
**A. Mission Description Continued**

*FY 2004 ($ in Thousands) Continued*

- 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.
- 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.
- 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.
- 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.
- 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.

**B. Project Change Summary**

Not Applicable.

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

- Related Activities:
  - PE 0601102F, Defense Research Sciences.
  - PE 0602203F, Aerospace Propulsion.
  - PE 0602303A, Missile Technology.
C. Other Program Funding Summary ($ in Thousands)

- PE 0602805F, Dual Use Science and Technology.
- PE 0603216F, Aerospace Propulsion and Power Technology.

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

D. Acquisition Strategy

Not Applicable.

E. Schedule Profile

Not Applicable.
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.

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

FY 2003 ($ in Thousands)
- Accomplishments/Planned Program: $223
- Initiate development of flight demonstrator vehicle concepts. Conduct vehicle design trades for integration of hydrocarbon fueled scramjet engine. $223
- 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. $946
- 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. $288
- Initiate development of critical components for advanced airbreathing engines and CCEs for robust performance over extended Mach range. $2,689
- Initiate development of high performance/low internal drag devices. This provides robust scramjet components applicable to affordable, on-demand access to space vehicles. $4,146
- Total: $5,027

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.
A. Mission Description Continued

FY 2004 ($ in Thousands)

$0 Accomplishments/Planned Program

$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.

$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.

$4,588 Total

B. Project Change Summary

Not Applicable.

C. Other Program Funding Summary ($ in Thousands)

Related Activities:

PE 0601102F, Defense Research Sciences.
PE 0602201F, Aerospace Flight Dynamics.
PE 0602203F, Aerospace Propulsion.
PE 0602602F, Conventional Munitions.
PE 0602702E, Tactical Technology.
PE 0603111F, Aerospace Structures.
PE 0603216F, Aerospace Propulsion and Power Technology.
PE 0603601F, Conventional Weapons Technology.

Program is reported to/coordinated by the Joint Army/Navy/NASA/Air Force (JANNAF) Executive Committee.

This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.
### D. Acquisition Strategy
Not Applicable.

### E. Schedule Profile
(Not Applicable.)
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) $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...
### A. Mission Description Continued

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.
- $43,549 Total

### FY 2004 ($ in Thousands)

- $0 Accomplishments/Planned Program
- $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.
- $242 Test and evaluate efficient, high coefficient chip-scale optical waveguide technology for mixed signal component subsystems.
- $244 Apply the results of modeling, test, and evaluation for space-qualified photonic components and integrated electro-optical devices for space-based sensors.
- $618 Study and analyze adaptive processing techniques for large, multi-mission, space-based, adaptive conformal arrays.
- $1,690 Total

### B. Project Change Summary

Not Applicable.

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

- Related Funding:
  - PE 0602204F, Aerospace Sensors.
  - PE 0603203F, Advanced Aerospace Sensors.

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

### D. Acquisition Strategy

Not Applicable.

### E. Schedule Profile

Not Applicable.
### 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.

#### FY 2002 ($ in Thousands)

- **Accomplishments/Planned Program**: $0
- **No Activity**: $0
- **Total**: $0

#### FY 2003 ($ in Thousands)

- **Accomplishments/Planned Program**: $0
- **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.**
  - $1,709
- **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.**
  - $87
- **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.**
  - $514
- **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.**
  - $101
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<tr>
<th>U</th>
<th>A. Mission Description Continued</th>
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<tr>
<td>U</td>
<td>FY 2003 ($ in Thousands) Continued</td>
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<tr>
<td>U</td>
<td>$514 Refine materials and processes for two-dimensional and three-dimensional interconnects for space applications.</td>
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<td>U</td>
<td>$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.</td>
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<td>U</td>
<td>$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.</td>
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<td>U</td>
<td>$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.</td>
</tr>
<tr>
<td>U</td>
<td>$6,884 Total</td>
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<tr>
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<td>FY 2004 ($ in Thousands)</td>
</tr>
<tr>
<td>U</td>
<td>$0 Accomplishments/Planned Program</td>
</tr>
<tr>
<td>U</td>
<td>$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.</td>
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<td>U</td>
<td>$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.</td>
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<td>U</td>
<td>$540 Demonstrate a large area (&gt;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.</td>
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<td>U</td>
<td>$433 Demonstrate mixed signal receiver/processor multi-functionality on flexible RF membranes using advanced two-dimensional and three-dimensional interconnects.</td>
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<td>U</td>
<td>$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.</td>
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(U) **A. Mission Description Continued**

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<th>FY 2004 ($ in Thousands) Continued</th>
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<tbody>
<tr>
<td>$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.</td>
</tr>
<tr>
<td>$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.</td>
</tr>
</tbody>
</table>

(U) **B. Project Change Summary**

Not Applicable.

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

- Related Activities:
  - PE 0602204F, Aerospace Sensors.
  - PE 0603203F, Advanced Aerospace Sensors.

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

(U) **D. Acquisition Strategy**

Not Applicable.

(U) **E. Schedule Profile**

Not Applicable.
BUDGET ACTIVITY 02 - Applied Research

PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH

PROJECT 5030

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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.

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.

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

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

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

B. Project Change Summary
Not Applicable.
### C. Other Program Funding Summary ($ in Thousands)

- Related Funding:
  - PE 0602201F, Aerospace Flight Dynamics.
  - PE 0602204F, Aerospace Sensors.
  - PE 0603211F, Aerospace Technology Dev/Demo.

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

### D. Acquisition Strategy
Not Applicable.

### E. Schedule Profile
Not Applicable.
**A. Mission Description**

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.

**FY 2002 ($ in Thousands)**

(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

**FY 2003 ($ in Thousands)**

(U) $0 Accomplishments/Planned Program
(U) $0 No Activity
(U) $0 Total

**FY 2004 ($ in Thousands)**

(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.
### A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U) $1,065 Total

### B. Project Change Summary

Not Applicable.

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

- PE 0602204F, Aerospace Sensors.
- PE 0603203F, Advanced Aerospace Sensors.

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

### D. Acquisition Strategy

Not Applicable.

### E. Schedule Profile

Not Applicable.
### 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.

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Note: In FY 2004, in Project 5082, the Air Force increased emphasis on developing optical networks for space-based applications.
A. Mission Description Continued

FY 2004 ($ in Thousands) Continued

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.

B. Project Change Summary

Not Applicable.

C. Other Program Funding Summary ($ in Thousands)

PE 0602702F, Command, Control, and Communications.
PE 0603789F, C3I Advanced Development.

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

D. Acquisition Strategy

Not Applicable.

E. Schedule Profile

Not Applicable.