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

DATE: **February 1995**

BUDGET ACTIVITY: **3 - Advanced Development**

PE NUMBER AND TITLE: **0603401F Advanced Spacecraft Technology**

COST (*In Thousands*)	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	Cost to Complete	Total Cost
Total Program Element (PE) Cost	19,900	48,291	32,627	36,443	40,941	45,780	49,640	51,753	Continuing	Continuing
0003 Reusable Launch Vehicle Technology	0	29,223	0	0	0	0	0	0	0	29,223
1026 Space Structures and Controls Technology	0	600	1,200	1,200	2,000	2,800	3,600	4,354	Continuing	Continuing
2181 Space Electronics and Software Technology	10,984	10,068	11,527	11,527	12,300	12,422	12,760	12,902	Continuing	Continuing
3784 Space Sensors and Satellite Communications Technology	0	700	2,700	2,700	3,000	3,500	4,000	4,700	Continuing	Continuing
3834 Space Technology Integration and Demonstration	4,672	3,300	8,500	12,967	15,442	17,913	19,355	19,500	Continuing	Continuing
4400 Space Control and Satellite Survivability Technology	0	0	3,200	2,549	2,199	2,345	2,425	2,497	Continuing	Continuing
682J Space Power and Thermal Management Technology	4,244	4,400	5,500	5,500	6,000	6,800	7,500	7,800	Continuing	Continuing

(U) A. <u>Mission Description and Budget Item Justification</u>: This Advanced Development program develops and demonstrates advanced spacecraft technologies including integrated space, ground, and flight demonstrations. The broad goal is to decrease innovative space technology transition time and reduce the associated development costs and risks of future space-based systems. Efforts are focused on five high payoff space technology areas: advanced space structures and structural controls; hardened space electronics and satellite control software; advanced passive/active space-based sensors and satellite communications; compact, low-cost, space power and thermal management; and satellite survivability. All efforts in this program element contain the resources necessary, including civilian salaries, to manage, conduct, and document the listed technical activities.

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BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology

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

	FY 1994	FY 1995	FY 1996	FY 1997	Total Cost
(U) Previous President's Budget	20,459	24,200	26,730	32,863	Cont
(U) Appropriated Value	21,091	49,400			
(U) Adjustments to Appropriated Value					
a. Congressional General Reductions	-632	-1,109			
b. SBIR	-278				
c. Below Threshold Reprogramming	-281				
(U) Current President's Budget	19,900	48,291	32,627	36,443	Cont

(U) Change Summary Explanation:

Funding: Changes reflect increased Air Force priority on space-related Science and Technology. The FY 1995 appropriation was increased $30 million by Congress for Reusable Launch Vehicle (RLV) technology in support of NASA.

Schedule: Not Applicable.

Technical: Not Applicable.

(U) C. Other Program Funding Summary: Not Applicable.

(U) D. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development				PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology						PROJECT 0003
COST (*In Thousands*)	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	Cost to Complete	Total Cost
0003 Reusable Launch Vehicle Technology	0	29,223	0	0	0	0	0	0	0	29,223

(U) A. Mission Description and Budget Item Justification: This project accounts for the FY 1995 Congressional add for Reusable (space) Launch Vehicle (RLV) technology development. Accompanying Congressional direction stipulated funds were to support the ongoing National Aeronautics and Space Administration (NASA) single-stage-to-orbit (SSTO) vehicle program. This Air Force RLV technology project directly complements and fully supports the NASA-led RLV program and has been coordinated and approved through NASA Headquarters. The tasks identified in this project summary represent the DoD equity in RLV technology development as recommended by the Space Launch Modernization Plan (SLMP) study and do not incur any outyear funding commitment except as budgeted in PE 0603302F, Project 0003. This project will be moved in FY 1996 to PE 0603302F, Space and Missile Rocket Propulsion Technology, and the title revised to Launch Vehicle Technologies.

(U) FY 1994: Not Applicable.

(U) FY 1995:
- (U) Apply advanced rocket propulsion technology to reusable launch vehicles. ($11,643K)
  - (U) Modify the design of the Integrated Power-Head (IPHD) pre-burner components.
  - (U) Demonstrate application of the advanced long life turbopump fluid film bearing technologies to reusable launch vehicles.
  - (U) Investigate high performance thrust cell unconventional nozzles and fundamental technologies.
- (U) Perform advanced reusable launch vehicle structures/tankage technology development. ($10,670K)
  - (U) Design and demonstrate lightweight, reusable launch vehicle structures.
  - (U) Design and demonstrate reusable launch vehicle (RLV) composite, cryogenic propellant tanks.
- (U) Perform advanced reusable launch vehicle thermal protection system technology development. ($2,910K)
  - (U) Design and demonstrate lightweight, reusable, maintainable and affordable thermal protection system critical technologies.
- (U) Perform advanced reusable launch vehicle operations technology development. ($1,000K)
  - (U) Develop and demonstrate reliable, cost effective reusable launch vehicle (RLV) ground and flight operations.
- (U) Perform advanced reusable launch vehicle high density propellant technology demonstration. ($3,000K)
  - (U) Investigate application of high density, high mass fraction propellant technologies to reusable launch vehicles.

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BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology

PROJECT
0003

(U) FY 1996: Not Applicable.

(U) FY 1997: Not Applicable.

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

	FY 1994	FY 1995	FY 1996	FY 1997	Total Cost
(U) Previous President's Budget	0	0	0	0	0
(U) Current President's Budget	0	29,223	0	0	29,223

(U) Change Summary Explanation:
Funding: Budget reflects Congressional add in FY 1995.

Schedule: Not Applicable.

Technical: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:
- (U) PE 0602102F, Materials.
- (U) PE 0602269F, Hypersonic Technology Program.
- (U) PE 0602601F, Phillips Laboratory.
- (U) PE 0603302F, Space and Missile Rocket Propulsion Technology.
- (U) PE 0603853F, Evolved Expendable Launch Vehicle Program.
- (U) UPN 242, NASA Reusable Launch Vehicle Program.
- (U) This project has been coordinated through the Project Reliance process and with NASA to harmonize efforts and eliminate duplication.

(U) D. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology		PROJECT 1026

COST (*In Thousands*)	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	Cost to Complete	Total Cost
1026 Space Structures and Controls Technology	0	600	1,200	1,200	2,000	2,800	3,600	4,354	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: This project develops advanced composite structures and structural control technologies for future Air Force space and missile systems. Prior to FY 1995, the Air Force relied on Ballistic Missile Defense Organization (BMDO) funding to address its needs in this technology area. As BMDO budgets have declined, so has their funding in this area, necessitating Air Force investment to maintain critical spacecraft structures and controls technologies. Advanced space structure component efforts focus on the demonstration of new composite structure technologies whose goal is to significantly improve the payload mass fraction and shorten overall spacecraft fabrication time and cost. This project also develops advanced passive and active spacecraft structural control technologies. Structure vibration and shock suppression technologies are intended to significantly enhance space platform stability, improving the focusing/imaging ability of space-based optical components such as focal plane arrays developed in Project 3784 or solar cell arrays developed in Project 682J.

(U) FY 1994: Not Applicable.

(U) FY 1995:
- (U) Continue former BMDO advanced composite space vehicle structure technology development. ($300K)
  - (U) Complete design of all-composite satellite bus technology demonstrator to be flown on MightySat-1.
- (U) Continue former BMDO advanced spacecraft structural control technology development. ($300K)
  - (U) Complete non-pyrotechnic release device technology hardware fabrication.

(U) FY 1996:
- (U) Continue advanced composite spacecraft structures technology development. ($600K)
  - (U) Complete fabrication of the all-composite satellite bus technology demonstration to be flown on MightySat-1, showing 30-50% weight savings.
- (U) Continue advanced spacecraft structural controls technology development. ($600K)
  - (U) Assemble the non-pyrotechnic release device technology demonstration experiment to be flown on MightySat-1.

(U) FY 1997:
- (U) Continue advanced composite spacecraft structures technology development. ($600K)
  - (U) Demonstrate preliminary design of the next generation composite satellite bus for future space applications like the MilSatCom program.
- (U) Continue advanced spacecraft structural controls technology development. ($600K)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology

PROJECT 1026

– (U) Initiate launch vibration isolation technology demonstration program.

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

	FY 1994	FY 1995	FY 1996	FY 1997	Total Cost
(U) Previous President's Budget	0	600	1,200	1,963	Cont
(U) Current President's Budget	0	600	1,200	1,200	Cont

(U) Change Summary Explanation:

Funding: This project started in FY 1995 to continue former Ballistic Missile Defense Organization funded efforts critical to the Air Force.

Schedule: Not Applicable.

Technical: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:

– (U) PE 0602102F, Materials.
– (U) PE 0602601F, Phillips Laboratory.
– (U) PE 0603218C, Research and Support.
– (U) PE 0603302F, Space and Missile Rocket Propulsion Technology.
– (U) This project has been coordinated through the Project Reliance process to harmonize efforts and eliminate duplication.

(U) D. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1995
BUDGET ACTIVITY: 3 - Advanced Development	PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology / PROJECT: 2181

COST (*In Thousands*)	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	Cost to Complete	Total Cost
2181 Space Electronics and Software Technology	10,984	10,068	11,527	11,527	12,300	12,422	12,760	12,902	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: This project develops, demonstrates, and evaluates hardware, software, and modeling/simulation technologies, enabling interchangeable, interoperable, and standardized data and signal processing for existing and future Air Force space and missile systems. This project will demonstrate the capability to produce space-qualified, Very High Speed Integrated Circuit (VHSIC)-based components, wafer scale integration (WSI) packages, electronic processors, and reusable standardized satellite control software. In the near-term, this project concentrates on converting (e.g., hardening) commercial data and signal processor technologies for use in Air Force space and missile systems. Advanced electronic packaging technologies, reducing weight and volume, are being developed for broad military space applications. This project develops and demonstrates space data processor technologies like the Advanced Technology Insertion Module (ATIM) (32-bit) technology. The Advanced Spaceborne Computer Module (ASCM), ATIM's 16-bit predecessor, is currently baselined into 65 DoD, NASA, and commercial programs. This project develops and demonstrates space signal processor technologies like the Hardened Ada Signal Processor (HASP) program. It also develops low-cost, easily modifiable software and hardware architectures for ground control, satellite components, and autonomous satellite operations. The Multi-mission Advanced Ground Intelligent Control (MAGIC) program has developed a low-cost, flexible architecture for satellite control and mission operations. In the long-term, this project focuses on developing an integrated avionics-like architecture for satellites where high-speed data busses centralize many of the functions now scattered about the spacecraft. Additionally, this project develops very low-power electronics allowing dramatic size, weight, and power reductions for future Air Force space applications.

(U) FY 1994:
- (U) Continued development of space-qualifiable, advanced low-power, hardened data processors and memory technologies. ($8,684K)
  - (U) Completed advanced technology insertion module fault tolerance demonstration.
  - (U) Completed advanced technology insertion module preliminary design reviews for single board computer fabrication and test.
  - (U) Completed design and began fabricating Rad-6000 single chip hardened processor.
  - (U) Demonstrated fully fault tolerant 16-bit space computer system which recovered from 45 consecutively inserted faults.
- (U) Continued development of space-qualifiable, hardened signal processor electronics technologies and standard electronic devices. ($500K)
  - (U) Completed hardened Ada signal processor single chip design and 92% of layout.
  - (U) Investigated alternate silicon on insulator digital signal processor potential sources for space.
- (U) Continued space-qualifiable, advanced mixed-signal electronics packaging technology development, using commercial technology base. ($700K)
  - (U) Fabricated enough multi-chip memory modules to demonstrate a space-qualifiable solid state recorder technology for magnetic tape replacement.
  - (U) Completed analog signal processing module fabrication, demonstrating the technical feasibility of mixed multi-chip modules for space.
  - (U) Delivered advanced technology multi-chip module anti-jam filters.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology
	PROJECT 2181

- (U) Continued development of astrodynamics routines and reusable, space standardized software technologies. ($600K)
  - (U) Completed continuous thrust orbit transfer analysis and started continuous thrust orbit relocation technology study.
  - (U) Ported a research version of the Goddard trajectory determination system on a personal computer (PC), resulting in the successful transition of 150,000 lines of mainframe computer code to a PC.
  - (U) Defined and demonstrated a visual interface for satellite telemetry analysis; first step of the multi-mission advanced ground intelligent control program.
  - (U) Expanded reusable software architecture for on-board satellite processing domain analysis for use with Defense Meteorological Support Program and GE A2100 satellites including the communication and electrical power subsystems.
- (U) Continued development of space-qualifiable accelerated insertion of standard microelectronics components. ($500K)
  - (U) Modified commercial integrated circuits so they can be fabricated on space-qualified manufacturing lines.

(U) FY 1995:
- (U) Continue development of space-qualifiable, advanced low-power, hardened data processors and memory technologies. ($6,968K)
  - (U) Design and fabricate processor chipsets and other integrated circuits to provide complete core chipset for advanced technology space computer.
  - (U) Fabricate a breadboard and test functionality of full computer and operating system software.
- (U) Continue development of space-qualifiable, hardened signal processor electronics technologies and standard electronic devices. ($1,000K)
  - (U) Purchase license to fabricate a space-qualifiable version of a commercial digital signal processor design.
  - (U) Initiate transfer of a commercial digital signal processor to a space-qualified integrated circuit manufacturing line.
- (U) Continue space-qualifiable, advanced mixed-signal electronics packaging technology development, using commercial technology base. ($600K)
  - (U) Complete high-speed, single layer computer for three-dimensional integrated sensor processor.
  - (U) Develop robust analog processor multi-chip module and brassboard for space flight, demonstrating advanced packaging reliability.
- (U) Continue development of reusable, space standardized software technologies. ($600K)
  - (U) Complete multi-mission advanced ground intelligent control telemetry analysis development and test.
  - (U) Enhance multi-mission advanced ground intelligent control to provide assistance to satellite operators in anomaly resolution.
  - (U) Enhance multi-mission advanced ground intelligent control to include satellite commanding.
- (U) Continue development of space-qualifiable accelerated insertion of standard microelectronics components. ($900K)
  - (U) Transfer commercial field programmable gate array to a space-qualified integrated circuit manufacturing line.
  - (U) Fabricate and ground test space-qualifiable 8,000 gate, field programmable gate array.

(U) FY 1996:
- (U) Continue development of space-qualifiable, advanced low-power, hardened data processors and memory technologies. ($7,127K)
  - (U) Fabricate engineering model of standard satellite computer to demonstrate functionality and performance of data processors.
  - (U) Develop full capability operating system and applications software environment using desktop computer and hardware-in-the-loop.

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BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology

PROJECT 2181

- (U) Continue development of space-qualifiable, hardened signal processor electronics technologies and standard electronic devices. ($1,100K)
  - (U) Fabricate Digital Signal Processor in bulk Silicon.
  - (U) Demonstrate functionality and performance of space-qualifiable digital signal processor using commercial hardware/software tools.
- (U) Continue space-qualifiable, advanced mixed-signal electronics packaging technology development using commercial technology base. ($1,300K)
  - (U) Demonstrate two times increase in density and decrease in cost to space qualify high density interconnect technology.
  - (U) Integrate plastic/non-hermetic and three-dimensional (3-D) packaging technologies into a space demonstration.
- (U) Continue development of reusable, space standardized software technologies. ($1,000K)
  - (U) Enhance multi-mission advanced ground intelligent control software to include independent decision making capability.
  - (U) Develop a realistic training environment for ground spacecraft operators.
- (U) Continue development of space-qualifiable accelerated insertion of standard microelectronics components. ($1,000K)
  - (U) Fabricate and ground test space-qualifiable 2,000 field programmable gate arrays.
  - (U) Start demonstrating programmability of 8,000 field programmable gate array using commercial hardware/software tools.

(U) FY 1997:

- (U) Continue development of space-qualifiable, advanced low-power, hardened data processors and memory technologies. ($7,527K)
  - (U) Fabricate space-qualifiable configuration of 32-bit processor-based computers and demonstrate the full range of performance capabilities.
  - (U) Initiate design of advanced high throughput, low-power data processor-based on commercial technology base.
- (U) Continue development of space-qualifiable, hardened signal processor electronics technologies. ($800K)
  - (U) Fabricate silicon on insulator (SOI) version of space-qualifiable digital signal processor.
  - (U) Evaluate the ability of both bulk silicon and SOI version of the digital signal processor to perform in the space environment.
- (U) Continue space-qualifiable, advanced mixed signal electronics packaging technology development such as 3-D wafer scale integration. ($1,400K)
  - (U) Demonstrate integrated sensor processing 3-D electronics assembly in robust space-qualifiable configuration.
  - (U) Demonstrate improved multi-chip module technology by constructing a complex multi-processor system.
- (U) Continue development of reusable, space standardized software technologies. ($1,100K)
  - (U) Add the ability to assist in the identification and resolution of unknown anomalies in multi-mission advanced ground intelligent control software.
  - (U) Analyze capabilities that can be integrated into autonomous satellite operations.
- (U) Continue development of space-qualifiable accelerated insertion of standard electronics. ($700K)
  - (U) Complete programmability demonstration of both 8,000 and 2,000 gate, field programmable gate arrays.
  - (U) Evaluate the functionality, performance, and ability of both the 8,000 and 2,000 gate, field programmable gate arrays to perform in space environment.

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	PROJECT 2181

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

	FY 1994	FY 1995	FY 1996	FY 1997	Total Cost
(U) Previous President's Budget	11,171	10,300	10,400	10,800	Cont
(U) Current President's Budget	10,984	10,068	11,527	11,527	Cont

(U) Change Summary Explanation:

Funding: Changes reflect increased Air Force priority on space-related Science and Technology.

Schedule: Not Applicable.

Technical: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:

- (U) PE 0303601F, MILSTAR Satellite Communications System.
- (U) PE 0305160F, Defense Meteorological Satellite Program (DMSP).
- (U) PE 0602601F, Phillips Laboratory.
- (U) PE 0603311F, Ballistic Missile Technology.
- (U) PE 0603215C, Limited Defense System.
- (U) PE 0603218C, Research and Support.
- (U) PE 0603226E, Experimental Evaluation of Major Innovative Technologies.
- (U) PE 0604609F, Reliability and Maintainability Technology Insertion Program (RAMTIP).
- (U) This project has been coordinated through the Project Reliance process to harmonize efforts and eliminate duplication.

(U) D. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology		PROJECT 3784

COST (*In Thousands*)	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	Cost to Complete	Total Cost
3784 Space Sensors and Satellite Communications Technology	0	700	2,700	2,700	3,000	3,500	4,000	4,700	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: This project was refocused last year because of previous Congressional actions on the 60 GigaHertz (GHz) communication work and because the Air Force is assuming responsibility for spaceborne passive sensors from the Ballistic Missile Defense Organization (BMDO). This project develops military space-based ground surveillance and satellite communication technologies. The project focuses on advancing space-based application of commercial sensors and communication technologies while improving performance, schedule, maturity, cost, and/or risk to future Air Force systems. The primary focus of the sensor efforts is to meet spaceborne sensor needs for theater missile defense. The focus of the satellite communication effort is to develop radio frequency (RF) and laser technologies for future military intra-space and space-ground communication systems. This project seeks to improve affordability, reliability, and performance while significantly reducing space sensor and satellite communication size, weight, cost, cooling, and power requirements.

(U) FY 1994: Not Applicable.

(U) FY 1995:
- (U) Continue former BMDO space-based reconnaissance/surveillance passive sensor technology meeting Air Force high priority needs. ($700K)
  - (U) Initiate and complete design and fabrication of large format focal plane array for mid-wave infrared applications.

(U) FY 1996:
- (U) Continue space-based reconnaissance/surveillance sensor technology meeting high priority Air Force needs. ($2,400K)
  - (U) Evaluate and deliver large format focal plane arrays for mid-wave infrared applications.
  - (U) Complete passive sensor subsystem affordability analysis.
  - (U) Evaluate performance of advanced signal processing algorithms for surveillance sensors.
  - (U) Assess operational utility of candidate space-based surveillance technologies.
- (U) Develop satellite communication technology which supports space communications needs. ($300K)
  - (U) Develop ultra-lightweight radio frequency crosslink subsystem component technology.
  - (U) Assess commercial communication technology for transition to military systems.

(U) FY 1997:
- (U) Continue space-based reconnaissance/surveillance sensor technology meeting Air Force high priority needs. ($2,400K)
  - (U) Initiate design study for dual-band space-based reconnaissance sensors for missile defense applications.

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PROJECT 3784

- (U) Investigate efforts to increase yield and reliability of large format infrared focal plane arrays.
- (U) Evaluate performance of advanced signal processing algorithms for surveillance sensors.
- (U) Assess operational utility of candidate space-based surveillance technologies.

– (U) Develop satellite communication technology which supports space communications needs. ($300K)
- (U) Develop 150 megabit multi-mode modem technology.
- (U) Assess commercial communication technology for transition to military systems.

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

	FY 1994	FY 1995	FY 1996	FY 1997	Total Cost
(U) Previous President's Budget	0	1,500	2,700	3,900	Cont
(U) Current President's Budget	0	700	2,700	2,700	Cont

(U) Change Summary Explanation:

Funding: The FY 1995 program continued former Ballistic Missile Defense Organization funded efforts critical to the Air Force. Changes reflect increased Air Force priority on various space-related Science and Technology efforts.

Schedule: Not Applicable.

Technical: Not Applicable,

(U) C. Other Program Funding Summary:

(U) Related Activities:

– (U) PE 0303601F, MILSTAR Satellite Communications System.
– (U) PE 0602601F, Phillips Laboratory.
– (U) PE 0602702F, Command/Control/Communication Technology.
– (U) PE 0603226E, Experimental Evaluation of Major Innovative Technologies.
– (U) PE 0604711F, Extremely High Frequency Satellite Communications Research and Development.
– (U) This project has been coordinated through the Project Reliance process to harmonize efforts and eliminate duplication.

(U) D. Schedule Profile: Not Applicable.

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COST (*In Thousands*)	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	Cost to Complete	Total Cost
3834 Space Technology Integration and Demonstration	4,672	3,300	8,500	12,967	15,442	17,913	19,355	19,500	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: This project integrates government and commercially developed technologies onto spacecraft and launch vehicles, demonstrating their value in addressing warfighter needs and in supporting the warfighter by defining new operational concepts, tactics procedures, and doctrine on the Integrated Space Technology Flight (ISTF) series. The highly successful Technology for Autonomous Operational Survivability (TAOS) program is the basis for the ISTF series. TAOS is the only DoD satellite autonomy and survivability demonstration. TAOS was launched in March 1994 and is currently demonstrating and validating advanced spaceborne computers, autonomous navigation hardware/software, laser sensors, radar sensors, advanced data buses, and other operational concepts. TAOS has allowed space system operators and users, for the first time, to conduct space exercises, directly leading to enhanced warfighter capabilities. In FY 1995, the space technology community is evaluating mission requirements and potential technology solutions in PE 0602601F, Project 8809. The results of this study will used to determine the final ISTF-1 space technology flight demonstration composition. ISTF-1 will demonstrate those selected technologies showing the greatest potential to meet Air Force Space Command's (AFSPC's) highest priorities as compiled in their current Mission Area Plans (MAPs) and MAP Deficiency lists.

(U) FY 1994:
- (U) Launched theTAOS flight experiment. ($2,600K)
  - (U) Completed TAOS launch vehicle and spacecraft bus integration and assembly.
  - (U) Conducted navigation, laser, and radar sensor experiments on-board the TAOS experiment.
  - (U) Supported and participated in several major U.S. Space Command exercises using the TAOS spacecraft.
- (U) Began data analysis of technology for autonomous operational survivability experiment. ($800K)
  - (U) Initiated analysis of navigation, laser, and radar sensor data.
  - (U) Analyzed major spacecraft anomalies and prepared recovery plan.
- (U) Began planning for next integrated space technology demonstration. ($1,272K)
  - (U) Completed briefing to industry for advanced space technology demonstration.
  - (U) Established integrated teams with Headquarters Space and Missiles System Center at Los Angeles AFB, the Space Warfare Center at Falcon AFB, Air Force Space Command at Peterson AFB, and Phillips Laboratory at Kirtland AFB for an advanced space technology demonstration program.

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	PROJECT 3834

(U) FY 1995:
- (U) Complete the Technology for Autonomous Operational Survivability (TAOS) flight experiment. ($2,300K)
  - (U) Complete spacecraft anomaly recovery.
  - (U) Complete exercises and assessments.
  - (U) Complete navigation, laser, and radar sensor experimentation.
- (U) Perform TAOS post-mission analysis. ($1,000K)
  - (U) Conduct final technology (navigation, laser, and radar sensors) assessments and complete the draft final reports.

(U) FY 1996:
- (U) Complete the TAOS post-mission analysis. ($3,000K)
  - (U) Complete TAOS mission data analysis and deliver final report.
  - (U) De-orbit TAOS spacecraft, dispense mission unique equipment/software, and close out contract.
- (U) Begin Integrated Space Technology Flight (ISTF-1) development. ($4,500K)
  - (U) Conduct ISTF-1 preliminary design.
  - (U) Complete ISTF-1 critical design.
  - (U) Begin ISTF-1 long-lead time hardware procurement.
- (U) Develop modeling/simulation for integrated satellite payloads, mission utility, and system engineering analysis. ($1,000K)
  - (U) Complete satellite prototype and environmental effects simulation software interfaces and demonstrate real-time throughput.

(U) FY 1997:
- (U) Continue ISTF-1 demonstration development. ($10,967K)
  - (U) Continue ISTF-1 long-lead time hardware procurement and fabrication.
  - (U) Begin ISTF-1 payload hardware fabrication.
  - (U) Start ISTF-1 payload module fabrication.
- (U) Perform requirements definition and technology studies to support ISTF-2. ($1,000K)
  - (U) Define concepts and technology objectives.
- (U) Develop modeling/simulation for integrated satellite payloads, mission utility, and system engineering analysis. ($1,000K)
  - (U) Establish real-time connectivity to synthetic operational test and evaluation environments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology
	PROJECT 3834

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

	FY 1994	FY 1995	FY 1996	FY 1997	Total Cost
(U) Previous President's Budget	4,858	7,300	7,730	10,700	Cont
(U) Current President's Budget	4,672	3,300	8,500	12,967	Cont

(U) Change Summary Explanation:

Funding: Changes reflect increased Air Force priority on space-related Science and Technology.

Schedule: Not Applicable.

Technical: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:

- (U) PE 0602601F, Phillips Laboratory.
- (U) PE 0603402F, Space Test Program.
- (U) PE 0603438F, Satellite Systems Survivability.
- (U) PE 0604609F, Reliability and Maintainability Technology Insertion Program (RAMTIP).
- (U) This project has been coordinated through the Project Reliance process to harmonize efforts and eliminate duplication.

(U) D. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology		PROJECT 4400

COST (*In Thousands*)	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	Cost to Complete	Total Cost
4400 Space Control and Satellite Survivability Technology	0	0	3,200	2,549	2,199	2,345	2,425	2,497	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: This project develops and demonstrates the technologies required to assure operation of U.S. space assets in hostile warfighting environments. It provides the resources necessary to perform threat susceptibility/vulnerability assessments of critical components, subsystems, and systems. This project also identifies and develop solutions to mitigate vulnerabilities. Further, it develops and demonstrates technology options to support balanced protection strategies to detect, avoid, and operate in hostile threat environments. Efforts under this project will be closely integrated with the core technologies development under Projects 1026, 2181, 3784, 682J, and, where appropriate, end products included in the demonstrations of Project 3834. This project assumes the Air Force's responsibility for spacecraft survivability technology from the Ballistic Missile Defense Organization (BMDO). Starting in FY 1996, PE 0603438F, Satellite Systems Survivability, was transferred to this PE as Project 4400.

(U) FY 1994: Not Applicable.

(U) FY 1995: Not Applicable.

(U) FY 1996:

- (U) Continue selected Directed Energy Weapon (DEW) threat environment susceptibility/vulnerability assessments on critical space-based sensor and communications subsystems. ($925K)
  - (U) Perform sensor laser jamming model refinements and vulnerability assessments.
  - (U) Perform sensor radio frequency (RF) susceptibility evaluations.
  - (U) Perform communication subsystems disruption/degradation modeling and susceptibility evaluations.
  - (U) Initiate ground-based observations of spacecraft environmental interactions.
- (U) Select candidate RF/high-powered microwave (HPM) detector technologies for threat warning sensor development. ($2,200K)
  - (U) Develop miniaturized radar warning detector.
  - (U) Evaluate communication intrusion/interference detection technologies.
  - (U) Evaluate HPM detection concepts.
  - (U) Develop/integrate sensor signal processor design.
- (U) Evaluate candidate DEW sensor jamming protection techniques for critical sensor optical components. ($75K)
  - (U) Assess candidate RF mitigation techniques for optical sensors.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology
	PROJECT 4400

(U) FY 1997:
- (U) Continue multi-threat assessments on critical space assets and evaluate the potential susceptibilities of evolving technologies. ($633K)
  - (U) Perform analytical and experimental verification of selected laser and radio frequency (RF) jamming sensor protection techniques.
  - (U) Perform analytical and experimental verification of RF interference mitigation techniques for advanced communication subsystems.
  - (U) Complete ground-based observations of spacecraft environmental interactions.
- (U) Perform RF/high-powered microwave (HPM) threat warning sensors testing. ($1,766K)
  - (U) Integrate radar warning, intrusion/interference, and HPM detector concepts.
  - (U) Optimize/integrate signal processor design.
  - (U) Integrate optimized antenna configuration.
  - (U) Test integrated RF/HPM threat warning sensor.
- (U) Continue evaluating and demonstrating Defense Early Warning (DEW) sensor jamming protection techniques. ($150K)
  - (U) Demonstrate communication subsystem front-end RF protection devices.

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

	FY 1994	FY 1995	FY 1996	FY 1997	Total Cost
(U) Previous President's Budget	0	0	0	0	0
(U) Current President's Budget	0	0	3,200	2,549	Cont

(U) Change Summary Explanation:

Funding: Starting in FY 1996, PE 0603438F, Satellite Systems Survivability, was transferred to this PE as Project 4400.

Schedule: Not Applicable.

Technical: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology
	PROJECT 4400

(U) C. Other Program Funding Summary:

(U) Related Activities:
- (U) PE 0602102F, Materials.
- (U) PE 0602601F, Phillips Laboratory.
- (U) PE 0603410F, Space Systems Environmental Interactions Technology.
- (U) PE 0603438F, Satellite Systems Survivability.
- (U) PE 0603605F, Advanced Weapons Technology.
- (U) This project has been coordinated through the Project Reliance process to harmonize efforts and eliminate duplication.

(U) D. Schedule Profile: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)			DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology		PROJECT 682J

COST (*In Thousands*)	FY 1994 Actual	FY 1995 Estimate	FY 1996 Estimate	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	Cost to Complete	Total Cost
682J Space Power and Thermal Management Technology	4,244	4,400	5,500	5,500	6,000	6,800	7,500	7,800	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: This project develops and demonstrates compact, low-cost, spacecraft and ballistic missile power generation, storage, distribution, and thermal management technologies, including cryogenic cooling technologies. Power generation work focuses on lightweight, low-cost, low volume, and survivable solar cell arrays. Energy storage work focuses on lightweight nickel hydrogen (NiH_2) and sodium sulfur (NaS) spacecraft batteries for extended (five-ten year) satellite missions. Power distribution efforts focus on producing lightweight, high efficiency, standardized power busses for use on future Air Force space and missile programs. This project also develops and demonstrates the non-nuclear technologies associated with space nuclear power systems such as power conversion, conditioning, and power system thermal management. It investigates alternative technologies to increase space vehicle power subsystem performance, lifetime, survivability, and safety while reducing costs/risks. In FY 1995, this project assumed responsibility from the Ballistic Missile Defense Organization (BMDO) to develop spacecraft thermal management technologies such as cryogenic coolers necessary to maintain passive sensors in low optical backgrounds.

(U) FY 1994:
- (U) Continued development of space conventional power technologies such as advanced solar cell arrays. ($1,200K)
  - (U) Flight-qualified primary power (for the spacecraft) panels and experimental solar cell panels and integrated them onto a research satellite.
  - (U) Recorded record efficiency rating for gallium indium phosphide /gallium arsenide solar cells with 24.2% energy conversion.
  - (U) Demonstrated world record efficiency (9.3%) for copper-indium-diselenide solar cell on a flexible, electrically insulating substrate.
- (U) Continued development of space vehicle conventional power technologies such as compact volume/weight batteries. ($2,400K)
  - (U) Placed over 200 nickel hydrogen (NiH_2) batteries on test, achieving over 30,000 cycles.
  - (U) Demonstrated sodium sulfur (NaS) batteries with 150 watt hour/kilogram power density on low earth orbit profile.
  - (U) Developed standardized manufacturing, testing, and modeling procedures for nickel cadmium (NiCd) and NiH_2 cells.
  - (U) Completed thermal vacuum and cycle testing of the integrated power panel.
  - (U) Fabricated 85 watt fully populated (in solar cells) integrated power panels for ground- and flight-qualification.
- (U) Continued development of non-nuclear technologies associated with space nuclear power systems such as thermionics. ($644K)
  - (U) Characterized lithium heat pipe assembly for thermionic heat pipe module which indicated significantly reduced temperature asymmetrics.
  - (U) Vacuum tested an alkali metal thermal to electric conversion cell.
  - (U) Completed characterization of the emitter heat pipe.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology
	PROJECT 682J

(U) FY 1995:
- (U) Continue development of space conventional power technologies such as advanced solar cell arrays. ($1,100K).
  - (U) Investigate addition of active germanium bottom cell to gallium indium phosphide /gallium arsenide dual-junction cell to boost efficiency to >26%.
  - (U) Investigate all-back mounted electrical contact, thin gallium arsenide cells for improved efficiency and system integration.
- (U) Continue development of space vehicle conventional power technologies such as compact volume/weight batteries. ($2,100K)
  - (U) Complete abuse testing of sodium sulfur cells for flight test in FY 1996.
  - (U) Conduct solid state primary battery development program for launch vehicle applications.
  - (U) Initiate life test verification of nickel hydrogen battery first in a two-cell pressure vessel then in operationally more realistic 22-cell.
- (U) Continue development of non-nuclear technologies associated with space nuclear power systems such as thermionics technology. ($600K)
  - (U) Continue testing energy conversion technologies such as alkali-metal thermal to electric converter (AMTEC), cascade converters, thermionics, and liquid metal heat pipes.
- (U) Continue former Ballistic Missile Defense Organization space vehicle thermal management technology development such as cryogenic coolers. ($600K)
  - (U) Start development of cryogenic integration technologies.

(U) FY 1996:
- (U) Continue development of space conventional power technologies such as advanced solar cells and arrays. ($2,800K)
  - (U) Complete and transition multi-junction higher efficiency solar cells to the Manufacturing Technology office.
  - (U) Complete development of Thin-Film Roll-out Array for improved stowage and deployment.
  - (U) Flight test 'Channel Astro' edge concentrating array (150 watts/kilogram) on a small satellite.
- (U) Continue development of space vehicle conventional power technologies such as compact volume/weight batteries. ($1,400K)
  - (U) Perform life testing of nickel hydrogen (NiH_2) batteries.
  - (U) Flight test sodium sulfur (NaS) batteries.
- (U) Continue development of non-nuclear technologies associated with space nuclear power systems such as thermionics technology. ($300K)
  - (U) Initiate more efficient AMTEC cells (25%) development.
- (U) Continue space vehicle thermal management technology development such as cryogenic coolers. ($1,000K)
  - (U) Initiate single stage reverse Brayton cryocooler development.

(U) FY 1997:
- (U) Continue development of space conventional power technologies such as advanced solar cells and arrays. ($2,800K)
  - (U) Flight test Thin Film Roll-Out Array.
  - (U) Develop 30% efficient energy conversion devices.
- (U) Continue development of space vehicle conventional power technologies such as compact volume/weight batteries. ($1,400K)
  - (U) Continue NiH_2 low earth orbit life testing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1995
BUDGET ACTIVITY 3 - Advanced Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology

PROJECT
682J

- (U) Develop 200 watt hour/kilogram (WHr/kg) solid state lithium battery for satellite applications.

– (U) Continue development of non-nuclear technologies associated with space nuclear power systems such as thermionics technology. ($300K)
  - (U) Develop 25% alkali metal thermal to electric conversion cells.
  - (U) Design and fabricate thermionic bed power system components for evaluation.

– (U) Continue space vehicle thermal management technology development such as cryogenic coolers. ($1,000K)
  - (U) Qualify single stage reverse Brayton cryocooler for space applications.

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

	FY 1994	FY 1995	FY 1996	FY 1997	Total Cost
(U) Previous President's Budget	4,430	4,500	4,700	5,500	Cont
(U) Current President's Budget	4,244	4,400	5,500	5,500	Cont

(U) Change Summary Explanation:

Funding: Changes reflect increased Air Force priority on space-related Science and Technology.

Schedule: Not Applicable.

Technical: Not Applicable.

(U) C. Other Program Funding Summary:

(U) Related Activities:

– (U) PE 0602203F, Aerospace Propulsion.
– (U) PE 0602601F, Phillips Laboratory.
– (U) PE 0603302F, Space and Missile Propulsion Technology.
– (U) PE 0603218C, Research and Support.
– (U) PE 0603226E, Experimental Evaluation of Major Innovative Technologies.
– (U) This project has been coordinated through the Project Reliance process to harmonize efforts and eliminate duplication.

(U) D. Schedule Profile: Not Applicable.