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

DATE: February 1997

BUDGET ACTIVITY: 3 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

	COST ($ In Thousands)	FY 1996 Actual	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	72,456	73,215	40,846	44,679	50,031	53,902	55,418	57,412	TBD	TBD
1026	Space Structures and Controls Technology	1,139	1,058	987	2,544	3,259	4,050	3,633	3,706	Continuing	Continuing
2181	Space Electronics and Software Technology	10,241	11,975	13,632	13,036	13,016	12,652	13,441	13,880	Continuing	Continuing
3784	Space Sensors and Satellite Communication Technology	2,551	2,423	2,848	3,295	3,643	4,395	3,994	4,079	Continuing	Continuing
3834	Integrated Space Technology Demonstrations	26,768	37,847	18,788	20,358	23,402	24,279	26,170	27,392	Continuing	Continuing
4400	Satellite Survivability Technology	3,037	5,778	592	582	604	606	570	547	Continuing	Continuing
4599	Reusable Launch Vehicle Technology	23,500	9,579	0	0	0	0	0	0	TBD	TBD
682J	Space Power and Thermal Management Technology	5,220	4,555	3,999	4,864	6,107	7,920	7,610	7,808	Continuing	Continuing
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	0	0

Note: Starting in FY 1996, PE 0603438F, Satellite Systems Survivability, was transferred to this PE as Project 4400. Also, Project 4599 was previously called Project 0003, Reusable Launch Vehicle Technology. However, in FY 1996, this project was moved to PE 0603302F, Space and Missile Launch Technology, and renamed Launch Vehicle Technology to allow for Air Force investigation of all reusable and expendable launch technologies. The only funds remaining in Project 0003 in PE 0603401F were the funds added by Congress specifically for Reusable Launch Vehicle technology. To avoid confusion with Project 0003, Launch Vehicle Technology, in PE 0603302F, Project 0003 in PE 0603401F was renumbered Project 4599, keeping its Reusable Launch Vehicle title.

(U) A. Mission Description and Budget Item Justification: This Advanced Technology Development program develops and demonstrates advanced spacecraft technologies through integrated ground, flight, and space demonstrations. The broad goal of the program are to decrease the time for innovative space technology to be transitioned to the warfighter and to reduce the associated development costs and risks of future Air Force space-based systems. Developmental efforts are focused on six high-payoff satellite technology areas: (1) reusable launch vehicle technologies; (2) advanced space structures and structural controls; (3) hardened space electronics and satellite control software; (4) advanced passive/active space-based sensors and satellite communication; (5) compact, low-cost space power and thermal management; and (6) satellite survivability. Note: Congress added $46 million in FY 1996 ($25 million for Reusable Launch Vehicle (RLV) technology, $20 million for Microsat

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development, and $1 million for Miniature Threat Reporting System) plus $37 million in FY 1997 ($10 million for RLV technology, $25 million for Microsat development, and $2 million for Miniature Threat Reporting System) which explains the perceived decrease in FYs 1998 and out. In FYs 1999 and out, additional emphasis has been placed on evolutionary growth in space technologies.

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

	FY 1996	FY 1997	FY 1998	FY 1999	Total Cost
(U) Previous President's Budget	71,629	39,637	44,942	48,044	Cont
(U) Appropriated Value	78,627	76,637			
(U) Adjustments to Appropriated Value					
a. Congressional/General Reductions	-1,593	-1,656			
b. SBIR	-1,640	-1,694			
c. Omnibus/Other Above Threshold Reprogrammings	-1,573	-72			
d. Below Threshold Reprogrammings	-1,365				
(U) Current Budget Submit/FY 1998 PB	72,456	73,215	40,846	44,679	Cont

(U) Change Summary Explanation:

Funding: Changes to this PE since the previous President's Budget are due to budget constraints and priorities within the Science and Technology (S&T) Program.

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 1997

BUDGET ACTIVITY: 3 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 1026

COST ($ In Thousands)	FY 1996 Actual	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	Cost to Complete	Total Cost
1026 Space Structures and Controls Technology	1,139	1,058	987	2,544	3,259	4,050	3,633	3,706	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: This project demonstrates 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 an increased 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. The goal is to significantly improve the payload mass fraction and reduce overall spacecraft fabrication time and cost. This project also pays for the development of advanced passive and active spacecraft structural control technologies. Structural 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 cells developed in Project 682J.

(U) FY 1996 ($ in Thousands)

- (U) $570 Develop advanced composite spacecraft structures.
  - (U) Completed fabrication of the all-composite satellite structure to be flown on MightySat-1 demonstrator, showing 30-50 percent weight savings.
- (U) $569 Develop advanced spacecraft structural controls technology.
  - (U) Prepared the non-pyrotechnic release device technology demonstration experiment for flight on MightySat-1 demonstrator.
- (U) $1,139 Total

(U) FY 1997 ($ in Thousands)

- (U) $484 Develop advanced composite spacecraft structures technology.
  - (U) Develop preliminary design of next generation composite satellite structure for future space applications like the MilSatCom program.
- (U) $574 Develop advanced spacecraft structural controls technology.
  - (U) Complete first phase of technology demonstration program to isolate sensitive payloads from vibrations during launch.
- (U) $1,058 Total

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(U) FY 1998 ($ in Thousands)

- (U) $100 Develop advanced composite spacecraft structures technology.
  - (U) Support lightweight, rollup solar array flight demonstration.
- (U) $887 Develop advanced spacecraft structural controls technology.
  - (U) Initiate second phase of technology demonstration program to isolate sensitive payloads from vibrations during launch
  - (U) Support flight experiment of a stable, precision optical platform.
- (U) $987 Total

(U) FY 1999 ($ in Thousands)

- (U) $1,212 Develop advanced composite spacecraft structures technology.
  - (U) Initiate the cryogenic propellant tank experiment.
  - (U) Initiate space-based lightweight antenna structure flight experiment.
- (U) $1,332 Develop advanced spacecraft structural controls technology.
  - (U) Continue technology demonstration program to isolate sensitive payloads from vibrations during launch
  - (U) Continue precision optical platform experiment.
- (U) $2,544 Total

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

	FY 1996	FY 1997	FY 1998	FY 1999	Total Cost
(U) Previous President's Budget	1,139	1,105	1,841	2,599	Cont
(U) Current Budget Submit/FY 1998 PB	1,139	1,058	987	2,544	Cont

(U) Change Summary Explanation:

Funding: Changes to this project since the previous President's Budget are due to budget constraints and priorities within the Science and Technology (S&T) Program.

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 Launch 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 1997

BUDGET ACTIVITY: 3 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 2181

COST ($ In Thousands)	FY 1996 Actual	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	Cost to Complete	Total Cost
2181 Space Electronics and Software Technology	10,241	11,975	13,632	13,036	13,016	12,652	13,441	13,880	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: This project funds the demonstration and evaluation of electronic hardware and software. Improved space-qualifiable electronics and software for data and signal processing are to be more interchangeable, interoperable, and standardized. This project sponsors the demonstration of space-qualified circuits such as 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's work concentrates on converting (i.e., hardening) commercial data and signal processor technologies for use in Air Force space systems. Advanced electronic packaging technologies that reduce weight and volume are being developed for military space applications. Space data processor technologies like the Advanced Technology Insertion Module (ATIM 32-bit) technology are developed and demonstrated. The Advanced Spaceborne Computer Module (ASCM), ATIM's 16-bit predecessor, is currently baselined into 65 DoD, NASA, and commercial programs. Also developed and demonstrated are space signal processor technologies like the Hardened Ada Signal Processor (HASP) program. Low-cost, easily modifiable software and hardware architectures for ground control, satellite components, and autonomous satellite operations are developed. The Multi-mission Advanced Ground Intelligent Control (MAGIC) program in this project has developed a low-cost, flexible architecture for satellite control and mission operations. In the long-term, this project area focuses on developing an integrated avionics-like architecture for satellites where high-speed data busses centralize many of the functions now distributed on the spacecraft. Additionally, this project demonstrates very low-power electronics allowing dramatic size, weight, and power reductions for future Air Force Space applications.

(U) FY 1996 ($ in Thousands)

- (U) $6,291 Develop space-qualifiable, advanced low-power, hardened data processors and memory technologies.
  - (U) Fabricated engineering model of standard satellite computer to improve functionality and performance of data processors.
  - (U) Developed fully capable operating system and applications software environment using desktop computer and hardware-in-the-loop.
- (U) $1,000 Develop space-qualifiable, hardened signal processor electronics and standard electronic devices.
  - (U) Fabricated digital signal processor in bulk silicon.
  - (U) Demonstrated functionality and performance of space-qualifiable digital signal processor using commercial hardware/software tools.
- (U) $1,150 Develop space-qualifiable, advanced mixed-signal electronics packaging technology using commercial technology.
  - (U) Demonstrated two-fold increase in density and two-fold decrease in cost to space-qualified, high-density electronic interconnections.
  - (U) Integrated plastic/non-hermetic and three-dimensional (3-D) packaging technologies into a space demonstration.

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BUDGET ACTIVITY: 3 - Advanced Technology Development	PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology / PROJECT: 2181

– (U) $900 Develop astrodynamic routines and reusable, space-standardized satellite operations software.
  – (U) Enhanced Multi-mission Advanced Ground Intelligent Control (MAGIC) software to provide operator assistance in known-anomaly resolution.
  – (U) Installed the MAGIC software system in the Falcon AFB, CO, Demonstration Laboratory.
  – (U) Continued software support of the command and control system upgrade.
– (U) $900 Develop space-qualifiable, standard microelectronic components.
  – (U) Fabricated and ground-tested space-qualifiable 2,000 gate, field-programmable gate array.
  – (U) Demonstrated programmability of 8,000 gate, field-programmable gate array using commercial hardware/software tools.
– (U) $10,241 Total

(U) FY 1997 ($ in Thousands)
– (U) $6,722 Develop space-qualifiable, advanced low-power, hardened data processors and memory technologies.
  – (U) Fabricate space-qualifiable 32-bit processor-based computers and demonstrate the full range of performance capabilities.
  – (U) Design an advanced high throughput, low-power data processor-based on commercial technology.
– (U) $1,242 Develop space-qualifiable, hardened signal processor electronics technologies.
  – (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) $1,337 Develop space-qualifiable, advanced, mixed-signal electronics packaging technology such as three-dimensional (3-D) wafer scale integration.
  – (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) $2,483 Develop astrodynamic routines and reusable, space-standardized satellite operations software.
  – (U) Continue enhancing multi-mission advanced ground intelligent control software to provide operator assistance with unknown anomaly resolution and expand to include independent decision making capability.
  – (U) Continue developing technology for an artificial intelligence satellite operator system.
  – (U) Integrate and test autonomous satellite operations software system technologies.
  – (U) Continue software support of the satellite command and control system upgrade.
– (U) $191 Design and develop space-qualifiable silicon components using advanced micro-electromechanical systems (MEMS) techniques.
  – Evaluate the compatibility of fabrication and packaging processes for highly integrated MEMS/electronics components able to operate in the space environment.
  – Design advanced experimental MEMS devices and demonstrate their performance in a space environment.

– (U) $11,975 Total

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(U) FY 1998 ($ in Thousands)

- (U) $6,899 Develop space-qualifiable, advanced low-power, hardened data processors and memory technologies.
  - (U) Complete space-qualifiable 32-bit processor-based computers and demonstrate the full range of performance capabilities.
  - (U) Continue design of an advanced high throughput, low-power data processor-based on commercial technology.
- (U) $1,213 Develop space-qualifiable, hardened signal processor electronics technologies.
  - (U) Complete current design of silicon on insulator (SOI) version of space-qualifiable digital signal processor.
  - (U) Complete evaluation of the ability of both bulk silicon and SOI version of the digital signal processor to perform in the space environment.
- (U) $1,787 Develop space-qualifiable, advanced, mixed-signal electronics packaging technology such as three-dimensional (3-D) wafer scale integration.
  - (U) Continue integrated sensor processing 3-D electronics assembly in robust space-qualifiable configuration.
  - (U) Continue improved multi-chip module technology by constructing a complex multi-processor system
- (U) $2,835 Develop astrodynamic routines and reusable, space-standardized satellite operations software.
  - (U) Continue enhancing multi-mission advanced ground intelligent control software to provide operator assistance with unknown anomaly resolution and expand to include independent decision making capability
  - (U) Complete technology for an intelligent satellite operator system and initiate automated intelligent machine learning system.
  - (U) Integrate and test autonomous satellite operations software system technologies; initiate integrated applications of modeling and simulation technologies.
  - (U) Continue software support of the satellite command and control system upgrade; initiate software engineering effort for space system specific applications.
- (U) $898 Design and develop space-qualifiable silicon components using advanced micro-electromechanical systems (MEMS) techniques.
  - Continue to evaluate the compatibility of fabrication and packaging processes for highly integrated MEMS/electronics components able to operate in the space environment.
  - Complete design advanced experimental MEMS devices and demonstrate their performance in a space environment.
- (U) $13,632 Total

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	PROJECT 2181

(U) FY 1999 ($ in Thousands)

- (U) $5,253 Develop space-qualifiable, advanced low-power, hardened data processors and memory technologies.
  - (U) Expand commercial electronics to space electronics production.
  - (U) Continue to design an advanced high throughput, low-power data processor based on commercial technology
- (U) $920 Develop space-qualifiable, hardened signal processor electronics technologies.
  - (U) Continue developing integrated space computer version of advanced digital signal processor to perform in the space environment.
  - (U) Initiate development of advanced next-generation digital signal processing technology and scaleable multi-processor arrays.
- (U) $1,677 Develop space-qualifiable, advanced, mixed-signal electronics packaging technology such as three-dimensional (3-D) wafer scale integration.
  - (U) Continue integrated sensor processing 3-D electronics assembly in robust space-qualifiable configuration; test in space environment.
  - (U) Continue improved multi-chip module technology by constructing a complex multi-processor system; test in space environment
- (U) $2,945 Develop astrodynamic routines and reusable, space-standardized satellite operations software.
  - (U) Continue enhancing multi-mission advanced ground intelligent control software to provide operator assistance with unknown anomaly resolution and expand to include independent decision making capability
  - (U) Continue developing technology for an automated intelligent satellite operations system.
  - (U) Continue to integrate and test autonomous satellite operations software system technologies using space system software engineering techniques.
  - (U) Continue software support of the satellite command and control system upgrade.
- (U) $1,307 Design and develop space-qualifiable silicon components using advanced micro-electromechanical systems (MEMS) techniques.
  - (U) Continue to evaluate the compatibility of fabrication and packaging processes for highly integrated MEMS/electronics components able to operate in the space environment.
  - (U) Test advanced experimental MEMS devices and demonstrate their performance in space flight tests.
- (U) $934 Develop real-time space simulation for training and CONOPs.
  - (U) Enhance simulation architecture for real time and variable fidelity operations.
  - (U) Advance bus health and status models for autonomous operations.
  - (U) Upgrade fidelity of surveillance payload models.
- (U) $13,036 Total

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	PROJECT 2181

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

	FY 1996	FY 1997	FY 1998	FY 1999	Total Cost
(U) Previous President's Budget	10,241	12,538	13,325	12,786	Cont
(U) Current Budget Submit/FY 1998 PB	10,241	11,975	13,632	13,036	Cont

(U) Change Summary Explanation:

Funding: Changes to this project since the previous President's Budget are due to budget constraints and priorities within the Science and Technology (S&T) Program.

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.

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DATE: February 1997

BUDGET ACTIVITY: 3 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 3784

COST *($ In Thousands)*	FY 1996 Actual	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	Cost to Complete	Total Cost
3784 Space Sensors and Satellite Communication Technology	2,551	2,423	2,848	3,295	3,643	4,395	3,994	4,079	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: This project funds the development of military space-based ground surveillance and satellite communication technologies. The project's work focuses on advancing space-based applications of commercial sensors and communication technologies while improving the performance, schedule, maturity, cost, and/or risk reduction. The focus of the space sensor effort is to meet spaceborne sensor needs for national missile defense and intelligence, surveillance, and reconnaissance missions. The focus of the satellite communications effort is to develop radio frequency (RF) 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, and cooling and power requirements.

(U) FY 1996 ($ in Thousands)

- (U) $2,251 Develop space-based reconnaissance/surveillance sensor technology to meet high priority Air Force needs.
  - (U) Evaluated and delivered large format focal plane arrays for mid-wave infrared applications.
  - (U) Evaluated performance of advanced signal processing algorithms for surveillance sensors.
  - (U) Assessed operational utility of candidate space-based surveillance technologies.
- (U) $300 Develop satellite communication technology which supports space communications needs.
  - (U) Assessed commercial communication technology for transition to military systems
- (U) $2,551 Total

(U) FY 1997 ($ in Thousands)

- (U) $2,138 Develop space-based reconnaissance/surveillance sensor technology to meet Air Force high priority needs.
  - (U) Conduct design study for dual-band space-based reconnaissance sensors for missile defense applications.
  - (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) $285 Develop satellite communication technology which supports space communications needs.
  - (U) Continue assessing commercial communication technology for transition to military systems.
- (U) $2,423 Total

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(U) FY 1998 ($ in Thousands)

- (U) $2,522 Develop space-based reconnaissance/surveillance sensor technology to meet Air Force high priority needs.
  - (U) Continue design studies for dual-band space-based reconnaissance sensors for missile defense applications.
  - (U) Continue to investigate efforts to increase yield and reliability of large format infrared focal plane arrays
  - (U) Continue to evaluate the performance of advanced signal processing algorithms for surveillance sensors.
  - (U) Continue to assess the operational utility of candidate space-based surveillance technologies.
- (U) $326 Develop satellite communication technology which supports space communications needs.
  - (U) Complete assessment of commercial communication technology for transition to military systems
- (U) $2,848 Total

(U) FY 1999 ($ in Thousands)

- (U) $2,916 Develop space-based reconnaissance/surveillance sensor technology to meet Air Force high priority needs.
  - (U) Continue design studies for dual-band space-based reconnaissance sensors for missile defense applications.
  - (U) Continue to investigate efforts to increase yield and reliability of large format infrared focal plane arrays.
  - (U) Conduct evaluation and design of large format quantum well focal plane arrays.
  - (U) Continue to evaluate the performance of advanced signal processing algorithms for surveillance sensors.
  - (U) Continue to assess the operational utility of candidate space-based surveillance technologies.
- (U) $379 Develop satellite communication technology which supports space communications needs.
  - (U) Initiate development of high-speed, low-power communication ship sets and digital high-speed rapid acquisition modems for satellite communication applications
- (U) $3,295 Total

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

	FY 1996	FY 1997	FY 1998	FY 1999	Total Cost
(U) Previous President's Budget	2,551	2,547	2,784	3,249	Cont
(U) Current Budget Submit/FY 1998 PB	2,551	2,423	2,848	3,295	Cont

(U) Change Summary Explanation:

Funding: Changes to this project since the previous President's Budget are due to budget constraints and priorities within the Science and Technology (S&T) Program.

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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BUDGET ACTIVITY: 3 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 3834

COST *($ In Thousands)*	FY 1996 Actual	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	Cost to Complete	Total Cost
3834 Integrated Space Technology Demonstrations	26,768	37,847	18,788	20,358	23,402	24,279	26,170	27,392	Continuing	Continuing

(U) A. Mission Description and Budget Item Justification: The Integrated Space Technology Demonstration (ISTD) program provides for the integration of government and commercially developed technologies onto satellites. The ISTD seeks to demonstrate the value of these new technologies to address new space tactics, techniques, procedures, doctrine, and possibly revolutionize future acquisitions of DoD space systems. The ISTD program will enhance commercial and civil space assets in a cost-effective manner, allowing the warfighter to assess the utility of new space technologies through leveraging opportunities and, when required, through space flight demonstration of this new program.

The highly successful Technology for Autonomous Operational Survivability (TAOS) satellite was the first of the ISTD series. TAOS was launched in March 1994 and is currently demonstrating advanced warfighter concepts and the viability of advanced computers, autonomous navigation hardware/software, laser sensors, radar sensors, and data busses in space. TAOS has allowed operators and users, for the first time, to directly conduct space exercises in conjunction with the Phillips Laboratory (PL).

In FY 1995, the ISTD program office initiated a cooperative agreement with NASA's small satellite technology program to leverage existing NASA research and development efforts with Air Force funding and technologies. PL agreed to integrate an S-band transmitter on a NASA satellite which would allow command, control, and reception of imaging payload data from mobile ground stations controlled by the warfighter. A second major FY 1995 effort was an evaluation to determine what were the right technologies to fly on the first mission. From this study, it was determined that the mission focus for the advanced space technology demonstration would be a commercially leveraged program focusing on a hyperspectral imaging sensor with automatic target recognition. In general, the ISTD series of space technology demonstrations will allow users to assess new space technologies, which, when integrated, will become technology options for space systems.

(U) FY 1996 ($ in Thousands):

- (U) $2,981 Perform the TAOS flight demonstration.
  - (U) Performed TAOS mission data analysis and continued the navigator, laser, and radar sensor experimentation with user operators.
- (U) $4,264 Conduct ISTD program: Clark and Warfighter-1.
  - (U) Integrated and tested an S-band transmitter on NASA's Clark demonstrator spacecraft.
  - (U) Fabricated, assembled, integrated, and tested the Clark spacecraft mobile ground station equipment.
  - (U) Released final Request for Proposal (RFP) for Warfighter-1 (Integrated Space Technology Flight-1).
- (U) $ 993 Develop algorithim for integrated satellite payloads and mission utility.
  - (U) Completed satellite and environmental effects simulation software interfaces and demonstrated real-time throughput.
- (U) $18,530 Develop and demonstrate miniaturized space technologies
  - (U) Identified appropriate technologies and conducted mission evaluations to determine best mission for this technology.
- (U) $26,768 Total

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	PROJECT 3834

(U) FY 1997 ($ in Thousands)

- (U) $1,433 Complete the Technology for Autonomous Operational Survivability (TAOS) flight demonstration.
  - (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) $11,567 Conduct Integrated Space Technology Demonstration (ISTD) demonstration series program.
  - (U) Continue joint Air Force-NASA on-orbit technology assessments and data collection.
  - (U) Complete demonstrator spacecraft long lead-time hardware fabrication.
  - (U) Begin design, fabrication, integration, and test of payload.
- (U) $ 956 Develop algorithm for integrated satellite payloads, mission utility, and system engineering.
  - (U) Establish real-time connectivity to operational test and evaluation environments.
- (U) $23,891 Develop and demonstrate miniaturized space technologies
  - (U) Select a mission and develop component technologies for the Clementine 2 microsatellite technology development
- (U) $37,847 Total

(U) FY 1998 ($ in Thousands)

- (U) $ 400 Continue joint Air Force-NASA on-orbit technology assessments, data collection, and algorithm development (Clark spacecraft mission).
- (U) $17,390 Conduct ISTD demonstration series program, Warfighter 1.
  - (U) Continue development of target detection payload.
  - (U) Continue design, fabrication, integration, and test of payload and spacecraft.
  - (U) Procure long lead items for launch vehicle integration requirements.
- (U) $ 998 Develop algorithm for integrated satellite payloads, mission utility, and system engineering.
  - (U) Complete satellite and environmental effects simulation software interfaces and demonstrate real-time throughput.
- (U) $18,788 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1997
BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology
PROJECT 3834	

(U) FY 1999 ($ in Thousands)

- (U) $100 Complete joint Air Force-NASA on-orbit technology assessments, data collection, and algorithm development.
  - Close out mission operations and prepare final report.
- (U) $20,258 Conduct Integrated Space Technology Demonstrations series program.
  - (U) Conduct system level test of payload with spacecraft.
  - (U) Ship spacecraft to launch site and begin spacecraft to launch vehicle integration.
  - (U) Begin mission operations.
- (U) $20,358 Total

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

	FY 1996	FY 1997	FY 1998	FY 1999	Total Cost
(U) Previous President's Budget	24,441	14,604	18,509	20,187	Cont
(U) Current Budget Submit/FY 1998 PB	26,768	37,847	18,788	20,358	Cont

(U) Change Summary Explanation:

Funding: Changes to this project since the previous President's Budget are due to budget constraints and priorities within the Science and Technology (S&T) Program.

Schedule: Not Applicable.

Technical: Not Applicable.

(U) C. Other Program Funding Summary

(U) Related Activities:

- (U) PE 0602601F, Phillips Laboratory.
- (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 1997
BUDGET ACTIVITY: 3 - Advanced Technology Development	PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology	PROJECT: 4400

COST *($ In Thousands)*	FY 1996 Actual	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	Cost to Complete	Total Cost
4400 Satellite Survivability Technology	3,037	5,778	592	582	604	606	570	547	Continuing	Continuing

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

(U) A. Mission Description and Budget Item Justification: This project funds the development and demonstration of technologies required to assure operation of U.S. space assets in potentially hostile warfighting environments. Work performed includes assessment of critical components, subsystems, and systems' threat susceptibility and vulnerability. This project also develops technologies to mitigate identified vulnerabilities. Further, technology options are developed and demonstrated to support balanced satellite protection strategies for detecting, avoiding, and operating in a hostile space environment. Efforts under this project will be closely integrated with exploratory space technologies such as those developed under PE 0602601F, Project 8809, and advanced space technologies developed under this PE in Projects 1026, 2181, 3784, and 682J. Where appropriate, end products include integrated demonstrations with technologies developed in Project 3834. Through this project, the Air Force assumes responsibility for critical spacecraft survivability technology from the Ballistic Missile Defense Organization (BMDO).

(U) FY 1996 ($ in Thousands):

- (U) $925 Assess selected directed energy weapon threat environment susceptibility/vulnerability of critical space-based sensor and communications subsystems.
  - (U) Performed sensor laser jamming model refinements and vulnerability assessments.
  - (U) Performed sensor radio frequency susceptibility evaluations.
  - (U) Performed communication subsystems disruption/degradation modeling and susceptibility evaluations.
  - (U) Initiated ground-based observations of vulnerability to spacecraft-environment interaction threat.
- (U) $2,037 Select candidate radio frequency/high-powered microwave detector technologies for threat warning sensor development.
  - (U) Developed miniaturized radar warning detector.
  - (U) Evaluated communication intrusion/interference detection technologies.
  - (U) Evaluated high-power microwave detection concepts.
  - (U) Developed/integrated sensor signal processor design.
- (U) $75 Evaluate candidate directed energy weapon sensor jamming protection techniques for critical sensor optical components.
  - (U) Assessed candidate radio frequency mitigation techniques for optical sensors.
- (U) $3,037 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1997
BUDGET ACTIVITY: 3 - Advanced Technology Development	PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology / PROJECT: 4400

(U) FY 1997 ($ in Thousands)

- (U) $1,146 Assess selected directed energy weapon threat environment susceptibility/vulnerability of critical space-based sensor and communications subsystems.
  - (U) Perform analytical and experimental verification of selected laser and radio frequency jamming sensor protection techniques.
  - (U) Perform analytical and experimental verification of radio frequency interference mitigation techniques for advanced space communication technologies.
  - (U) Complete ground-based observations of vulnerability to spacecraft-environment interaction threat.
- (U) $3,766 Perform radio frequency/high-powered microwave (HPM) threat warning space-based sensors testing.
  - (U) Integrate radar warning, intrusion/interference, and high powered microwave detector concepts.
  - (U) Optimize/integrate spacecraft signal processor designs.
  - (U) Test integrated radio frequency/high-powered microwave threat warning sensor.
- (U) $440 Select, for evaluation, laser weapon detector technologies for satellites in hostile environments.
  - (U) Develop and evaluate selected pulsed laser detection concepts.
- (U) $426 Evaluate and demonstrate directed energy weapon space sensor and communications jamming protection techniques.
  - (U) Demonstrate satellite communication subsystem front-end radio frequency protection devices.
- (U) $5,778 Total

(U) FY 1998 ($ in Thousands)

- (U) $592 Perform susceptibility/vulnerability assessments of critical space-based subsystems to ambient/enhanced space environments and directed energy weapon threats.
  - (U) Assess hostile/stressing environment impact on subsystem performance parameters.
  - (U) Develop criteria and technical requirements for effects mitigation and subsystem protection.
  - (U) Evaluate protection implications of selected advanced spacecraft technologies.
- (U) $592 Total

(U) FY 1999 ($ in Thousands)

- (U) $ 582 Continue susceptibility/vulnerability assessments of critical space-based subsystems to ambient/enhanced space environments and directed energy weapon threats.
  - (U) Assess hostile/stressing environment impact on subsystem performance parameters.
  - (U) Develop criteria and technical requirements for effects mitigation and subsystem protection.
  - (U) Evaluate protection implications of selected advanced spacecraft technologies.
- (U) $582 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1997
BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology
	PROJECT 4400

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

	FY 1996	FY 1997	FY 1998	FY 1999	Total Cost
(U) Previous President's Budget	3,037	4,049	3,599	3,445	Cont
(U) Current Budget Submit/FY 1998 PB	3,037	5,778	592	582	Cont

(U) Change Summary Explanation:

Funding: Changes in this project since the previous President's Budget are due to budget constraints and priorities within the Science and Technology (S&T) Program.

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 0603410F, Space Systems Environmental Interactions Technology
- (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 1997

BUDGET ACTIVITY: 3 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 4599

COST ($ In Thousands)	FY 1996 Actual	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	Cost to Complete	Total Cost
4599 Reusable Launch Vehicle Technology	23,500	9,579	0	0	0	0	0	0	TBD	TBD

Note: This project was previously called Project 0003, Reusable Launch Vehicle Technology. However, in FY 1996, this project was moved to PE 0603302F, Space and Missile Launch Technology, and renamed Launch Vehicle Technology to allow for Air Force investigation of all reusable and expendable launch technologies. The only funds remaining in Project 0003 in PE 0603401F were the funds added by Congress specifically for Reusable Launch Vehicle technology. To avoid confusion with Project 0003, Launch Vehicle Technology, in PE 0603302F, Project 0003 in PE 0603401F was renumbered Project 4599, keeping its Reusable Launch Vehicle title.

(U) A. Mission Description and Budget Item Justification: This project accounts for the FY1996 and 1997 Congressional adds for Reusable (space) Launch Vehicle (RLV) technology development. This Air Force RLV technology project directly complements and leverages off of the NASA-led RLV program. The spending plan has also been coordinated and approved by NASA Headquarters. The tasks identified in this project summary represent the DoD stake in RLV technology development as recommended by the Space Launch Modernization Plan (SLMP) study.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1997
BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology
	PROJECT 4599

(U) FY 1996 ($ in Thousands)

- (U) $4,500 Apply advanced rocket propulsion technology to Reusable Launch Vehicles (RLVs)
  - (U) Continued modifications to the design of the Integrated Power-Head pre-burner components.
  - (U) Continued demonstration of the advanced long life turbopump fluid film bearing technologies to RLVs.
  - (U) Continued investigation of high performance thrust cell unconventional nozzles and fundamental technologies.
- (U) $4,500 Perform RLV structures/tankage technology development
  - (U) Continued demonstrations of lightweight, RLV structures.
  - (U) Continued demonstrations of RLV composite, cryogenic propellant tanks.
- (U) $2,000 Perform advanced RLV thermal protection system technology development
  - (U) Continued demonstration of lightweight, reusable, maintainable, and affordable RLV thermal protection critical technologies.
- (U) $4,500 Perform advanced RLV operations technology development
  - (U) Continued development and demonstration of reliable, cost-effective RLV ground and flight operations.
  - (U) Developed technologies for integrated avionics and guidance, navigation, and control, vehicle health monitoring, and automated mission planning.
- (U) $2,000 Perform technology development for upperstages as they apply to RLVs
  - (U) Developed concepts and technologies for use in an upperstage.
- (U) $3,000 Perform application and feasibility analyses to assess capability of RLVs to meet military unique needs.
  - (U) Developed concepts and technologies which are necessary to meet the unique needs of the military in its application of an RLV.
- (U) $3,000 Execute and coordinate the Department of Defense RLV program including operations at White Sands.
- (U) $23,500 Total

(U) FY 1997 ($ in Thousands)

- (U) $6,705 Apply advanced military unique technologies to military spaceplanes.
  - (U) Develop an integrated technology testbed to coordinate technology development.
- (U) $958 Perform technology development for upperstages as they apply to military spaceplanes.
  - (U) Continue development of concepts and military unique technologies for use in an upperstage.
- (U) $1,916 Execute and coordinate the Department of Defense Military Spaceplane program including coordination with NASA's X-33 program.
- (U) $9,579 Total

(U) FY 1998: Not Applicable.

(U) FY 1999: Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1997
BUDGET ACTIVITY: 3 - Advanced Technology Development	PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology / PROJECT: 4599

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

	FY 1996	FY 1997	FY 1998	FY 1999	Total Cost
(U) Previous President's Budget	25,000	0	0	0	TBD
(U) Current Budget Submit/FY 1998 PB	23,500	9,579	0	0	TBD

(U) Change Summary Explanation:

Funding: Congress added $25 million in FY 1996 and $10 million in FY 1997 for Reusable Launch Vehicle technology.

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 Launch 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 1997

BUDGET ACTIVITY: 3 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 682J

COST ($ In Thousands)	FY 1996 Actual	FY 1997 Estimate	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	Cost to Complete	Total Cost
682J Space Power and Thermal Management Technology	5,220	4,555	3,999	4,864	6,107	7,920	7,610	7,808	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 programs. This project also funds the development and demonstration of the non-nuclear technologies associated with space nuclear power systems such as power conversion, conditioning, and power system thermal management. In addition, investigations into alternative technologies to increase space vehicle power subsystem performance, lifetime, survivability, and safety while reducing costs/risks. In FY 1995, the Air Force assumed responsibility for the Ballistic Missile Defense Organization's (BMDO's) goal to develop spacecraft thermal management technologies. Examples of this are cryogenic coolers necessary to maintain passive (e.g., infrared focal plane array) sensors in low-light backgrounds through this project.

(U) FY 1996 ($ in Thousands):

- (U) $2,520 Develop space conventional power technologies such as advanced solar cells and arrays.
  - (U) Completed and transitioned multi-junction higher efficiency solar cell technology to the Manufacturing Technology office.
  - (U) Completed development of Thin-Film Roll-out Array for improved stowage and deployment.
  - (U) Flight-tested 'Channel Astro' edge concentrating solar array (150 watts/kilogram) on a small satellite.
- (U) $1,400 Develop space vehicle conventional power technologies such as compact volume/weight batteries.
  - (U) Performed life testing of nickel hydrogen (NiH_2) batteries.
  - (U) Flight-tested sodium sulfur (NaS) batteries.
- (U) $300 Develop non-nuclear technologies associated with space nuclear power systems such as thermionics technology.
  - (U) Initiated more efficient alkali-metal thermal to electric converter cells (25%) development
- (U) $1,000 Develop space vehicle thermal management technology such as cryogenic coolers for infrared focal plane arrays
  - (U) Conducted first phases of single-stage, reverse Brayton-cycle cryocooler development.
- (U) $5,220 Total

(U) FY 1997 ($ in Thousands):

- (U) $2,660 Develop space conventional power technologies such as advanced solar cells and arrays.
  - (U) Flight test Thin Film Roll-Out Array and develop 30% efficient energy conversion devices

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1997
BUDGET ACTIVITY 3 - Advanced Technology Development	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology
	PROJECT 682J

– (U) $1,330 Develop space vehicle conventional power technologies such as compact volume/weight batteries.
  – (U) Continue NiH_2 low earth orbit life testing.
  – (U) Develop 200 watt hour/kilogram (WHr/kg) solid state lithium battery for satellite applications.
– (U) $190 Develop non-nuclear technologies associated with space nuclear power systems such as thermionics technology.
  – (U) Develop 25% alkali metal thermal to electric conversion cells.
  – (U) Design and fabricate thermionic bed power system components for evaluation.
– (U) $375 Develop space vehicle thermal management technology such as cryogenic coolers for infrared focal plane arrays
  – (U) Qualify single-stage reverse Brayton-cycle cryocooler for space applications.
– (U) $4,555 Total

(U) FY 1998 ($ in Thousands)
– (U) $1,977 Develop space conventional power technologies such as advanced solar cells and arrays.
  – (U) Initiate advanced concentrator array follow-on development.
  – (U) Initiate multi-bandgap flight test program.
  – (U) Continue to develop 30% efficient energy conversion devices.
– (U) $1,622 Develop space vehicle conventional power technologies such as compact volume/weight batteries.
  – (U) Expand cooperative development of high power, high efficiency Power Management and Distribution (PMAD) components exploring dc/dc converters and solid state switches.
– (U) $400 Develop space vehicle thermal management technology such as cryogenic coolers for infrared focal plane arrays
  – (U) Fabricate and begin testing of prototype flight unit of single-stage reverse Brayton-cycle cryocooler for space applications.
– (U) $3,999 Total

(U) FY 1999 ($ in Thousands)
– (U) $2,486 Develop space conventional power technologies such as advanced solar cells and arrays.
  – (U) Continue advanced concentrator follow-on.
  – (U) Continue multi-bandgap flight test program.
  – (U) Continue to develop 30% efficient energy conversion devices, fabricate, and test for space environment.
– (U) $1,910 Develop space vehicle conventional power technologies such as compact volume/weight batteries.
  – (U) Continue development of high-power, high efficiency PMAD components focusing on integration into flight test program.
– (U) $468 Develop space vehicle thermal management technology such as cryogenic coolers for infrared focal plane arrays
  – (U) Qualify and test flight test unit of single-stage reverse Brayton-cycle cryocooler for space applications.
– (U) $4,864 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 1997

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
3 - Advanced Technology Development	0603401F Advanced Spacecraft Technology	682J

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

	FY 1996	FY 1997	FY 1998	FY 1999	Total Cost
(U) Previous President's Budget	5,220	4,794	4,884	5,778	Cont
(U) Current Budget Submit/FY 1998 PB	5,220	4,555	3,999	4,864	Cont

(U) Change Summary Explanation:

Funding: Changes to this project since the previous President's Budget are due to budget constraints and priorities within the Science and Technology (S&T) Program.

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 Launch 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.

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