SPACE TEST PROGRAM STATUS REPORT

This status report is published semi-annually by the Space Test Program Office, in accordance with Program Management Directive 2140(42), paragraph III(12). It is distributed to SAF/AQSL, to members of the Space Experiments Review Board, to STP experimenters, and to other organizations upon request. For changes to the distribution list, please contact SMC/TELO, 3550 Aberdeen Ave SE, Kirtland AFB NM 87117-5776, DSN 246-2505.

November 29, 1999 **Volume 5, Issue 1**

STP Mission:

The Air Force Space and Missile Systems Center, Space and Missile Test and Evaluation Directorate's Space Test Program (SMC/TEL) advances space system technology by providing spaceflight for experiments generated within the entire Department of Defense space research and development community. The experiments the program supports fly by priority based on relevance to existing military requirements and the availability of cost-effective means of spaceflight.

2000 DoD SERB Moved to November!

In order to convene the SERB prior to the services' POM cycle, the DoD SERB is rescheduled from April to November. Mid-cycle insertions to the 1999 SERB will be considered at a SERB meeting in April 2000.

1999 DoD SERB Process Results!

The 1999 Department of Defense SERB was held in Crystal City, Virginia, from 13 to 15 April 1999. The results of the DoD SERB are listed below:

1. **C/NOFS** - Communication/Navigation Outage Forecasting System
2. **PASIT-1** – Passive and Active Sensor Integrated Test 1
3. **RAIDS** – Remote Atmospheric & Ionospheric Detection System
4. **STW/AR** - Satellite Threat Warning/Attack Reporting
5. **MU-SIGMA** – Growth of High Aspect Ratio Microstructures for Signature Management
6. **MACE-II** - Middeck Active Control Experiment - Flight II
7. **MODRAS** – MODulating Retro Array in Space
8. **COSMIC** – Constellation Observing System for Meteorology, Ionosphere, and Climate
9. **ADS** – Atmospheric Density Specification
10. **TechSat 21** – Distributed Satellite Technology Demonstration
11. **IMAGE** - Ionospheric Mapping and Geocoronal Experiment
12. **WSSP** – Wafer Scale Signal Processing
13. **SPEDE** – SCARLET Plasma induced Electrostatic Discharge Experiment
14. **CMEWS** – Coronal Mass Ejection Warning System
15. **SIXI** – Silicon X-Ray Imager
16. **FAME** – Full-sky Astrometric Mapping Explorer
17. **REEPER** – Relativistic Electron and Energetic Proton Experiment
18. **TtANOS** – Thermospheric temperature and Nitric Oxide Spectrograph
19. **STL** – Space Tissue Loss

20. **MEPSI** – Micro-Electromechanical Based Autonomous On-Orbit Satellite Inspection Experiment

21. **CloudSat** – Cloud and Aerosol Vertical Profiler

22. **NanoSats** – NanoSatellite Constellation

23. **SHIMMER** – Spatial Heterodyne Imager for Mesospheric Radicals

24. **OISL** – High Speed Optical Inter-Satellite Link

25. **TASSII** – Total and Spectral Solar Irradiance Investigation

26. **PCSat** – Prototype Mobile Communications Satellite

27. **GEOSTORM** – Deep Space 5: Solar Sail

28. **MLPH** – Miniature Loop Heat Pipes

29. **TIMS** – Tactical Ionospheric Monitoring System

30. **AMTEC** – Alkali Metal Thermal-to-Electric Converter Flight Experiment

31. **EMRCE** – Electromagnetic Radiation Control Experiment

32. **OOAM** – Orbiting Ozone and Aerosol Monitor

33. **CITRIS** – Computerized Ionospheric Tomography Receiver in Space

34. **SAPPHIRE** – Test and Evaluation of Micromachined Tunneling Infrared Horizon Detectors

35. **MEMS 2**- Micro-Electromechanical Systems for Space Applications 2

36. **SIMPLEX** – Shuttle Ionospheric Modification with Pulsed Localized Exhaust

37. **GUANDSO** – Global Upper Atmosphere Neutral Density measurements by Stellar Occultations

38. **DAD** – Dust Agglomeration and Dispersion Experiment

39. **OTTI** – Orbiting Technology Testbed Initiative

40. **StOLSS** – Stellar Occultation and Limb Scattering Spectrometer

OPERATING FREEFLYERS

ARGOS (P91-1)

As nearly everybody now knows, ARGOS **successfully** launched on February 23, 1999. ARGOS remains one of the most challenging STP missions; it provides world class experimental and operational space technologies to key agencies within the Air Force, Army, Navy, and BMDO. The three-axis stabilized ARGOS vehicle weighs just under three tons with a 1000 W power system providing an operations platform for nine DoD space experiments. The combined onboard systems and payloads make ARGOS the largest research and development (R&D) satellite to be flown by the Space Test Program. In addition to flight qualifying key components for operational programs, the wide range of experiment objectives include: evaluating superconducting applications, atmospheric research, electric propulsion, next-generation navigation

concepts in lieu of GPS, and prototype leading technologies for space tracking and detection capabilities. The satellite flies in a sun-synchronous, 450 nmi circular orbit.

Since the last newsletter, ARGOS completed Phase II of the mission. Phase II consisted of the short-term experiment objective which include CIV and ESEX. One of ESEX's major achievements was the operation of the **largest** (26 kilowatt) power system **EVER** in space. The CIV experiment observed several Xe releases from ground stations on the East Coast and in Hawaii. In addition, the CIV experiment plans future gas releases as a special operation in Phase III.

ARGOS is well underway in Phase III of the mission, which includes the long duration experiments. GIMI, HIRAAS, HTSSE, and SPADUS are functioning nominally and collecting valuable science data. The USA experiment has been down to collecting data on their fault-tolerant computer experiments while we are trouble-shooting a pointing accuracy problem on the space vehicle. Their computer experiment alone, however, greatly interests BMDO and could lead to cheaper and faster computer systems for future satellites. On a sad note, a saturated detector plagued the EUVIP experiment for much of their operations. Overall the ARGOS mission so far has been an outstanding success and promises to be so for the foreseeable future.

Co-manifested with the ARGOS mission were two secondary spacecraft from Denmark and South Africa, both first-time satellite launches for each country. A coalition of international test teams assembled to support space test programs from the United States, Denmark and South Africa. OERSTED will map the Earth's magnetic fields while SUNSAT will map Earth's gravitational fields. NASA Orbital Launch Services Project provided oversight for these foreign spacecraft.

- Capt Bruce J. Wilder, Mission Manager, SMC/TELS, DSN 246-9323, (505) 846-9323

OPERATIONAL PIGGYBACKS

POAM III (S96-2)

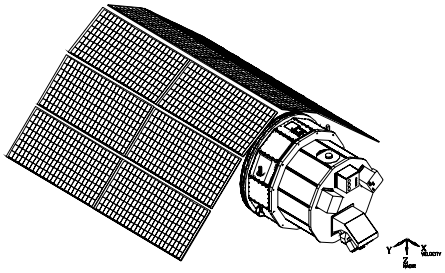
Polar Ozone Aerosol Measurement III (POAM III) is a congressionally mandated follow-on to the POAM II project in support of an integrated NRL effort to globally monitor environmental atmospheric parameters. NRL contracted with the Centre National d'Etudes Spatial (CNES, The French Space Agency) to fly POAM III on the SPOT 4 spacecraft. An Ariane 4 launch vehicle boosted POAM III/SPOT4 to a 833 km sun synchronous orbit from Kourou, French Guiana, in March 1998.

The POAM III experiment has been collecting mission data since on-orbit checkout. The Office of Naval Research (ONR) is paying to collect data using the RDT&E Support Complex (RSC) beyond the STP standard of one year of operations. Thus far, the mission is a 100% success.

- Lt Demian Bailey (USN), Manager, Mission Design, SMC/TELO; DSN 246-8704, (505) 846-8704

MANIFESTED FREE FLYERS

TSX Mission 5 (P95-2)



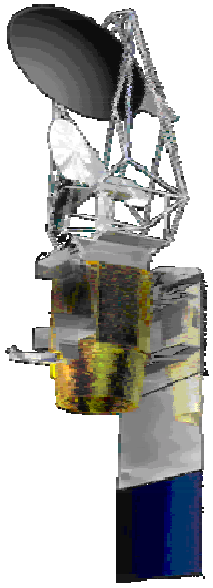
Tri-Service Experiments Mission 5 (TSX-5) is recovering from several setbacks encountered during Integration and Testing of the spacecraft. The program incurred a 4-month schedule delay due to changes made in its Experiment Interface Processor. Identified in Feb 99, these changes were completed in Jun 99. Since that time, the program completed factory compatibility testing, spacecraft integration and testing, and the majority of environmental tests. The TSX-5 program encountered several anomalies seen during thermal vacuum testing. The prime contractor, Orbital Sciences Corporation of McLean, Virginia, resolved these issues and a second thermal vacuum test was performed in late Oct 99. The program is currently working through some software problems. STP anticipates a launch date for TSX-5 in Apr 00.

The two experiments manifested on this mission are STRV-2 and the Compact Environmental Anomaly Sensor Experiment (CEASE). Jointly sponsored by the Ballistic Missile Defense Organization (BMDO) and the United Kingdom's Defense Research Agency (DRA), STRV-2 will evaluate several space technologies. CEASE is an AFRL instrument designed to monitor the damaging radiation environment around the spacecraft. If this demonstration flight is successful, future CEASE instruments may be "bolted on" to operational spacecraft to help predict and detect environmental conditions that may be a threat to the spacecraft.

The Pegasus XL launch vehicle will directly inject TSX-5 into the 69 degree inclined, 410 km x 1750 km mission orbit. The space vehicle will launch from the Western Test Range at Vandenberg AFB, and will be controlled from SMC/TEO's RSC located at Kirtland AFB, NM. The experiments call for a 6-month mission, with a one-year life goal.

- *Capt Kevin D. Benedict, Mission Manager, SMC/TELS, DSN 246-8723, (505) 846-8723*

Coriolis (P98-2)



The Space Test Program contracted for the Coriolis satellite under NASA's Rapid Satellite Acquisition (RSA) process**.** The ONR sponsored WindSat (built by NRL) and the AFRL-sponsored Solar Mass Ejection Imager

(SMEI - built by the University of Birmingham and the University of California San Diego) comprise the Coriolis mission. These experiments should start integration with the spacecraft bus, built by Spectrum Astro Inc (SAI), in April 2001. Coriolis is scheduled to launch 15 Dec 2001, on a Titan II from Vandenberg AFB into an 830-km sun-synchronous orbit at 98.7° inclination.

WindSat's polarimetric radiometer sensor uses 11 feed horns to passively measure five separate frequencies emitting from the ocean. The first year of WindSat's mission will determine the optimal radiometric polarimetry method for accurate detection of wind speed and direction. Years two and three will test the operational feasibility of WindSat as its real-time data will be down-linked to military users of the SMQ-11 and Small Tactical Terminal. WindSat's success will mitigate the risk of the Conical Microwave Imager and Sounder (CMIS) sensor, a radiometric polarimeter, scheduled to fly on the National Polar-orbiting Operational Environmental Satellite System.

The SMEI experiment uses three cameras that will measure the size, shape, speed, frequency, energy flux, mass, and momentum of coronal mass ejections (CMEs). These CMEs cause such problems as geolocation errors, satcom disruption, spacecraft anomalies, satellite drag, and power grid damage. SMEI's success will provide 1-3 days warning of Earth-intersecting solar shocks and mass ejections, including predicted ionospheric impacts on communication, navigation and surveillance.

The spacecraft bus is based on the SA-200HP RSA catalog bus, a low-risk version of the highly successful Deep Space -1 bus, with specific tailoring for the unique requirements of Coriolis.

Currently, SAI has met all contractual delivery requirements and milestone due dates, including its Mission Design Review. SAI will release the final version of the Interface Control Document later this month. Both experiments already held their Critical Design Reviews.

The major performance issue is a mass increase of both WindSat and the spacecraft bus, which necessitated a modification to the spacecraft propulsion tank. SAI is pursuing a new design with a larger propellant tank to regain comfortable margins.

- Maj Paul Dotzler, Project Manager, SMC/TELS, DSN 246-7042, (505) 846-7042

PICOSat (P97-1)
(Formerly known as "Foreign Comparative Test Project")

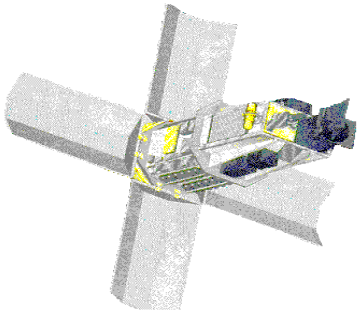
The PICOSat spacecraft is on contract with Surrey Satellite Technology Limited (SSTL) of Guildford, UK. The fully integrated spacecraft completed all system level environmental testing in June 1999. After completion of the spacecraft, the PICOSat Flight Readiness Review was held at Kirtland Air Force Base, New Mexico, on 19 August 1999. The satellite was deemed prepared for launch pending minor outstanding issues and identification of a viable launch vehicle. Currently in storage at the SSTL facility in the UK, PICOSat awaits a firm launch date.

PICOSat is a Foreign Comparative Test (FCT) program sponsored mission. The four experiments manifested on this mission comprise of the **P**olymer Battery Experiment (PBEX), **I**onospheric Occultation Experiment (IOX), **C**oherent Electromagnetic Radio Tomography (CERTO), and **O**ptical Precision Platform Experiment (OPPEX). PBEX is an all-plastic battery that has virtually limitless charge/discharge cycles and other space-favorable characteristics. The CERTO and IOX experiments measure electron content and densities in the ionosphere. OPPEX as an experimental platform will demonstrate active and passive vibration isolation for future precision instrument applications.

The 68kg spacecraft has been completed and ready for launch since early September 1999. STP continues to search for a US secondary launch capable of taking PICOSat to an acceptable orbit.

- Lt Dale White, Mission Manager, SMC/TELS, DSN 246-6406, (505) 846-6406

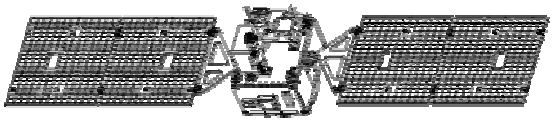
MTI (P97-3)



The Department of Energy's Multi-spectral Thermal Imager (MTI) satellite is complete, along with all system level and environmental testing. The MTI team is currently in mission simulations preparing for the operations of the satellite on orbit. The mission pre-ship review and operations readiness review will take place in mid-December just prior to the satellite being shipped to Vandenberg AFB, California, for launch base processing. MTI ranked #2 on the 1996 DoD SERB list and should launch out of Vandenberg AFB, California, in early February 2000 on a Taurus. MTI will demonstrate and evaluate space-based multi-spectral and thermal imaging technology for military and civilian applications including counter-proliferation and non-proliferation. The 1300 pound three-axis stabilized spacecraft will fly in a 575km sun-synchronous orbit for a three year mission. The Hard X-Ray Spectrometer (HXRS), rated #5 of 33 on the 1996 DoD SERB list, is also manifested as a piggyback experiment on the MTI spacecraft.

- Lt Dale White, Mission Manager, SMC/TELS, DSN 246-6406, (505) 846-6406

MightySat II.1

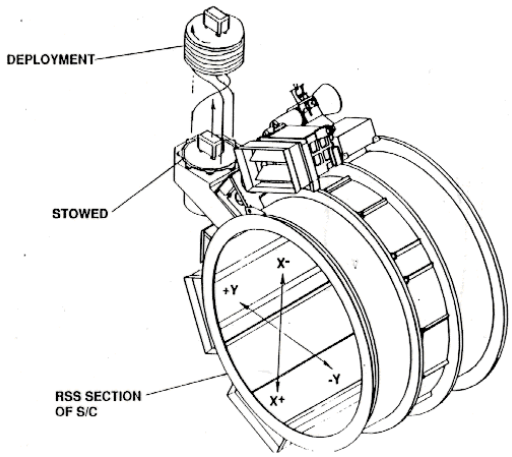


SINDRI (MightySat II.1) is the second satellite in the Air Force Research Laboratory (AFRL) MightySat series. The Space Test Program (STP) agreed to fund the majority of ground operations for MightySat II.1 and contribute funding to MightySat II.1 launch services. According to its objective, the MightySat series provides space flight for AFRL technologies. MightySat II.1 carries a total of nine experiments. The main experiment is Fourier Transform Hyperspectral Imager (FTHSI). FTHSI proves the concept of space-based Fourier transform hyperspectral imager technology. FTHSI contains 256 spectral bands, a spectral region between 470-1050 nm, a swath length of 20 km, and a swath width of 13 km. The experiment is designed to take one picture every three days. The other eight experiments include the Quad-C40 processor (QC40), the Shaped Memory Alloy Thermo-Elastic Tailoring Experiment (SMATTE), a PICOSat Launch Assembly (PLA), a Multi-functional Composite Structure, a Solar Array Concentrator (SAC), a Solar Array Flexible Interconnect (SAFI), the NRL mini SGLS Transponder (NSX) and finally a new type of solar array substrate structure. MightySat II.1 will launch on the SMC/TEB Orbital/Sub-orbital Program mission two (OSP II) into a 300 nmi orbit with a 97.6° inclination and 11:15 nodal crossing time. SMC/TEO RDT&E Support Complex (RSC) at Kirtland AFB, NM, will conduct on-orbit operations. MightySat II.1 recently started system level testing after all the payloads were successfully integrated. STP expects a 25 Apr 00 launch.

- Lt Brandon Wilkerson, Project Manager, SMC/TELS, DSN 263-4221, (505) 853-4221

MANIFESTED PIGGYBACKS

POGS II (S92-1)



The Polar Orbiting Geomagnetic Survey II (POGS II) experiment uses a Special Sensor Magnetometer (SSM) to collect data which will be used to update the geomagnetic maps of the earth. The SSM will be placed on an experimental extendible five-meter boom in order to reduce the effects of electromagnetic noise from the spacecraft. POGS II will be carried onboard a Defense Meteorological Satellite Program (DMSP) spacecraft (Flight S-15), which has a scheduled launch date of December 99 pending the resolution of Solid State Recorder issues with the spacecraft

Following the launch of spacecraft S-15, operational versions of the boom-mounted SSM are planned for DMSP spacecraft S-16 through S-20. This will provide for the collection of

geomagnetic data through the year 2010.

- Lt Dale White, Mission Manager, SMC/TELS DSN 246-6406, (505) 846-6406

HXRS (S97-4)

The Hard X-Ray Spectrometer (HXRS) is fully integrated and has completed all satellite system level and environmental testing with minor technical issues. HXRS, rated #5 of 33 on the 96 DoD SERB list, is manifested as a piggyback experiment on the MTI spacecraft. The HXRS staring sensor design gives advanced warning of Hard X-Ray Solar events. HXRS weighs 6.5 kg and consumes 6 watts of power per orbit. Advanced knowledge of Hard X-Ray events can prevent damage to orbiting spacecraft and prevent radiation injuries to astronauts. HXRS and MTI are slated for a February 2000 launch.

- Lt Dale White, Mission Manager, SMC/TELS, DSN 246-6406, (505) 846-6406

CEASE (S97-1) and CERTO PLUS (S97-2)

The AFRL "Compact Environmental Anomaly Sensor Experiment" (ranked #1 at the 1996 SERB) has been manifested on STRV IC. CEASE, a low power instrument, monitors the environment around a spacecraft and provides alerts when the environment will cause surface charging, deep dielectric charging, single-event upsets and radiation dose effects. The spacecraft builder, the Defense Evaluation and Research Agency (DERA), accepted the delivered CEASE experiment hardware. The CEASE experiment is currently being integrated to the spacecraft, STRV IC.

The Naval Research Laboratory's Coherent Electromagnetic Radio Tomography/Profiling the Limb with Ultraviolet Sensors (CERTO/PLUS) experiment will provide measurements of the integrated electron density of the ionosphere in the satellite orbit plane. CERTO/PLUS has been manifested on the STRV ID spacecraft. CERTO/PLUS will also provide a database for global models of the ionosphere and will test tomographic algorithms for reconstruction of ionospheric densities and irregularities. CERTO and PLUS have been delivered to and accepted by the Defense Evaluation and Research Agency (DERA).

Both spacecraft (STRV IC and ID) are slated for launch into geosynchronous transfer orbit by the same Ariane 5 launch vehicle. STRV IC and ID are spin-stabilized, 100kg-class spacecraft. The system CDR for both spacecraft occurred in March 98 with launch scheduled for first quarter, calendar year 2000.

- *Lt Dale White, Mission Manager, SMC/TELS, DSN 246-6406, (505) 846-6406*

SAVE (S99-1)

The Los Alamos National Lab's Space and Atmospheric Burst Reporting System (SABRS) Space Validation Experiment (SAVE) shall demonstrate a low cost, integrated Nuclear Detonation (NuDet) system for detecting upper atmospheric and space detonations. The mission will verify the ability of the systems to meet mission sensitivity requirements while simultaneously producing acceptable low false alarm rates in the presence of a complex natural space environment, utilizing a new integrated packaging design and an advanced coincidence scheme. SAVE ranked 22 of 40 on the 1998 SERB list and is scheduled to fly with Defense Support Program (DSP) Flight 22 or 23 as a piggyback experiment.

- Lt. Jeff Zdenek, Manager, Mission Design, SMC/TELO, DSN 246-9439, (505) 846-9439

CHAWS-LD on FalconSat 1 (S99-2)

The US Air Force Academy created the FalconSat program to give cadets a hands-on opportunity to design, build, and operate free-flying satellites. FalconSat 1 is the first of this planned series of spacecraft. The payload on FalconSat 1 is Charging Hazards and Wake Studies – Long Duration (CHAWS-LD), ranked 30 of 40 experiments in the 1998 SERB. CHAWS-LD will measure spacecraft electrical charging. The Space Test Program sponsored integration of CHAWS-LD on FalconSat 1.

FalconSat 1 was delivered on 4 Jun 99, to the payload integrator, One Stop Satellite Solutions (OSSS) at Weber State University. OSSS built the cornerstone of the payload suite, the JAWSAT spacecraft/multi-payload adapter. JAWSAT carries three satellites: FalconSat 1, ASUSat from Arizona State University, and OPAL from Stanford University. Additionally, JAWSAT will deploy the Optical Calibration Sphere Experiment (OCSE) built by AFRL. When all other payloads are deployed, JAWSAT itself will separate and operate as a free-flyer spacecraft carrying the PEST experiment from NASA's Marshall Space Flight Center.

The JAWSAT/FalconSat 1 payload suite is scheduled to fly on the inaugural launch of the Orbital/Suborbital Program (OSP) or "Minotaur" launch vehicle. OSP/Minotaur, a four-stage booster, uses the first two stages of a Minuteman II ICBM (M-55 and SR-19 motors) and the second and third stage motors of a Pegasus XL (Orion 50XL and Orion 38) as stages three and four. The first OSP is scheduled to launch from Vandenberg AFB on 8 Dec 99.

- Capt Scott Haskett, Manager, Mission Design, SMC/TELO, DSN 246-8570, (505) 846-8570

PLANNED FREEFLYERS

C/NOFS

The Space Test Program (STP) is planning a new mission to support AFRL's Communications/Navigation Outage Forecasting System (C/NOFS), ranked #1 of 40 experiments in the 1999 SERB. C/NOFS will forecast and specify ionospheric scintillation in the Earth's equatorial region. These scintillations degrade the performance of communication, navigation, and surveillance systems that rely on trans-ionospheric radio wave propagation.

C/NOFS will require a free-flyer spacecraft with body-mounted solar cells (to avoid electromagnetic interference with an electric field experiment in the payload). Furthermore, the spacecraft will be placed in a rather unique orbit – 700km by 400km elliptical orbit at 11° to 15° inclination. STP will operate C/NOFS for one year in a "scientific survey mode." AFRL hopes to then operate C/NOFS for a further two years in an "scintillation forecast" mode.

STP is currently scrubbing the requirements for the C/NOFS mission and should release a Mission Requirements Document by the end of 1999. We are also devising our acquisition strategy. If funding permits, we look forward to awarding a contract for the C/NOFS spacecraft by mid-June 2000.

- *Capt Scott Haskett, Manager, Mission Design, SMC/TELO, DSN 246-8570, (505) 846-8570*

CloudSat

The Space Test Program (STP) is currently working with NASA's Jet Propulsion Laboratory on the CloudSat Mission which will provide cloud base measurements to the DoD and scientific communities. STP committed to provide the on-orbit operations for the CloudSat mission may fly an additional DoD SERB experiment to be identified in late calendar year 1999.

The CloudSat Mission Team at JPL succeeded in winning the required mission funding from NASA's Earth System Science Pathfinder (ESSP) competitive proposal process (Announcement of Opportunity AO-98-OES-01) in April 1999. The CloudSat team at JPL is currently working with STP to define the satellite design features to allow the mission to be flown out of the Research and Development Support Complex (RSC) at Kirtland AFB, New Mexico. CloudSat ranked #21 of 40 on the 1999 DoD SERB list and STP expects a launch in March 2003.

- *Lt Dale White, Mission Manager, SMC/TELS, DSN 246-6406, (505) 846-6406*

COMPLETED SHUTTLE MISSIONS

STS-95
Discovery (OV-103)

The launch of STS-95 on 29 Oct 98, kept STP very busy. The addition of Senator John Glenn made for a highly publicized flight. Since we had four payloads on board it made an important mission for us as well. Capt Nichols, Capt McCamish, and Capt Tavanese trained the crewmembers responsible for the successful operations of the Cell Culture Module (CCM) payload including Sen. John Glenn, Jr., Scott Parazynski, and Chiaki Mukai (Japan), on these procedures. This was just one of the many activities involved in integrating payloads on board the space shuttle.

The Cryogenic Thermal Storage Unit (CRYOTSU) got a ride as a Hitchhiker (HH) experiment designed to generate micro-gravity performance data for future cryogenic/ambient thermal management devices. The experiment was located in the canister that is connected to the HH avionics.

Technology Applications and Science Beryllium Experiment (TASBE), an NRL payload, measured the concentration of Beryllium-7 in Low-Earth-Orbit.

Above: Capt Todd Nichols (at the time, Lt, right) is training Sen. John Glenn, Jr., Scott Parazynski, and Chiaki Mukai (Japan) (right to left) while Capt Amie Tavanese, Capt Shawn McCamish, and Luis Rodriguez provide backup support

Another STP sponsored payload on board includes the Petite Amateur Navy Satellite (PANSAT, NPS-901). PANSAT will provide digital communications using spread spectrum from a low-cost, quick-reaction system.

In addition to integrating PANSAT, we acquired the new Pallet Ejection System (PES) to provide the ejection mechanism for PANSAT. The PES can eject a 150lb satellite, provides more volume in the HH canister than the current ejection system, and can be mounted on top of a HH bridge without the use of a HH canister. PANSAT was installed onto IEH-3 (the HH bridge).

The last DoD payload flown on STS-95 was a middeck experiment, CCM-A. CCM-A is a single locker experiment from the Walter Reed Army Institute of Research and is a tissue atrophy model developed to aid in the investigation of tissue atrophy pathways. The model consists of cultured human or animal cells.

- *Capt Gustavo Hernandez, Chief, DoD Shuttle/ISS Payload Integration and Operations, SMC/TELH, JSC, TX, (281) 483-3425*

STS-88
Endeavor (OV-105)

STS-88 (4 Dec 98) was another successful mission that we worked in 1998. As the first U.S. shuttle flight in support of the ISS, the mission carried the first ISS node, Unity. For this flight, we supported two payloads, Mighty Sat 1 and SIMPLEX.

Mighty Sat 1 ejection from the HH Canister.

AFRL's Mighty Sat 1 (MSAT 1) is a 150lb micro-sat with three primary payloads. Shape-Memory Actuated Release Device (SMARD) demonstrates a low shock alternative release device, Micro-systems and Packaging for Low Power electronics (MAPLE) demonstrates the latest advances in low-power electronics, and Advanced Solar Cell Experiment (ASCE) demonstrates the performance of dual-junction solar cells in space.

SIMPLEX (Shuttle Ionospheric Modification with Pulsed Localized Exhaust) has no flight hardware, but requires orbiter Orbital Maneuvering System (OMS) firings to create ionospheric disturbances for observation by five SIMPLEX radar sites. SIMPLEX characterizes ionospheric disturbances from rocket plumes.

- *Capt Amie Tavanese, Chief, DoD Shuttle Cargo Bay Payloads, SMC/TELH, JSC, TX, (281) 483-3506*

STS-93
Columbia (OV-102)

Throughout the spring and summer of 1999, OLAW focused its efforts on STS-93, which finally launched this past July. The primary objective of the STS-93 mission was to deploy the Chandra X-ray Observatory, formerly known as the Advanced X-ray Astrophysics Facility (AXAF). Chandra is the most sophisticated X-ray observatory ever built and, at 10,560 pounds, the heaviest payload ever deployed from a space shuttle. It was designed to observe X-rays from high-energy regions of the universe, such as hot gases in the remnants of exploded stars.[1] Its highly sophisticated instruments will allow the observatory to detect objects separated by one-half arc second. This is comparable to reading the letters of a stop sign 12 miles away!

Chandra Spacecraft awaiting transportation to pad

Despite the advanced instrumentation and impressive capability noted above, perhaps what is most astonishing about Chandra is the fact that it was even launched at all! On 24 June, The Chandra X-Ray Observatory and attached IUS arrived at pad 39B in preparation for a July 20th launch. However, had things gone as originally planned, the spacecraft would have lifted off late last summer on 27 Aug 98.

[1] Excerpted from STS-93 Web page, http://www.ksc.nasa.gov/shuttle/missions/sts-93/mission-sts-93.html

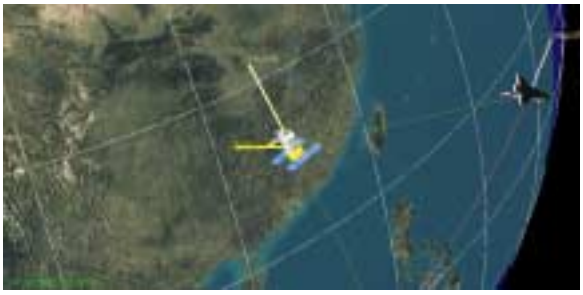
Unfortunately, due to a series of internal instrumentation problems, as well as the highly publicized Air Force IUS failures, delivery and mating of the spacecraft were delayed. Of course, this meant the delay of TELH's six secondary payloads: MSX, SIMPLEX, CCM-C, STL-B, MEMS, and LFSAH, all scheduled for launch on STS-93.

Chandra's bad luck finally passed this summer when Columbia lifted off from Cape Canaveral on its third launch attempt in one week. The observatory was carried into low Earth orbit and deployed from the cargo bay at 155 miles above the Earth. Two firings of an attached Inertial Upper Stage (IUS) rocket (obtained through an agreement with the Air Force) and several firings of its own on-board rocket motors after separating from the Inertial Upper Stage placed the observatory into its working orbit, over one-third of the distance to the moon.[2] Chandra was successfully deployed and more importantly (for STP), all six secondary DoD payloads performed as planned.

STP Payloads on STS-93:

(1) The Midcourse Space Experiment (MSX) has been the premier space technology experiment of the Ballistic Missile Defense Organization (BMDO). The primary objective of the experiment continues calls for the collection and analysis of data on target and background phenomenology using three multi-spectral (ultraviolet, visible, infrared) imaging sensor subsystems.

MSX offers major benefits for both the defense and civilian sectors. With a solid heritage in the successful



Typical set-up for MSX/Shuttle Orbiter Conjunction

Delta series, MSX represents the first system demonstration of technology in space to identify and track ballistic missiles during their midcourse flight phase. The MSX spacecraft features an advanced multi-spectral imaging capability to gather data on test targets and space background phenomena. MSX will also aid future spacecraft design by monitoring and characterizing on-orbit contamination of optical instruments. In addition, its investigation of the composition and dynamics of Earth's atmosphere promises increased understanding of the environment.

The MSX satellite gathered data from the Orbiter's PRCS and OMS engine firings that were used as part of the effort to achieve the MSX objectives.

(2) Shuttle Ionospheric Modification with Pulsed Localized Exhaust (SIMPLEX) was actually a "simple experiment" to study the complex interactions of exhaust vapors with the background atmosphere. This will help us to someday detect, identify, and track the flight of unfriendly space vehicles by using instruments to characterize and interpret the vehicle's exhaust plume.

The ionosphere becomes disturbed with the release of gaseous materials found in exhaust from engines, like those in the Space Shuttle. The gasses react chemically with the ions to produce ion beams. These ion beams move at orbital speeds leaving a trail of

[2] Excerpted from NASA newsroom, http://www1.msfc.nasa.gov/NEWSROOM/background/facts/axaf.htm

turbulence in their wake. Eventually the ions recombine with electrons producing an ionospheric hole covering an area of 30 by 30 miles or greater.

The SIMPLEX experiment monitored the effects of the space shuttle exhaust in the ionosphere using ground based radars located in Massachusetts, Puerto Rico, Peru, Australia, and the Marshall Islands. The SIMPLEX engine burns were scheduled over each radar site. The radar sent up radio wave pulses that scattered off the electrons in the ionosphere. The radar monitored both the turbulence produced by the ion beams and the ultimate reduction in electron density that forms the ionospheric hole.

(3) STS-93 was the maiden voyage of Walter Reed Army Institute of Research's (WRAIR) Cell Culture Module with Cooling (CCM-C). The CCM-C is the sister payload of the CCM, which has been used to support collaborative cell culture experiments since 1994. The CCM-C is identical to the CCM except that it reduces the number of experiment bioreactors to accommodate a resident cooling chamber. This chamber can extend the life of fluids stores that are essential for cell culture nutrients and samples that would normally break down within the 37°C environment of the CCM.

The Kwajelein radar cone depicted above is 40 degrees. The orbiter attitude is Pitch 195.1 degrees, Yaw 0.0 degrees and Roll 0.0 degrees. The view above is looking southeast to northwest.

CCM-C Payload

The CCM-C featured two exciting collaborative experiments that have not previously been flown in space. The first experiment was provided by Dr. Kenton Gregory from the Oregon Medical Laser Center in Portland, OR. It involved endothelialized elastin heterografts, which seeks to demonstrate micro-gravity effects on blood vessel function and gene expression. The second experiment was provided by Dr. Eugenia Wang of McGill University in Montreal, Quebec (Canada). This collaborative experiment studied rapid aging effects and genetic alterations that occur in space and are thought to correlate with on-Earth aging.

STL-B Payload

The CCM-C also flight qualified three different sensors that will be essential for long duration experimentation in space and will also have applications on the ground. The sensors included a miniature pH electrode, developed by NASA Ames Sensors 2000 program, a non-invasive pH sensor developed by engineers at WRAIR, and a non-invasive oxygen sensor developed by Dr. Mark Arnold at the University of Iowa in Iowa City, IA. These sensors were used to determine and record cell growth and metabolism during the mission and allowed feedback control for better, more reproducible experiments.

(4) STS-93 was a unique mission for the Walter Reed Army Institute of Research's (WRAIR) Space Tissue Loss (STL-B) payload. The STL-B allowed scientists to watch how single cells that normally use gravity to guide their development reacted when that guidance system was removed in microgravity. The cells that were watched by the STL-B microscopy module were single spore cells of the fern Ceratopteris richardii. These cells were activated to emerge from dormancy by a light signal. They have a nucleus that starts out in a central position in the cell, where it moves in a kind of random walk restricted near the cell center for the first 20 hours or so after the cells are activated. Then, under the guidance of 1-g on earth, the nucleus suddenly migrates to the lower part of the cell. There it divides, producing two cells, a smaller one that develops into a root-like rhizoid, and a larger one that develops into the leafy part of the plant, the prothallus. The gravity-directed migration of the nucleus exactly predicts the direction of the emergence and growth of the rhizoid after the spore germinates. Furthermore, the unequal cell division that results from the asymmetric positioning of the nucleus after its downward migration may be a prerequisite for two different cell types to form (rhizoid and prothallus). The main objective of the STS-93 STL-B experiment was to find out whether, in the absence of a strong gravity signal, the nucleus would migrate randomly or not at all, and, if not, whether the failure to migrate would prevent normal development of the rhizoid and prothallus.

A second fascinating question to be answered by the STL-B concerned the "random walk" of the nucleus about the center of the cell during the first 20 hours after the spore cell is activated. Molecular motors drive this movement as well as the later downward movement of the nucleus. These molecular motors might need the tension and compression forces that gravity sets up in the cell in order to turn on. The STL-B allowed us to see whether in microgravity the molecular motors operate normally, or fail to turn on, leaving the nucleus motionless in the center of the cell. Continued analysis of the data collected from the STL-B may give us an insight into how these molecular motors, which are common to all plant and animal cells, can be controlled.

MEMS Payload

(5) Micro-Electromechanical Systems (MEMS) have already found their way into our lives (air bag triggers, combustion control sensors, ink jet printer heads, etc…). Using electronics fabrication technology, micro molding, and laser processing, miniature machines are being carved out of silicon and integrated with electronics to form these MEMS. The best advantages of MEMS are their potential uses in spacecraft. MEMS have low weight, low power consumption, and low volume. They are also extremely reliable, low cost, and have a certain amount of autonomy from other systems, making them highly useful for spacecraft.

This program, sponsored by the Air Force Research Lab, Kirtland AFB, NM, is engaged in the first systematic ongoing flight testing of MEMS in order to secure these advantages for space applications. The experiment provided a testbed for micro-devices with specific uses in space. Several types of micro-accelerometers and micro-gyros that can be used for monitoring large spacecraft or navigating miniature spacecraft were tested during the launch phase and on orbit to compare their performance under launch stresses and in micro-gravity. Chemical micro-sensors monitored the middeck environment for traces of potentially harmful gasses (carbon dioxide, methane, and hydrogen). Subminiature arrays of solid rocket motors being developed for attitude control, were tested for configuration stability during launch and for materials stability on orbit. Very high-density nanoelectronic devices were tested for their operational stability in the enhanced radiation environment of space and the performance of a micro-array of thermal control elements was evaluated. These devices all represent functions

LFSAH Payload

(navigation and control, sensing, propulsion, computation, thermal control) that any size spacecraft require. They were chosen for this experiment since the near term goal was to help achieve the advantages of MEMS for all spacecraft.

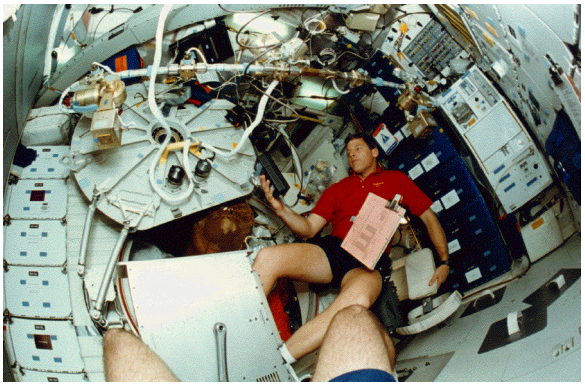
(6) The Lightweight Flexible Solar Array Hinge (LFSAH) experiment, sponsored by the Air Force Research Lab, Kirtland AFB, NM, provided a means to test a lightweight, low shock, reliable mechanism for solar array deployment. Hinges are the primary mechanism used to deploy spacecraft solar arrays that are folded together for launch. Once on-orbit, these solar array systems deploy, or unfold and generate power for the spacecraft. Flight testing of the hinges provided an opportunity to evaluate various hinges in a realistic environment and allowed investigators to verify the mechanical design data and evaluate the dynamic properties of the hinges. The LFSAH consisted of 6 hinges made of shape memory alloys (SMA). The key advantages of a SMA hinge over other hinges includes low-shock controlled deployment, fewer parts, lighter weight, higher reliability, and ease of production and assembly. The LFSAH on STS-93 provided a way to test this technology in a weightless

environment prior to application in a future spacecraft design, including the New Millennium - Earth Observer-1 (EO-1) experiment and the Deep Space 3 (DS3) spacecraft.

- *Capt Todd Nichols, Chief, DoD International Space Station Planning and Utilization, SMC/TELH, JSC, TX, (281) 483-4803*

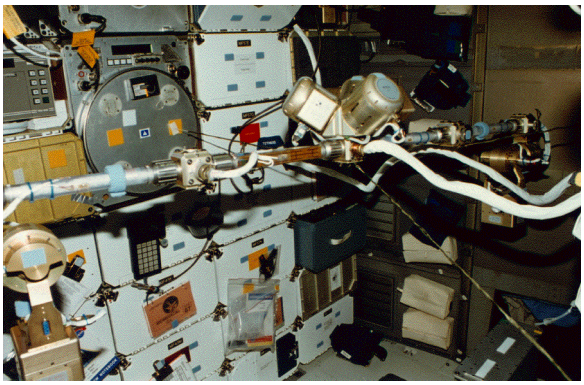
FUTURE SHUTTLE MISSIONS

STS-100 (ISS-08-6A)
Endeavour (OV-105)

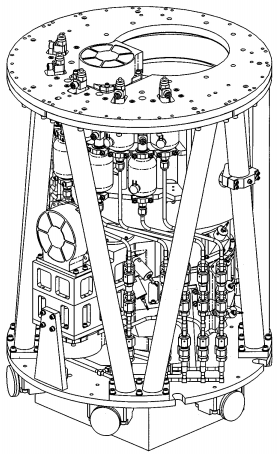


The first DoD payload planned for operation aboard the International Space Station (ISS) is the Middeck Active Control Experiment II (MACE II). MACE II will be a re-flight of MACE, which flew on STS-67 in Mar 95. The primary objectives of MACE II are to validate, in a micro-gravity environment, advanced modeling and control designs for adaptive neural net control and multi-body dynamics and control.

AFRL functions as the lead payload developer with contributions from he Massachusetts Institute of Technology, the University of Michigan, and Virginia Tech.



STS-107
Columbia (OV-102)



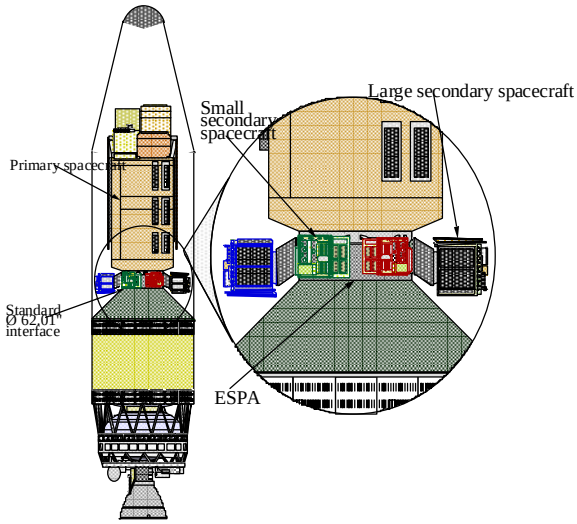
ACSBIRS Structural/Mechanical Design

Active Cleaning Experiments for SBIRS-Low (ACSBIRS) is planning to make its flight aboard the STS-107 mission slated for Jan 01. The technology from the ACSBIRS payload is to be incorporated into the operational SBIRS-Low system. ACSBIRS is being run out of AFRL with Raytheon as the prime contractor. ACSBIRS is a technology demonstration of a CO2 jet spray cleaning technique that can be used as a particulate contamination removal technology in a space environment. The CO2 jet spray cleaning technique will “push” particles from the surface of an optical quality mirror. The surface of the mirror will then be analyzed for cleanliness.

Once the payload has been activated on orbit, ACSBIRS will perform an initial checkout where various components will be powered-up. A calibration mode will then be entered in order to establish a baseline measurement for the cleanliness of the mirror. A cleaning mode will be entered several times throughout the mission, in this configuration; the lid on the canister will be open and the CO2 jet spray cleaning mode will be activated. Before and after the cleaning mode is activated, particle scatter measurements will be taken on the mirror.

TECHNOLOGY DEVELOPMENT

ESPA



STP teamed with AFRL to design, build, and fly the EELV Secondary Payload Adapter (ESPA). ESPA capitalizes on payload margin on EELV-Medium boosters to carry up to six small satellites in addition to the large primary payload. The primary payload can weigh up to 15,000 pounds. Each secondary payload may weigh as much as 400 pounds and is limited to a usable volume of about 24” x 30” x 30”.

Currently, launching small satellites on US expendable launch vehicles costs in excess of $7M. The goal of the ESPA program is to reduce this cost below $1M, and perhaps as low as only $500K, per small satellite. This cost figure assumes six-way launch cost sharing among the secondary payloads (a fully loaded ESPA).

The EELV System Program Office (SMC/MV) initiated special studies with the EELV Prime Contractors (Boeing and Lockheed-Martin) to study the use of ESPA on EELV. These studies should be complete in Dec 99. An Interim Design Review for ESPA is scheduled on 12 Oct 99 at Aerospace in El Segundo. The ESPA Preliminary Design Review is scheduled for Jan 00 in El Segundo (to coincide with completion of the EELV special studies) and CDR is scheduled for Aug 00.

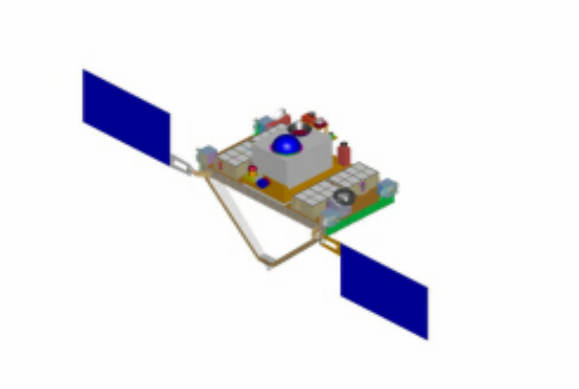
STP hopes to conduct two demonstration launches of ESPA. AFRL will manufacture the flight units. These demo missions were selected on the basis of available margin and the primary payload mission orbit. Beyond these demo launches, we look forward to license the ESPA design to commercial industry to produce flight units for future US Government missions and also for commercial use.

Pending approval from SMC/MV, we hope to fly ESPA with the Defense Meteorological Satellite Program (DMSP) spacecraft, going to polar orbit, in Mar 03. We also hope to fly ESPA with the Defense Satellite Communications System (DSCS) spacecraft, going to geosynchronous transfer orbit, in May 03. Payloads for these ESPA missions have not been defined, but STP would

like to begin a secondary payload manifest process in early 2000.

- Capt Scott Haskett, Manager, Mission Design, SMC/TELO, DSN 246-8570, (505) 846-8570

SPARTAN 400 – PHASE A STUDY



The Spartan Phase A study concluded in late September. The SMC/OLAW (TELH) office at Johnson Space Center (JSC), TX conducted this study that STP funded. The SPARTAN Project office at Goddard Space Flight Center (GSFC) provided the majority of the technical engineering support for the study.

The SPARTAN 400 is a design concept for a standardized, re-usable bus that can be deployed from the Shuttle cargobay and retrieved on a latter Shuttle flight. The study focused on a SPARTAN 401 mission that could accommodate at least eight experiments for a year on orbit, with an additional six-month contingency. The Spartan 401 supports viewing orientation of Nadir/Earth limb or Solar, with up to 750 watts of experiment power, 500 Kbps of experiment telemetry, and a propulsion system that can adjust from Shuttle orbits up to 600km circular, or 350 x 900 km elliptical orbit, and back to a retrievable Shuttle orbit. The diverse and challenging requirements of the STP were rolled into the SPARTAN 400 carrier requirements and the mission concept. As a result, the study found no technical risks that would restrict the development and flight of the SPARTAN 401. The development schedule of the approximately three years and related costs easily compete with the other methods that STP has to get experiments to space. The SPARTAN 400 Phase A Study concluded with a final presentation at Kirtland AFB in late September of 1999.

- Capt Shawn McCamish, Spartan Program Manager, SMC/TELH, JSC, TX, (281) 483-8669

REMINDER TO EXPERIMENTERS

In accordance with AFR 80-2, the new AFI 12-1202, and all STP MOAs, all experiments that utilize STP funds require After Action Reports. A preliminary report is due **no later** than six months after launch. STP requires an updated status report **annually** thereafter upon submission of the preliminary report. A final After Action Report is due six months **after completion** of experiment operations. The standard format for the After Action Report is the DD Form 1721-2, which is available upon request. There are a few overdue After Action Reports and STP would appreciate the experimenters' cooperation in closing them out.

Also, an Experiment Requirements Document (ERD) is one of the most valuable documents in the mission planning process. While the Request for Spaceflight (DD form 1721) provides basic information about an experiment's requirements, it is not sufficient to support the mission planning process be-

yond a very preliminary assessment. In the past, ERDs were only generated when mission planning was nearly complete, usually only when the ERD was needed for the acquisition process (i.e., the Request for Proposal phase). The lack of ERDs has made the initial mission planning process much more difficult. The result has been missed flight opportunities (based on outdated or misleading form 1721 info) or a tedious (for both parties) series of phone calls and/or e-mails to the experimenter to get additional data needed to complete the mission planning process.

STP generated two ERD templates that will help you refine your true experiment requirements (vice goals or desires) and get you thinking about areas that you may not have considered thus far in your planning (such as on-orbit operations scenarios). The full ERD template should be prepared for all experiments that are past the preliminary design review (PDR) stage. This detailed ERD addresses all the information that will be needed to acquire a spacecraft to fly your experiment. The Experiment General Requirements Document (EGRD) is a summary version of the ERD tailored for experiments that are only in the concept stage (prior to experiment PDR) and contains less detailed information about the experiment. STP needs an ERD or EGRD for all SERB listed experiments. Please contact Lt Jeff Zdenek (505-846-9439, DSN 246-9439, or email jeffrey.zdenek @comanche.plk.af.mil) for a copy of the ERD templates. We will be more than happy to assist you in completing your ERD. WITHOUT AN ERD, IT IS MUCH MORE DIFFICULT FOR STP TO FIND A MISSION TO FLY YOUR EXPERIMENT - PLEASE COMPLETE YOURS AS SOON AS POSSIBLE!!

NOTICE: Please be sure to fax back the information sheet on the front of the newsletter or notify us via e-mail/phone of your new address so that SMC/TEL may ensure that the STP Status Report distribution list remains up to date. This will help us better keep track of our customers and allow our customers to know what the Space Test Program is working on.

In addition, if you no longer want to receive our newsletter, or you know someone who should be added to our distribution list, please feel free to let us know. You may annotate this information on your return fax sheet or give us a call.