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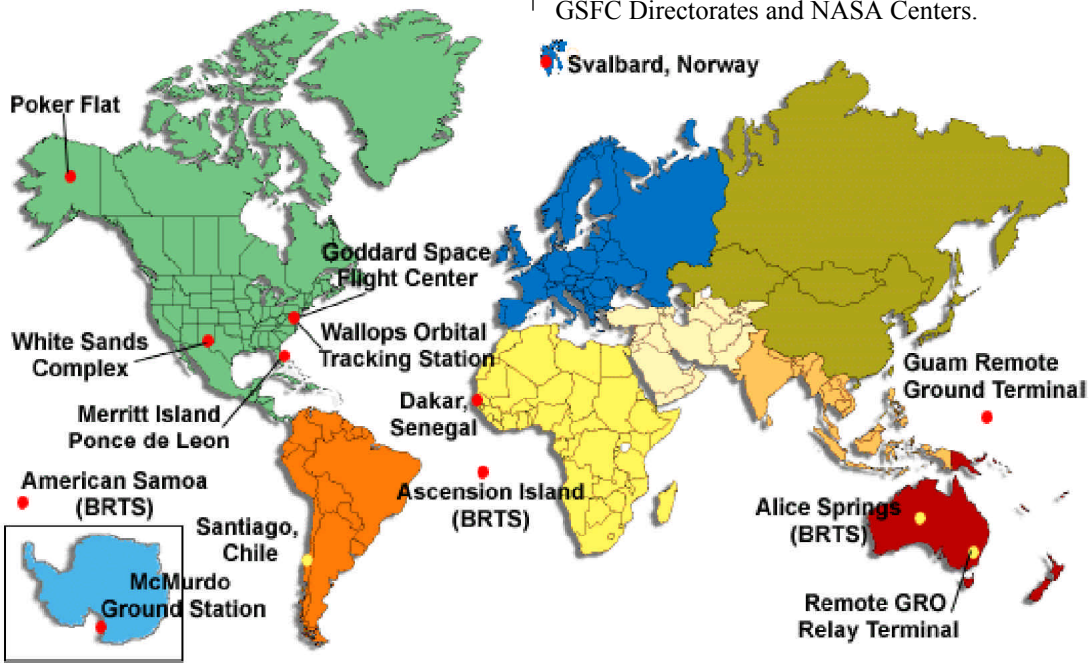
An Overview of the Networks and Mission Services Project Organization

The Networks and Mission Services Project (N&MSP) team was established in December 1997. Mr. Phil Liebrecht, Associate Director of Projects for the N&MSP, leads the Code 450 team. His management staff, Mr. Richard Tagler, Deputy Associate Director of Projects; Mr. William Watson, Center Data Services Manager; and Mr. Richard Harris, Center Mission Services Manager, provide the additional expertise needed to lead the new organization. The organization is comprised of three projects, the Space Network Project (Code 451) led by Mr. Roger Flaherty, the Ground Network Project (Code 452) led by Mr. Steve Currier, and the Mission and Data Systems Project, led by acting Project Manager, Mr. Paul McCeney. The organizational focus is on the management of end-to-end network architectures and space operations, including mission operations, information processing, tracking, and data transport.

The management team and Project staff provide the organization with a wide range of expertise and talent. To accomplish its responsibilities, the N&MSP organization works with other Directorates within Goddard to establish an integrated product development team environment. Key leadership roles include the Center Space Operations Management Office (SOMO) Mission Services Manager, Center SOMO Data Services Manager, Business Manager, Spectrum Manager, Enterprise Customer Support Representatives, and management of space operations contracts. The Center Mission Services Manager and Center Data Services Manager are an integral part of the team, facilitating a mutual understanding of the SOMO-Goddard structures and capabilities. By being a part of the Flight Projects Directorate, the N&MSP organization has gained a closer tie to the scientific community — ultimately, this will enable the N&MSP organization to better understand and meet the needs of its customer community.

The N&MSP charter includes supporting new and future mission concepts, and promoting new operations technology infusion. N&MSP personnel provide technical expertise to space flight projects during the concept and development phases, so that we can effectively plan, coordinate, and direct flight operations of the spacecraft. The N&MSP manages the program planning and direction of NASA's near-earth networks of space and ground based tracking and data communications facilities and systems. The N&MSP directs enhancement programs to provide state-of-the-art integrated mission operations and tracking and data acquisition services and products in collaboration with customers, industry, and other GSFC Directorates and NASA Centers.



The N&MSP organization is responsible for the worldwide set of networks facilities shown above, including Bilateration Ranging Transponder System (BRTS) sites used to manage orbits of Tracking and Data Relay Satellites.

The N&MSP Business Management Office, Code 450.5, provides critical functions to the organization. It is responsible for business management functions and management of the financial resources of the Networks and Mission Services Project. It establishes and maintains service pricing rates and policies, and has been delegated authority to develop and maintain guidelines for implementing the space network use and reimbursement policy. The N&MSP Business Management Office provides business and financial analysis for contract negotiation, performance evaluation board coordination, and cost performance evaluation. It manages and administratively supports planning and analysis of human resources, office space and technical facility space, travel, and training. In addition to its business and financial management functions, the Business Management Office also manages logistics required to support mission operations and tracking and data acquisition services provided by the N&MS Project.

The Space Network Project, Code 451, is responsible for program planning and direction of NASA's near-earth space network tracking and data acquisition facilities and systems in support of spaceflight missions supported by Goddard. It is responsible for managing the definition, design, development, and implementation of evolutionary changes to systems to support continued operation, improve services, and provide new services to customers of the space network. The Space Network Project manages development of the TDRSS Ground Segment and the TDRSS Relay, including resource enhancements such as the Guam Remote Ground Terminal, and TDRSS relays at McMurdo and the South Pole. The Demand Access Project is pioneering new customer service options that minimize infrastructure and reduce complexity and cost to customers. Additionally, the Space Network Project provides launch support for Expendable Launch Vehicles (ELVs).

The Ground Network Project, Code 452, is responsible for managing the operation, maintenance, and development of ground tracking systems. These ground tracking resources provide tracking and data acquisition services for a diverse NASA and non-NASA orbital customer base. The Ground Network Project maintains responsibility for systems performance, planning, systems engineering, requirements analysis, design, implementation, integration, testing, and sustaining engineering of ground network services, including software, hardware, and security. The Ground Network Project is responsible for managing development of the Low Earth Orbit Tracking (LEOT), the Automated Wallops Orbital Tracking Station (AWOTS), the EOS Polar Ground Network (EPGN), the Merritt Island Launch Area (MILA) Bermuda Reengineering (MBR), and the Landsat Ground Station (LGS) efforts.

The Mission and Data Systems Project, Code 453, is responsible for providing management of data and mission operations services to in-flight spacecraft missions following mission orbital verification. Code 453 personnel also plan and manage the reengineering of operational systems to upgrade their capabilities and reduce their operational costs by reducing reliance on legacy systems and by reducing operator requirements. The Mission and Data Systems Project is responsible for managing Mission Operation Centers, Science Data Processing, and Flight Dynamics services and associated facilities for the conduct of on-orbit operations. Code 453 provides management and direction to assure spacecraft-to-ground system compatibility through simulations validation and certification. The Mission and Data Systems Project is responsible for working with space flight projects system engineers, and science investigators regarding spacecraft health and safety, anomaly resolution, and data acquisition, processing, and distribution. It manages activities associated with routine generation of orbit and attitude products for on-orbit missions, as defined by each flight project.

Our customers include each of the NASA Enterprises: Space Science, Earth Science, Human Exploration and Development of Space, and Aeronautics; other U.S. government agencies; universities and the science community; and foreign government agencies. The N&MSP will continue to manage support activities for many missions, including Shuttle, Hubble Space Telescope (HST), Tropical Rainfall Measuring Mission (TRMM) and the Compton Gamma Ray Observatory (CGRO). Operations for the Flight Dynamics Facility; the Sensor Data Processing Facilities; the Space and Ground Networks and numerous Mission Operations Centers, such as Rossi X-Ray Timing Explorer (RXTE); Advanced Composition Explorer (ACE); and Submillimeter Wave Astronomy Satellite (SWAS); are also part of this new organization. In addition, we are looking forward to providing launch and on-board support for customers such as the International Space Station, Landsat-7, EOS AM-1, and other smaller missions such as Quick Scatterometer (QuikSCAT), Microwave Anistropy Probe (MAP), and Imager for Magnetopause-to-Aurora Global Exploration (IMAGE).

*** *To obtain more information about the N&MSP, visit the Code 450 web site at http://nmsp.gsfc.nasa.gov* ***

Consolidated Space Operations Contract (CSOC) to be Awarded Soon

Award of the CSOC contract is scheduled for July 1, 1998. This far-reaching contract encompasses operations across virtually all NASA space operations elements, including GSFC. The contract winner will implement an Integrated Operations Architecture for the conduct of space operations with the goal of cost reduction. Look for more details about this exciting event in the next issue of *The Integrator!*

Network Elements

White Sands Complex News

The White Sands Complex (WSC) has many, many accomplishments to report in this issue of *The Integrator*. The WSC has had a very "full plate" of activities this year including support of the Guam Remote Ground Terminal (GRGT) effort, support of the next generation Tracking and Data Relay Satellites (TDRS H, I, J), installation of a new senior manager, support of Year 2000 testing, the redefinition of our relationship with the White Sands Test Facility (WSTF), and other projects. WSC personnel deserve recognition for the hard work, dedication, and their proven ability to support a number of major projects and changes in such a compressed period of time.

Support of the GRGT project has been the major effort undertaken by WSC personnel in 1998 (see GRGT article on page 23). We are proud to report that the project is currently on time and under budget. The GRGT implementation was accomplished by the reuse of existing design systems and equipment from Space-to-Ground Link Terminal-6 (SGLT-6) from the Cacique. SGLT-6 supports the complete spectrum of TDRS services to customer spacecraft. GRGT assumed control of a Tracking and Data Relay Satellite (TDRS) on Monday, May 4, 1998, for test purposes.

In addition, Cacique will be the first TDRS ground terminal to support the second generation TDRS, known as TDRS H, I, and J. Hughes has completed modifications to SGLT-4 at Cacique and will provide initial training on the modifications to WSC personnel starting on May 13. WSC Engineering, Software Maintenance and Training Facility (SMTF), and Hardware Maintenance Depot (HMD) personnel have directly supported the engineering changes required for the TDRS H, I, J spacecraft and will continue to support this major project.

WSC software has successfully passed all phases of Year 2000 testing. The delivery of the approved software has begun and was completed in the first week of May. This accomplishment is significant, as the WSC software base consists of several million lines of code in Ada, C, FORTRAN, firmware, and other languages.

Recently, Mr. Don Shinners of AlliedSignal Technical Services Corporation (ATSC), was appointed as WSC Senior Manager, replacing Mr. Gardner Rhoderick, formerly of ATSC, who has retired.

The relationship between the WSTF and WSC project has undergone a major change. WSTF has become a full service host to WSC, which in turn has become a tenant organization. Responsibility for WSC's facilities, logistics, and security has been transferred to WSTF. This fundamental change in operations was smoothly accomplished without any disruption to the support of the customer community.

Article by Douglas Perkins/ATSC/WSC Training Coordinator

For more information, please see the WSC Project Office homepage at http://wscproj.gsfc.nasa.gov, or contact Jim Gavura, Station Director, or Bryan Gioannini, Deputy Station Director at (505) 527-7000.

Danzante 10-m and 19-m Antennas at the White Sands Complex

Activities Abound in the Network Control Center!

The Network Control Center (NCC) continues to provide operational support with over a 99.9% operational proficiency. In addition to daily support requirements, the NCC has supported 25 Expendable Launch Vehicle (ELV) launches and three Shuttle missions since November of last year.

Several significant milestones (many of which are described in detail elsewhere in this issue) concerning the NCC have occurred since the last issue of *The Integrator*. TDRS-7 became

available for customer support effective October 27, 1998. However, TDRS-7 will be unavailable for customer support from May 5 - June 9, due to Guam Remote Ground Terminal (GRGT) system acceptance testing.

A new NCC software delivery (97.1) was implemented on October 16, adding Internet Protocol (IP) capability through the NCC Data Systems Protocol Gateway (NPG) and Firewall, for IP customers such as Landsat-7.

The NCC began providing routine support of the Tropical Rainfall Measuring Mission (TRMM) Spacecraft Space Network events starting November 28. TRMM was successfully launched on November 27, along with the National Space Development Agency of Japan's (NASDA's) Engineering Test Satellite VII (ETS-VII). ETS-VII events were declared operational in the NCC on February 5, 1998.

Routine operations for the South Pole TDRSS Relay (SPTR) began on January 5. South Pole Support was turned over to NCC operations effective February 9, 1998.

The NCC also is taking a larger role in tracking Nascom IP transition status and problems. Using the Trouble Tracking Report (TTR) system, all problems reported to the NCC Performance Analysts (PAs) will be documented, followed, and tracked until closure.

The annual NCC safety walk-through was performed on April 16, 1998 with nominal results. Approximately ten minor items were identified and corrected. The NCC continues to maintain an outstanding safety record.

NCC Operations personnel continued work on developing a floor plan for the Auxiliary Network Control Center (ANCC) – currently the Emergency Network Control Center (ENCC) – for the NCC 98 era. The reconfiguration of the ENCC into the ANCC will occur this June through October, during which time NCC Operations will use Room 180 as the operational backup.

The NCC is also planning the implementation of NCC 98 and the NCC floor space reduction. Phase I activities are currently underway, and include the installation of the initial NCC 98 workstations in the front row of the Operations Control Room (OCR). This activity is being followed by Operational Evaluation Testing (OET) in the OCR, which began in May 1998.

During the June-August 1998 time frame, Physical Security and Access Control for the Network Control Center (NCC) will transition from an internal discipline to Code 205.1. Consequently, all personnel who currently have access to the NCC will be required to re-submit their access request. This change will render current NCC key cards inactive by August 1, 1998. Access requests can be completed via the Internet by accessing *http://ncc.gsfc.nasa.gov*

Article by Joe Snyder/ATSC

For more information, please contact Bill Webb at (301) 286-3264 or visit the WWW site cited in the article, above.

NCC 97 Ready to Support Customer Operations

The Network Control Center (NCC) has delivered its final NCC 97 release and is prepared to support full Transmission Control Protocol/Internet Protocol (TCP/IP) customer operations. Through the use of High Availability (HA) software and individual component redundancy, the NCC 97 system provides a secure, reliable IP interface between Mission Operations Centers (MOCs) and the NCC Data System (NCCDS).

The NCC 97 system consists of NCCDS Protocol Gateways (NPGs) and firewalls residing on Sun Ultra-1 UNIX platforms. The NPGs serve as the protocol translators for incoming TCP/IP messages from the MOCs and outgoing 4800 bit blocks from the current NCCDS. The firewalls offer network security, in the form of identification and authentication, to protect this gateway from external attack by unauthorized hosts.

An added feature of the system is a File Transfer Protocol (FTP) capability allowing MOCs to place spacecraft acquisition data in a designated storage area resident on the NPG. These vectors are then translated by the NPG application and provided to the NCCDS. Additionally, the intr□duction of HA software and full reÑundancy to the NCC 97 system allows full operations support to Space Network (SN) customers 24 hours a day and 7 days per week prior to the implementation of NCC 98.

This project has made great strides since its inception in early 1997 and it would not have been realized without the outstanding efforts of the development and test teams. Their dedication to this task made it possible for the NCC to offer SN customers uninterrupted operations support in a time of transition.

Article by Steve Simmons/BA&H

For more information on NCC 97, please contact Roger Clason at (301) 286-7431.

NCC Firewall Complete

The NCC 97 Firewall team is happy to report the successful conclusion of another phase of security enforcement. The NCC 97 Firewall is currently delivered and fully operational. Operational testing is now going on weekly between TCP/IP customers and NCC 97. The Firewall provides security for NCC 97 and isolates its components from the hostile world outside.

The Firewall controls message traffic between the NCC 97 components and the external sources that it communicates with using TCP/IP. This control is accomplished through the use of rule sets that completely specify what traffic is permitted or excluded for each interaction between the external sources and the NCC Data System (NCCDS). The Firewall will not permit any communications that are not explicitly allowed by the rule set.

The Firewall also provides administrative functions that include logging, start up, shut down, and high availability operation via automatic switchover between the operational unit and a redundant backup unit. Rule set maintenance is also supported.

In addition to the Firewall software, other software residing on the workstation consists of Domain Name Services (DNS), Network Time Protocol (NTP), and Mproxy. DNS resolves addresses with NCC 97 and the Closed IP Operational Network (IONET). NTP places NCC 97 workstations in time synchronization with workstations on the Closed IONET. Mproxy receives multicast traffic for the NCCDS and converts it to unicast traffic for transmission to the Network Protocol Gateway (NPG). It also receives unicast traffic from the NPG and converts it to multicast traffic when applicable.

As its next step, the Firewall development team is building the full rules set for all the NCC 98 components. These components include a Web server and FTP server that are isolated in a demilitarized zone (DMZ). By limiting access to critical functionality, the full rules set will help protect the NCC 98 components while it serves outside customers.

Article by Reine Chimiak/ GSFC Code 583, Mary Foote/CSC, and Frank Weinstein/CSC

For further information, please contact Reine Chimiak at (301) 286-3469 or via email at reine.chimiak@gsfc.nasa.gov

NCC 98 Enters Final Phase of Testing

Following successful integration of new equipment in the operations environment, the final NCC 98 system configuration is prepared to begin Operations Evaluation Testing (OET), as conducted by the Network Systems Integration and Analysis (NSIA) team. This phase of testing will mark the end of major development efforts and offer validation of the system from an operations perspective.

Recall that NCC 98 will provide customers increased Space Network resource scheduling flexibility; scheduling of new TDRS H, I, J services as they become available; and the ability to communicate with the NCC via either 4800 bit blocks or Transmission Control Protocol/Internet Protocol (TCP/IP). To accomplish these goals and reduce the cost of operations, NCC 98 is utilizing Commercial Off The Shelf (COTS) technology and migrating the current system to a networked Client/Server environment.

To prepare for OET, development is being completed on major subsystems such as the Service Planning Segment Replacement (SPSR), Communications and Control Segment, Network and Systems Management (NSM) system, NCCDS Protocol Gateway (NPG), and the Firewall. Additionally, enhancements to ancillary systems such as the Central Delogger, TDRSS Unscheduled Time (TUT)/File Transfer Protocol (FTP) server, Automated Conflict Resolution System (ACRS), and Service Accounting Segment (SAS) have been completed or are currently underway. Lessons learned from the recent development and testing of the NCC 97 system will aid NSIA and the development teams in identifying and resolving anomalies in Firewall and NPG operations, as well as providing insight into the NCC's interface with Nascom's IP Transition Network. Experience gained in these areas should reduce the amount of problems encountered during testing.

During the OET phase, full external testing will be performed with Space Network customers and elements using the new NCC 98 operations environment. These Engineering Interface (EIF) tests will verify IP connectivity; test TDRS H, I, J scheduling; and provide Year 2000 compatibility verification. Baseline customers will not be affected by the NCC 98 upgrade; however, regression testing will be performed with all SN customers to ensure full backward compatibility with the new system. EIF tests with customers choosing to take advantage of flexible scheduling and/or TDRS H, I, J enhanced services will also be conducted, as requested by the customer, and will require minor database changes only.

The system test effort is currently behind schedule; test cases are not being completed on time. Currently, a schedule re-evaluation is in progress, and a three- to six- month schedule slip is expected. Mitigating options, such as limited overtime and use of additional test facilities, are being explored.

As always, customers who choose to migrate their communications interface with the NCC to TCP/IP are welcome. Following NCC 98 transition to operations, receiving TUT information will be as easy as accessing a web page from a commercial browser, provided that the customer has connectivity to the closed IP Operational Network (IONET). Additionally, the NCC is capable of receiving and storing spacecraft vectors directly from a Mission Operations Center (MOC) via FTP.

Article by Steve Simmons/BA&H

For further information, please contact Roger Clason at (301) 286-7431.

Nascom Internet Protocol Transition To Finish This Summer

Nascom engineers are diligently working to implement the complex transition from 4800 bit block data transport protocol to utilization of Internet Protocol (IP) by July 1998. The rapidly approaching deadline was recently instituted by Nascom and NASA Integrated Support Network (NISN) management for budgetary reasons.

To accomplish the transition, Nascom has installed conversion devices [either the Small Conversion Device (SCD) or Programmable Telemetry Processor (PTP)] at each customer site where the Message Switching System (MSS) or Multiplexer/Demultiplexer (MDM) systems are used. By November 1997, all MSS and MDM sites had conversion devices installed. Currently, the AlliedSignal Technical Services Corporation (ATSC) Network Integration and Analysis Team is working with Nascom engineers and customers to test the IP implementation at each site. After testing is completed at a particular site, the site will move operations to the new IP network permanently.

A new release of the router software used in the new IP system, Release 12.01, was delivered on March 9, 1998. It was tested and then deployed at the Jet Propulsion Lab, Onizuka Air Force Base, Ames Research Center, and Redondo Beach prior to the STS 90 mission. The experiences gained as a result of this installation process proved valuable when the new release was deployed throughout the network immediately after the STS 90 mission. This new release moved Multicast Open Shortest Path First (MOSPF) support to a fully COTS software environment and allows for improved network management.

In addition, NISN and Nascom management recently approved new policy statements and definitions describing the roles and responsibilities of Nascom/NISN and customers during and after the IP transition. Many customers had further questions and concerns, and as a result, Nascom is authoring a new User Maintenance Plan, available in May, that will address these issues.

The IP Transition Homepage (see URL below) is now updated weekly to ensure accuracy. Monthly status reports, the IP Transition Plan, Test Approach, and other information are available. The IP Transition Status Presentation given at the latest NISN User Forum in February 1998 as well as the new policy statements issued by Nascom/NISN can also be obtained at this site.

To obtain further technical information and points of contact concerning the Nascom IP transition effort, refer to the IP Transition Homepage at http://skynet.gsfc.nasa.gov/transition/ip-main.htm or contact IP Transition Manager, Scott Douglas at (301) 286-9550.

Nascom's New Secure Gateway Nearly Ready for Operational Use

The NASA Communications Division is nearing the completion of many configuration and software capability changes, including the IP transition (see previous article). Once these changes are accomplished, the new Secure Gateway system will be considered for operational use. Currently, Nascom is working between Shuttle mission freezes to put on the "finishing touches."

Nascom is asking all projects that make use of the Secure Gateway to contact Matthew Kirichok (see contact information, below) and notify him of a primary and secondary (if any) security point of contact. Mr. Kirichok will work with the points of contact from each project, providing an explanation of how the project will use the new Secure Gateway, and coordinating the changes that will be required to use the gateway. This effort will also allow Nascom to maintain an up-to-date list of the points of contact for each project, which is especially vital in light of the recent reorganization that took place at GSFC.

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In addition to coordinating the switch to the new Secure Gateway system, Nascom is working on a more automated means of submitting Secure Gateway requests. It is very important for all projects using the Nascom Secure Gateway to provide a primary and secondary (if any) point of contact, since Nascom will allow only these personnel to submit Secure Gateway requests in the future. With the new automated means of submitting Secure Gateway requests, the points of contact for each project will be able to log onto a Web server to submit their Secure Gateway requests, and to access reports on the current status and a listing of previous requests that they have submitted.

Nascom will also require all projects that use the Secure Gateway to re-evaluate their mission requirements and to submit deletions to those services that are no longer required or needed. Currently, there are numerous obsolete rules based on old Secure Gateway requests, because many projects forget to notify Nascom when services are no longer required. If a service is not used but is still in place, others can possibly exploit the service and gain unauthorized access. Thus, these unneeded rules increase the possibility of security breaches, thereby weakening the protection provided to other projects.

Secure Gateway request forms and Domain Name Services (DNS) request forms can be located at the WWW site: *http://skynet.gsfc.nasa.gov/IONET* When the new automated procedures are implemented, information on how to submit Secure Gateway requests will be posted at this location also.

Article by Matthew Kirichok/GSFC Code 241

For more information, please check out the URL listed above, or contact the author at (301) 286-3435 or via email at matthew.kirichok@gsfc.nasa.gov

NASA's TDRS-1 Satellite Celebrates Fifteen-Year Anniversary

Just like the Timex commercial, NASA's first Tracking and Data Relay Satellite (TDRS-1) spacecraft took a licking and keeps on ticking. Designed to operate for up to ten years, TDRS-1 is at T+15 years and still going strong.

TDRS-1 overcame numerous post-launch anomalies to become quite a success story. Sent into a rapid tumble by a problem with the second stage of the Inertial Upper Stage booster, TDRS-1 temporarily lost all communications with the ground stations. Communications were re-established with the spacecraft within three hours and the tumble was brought under control, but TDRS-1 was in an orbit far too low to perform its intended mission. NASA engineers managed to deploy the spacecraft's solar arrays, space-to-ground link antenna, and Single Access antennas. Over the next three months, NASA engineers boosted TDRS-1 into its proper orbit. By June 1983, the spacecraft once thought to be severely damaged, initiated customer support services with NASA's Landsat-4 satellite and STS-9 spacelab mission.

Fifteen years later, TDRS-1 continues to provide excellent communication services for NASA's Space Shuttles, Hubble Space Telescope, Gamma Ray Observatory, and numerous other satellites.

"TDRS-1 is the only NASA satellite providing data relay service to and from the South Pole," said Dick Schonbachler, Mission Manager for the Operations Management Group at Goddard. "During a daily three-hour window, the spacecraft is able to provide two-way, high speed communications with the South Pole. Data coming from the South Pole via TDRS-1 is downlinked to NASA's ground station located in White Sands, NM, and then transmitted to scientists located at Goddard and around the world."

Since the launch of TDRS-1 in April 1983, NASA has successfully commissioned five other TDRS satellites, thus creating a communications capability to serve NASA and the scientific community well into the twenty-first century. Not too shabby for a satellite many feared would never reach its intended orbit.

Article by Susan Hendrix/GSFC Office of Public Affairs

All About the Multi-Mission Flight Dynamics Facility

The Multi-Mission Flight Dynamics (MMFD) Facility is located in Building 28 on the Second Floor in the North Wing. This facility used to be the GSFC institutional Flight Dynamics Facility managed by Code 550 before the "Project Goddard" reorganization. It is now managed and operated by the Consolidated Network and Mission Operations Support (CNMOS) team of AlliedSignal Technical Services Corporation (ATSC), Computer Sciences Corporation (CSC), and RMS personnel for Code 453 as part of the Mission and Data Systems Project.

The CNMOS team provides navigation, acquisition, launch, attitude, mission

design, and tracking network support for a multitude of customers under several CNMOS Service Level Agreements (SLAs) and General Support Agreements (GSAs). Flight Dynamics Mission Specialists are assigned to each mission to ensure that mission requirements are being adequately met. Personnel are being trained to support all aspects of flight dynamics rather than to be experts in any one flight dynamics function. This is a recent change instituted to cope with budget reductions, while continuing to support ongoing operations and new missions. Flight dynamics expertise is also being loaned out to the Mission Operations Control Centers (MOCCs) to facilitate the concept of incorporating flight dynamics functions in the MOCCs.

The MMFD legacy systems are primarily on an HP/UNIX platform and are the only systems across all NASA centers that can support the variety of data formats needed for manned or unmanned, low earth to deep space, and powered flight or free flight mission phases.

Navigation services provided by the MMFD Facility include orbit determination, ephemeris generation, on-board orbit representation/validation, and maintenance of navigation models.

Acquisition services include generation of state vectors, antenna pointing parameters, planning aids, and event predictions to support the Space and Ground Networks. These services have been extended to non-NASA and foreign sites as needed.

Launch services provided include pre-mission launch trajectory analysis, pre-mission acquisition data, and real-time vehicle and satellite state estimation. The facility has been a key element in the use of TDRSS for Expendable Launch Vehicle launches and has worked one-on-one with the customer to accommodate new data formats for this service.

Launch services also include Shuttle acquisition data support from launch through landing, tracking data evaluation and backup orbit determination support, and providing trajectory related displays. Among other enhancements for Shuttle support, the MMFD team has recommended innovative ways of supporting maneuver sequences and ditch cases using the Space Network.

The MMFD Facility currently provides attitude services support to 12 missions. Support includes attitude determination for spinning and 3-axis stabilized spacecraft, design and execution of maneuvers for attitude control, and sensor calibration to enhance attitude determination accuracy.

Mission Design Services include selection of orbit and maneuver scenarios based on mission requirements, thruster sizing and configurations, spacecraft hardware selection and modeling, fuel budgets, launch windows, and contact frequencies. The MMFD team played an essential role in the WIND Extended Mission Trajectory Design.

The MMFD Facility is responsible for tracking support services including validation and calibration of the tracking network, integration and certification of new/modified tracking sites, antenna error modeling, and algorithm development for new tracker types. These services also include support of new satellites in the area of center frequency determination and oscillator stability studies.

Article by Shuby Ambardekar/CNMOS

For more information, please contact the facility owner Mr. William Struthers/ GSFC Code 585 at (301) 286-6223 or the MMFD Manager Dr. Scott Wallace/ CNMOS at (301) 286-5314.

Sensor Data Processing Facility Supports Noteworthy Launch

The Sensor Data Processing Facility (SDPF) celebrated Thanksgiving Day in 1997 by supporting the Tropical Rainfall Measuring Mission (TRMM) launch on November 27. The addition of TRMM to Pacor (Packet Processor) was notable in that no software changes were required to process TRMM data. Since TRMM is a Consultative Committee for Space Data Systems (CCSDS) compliant mission, the only changes required were database table updates. TRMM is the last mission planned for inclusion in Pacor multi-mission support. Pacor currently supports the Hubble Space Telescope (HST); Compton Gamma Ray Observatory (CGRO); Rossi X-Ray Timing Explorer (RXTE); and Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) missions.

In addition, two SDPF team members recently received recognition for their outstanding support during HST's Second Servicing Mission (SM-2). Yak Zinkewych (ATSC) and Angela Manifold (ATSC) each received the Space Flight Awareness Award. As analysts for Pacor, their responsibilities included SM-2 test support, extensive pre-launch test data analysis and anomaly investigation, and the development of SM-2 operating procedures. The most significant part of their support occurred during the mission itself. Their preparation and knowledge of the system allowed them to verify the new HST instruments, the Space Telescope Imaging Spectrograph (STIS), and the Near Infrared Camera and Multi-Object Spectrometer (NICMOS), within three minutes of their installation. This quick response time increased the safety of the astronauts by shortening the length of

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Extra-Vehicular Activity 1 (EVA1). Angela went to KSC to receive her award in December, and Yak will go during May. Congratulations!

Article by Don Davenport/ATSC and Joan Frank/ATSC

For further information, please contact Don Davenport via email at donald.g.davenport.1@gsfc.nasa.gov

User Planning System 98 Development Continues On Schedule

User Planning System (UPS) 98 development continues in parallel with that of its counterpart project, NCC 98 (see article, page 6). Several UPS builds are scheduled during development, culminating in Release 12 Build 2, the operational release for UPS 98, which will support all NCC 98 flexible scheduling capabilities.

Recently, UPS Release 11 Build 2 Internet Protocol (IP) capability was verified during Landsat-7 spacecraft simulations involving NCC operations. Release 11 Build 3 will provide support for the year 2000 (see *The Integrator*, November 1997, page 7) and will be developed in September. Release 12 Build 1, the first UPS 98 release, will not be an operational release, although it will be tested extensively with NCC 98 starting in early June. All Release 12 builds will support communications with the NCC via IP only.

Testing of Release 12 Build 2 is scheduled to complete in September 1998. The release cannot become operational, however, until after NCC 98 is operational. To reduce the risk associated with fallback, UPS 98 will probably not be promoted to operations until after NCC 98 has been operational for at least one month.

In addition, several UPS customers are presently upgrading or planning to upgrade their UPS hardware. The Hubble Space Telescope (HST) project is in the process of testing their new Hewlett-Packard hardware systems. Shuttle operations personnel at the Johnson Spaceflight Center (JSC) are currently procuring a Hewlett-Packard upgrade to their UPS Dec platform. Discussions with the STARLink Project concerning their hardware alternatives are also in the works.

Article by John Brown/CSC

Further information regarding the UPS project can be found on the WWW at http://isolde.gsfc.nasa.gov/ups/ or contact the author via email at John.e.Brown@gsfc.nasa.gov

TDRS H, I, J Spacecraft

TDRS-H is scheduled for launch in July 1999. You can find additional details about this project by visiting the Code 400 Flight Projects web page (*http://fpd.gsfc.nasa.gov/projects.html*) and choosing to view information about Code 405's Tracking and Data Relay Satellite project.

Merritt Island Launch Area/Bermuda Reengineering Effort Progresses

Motivated by the necessity to modernize the last remaining Spaceflight Data and Tracking Network (STDN) tracking stations, the Project was initiated in late 1995. Automated technology experience gained from earlier involvement in the GRO Remote Terminal System (GRTS) and the Automated Ground Network Systems (AGNES) has been applied to the reengineering initiative.

Hardware procurement began in late 1995. The system design review was conducted in March 1996. Major subsystem design reviews were completed in 1997.

Originally planned to take place in three phases, the initial phase was completed in mid-1997 with the installation of digital recorders at the Merritt Island Launch Area (MILA), Ponce de Leon (PDL), and Bermuda. These recorders have successfully supported STS-87, 89, 90, and 91.

Early in 1998, work was halted on reengineering the Bermuda station. Subsequently it was decided to phase out Bermuda S- and C-band capabilities as the result of changing support requirements. Bermuda C-band capabilities ceased in April 1998. By October 1, 1998, S-band capabilities will also cease, and the Bermuda tracking station will be reduced to providing UHF air-to-ground voice capability only in support of Shuttle launches.

Later in 1998, the decision was made to replace the MILA - PDL microwave communications link with new multiplex equipment connected by a leased landline. The multiplex equipment provides the additional channel capacity needed to automate the PDL station. The new multiplexers are currently being installed and checked out.

In May 1998, the final hardware installation was scheduled to be completed at MILA and PDL. In-house testing of the new configuration will follow. Initial interface tests with the Goddard Mission Operation Support Area (MOSA) and JSC have been scheduled.

The next software upgrades and final equipment configurations will be installed and tested in the MILA and PDL computers following the STS 91 mission. The software delivery is planned for June 8. It will include new Remote Control Interface capabilities, automatic backup capability for the Mission Database, and installation of UHF Air to Ground remote control at PDL.

As the MBR Project nears completion, significant operating cost reductions are being realized through staff reductions. Additional Project objectives will be met in the future as the modernized stations at MILA and PDL will provide a more flexible architecture to accommodate future upgrades at lower cost. The ongoing cost of sustaining engineering is also expected to be lower.

The Project is currently on schedule. The target date for completion is October 5, 1998.

Article by Ben Gallup/BA&H

For more information, contact Frank Stocklin at (301) 286-6339 or via email at Frank.Stocklin@gsfc.nasa.gov

Scientists Pleased With South Pole TDRS Relay Capabilities

The South Pole TDRS Relay (SPTR) was designed this past year and installed at the south pole in December 1997. Its main purpose is to enable Internet connectivity from the Continental US to the south pole through TDRS. The SPTR allows scientists to use the Internet to retrieve data from instruments at the south pole, and to send information to the pole for reconfiguring instruments, all from a desktop computer at the office or even from home!

The SPTR consists of a 1 Mbps S-Band duplex link and a high-rate K-Band return only (currently running at 2 Mbps but with 50 Mbps capability for future expansion). SPTR uses TDRS-1, which is over 15 years old, (see article, page 26) and has sufficient orbital inclination to be visible at the south pole for about 3.5 hours each day. Scientists throughout the country retrieve large amounts of data (3 Gbytes per day) during the visibility period. The SPTR effort is a collaboration between NASA and the National Science Foundation, which manages the south pole station and sponsors many of the scientific investigations.

In addition to the challenge of installing and operating this equipment in the harsh south pole environment (-50º F but surprisingly little wind), SPTR demonstrates the ability to use TCP/IP protocol at relatively high rates through a relay satellite. There was some question as to whether this could be achieved; now the SPTR has proven the technology.

Indications from the science community are that scientists are delighted by the performance of SPTR, as evidenced by the usage, which is monitored daily. Scientists now have access to large volumes of data in almost real time – a scientist's dream. Code 560 Engineers continue to monitor the SPTR status and usage from a desktop PC and to manage the file server at the White Sands Complex keeping SPTR running smoothly. We eagerly await the opportunity to extend operation to the 50 Mbps level and hope that TDRS-1 continues its long, long successful life.

Article by Frank Stocklin/GSFC Code 450.4

For more information regarding this effort, please contact the author via email at Frank.Stocklin@gsfc.nasa.gov

McMurdo TDRS Relay System Going Strong

The McMurdo TDRS Relay System (MTRS) continues to perform well. GSFC folks on their way to the south pole for the South Pole TDRS Relay project (see article above) performed some minor upgrades/fixes to MTRS during their recent visit. In addition to its normal support of RADARSAT data, MTRS recently was part of a demonstration of potential weather satellite support from the Antarctic region. MTRS has survived two winters and is approaching its third — not bad for a "proof of concept" system. MTRS status and health continue to be monitored from a desktop PC at GSFC. GSFC personnel are currently working on plans for an upgrade effort we hope to implement next season.

Article by Frank Stocklin/GSFC Code 450.4

For more information regarding this effort, please contact the author via email at Frank.Stocklin@gsfc.nasa.gov

Network Customers

The Compton Gamma Ray Observatory

The Compton Gamma Ray Observatory (CGRO), launched in April 1991 by the space shuttle Atlantis, is currently in its seventh year of operations. The spacecraft and its various subsystems are, for the most part, continuing to function well, and scientific results continue to accumulate. There have been some subsystem anomalies — one of the gyroscope motor currents increased and exhibited mild fluctuations, but it has not yet exceeded accepted design limits. Automation of a number of flight operations activities using theReduced Operations By Optimizing Tasks and Technologies (ROBOTT) software system (see the November 1997 issue of *The Integrator*, page 8) has now been implemented. ROBOTT now performs health and safety monitoring operations at night and on weekends. So far, this has been accomplished without any loss of scientific data or the occurrence of any spacecraft operational difficulties.

The scientific instruments are mainly performing in a near flawless manner. A few problems have occurred; one component of the Energetic Gamma Ray Experiment Telescope (EGRET) spark chamber failed during the fall of 1997, resulting in event recognition efficiency at a level of only about 25% that at launch. However, turning off the failed component has reduced spurious sparking, and thus will reduce gas consumption and extend the life of the instrument. Even in its reduced mode of operation, EGRET has discovered yet another gamma-ray quasar!

The Oriented Scintillation Spectrometer Experiment (OSSE) continues to operate nominally. No component or subsystem failures have occurred and no redundant systems have been activated. The Imaging Compton Telescope (COMPTEL) has been stable for several years with 6 out of 7 upper detector modules and all 14 lower detector modules still operating. Each of the Burst and Transient Source Experiment (BATSE) detectors is operating properly. Some small gain changes have been made, but voltages are still well below limits. BATSE's anticipated useful lifetime is another 5-10 years!

Recent studies using CGRO data have revealed new information about our own Sun. Usually, we receive little gamma radiation from the Sun, but, there are brief spasms of intense gamma ray production during rare, very large solar flare explosions. The solar flares occur in loops of magnetic field that extend high into the solar atmosphere, emanating from points on or near the visible surface. The gamma rays from the flares were widely believed to be generated by electrons accelerated to enormous speeds by physical processes in the explosions. There are also gamma-ray emission lines, associated with nuclear reactions.

Observations made by CGRO only a few months into its orbital life, however, revealed unexpected results. Recordings made with two CGRO instruments, EGRET and COMPTEL, of the gamma ray emissions from several large solar flares, revealed that the gamma rays from these explosions sometimes stream outward from the flare sites for as much as eight hours after the flare erupted. This means that a flare does not just blast electrons at enormous speeds, it sets up a natural cyclotron or particle accelerator that runs for hours afterwards, somewhat like huge particle accelerators used for laboratory physics studies on Earth.

Some other examples of recent scientific discoveries include a possible

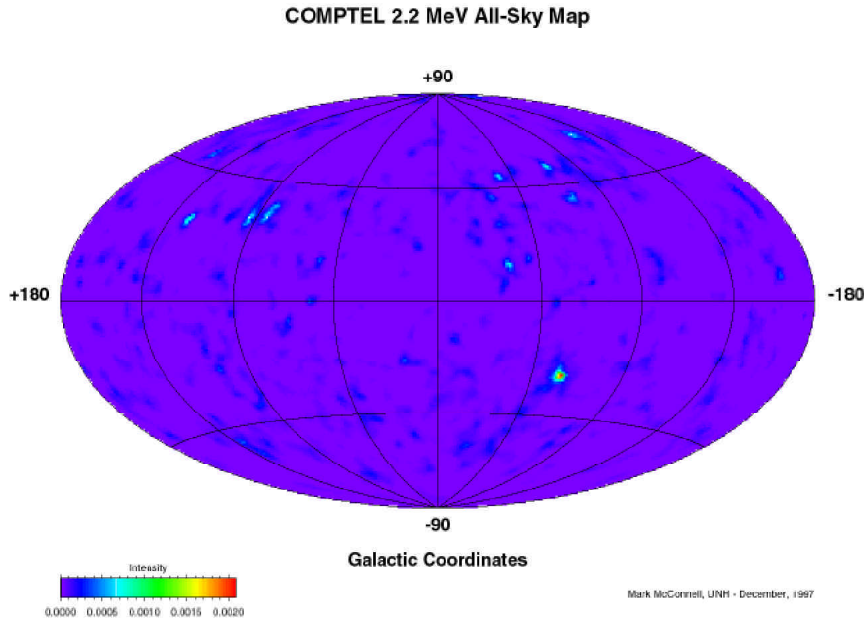

Figure 1: COMPTEL image of the full sky at the 2.2 MeV energy associated with neutron-proton capture events. The source, suspected to be associated with the hot "White Dwarf" star, is clearly visible in the lower right quadrant.

point-source of 2.2 MeV line-radiation reported by scientists using the COMPTEL instrument. A line at this energy could emanate from neutron-proton capture events, leading to deuteron formation. This phenomenon has been seen frequently in laboratories, but no celestial sources are known, other than solar flares. The source is coincident with an unusual White Dwarf RE J0317-853, discovered by ROSAT (Figure 1). It is among the hottest (50,000ºK) and most strongly magnetized (340 million Gauss) White Dwarfs known. It is noted, however, that the COMPTEL positional uncertainty cannot unambiguously allow for association of the White Dwarf and the 2.2-MeV source. This result may be evidence that phenomenon analogous to flares seen in our own sun are a common occurrence elsewhere in the galaxy. Further observation of this region with COMPTEL will lead to an improved measurement.

The CGRO mission is currently budgeted to continue through the year 2000. A review of all active NASA scientific missions this summer will determine the status of CGRO beyond 2000. Project scientists and engineers are highly optimistic that an extension of the current mission plan will be approved, and that CGRO will continue to return exciting scientific data well into the next century!

Article by Dr. Chris R. Shrader, Compton Gamma Ray Observatory Science Support Center, NASA Goddard Space Flight Center

For additional information, refer to http://cossc.gsfc.nasa.gov on the World Wide Web.

TOPEX/Poseidon Approaches Six Year Mark, Studying Earth's Oceans

Exceeding all expectations of measurement accuracy, the U.S./French TOPEX/Poseidon satellite mission approaches a six year operational milestone this coming August. TOPEX/Poseidon employs radar altimetry and unprecedented high-precision orbit determination techniques to map over 95 percent of the world's ice-free oceans. The satellite has provided data for almost twice the original primary mission objective of three years. Although the satellite has encountered the usual hardware problems expected with any aging satellite, the overall outlook for continued operations currently is very promising.

Highlights of results from TOPEX/Poseidon science data analysis include:

- Providing the first multi-year set of global ocean circulation data
- Discovering seasonal changes in the oceans
- Providing very precise measurements that improve knowledge of ocean tides
- Helping marine biologists locate whales and dolphins in the Gulf of Mexico for a marine mammal census
- Assisting in planning offshore oil operations by monitoring ocean eddies.

Of course, the satellite is probably best known for tracking warm water signals associated with El Nino events, with the 1997-98 El Nino observed by TOPEX/Poseidon being the largest such event ever recorded.

Given the good health of TOPEX/Poseidon and the recent approval for its follow-on mission (Jason-1, which is scheduled to launch in May 2000), the Flight Control Team is confident that there will be many more years of outstanding global sea level data and scientific discoveries ahead.

Article by Mark Fujishin, TOPEX/Poseidon Mission Manager

More information about the TOPEX/Poseidon spacecraft is available on the WWW at http://www.jpl.nasa.gov/mip/topex.html, or contact the author via email at Mark.Fujishin@jpl.nasa.gov

Upper Atmosphere Research Satellite News

The Upper Atmosphere Research Satellite (UARS) continues to collect science data from eight of its original ten instruments. Science data collection remains a complicated function, requiring an effective team approach to maximize the total science mission objective with the available power resources.

UARS continues to maximize power available for instrument operation from the parked solar array. Another On Board Computer (OBC) software update is underway which will further increase power usage efficiency.

An orbit maintenance burn maneuver is being planned for this summer after more than 42 months of operation in which orbit decay was minimal. The last orbit maintenance maneuver was performed on 20 October 1994!

UARS data capture remains excellent at 99.9642 percent, due in no small part to superior Space Network and Telemetry Processing Facility (TPF) support. This excellent support was recently demonstrated during two separate weekend power outages in GSFC Building 23, where UARS playback data is

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normally captured. UARS data was recorded at the White Sands Complex, and then replayed to GSFC using the Line Outage Recorder after Building 23 power was restored. The Line Outage personnel also provided a data quality indication.

Article by John C. Speer/ UARS Flight Operations Team

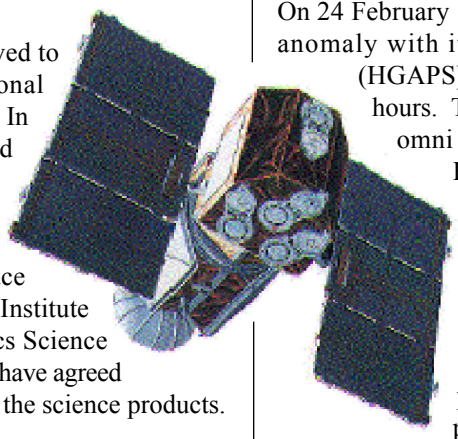
Comments and questions may be directed to Edward J. Macie, UARS Project Manager/GSFC Code 453 at (301) 614-5416 or via email at Edward.J.Macie.1@gsfc.nasa.gov

The First Year of Outsourced Extreme Ultraviolet Explorer Operations Winds Up With a Bang

On 14 March 1998, the University of California, Berkeley (UCB) celebrated the one-year anniversary of the official completion of the handover of Extreme Ultraviolet Explorer (EUVE) spacecraft operations and science/mission management from GSFC to UCB. The outsourcing has been a great success at UCB, and assuming spacecraft operations has been challenging, educational, and definitely fun! The past eight months of outsourced operations have been extremely busy and interesting.

From September 1997 through mid-April 1998, EUVE carried out approximately 120 observations of nearly 100 different targets, including views of the near interstellar medium (NISM); the diffuse EUV background; comets Hale-Bopp and Temple-Tuttle; the Moon; Saturn; and, most especially, Venus (see below). The EUVE Project also conducted its sixth proposal cycle for guest observers (GOs), the first cycle conducted and managed solely by and at UCB. The process was simple and low-cost, consisting of an electronic proposal submission process and an on-line e-mail/telecon time-allocation committee (TAC) for proposal review.

Also, the EUVE archive has been moved to its permanent home at GSFC's National Space Science Data Center (NSSDC). In November 1998, the NSSDC assumed from UCB the responsibility for delivering EUVE archival data – packaged science data products and/or the raw telemetry — and Hubble Space Telescope's Space Telescope Science Institute and GSFC's High Energy Astrophysics Science Archive Research Center (HEASARC), have agreed to provide on-line WWW interfaces to the science products.



This year was not without its engineering challenges as well. At around 06:00 GMT on 19 September 1997 EUVE experienced an unexpected instantaneous 2 cm/sec decrease in its velocity. By the time this was detected by the Flight Dynamics Facility (FDF) three days later, this small decrease had propagated itself to approximately a 2 m/sec change. FDF independently confirmed this event using both TDRSS and North American Aerospace Defense Command (NORAD) tracking data, although UCB saw no sign or after-effects of any disturbance on-board (EUVE was not recording data at the time). FDF theorizes that the decrease was the result of a collision between the EUVE satellite and a micrometeoroid.

In September 1997, the Flight Operations Team (FOT) revised its tape recorder management strategy in response to the tape units running too hot (over 45ºC). The revised strategy included operational changes as well as the use of two additional NCC services (a new ground configuration code and a third daily Critical Science event as the scheduling allows). The results have been very positive, with the tape unit temperatures again nominal, and with no interim loss of science data. Our thanks to the NCC for their continued excellent support!

In November 1997, UCB assumed the data processing functions previously conducted by the Packet Processor (PACOR) facility at GSFC. During September and October 1997 UCB phased in, one by one, the three PACOR functions — routine tape recorder dump, real-time data processing, and weekly processing and transfer of attitude data to FDF — with PACOR remaining available as a backup. On 15 November, UCB officially assumed all PACOR responsibilities and terminated PACOR support for EUVE.

Another change at UCB occurred in early December 1997 when, as a cost-cutting measure, management folded the Guest Observer science data processing support activities into the existing FOT's responsibilities. Relevant training was completed in January 1998 and the small and highly integrated FOT now handles all EUVE mission activities, supporting both satellite operations and science processing.

On 24 February 1998, the EUVE spacecraft experienced an anomaly with its High-Gain Antenna Pointing System (HGAPS) when it disabled itself twice within a few hours. The anomaly prompted the FOT to switch to omni communications for a few orbits until the HGAPS system was reset and back to nominal operations. The subsequent analysis of the anomaly reveals it to be unlike any EUVE has experienced before. The FOT has ruled out all conceivable reasons for the anomaly, the cause of which remains a mystery. Since this anomaly, the HGAPS system has performed nominally and without any problems.

On 18-19 March 1998 the FOT conducted a two-day reconditioning of the spacecraft batteries. Although most battery engineers agree that such reconditioning is beneficial, missions typically hesitate to do so because of concern over potentially harming such a critical flight system. The EUVE Project performed the reconditioning both in order to improve battery performance and as a flight testbed exercise. On both days of the reconditioning the three Nickel-Cadmium batteries were discharged over the course of three orbits to ~75% state-of-charge. As a result we've seen improved battery capacity as exhibited by increased load-bus voltage and battery state-of-charge, as well as decreased battery differential voltages. These results are being communicated to an eager power community, in particular to those missions having similar batteries (e.g., CGRO, TOPEX, and UARS have the same batteries as EUVE).

Finally, the EUVE Project wound up the first year of outsourced observations with a bang by achieving a first: in April 1998 EUVE observed Venus. This observation was the most technically challenging one to date. The Venus observation had been approved (pending an engineering feasibility study) for 20 ksec and was time-critical, since Venus had to be observed while at its maximum elongation (46º) from the Sun. This small angular elongation required major violations of the normal EUVE pointing constraints (less than 90º from the Sun) and resulted in extremely low observing efficiency due to earth blockage and interference from the South Atlantic Anomaly. The FOT's observation plan was developed over 11 months through intermittent investigations and tests. It required a great number of operational modifications. The observation was safely and successfully conducted on 7-11 April — requiring 58 orbits, 116 slews, and more than 2400 commands! The vehicle remained safe and healthy throughout and the science results look very promising (an image of Venus was visible in the deep survey detector during each orbit). The FOT is commended for a job extremely well done!

So, as can be seen, life is busier and more interesting than ever on the EUVE Project at UCB. We feel we've accomplished much in this last year and look forward to at least an equally challenging year ahead.

Article by Brett Stroozas/EUVE Mission Flight Director

For more information, visit the UCB/EUVE WWW site at http://www.cea.berkeley.edu or contact the author at (510) 643-7312 or via email at bretts@cea.berkeley.edu

Tropical Rainfall Measuring Mission A Success!

The Tropical Rainfall Measuring Mission (TRMM) satellite was built as an in-house project at NASA Goddard and launched by the National Space Development Agency (NASDA) of Japan. NASDA provided one of the five instruments, the Precipitation Radar (PR). NASA's Marshall Space Flight Center provided the Lightning Imaging Sensor (LIS), Langley Research Center provided the Cloud and Earth Radiant Energy System (CERES) instrument, while Goddard provided the remaining two instruments — the TRMM Microwave Imager (TMI) and the Visible Infrared Scanner (VIRS).

The primary objectives of the TRMM program are to obtain and study multi-year science data sets of tropical and subtropical rainfall measurements; to understand how interactions between the sea, air, and land masses produce changes in global rainfall and climate; to improve modeling of tropical rainfall processes and their influence on global circulation in order to predict rainfall and variability at various periods of time; and to test, evaluate, and improve satellite rainfall measurement techniques.

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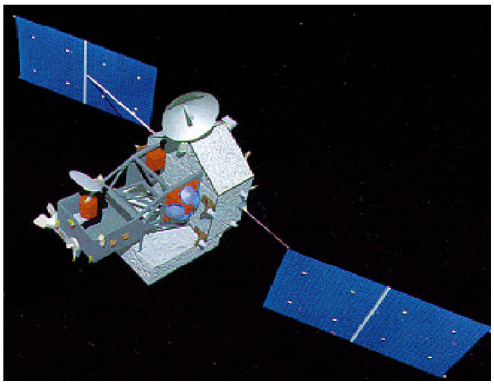
TRMM Observatory Characteristics

SIZE
- Launch configuration: 16.7 ft (5.1m) long; 12.1 ft (3.7m) in diameter
- Orbit configuration: 16.7 ft (5.1m) long; 47.9 ft (14.6m) across solar arrays

WEIGHT
- Observatory total weight 7974 lbs (3616 kg)
- Observatory fuel weight 1962 lbs (890 kg)
- Observatory dry weight 6012 lbs (2726 kg)

MISSION LIFE: 3 Years



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Tropical rainfall affects the lives and economics of half the Earth's population, many of whom are residents of developing countries on or near the Equator. Rainfall variation in the tropics can affect the weather in locations thousands of miles away, impacting the lives and livelihoods of populations worldwide. Some examples include tropical rain systems such as typhoons, hurricanes, and monsoons that produce floods and drought in areas of the world. The best known effect of tropical variations on the world is the El Nino Southern Oscillation (ENSO) of the Pacific Ocean. An El Nino involves the spreading of warm water and its coupled cloud systems eastward. Weather conditions associated with El Nino include wetter than normal weather in California, wetter and colder winters than normal in the eastern United States, and drier summer monsoon seasons across the Southern Hemisphere.

TRMM, the first space mission dedicated to studying tropical and subtropical rainfall, was launched Thanksgiving day from the Japanese Space Center, Tanegashima, Japan. TRMM lifted off at 4:27 p.m. EST on a Japanese H-II rocket, and just fourteen minutes later separated from the rocket's second stage. The automatic sequencer on TRMM successfully deployed the solar arrays and the high gain antenna after a short time-out period initiated at separation.

For nearly six months the Flight Operations Team at GSFC has conducted normal operations using the Space Network, and continues to provide high-quality science data to the science community from all instruments.

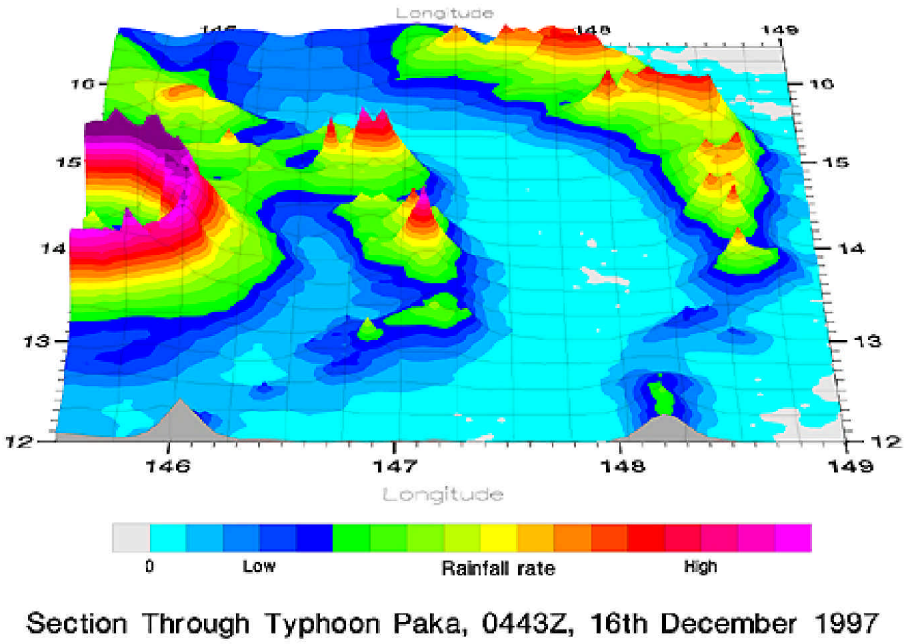
The TRMM satellite's low inclination (35 degrees) and non-sunsynchronous, highly precessing orbit allow TRMM to fly over each position on the Earth's surface at a different local time each day. This allows the examination of the diurnal cycle of precipitation. The orbit is maintained at approximately 350 km.

Data from the TRMM sensors are being processed at GSFC by the TRMM Science Data and Information System (TSDIS). Data are also processed at the Earth Observation Center (EOC) in Japan. Once verified by the TRMM algorithm development team, the data will be distributed to scientists in the fields of climatology, meteorology, hydrology, and other disciplines in Japan and the United States. Early images from the satellite radar indicate that the instrument is working very well and matches ground based radar data precisely. The success of the TRMM mission is another major milestone for GSFC and the science community.

It takes a knowledgeable and dedicated team to ensure a success such as TRMM. The mission was the dream of Project Scientist Dr. Joanne Simpson, and made operational under the direction of Mr. Thomas LaVigna, Project Manager, and Dr. Christian Kummerow, Project Scientist. The design mission life expectancy is three years. Now after nearly six successful months in orbit, the operational responsibility has been turned over to Code 453 personnel who are committed to the continuation of providing science data, and to stretching the life of this unique mission for the global observation of rainfall.

Article by Ed Macie/GSFC Code 453

For further information, please refer to the TRMM web site at trmm.gsfc.nasa.gov , or contact the author at (301) 614-5416 or via email at Edward.J.Macie1@ gsfc.nasa.gov



Sample Science Data from TRMM: 3-D view of Super Typhoon Paka

Hubble Space Telescope: Busy On-orbit, Busy on the Ground

The past quarter has been a very active one for Hubble Space Telescope (HST) Project personnel! The HST Project has achieved several significant milestones of late, both in the science and operations venues.

A few months ago, HST celebrated eight years of space exploration. HST began work in April 1990, when the Shuttle Discovery released her on orbit. Just as she has in her previous seven plus years of exploration, HST again enabled more discoveries this quarter. One example is the observation of the youngest known planetary nebula, Stingray Nebula (Hen-1357). This nebula is so named because its shape is similar to the stingray fish. This type of Nebula is formed after an aging, low mass star swells to become a "red giant," and blows off material from its outer layers. The interest in this particular event was due to how fast the star heated up — a surprising occurrence to the observing community.

HST also partnered with the United Kingdom's Radio Telescope to view an "Einstein Ring." This kind of ring is due to the gravitational effect predicted by Albert Einstein as part of his General Theory of Relativity. The effect is a cosmic mirage. In this case, the gravity of a massive galaxy is bending the light of the object behind it and acting as a "gravitational lens." In addition, astronomers used HST in collaboration with the European Space Agency's Infrared Space Observatory (ISO) to prove the high level of dust in galaxies.

While exciting science operations continue, the attention of HST Project personnel is also focused on the ground. Deployment of the new Vision 2000 Control Center System is underway, and is now in the transition phase. The Project has implemented an intensive delivery, testing, and validation program over the last few months. This effort will culminate in the complete operation of the spacecraft with the new system this August. Testing and operations personnel continue to work closely with the Space Network, validating all the new ground system components and procedures to ensure correct operation of the observatory. The new Vision 2000 systems have been deployed in many of the HST flight software testing facilities at GSFC and elsewhere, including the high-fidelity flight hardware and software simulator in the GSFC Building 29 highbay known as the Vehicle Electrical Systems Test Facility (VEST).

Recently, the decision was made to slip the schedule for Servicing Mission-3 (SM-3) due to rescheduling of Shuttle refurbishment. The SM-3 Launch Readiness date changed from November 3, 1999 to April 17, 2000. The Launch Readiness date for HST Servicing Mission-4 (SM-4) was also rescheduled from November 2, 2002 to March 5, 2003.

HST is scheduled at the Space Telescope Science Institute (STScI), in Baltimore, the institution that carries out the scientific mission of the telescope. The Association of Universities for Research in Astronomy, Inc. (AURA) manages STScI for NASA. The European Space Agency (ESA) participates in the HST Project under a long-term arrangement with NASA. A new Director of the STScI, Dr. Steven V. W. Beckwith, has been appointed effective September 1, 1998. Dr. Beckwith is currently the managing director of the Max-Planck Institute for Astronomy in Heidelberg, Germany.

HST continues to rely on the GSFC Space Network for communication services as it produces important science observations. The failure of the HST S-band Single Access (SSA-1) transmitter in April 1998 required the Network folks to accommodate various operational changes and special testing. The transmitter is now slated for replacement during SM-3. HST's success is due in part to the GSFC/NASA family who supports every mission with hard work and dedication. Thanks to all.

Article by Art Hughes/GSFC Code 583

For additional information on HST activities, visit http://marvel.stsci.edu/top.html on the World Wide Web, or contact the author at (301) 286-7311 or via email at Arthur.R.Hughes.1@ gsfc.nasa.gov

Rossi X-ray Timing Explorer Flight Operations Team Solves Re-boot Problem

The Rossi X-Ray Timing Explorer (RXTE) continues on its quest to study more than a thousand of the brightest X-ray sources in the sky, helping to solve some of the mysteries about these exotic systems. By using its All-Sky Monitor, RXTE transmits data to the Science Operations Facility (SOF), located at the Goddard Space Flight Center (GSFC). From there, Targets of Opportunities (TOO) are determined and put into a science time-line that is then uplinked to the spacecraft. This time-line then instructs the spacecraft when and where to point its two instruments which collect data covering both the lower and upper energy range of the sources. Once downlinked through TDRSS, this science data is processed, distributed, and archived at the XTE Science Data Center (XSDC) located in Berkeley, California. To date, RXTE has performed 1704 TOO observations for 120 sources since its December 1995 launch.

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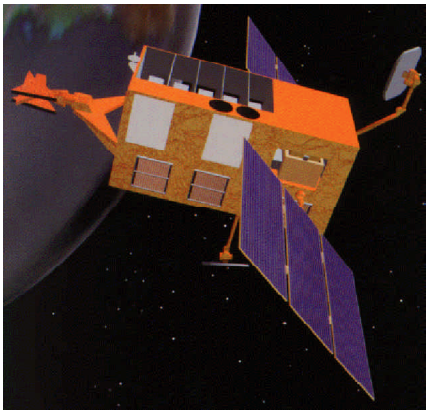
(continued from page 17)

Passage through the South Atlantic Anomaly (SAA) area continues to cause problems for the spacecraft, resulting in the partial re-boot of on-board processors. These re-boots, while having no extensive effect on science data collection, erase code that has been appended to the operational software in RAM. These software patches prevent known anomalies (such as the September 1997 event where the spacecraft forced a hardware re-boot resulting in safehold and science data loss) from re-occurring. To prevent these patches from being erased, the Flight Operations Team (FOT) has begun to write this preventative code into Electrically Erasable Programmable Read-Only Memory (EEPROM). The first successful write took place on April 22, 1998. With this additional code etched in EEPROM, the effect of a partial re-boot is diminished since the preventative code will now be copied automatically into RAM by the spacecraft instead of waiting for the FOT to uplink it again from the ground. Additional writes are to follow in the future.

The RXTE FOT continues to downsize as confidence in automation increases. Currently, techniques have been implemented to lessen real-time activities from the FOT. While the FOT schedule continues to be 7 days per week, 24 hours per day, automation performs — with human monitoring — a good portion of repetitious work. In the near future, the FOT will transition from its current schedule to 7 days per week, 16 hours per day, with an end goal of 5 days per week, 8 hours per day. Along with performing certain real-time tasks, the automated system can detect anomalies and page appropriate personnel with anomaly codes. RXTE personnel will eventually be able to view selected telemetry snaps of the spacecraft from the World Wide Web and determine what, if any, action is warranted.

Article by Tim Coulter/ATSC

For further information, check out the following WWW site: http://heasarc.gsfc.nasa.gov/docs/xte/xte.html, or contact Bob Sodano/GSFC Code 581 at (301) 286-6506



The Rossi X-Ray Timing Explorer

Coming Attractions

Early Communications TDRSS Transceiver Tested at GSFC

The Early Communications (ECOMM) transceiver is a key component of the initial U.S. communications system on the International Space Station, providing the early S-band voice, data, and video conferencing capability prior to installation of the baseline U.S. Communications and Tracking System. Compatibility testing of the ECOMM TDRSS Transceiver Qualification Model (QM) was successfully completed in December 1997 at GSFC. The performance of the QM was significantly better than the Engineering Model (EM) results. Refinements in the JSC requirements plus design changes intended to improve performance were incorporated into the QM.

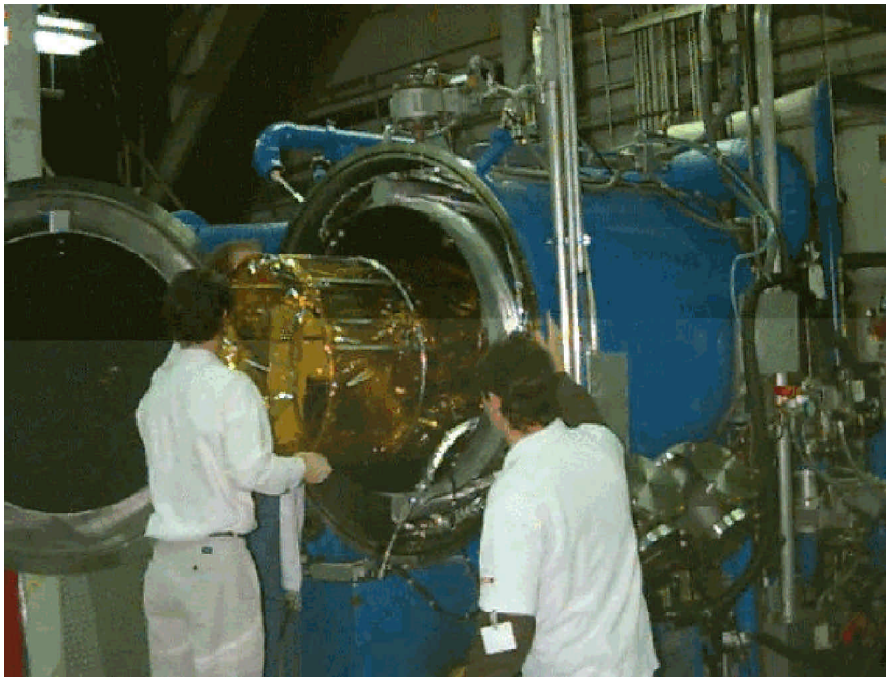
The ECOMM Transceiver

Since the ECOMM Transceiver was not designed for a space radiation environment, after successful testing at GSFC, the QM was delivered to Indiana University where it underwent radiation testing. During the radiation testing, the QM Digital Signal Processor (DSP) experienced significant damage and was returned to Stanford Telecommunications (STel) in Reston, VA. The unit was repaired and shipped to JSC where a successful functional checkout was performed.

The results of the radiation testing on the QM had a rippling effect through the ECOMM transceiver program. JSC ECOMM management determined two changes were required to the QM and the two pending Flight Models (FM) — a design modification to include a JSC-designed "Latch-Up" detect board (to detect power draw and shut down the transceiver before damage occurs in the event of on-orbit proton radiation hits) and replacement of the 0.6 micron DSP chips with less radiation sensitive 0.8 micron DSPs. Although GSFC responsibilities for the QM ended with delivery to JSC, GSFC's FM testing role was expanded to include extensive environmental tests in GSFC environmental chambers. In an effort to help JSC realize their aggressive schedule, GSFC took on the responsibility of performing the flight acceptance testing for the ECOMM Transceiver FMs.

Formal delivery of FM #1 was not expected until the January 1998 timeframe; however, at JSC's request, GSFC Environmental Facility personnel participated in an early checkout of the thermal control subsystem prior to formal testing. Due to facility schedule conflicts at JSC, they would not have been able to test the thermal control performance of the design in the QM prior to FM delivery. To verify that the ECOMM Transceiver would successfully power on during flight equivalent cold cycles (-35º C), a functional performance test was conducted at GSFC three days before Christmas.

FM #1 was formally delivered from STel to GSFC on January 7, 1998, and was immediately placed into the GSFC compatibility testing process. FM #1 underwent and successfully completed GSFC Compatibility Test Lab (CTL) Testing and Space Network (SN) RF Testing with TDRSS. After that, the GSFC Test Team's role increased as FM #1 entered formal environmental/acceptance testing — verification vibration testing and formal thermal vacuum testing. After completion of the GSFC Acceptance tests, the FM #1 was shipped to JSC for integrated system tests at the JSC Electronic Systems Test Laboratory (ESTL). JSC conducted a battery of system performance tests, including tests via TDRSS and the Space Network, and was delighted with the system performance.



The Thermal Chamber Being Prepared for ECOMM Transceiver Installation

FM #2 was delivered to GSFC on February 10, 1998, and completed vibration and RF performance testing. Due to schedule constraints, JSC requested that the JSC "Latch-Up" detect board be installed at GSFC. During compatibility evaluation at GSFC, test personnel discovered a power-up problem resulting from the "Latch-Up" detect board. The FM #2 was sent to JSC for correction, and was returned to GSFC for retest.

A KSC Cargo Element (CE2A) End-to-End test using the QM was an overwhelming success operating via the Space Network to the JSC Mission Control Center. This first CE2A test confirmed the QM fit into the Node. The formal CE2A test in which the complete ECOMM flight system is installed into the Node at KSC is scheduled for mid May using FM #2.

During the last six months, JSC increased the role of the GSFC ISS Test Team in order to achieve their demanding schedule. The GSFC ISS Test Team's flexibility and dedicated efforts on behalf of JSC during this difficult phase of the program enabled them to achieve their goal of customer satisfaction and earned them recognition for getting the job done.

Article by John Smith/LMS

For additional information, contact Ted Sobchak/GSFC Code 451 at (301) 286-7813 or via email at Ted.Sobchak@gsfc.nasa.gov.

Earth Observing System Polar Ground Stations Project

The Earth Observation System (EOS) Polar Ground Stations Project (EPGS) is currently being engineered by NASA/GSFC Code 452 [Wallops Flight Facility (WFF)]. The project consists of two high latitude stations: one at Poker Flats, Alaska, the other at Svalbard, Norway. The Norwegian Space Center is helping to construct the Norwegian station, and will eventually be responsible for its operations. The stations are designed to provide TT&C (S-band) and high rate science data (X-band) support primarily for the EOS AM-1, LANDSAT-7, and QuikSCAT Missions, but will eventually be augmented with more capability to serve as a multi-mission resource for the growing fleet of NASA's polar orbiting science spacecraft. The stations are now undergoing engineering testing and will be operational by mid-1998.

Each of these stations consists of a Radio Frequency Subsystem (RFS), a Baseband Data Subsystem (BDS), and a Monitor and Control Subsystem (MCS). The RFS will provide receive capability for X-band science data at rates up to 150 Mbps, receive capability for S-band telemetry from 1 kbps to 524 kbps, and command capability for S-band at 2 kbps. The BDS will capture and forward science data to the EOS Data Operations System (or other mission data processing centers), receive and forward commands to the RFS, and record data on non-volatile memory.

The MCS consists of the Wallops Orbital Tracking Information System (WOTIS), located at the WFF, and associated control equipment located at each ground station. The MCS is a PC based system with custom software developed in-house by at WFF. The WOTIS is the central facility that the spacecraft Mission Operations Centers interface with for scheduling ground station resources and obtaining post-pass reports. The MCS utilizes a master/remote node architecture, incorporating multiple on-line masters at each site for redundancy. All communications between the masters and WOTIS are provided by by the NASA Integrated Support Network (NISN) Closed and Open IP Operational Networks (IONET).

Telemetry processing is also provided at each ground station by Programmable Telemetry Processors (PTPs). The PTPs provide frame synchronization, Reed-Solomon decoding, data receipt time stamping, and Internet Protocol Data Unit (IPDU) header formulation/application. The PTPs will support both real-time telemetry data at rates up to 4.8 kbps and solid state recorder playbacks at rates up to 256 kbps.

Future enhancements to the ground stations will allow frame synchronization and Reed-Solomon decoding at rates up to 150 Mbps.

Article by Mark Burns/STel

For more information on EPGS, please contact Bob Stelmaszek at (301) 286-5263.

Earth Science Data Information System Update

The following has been extracted from a NASA release (98-60) of April 10, 1998 and edited for inclusion in The Integrator:

ESDIS FINDS PROBLEMS IN EARTH OBSERVING SYSTEM DATA AND INFORMATION SYSTEM (EOSDIS) FLIGHT OPERATIONS SOFTWARE DEVELOPMENT...

The Earth Science Data Information System (ESDIS), GSFC Code 423, has found software performance problems with software required to control, monitor, and schedule science activities on EOS AM-1. These problems will impact the launch date for AM-1. The launch, originally planned for late June 1998, from Vandenberg Air Force Base, CA, will be delayed at least until the end of the year.

The final version of the software was to have been delivered to ESDIS on March 31 to support integrated simulations with the EOS AM-1 spacecraft. Testing of this software delivery revealed significant performance problems, including unacceptable response time in developing spacecraft schedules, poor performance in analyzing spacecraft status and trends from telemetry data, and improper implementation of decision rules in the control language used by the flight team to automate operations.

Government/contractor teams have been formed to evaluate options for correcting these problems to minimize impact on the AM-1 launch. A recovery plan is being developed and was reviewed during the last week of April.

The Flight Operations Segment is being developed by Lockheed Martin (nee LORAL) under subcontract to Raytheon Information Systems (nee Hughes) under the EOSDIS Core System (ECS) contract.

ESDIS SCIENCE DEVELOPMENT RECOVERY UNDER WAY...

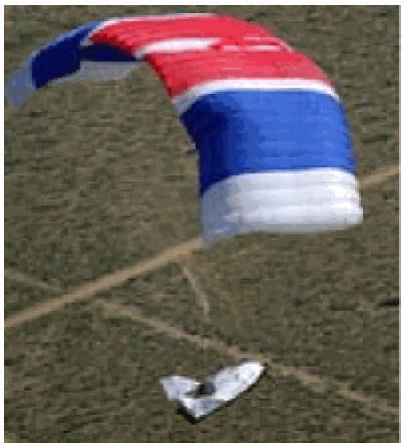
Problems with the EOSDIS Core System (ECS) Science Data Processing Segment (SDPS) required replan, rescope, reassignments, and dedicated effort on the part of the ECS, Independent Verification and Validation (IV&V), and ESDIS personnel over the past year and a half, but testing of recent software drops and releases indicate that the SDPS will be fully operational for the new launch date.

For more information, contact Gene Smith via email at gene.smith@gsfc.nasa.gov

X-38 Atmospheric Vehicle Completes First Unpiloted Flight Test

Development of the X-38, an innovative new spacecraft design planned for use as a future International Space Station (ISS) Crew Return Vehicle (CRV), recently passed a major milestone. On March 12, 1998, at the Dryden Flight Research Center in Edwards, CA, the X-38 successfully completed its first unpiloted flight test.

This test flight was the first in a series of 20 planned tests to prove the concept of the X-38 as an emergency CRV. The test focused on the use of the X-38's parafoil parachute, which was deployed as planned upon the vehicle's release from a B-52, and guided the craft to landing.



The X-38, with parafoil parachute deployed, during its first flight test

Future atmospheric drop tests of the X-38 will continue for the next two years using three increasingly complex test vehicles. In 2000, an unpiloted space test vehicle is planned to be deployed from a Space Shuttle and to descend to a landing in Australia. Methods of communication for this test are currently under evaluation, and include Ground Network (GN) mode via the Tracking Data Relay Satellite System (TDRSS) and the Space Network, and the use of a GN compatible Transportable Orbital Tracking System (TOTS). The X-38 operational vehicle, the CRV, is targeted to begin operations aboard the International Space Station (ISS) in 2003. The vehicle would serve as an emergency lifeboat for the ISS. Plans to use NASA's Space Network to provide communications services during proximity operations, flight-to-ground, and landing during the CRV ISS operational phase are being evaluated.

Article by Ernie Keith/ATSC and Ted Sobchak/GSFC Code 451

For additional information, check out the Human Spaceflight web site at http://tip.gsfc.nasa.gov/hpshuttl/hsd/hsd.html, or contact Ted Sobchak at (301) 286-7813 or via email at Ted.Sobchak@gsfc.nasa.gov

Landsat-7 Launch Delayed

The Landsat-7 Launch has been delayed to no earlier than December of 1998, due to failure of the instrument power supplies during thermal vacuum testing. A new launch date will be selected upon delivery of the Enhanced Thematic Mapper Plus (ETM+) instrument, scheduled for August.

During the ETM+ thermal vacuum tests beginning in December, the power supplies in the Main Electronics Module (MEM) failed on two separate occasions. Extensive troubleshooting determined that the rectifying diodes in the power supply were overheating and eventually failing. The failure mechanism was traced to the reverse recovery time characteristics of the diodes. Diodes with faster reverse recovery time have been selected, the fix was verified, and the new diodes have been installed in the power supplies. The power supplies are undergoing a complete environmental test program following repair.

Upon delivery on May 15, the power supplies will be re-integrated, and ETM+ testing will begin. Testing will consist of a battery of baseline tests, sine and random vibration, and thermal vacuum/balance testing. In addition, an early ETM+ to spacecraft integration will be done to check the electrical and mechanical interfaces, and to acquire wideband instrument data to verify the ground processing systems.

The spacecraft bus, sans instrument, has completed the following tests: electromagnetic interference/ electromagnetic compatibility (EMI/ EMC), acoustic and sine vibration, plus two comprehensive performance tests. In parallel with instrument testing, the bus will go through a thermal vacuum/

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balance test and then meet up with the instrument in August. After instrument integration, the satellite will go through thermal vacuum testing and acoustics before shipment to the launch site.

The Landsat Ground System [Landsat Ground Station (LGS), Landsat Processing System (LPS), Mission Operations Center (MOC), and Image Assessment System (IAS)] being developed by Goddard for National Oceanographic and Atmospheric Administration (NOAA) operations is proceeding on schedule and will be launch ready in July. The MOC has run compatibility tests with the spacecraft and has verified all command and telemetry paths. The LGS antenna and electronic equipment at the Earth Resources Observing System (EROS) Data Center (EDC) in Sioux Falls, SD, has been installed and acceptance testing is complete. LPS hardware and software at EDC is being used to process instrument data in support of end-to-end verification of wideband data integrity. The IAS Critical Design Review was held and development of hardware and software is proceeding smoothly.

The Earth Science Data Information System (ESDIS) Project will archive the Landsat data at the EDC Distributed Active Archive Center (DAAC). In addition, ESDIS has funded a Level 1 Product Generation System (LPGS) and a Landsat Product Distribution System (LPDS). These systems will be able to process up to 100 Level 0 scenes (i.e. scenes corrected for scan direction and band alignment, but without radiometric or geometric correction) to Level 1 (systematically corrected), and distribute the products to customers. These systems should be in place when Landsat-7 becomes operational.

The Landsat Science Team held their fourth team meeting in April. NOAA hosted the Landsat Ground Station Operator's Working Group, made up of ground station operators from around the world, at EDC in May. As an addendum to this meeting, technical representatives from the ground stations and the contractors building hardware and software for them were given a technical briefing on the Landsat-7 system, its data characteristics, data reception, and data processing.

Launch will be from the Western Test Range at Vandenberg Air Force Base, CA, on a Delta-II Expendable Launch Vehicle. Landsat-7 will provide a continuous set of calibrated Earth science data to both national and international customers. It will provide images of the land surface and surrounding coastal regions to a diverse national and international customer community for global change research, regional environmental change studies, national security uses, and other civil and commercial purposes. The Landsat-7 program is a tri-agency program, established by a Presidential Decision Directive, with unique responsibilities assigned to the NASA, NOAA, and the U.S. Geological Survey (USGS).

Article by Ken Dolan/GSFC Code 430

For more information, please contact the author via email at stephen.k.dolan.1@gsfc.nasa.gov or visit the Landast Web site at http://landsat.gsfc.nasa.gov

Landsat-7 Ground Station Update

The Landsat-7 Ground Station (LGS), located at the Earth Resources Observing System (EROS) Data Center (EDC) in Sioux Falls, SD, is being built by GSFC for the U.S. Geological Survey (USGS). AlliedSignal Technical Services Corporation (ATSC) is integrating the LGS from Commercial Off the Shelf (COTS) hardware procured by the Raytheon Services Company (RSC).

Last summer, final preparations were being made for the LGS Antenna Site Acceptance Test (SAT), when a violent hailstorm severely damaged the LGS 10-meter Datron antenna (see November 1997 issue of *The Integrator* for photos of the damage). After a thorough damage inspection, the antenna reflector was disassembled and sent back to the subcontractor for installation of a new reflecting surface. The subreflector, feeds, and cabling were shipped back to the antenna vendor for testing and repair. The antenna was reassembled in early 1998 and the SAT was held the week of February 23, 1998. The antenna system passed the SAT with only minor open items. A testing highlight was the successful tracking of the Landsat-5 satellite in an overhead pass with 40+ mph wind loads.

As a part of final acceptance testing, a GSFC Compatibility Test Van (CTV) will visit EDC and provide the LGS with a simulated Landsat-7 downlink. The LGS will receive the X-Band simulated downlink, demodulate and bit-synchronize the data, and send the data to the Landsat-7 Processing System (LGS) for recording and analysis. The LGS is expected to be operational in the summer of 1998. More information on the Landsat-7 project, including the latest launch date, can be found at: *http://geo.arc.nasa.gov/sge/landsat/landsat.html.*

Article by Armen Caroglanian/GSFC Code 567.2

For additional information, please refer to the URL above, or contact the author at (301)-286-4340 or via email at armen.caroglanian@gsfc.nasa.gov

Guam Remote Ground Terminal Nearing Completion

The Guam Remote Ground Terminal (GRGT) development effort continues towards the scheduled acceptance date of June 9, 1998, and an operational date of July 9, 1998, despite a two week delay caused by Super Typhoon Paka on December 17, 1997. GRGT, which will replace the current GRO Remote Terminal System (GRTS) in Canberra, Australia, will provide expanded customer service capabilities in the former TDRSS Zone of Exclusion.

The GRGT implementation effort began in September 1996 while the major facility modifications work began in January 1997. Navy SEABEES performed the facilities work required to modify an existing Navy building to allow the installation of the GRGT equipment. The SEABEES also built two antenna foundations and radome ringwalls. The facilities effort is over 90% complete.

In addition to the construction progress, the integration testing of the GRGT subsystems is well underway. The 11m antenna system has undergone complete and successful test. Lockheed Martin, the supplier of the Guam Data Interface System (GDIS) Multiplexer/Demultiplexer, has delivered the Phase I version of the GDIS. The Space-to-Ground Link Terminal (SGLT-6) equipment relocation from Cacique to Guam is complete. AlliedSignal Technical Services Corporation (ATSC) has completed the construction of several chassis required for proper operation of SGLT-6. The extraordinary dedication of the personnel on the GRGT team has allowed us to begin the crucial system performance verification test program.

To ensure that GRGT systems function as expected, several test programs have been and will be conducted. In December 1997, Space Network Confidence Testing was conducted at Cacique to verify the capability of the GRGT-bound equipment to support various customer spacecraft configurations. Currently, GRGT Systems Verification Testing is being conducted on the integrated system in Guam. After GRGT Systems Verification Testing concluded on May 21, 1998, GRGT Customer/Network Acceptance Testing was conducted May 26 through June 8, 1998. This testing program verified that the GRGT is compatible with the other Space Network (SN) elements and with SN customers. Finally, GRGT Post-Acceptance Testing is being performed to qualify the system for routine operations.

In preparation for testing and operational readiness, meetings were conducted to inform the community of testing issues. A GRGT Project Systems Verification Test Readiness Review was conducted on April 15, 1998 to prepare for the current testing in Guam. The next forum will be held on May 6, 1998 to discuss the planning for the upcoming GRGT Customer/ Network Acceptance Tests and the GRGT Post-Acceptance Tests. A final meeting, the Operational Readiness Review, will be held on July 9, 1998 to assess the GRGT's readiness to support required operations. GRGT Program Managers are actively monitoring project activities, ensuring the timely completion of the GRGT facility while maintaining cost effectiveness.

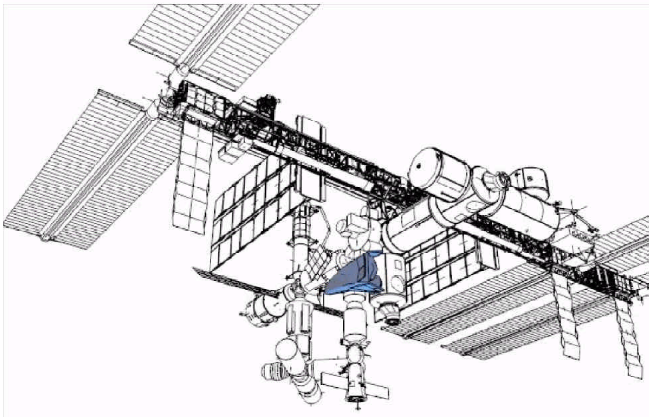
For more information, please contact Tom Gitlin at (301) 286-9257. You may also want refer to the WSC Project homepage on the Internet at http://wscproj.gsfc.nasa.gov. The web page contains current information about the GRGT project.

The top of the GRGT radome enclosing the 11m antenna is lifted into place by a crane

International Space Station Phases Proceeding

The International Space Station (ISS), as the largest international civil program in history, features unprecedented technical, managerial, and international complexity. Seven international partners and participants encompassing fifteen countries are involved in the ISS.

The ISS Program has three distinct phases, each building on the preceding one and each representing new milestones and capabilities.



The International Space Station

Phase 1, now in progress, involves stays by U.S. astronauts aboard the Russian Mir Space Station and dockings between the Space Shuttle and the Mir. Phase 1 provides experience and test data that will reduce technical risks for ISS development, assembly, and operation.

Phase 2, currently scheduled to begin this year, will create an advanced orbital research facility with early human-tended capability using hardware developed by U.S., Russian, Italian, European, and Canadian resources. This facility will significantly expand the scientific and research activities begun in Phase 1, and forms the core of the ISS. Phase 2 construction begins with the launch of the Russian-built Functional Cargo Block (FGB) on a Russian Proton rocket, followed by Node 1 with Pressurized Mating Adapters to be delivered by the Space Shuttle and attached to the FGB on orbit.

Phase 3 completes ISS construction, readying the Station to support a permanent human presence with a minimum operational lifetime of 10 years. Phase 3 begins with delivery of the Russian Docking Compartment, and includes delivery of the Japanese Experiment Module, the Columbus Orbital Facility, and two Italian-built nodes. Phase 3 will conclude with delivery of the U.S. Habitation Module in 2003. Capability is increased incrementally by adding modules and systems. Phase 3 also completes the truss, provides additional U.S. power modules and research facilities, additional Russian science modules, and completes the outfitting for full science utilization. Phase 3 also includes the capability for Visiting Vehicles, such as the European Automated Transfer Vehicle (ATV), the Japanese H-II Transfer Vehicle (HTV), and European/Russian Inspector.

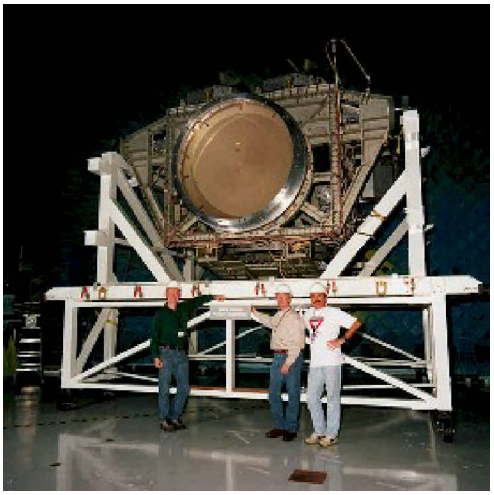
Article by Dave Goff/ATSC

For additional information, check out the Human Spaceflight Web site at http://tip.gsfc.nasa.gov/hpshuttl/hsd/hsd.html, or contact Ted Sobchak/GSFC Code 451 at (301) 286-7813 or via email at Ted.Sobchak@gsfc.nasa.gov

GSFC International Space System Team Successfully Completes Communications and Tracking Testing

The GSFC International Space Station (ISS) Test Team (AlliedSignal Technical Services Corporation, Lockheed Martin, NASA) culminated many months of test planning by successfully conducting the SN/TDRSS compatibility tests on the ISS Communications and Tracking (C&T) S-band and Ku-band proto-flight units. Four phases of intensive testing were conducted March 3 through April 2, 1998 at a Boeing (the ISS prime contractor) facility in Seattle, Washington. The personnel from the GSFC ISS Test Team and the Compatibility Test Van (CTV) were on location in Seattle for the duration of the test. The successful completion of the testing required the GSFC Test Team to maintain detailed technical coordination, ensure cohesion of a diverse and geographically dispersed test team, solve technical issues that arose, and achieve the formidable tasks presented by the Program's rather fluid and quick integration and test schedule. This proto-flight testing completes a major milestone for the ISS program in verifying Station communication system readiness.

Although the actual S-band and Ku-band antennas were not used, the proto-flight units (i.e. transponder, baseband signal processors, K-Band transmitter, etc.) were mounted on the Z1 Truss in a flight configuration (see picture at right).



Z1 Truss Fit Test with Flight Equivalent Hardware

The GSFC CTV provided the antenna and the RF link to SN/TDRSS. The CTV initially conducted nearly 100 hours of SN/TDRSS RF engineering tests which characterized and verified SN/TDRSS compatibility of both S-band and Ku-band subsystems prior to testing RF through SN/TDRSS (see CTV pictured below). Testing included a standard series of Spaceflight Data and Tracking Network (STDN) characterization measurements, spectrum analysis, signal level and transponder acquisition tests, PN code verification, and special phase noise measurements.

The GSFC CTV relayed the ISS signals through TDRS-West to test the RF performance of the system with SN/TDRSS. This activity included Bit Error Rate (BER) curves as well as exercising the voice encoding system, digitized TV, combinations of TV/payload data, 75 and 150 Mbps data.

Compatibility Test Van at the Boeing Facility

The test team conducted 50 hours of SN/TDRSS RF testing on the S-band subsystem with good results. Estimates for on-orbit link performance exhibited significant margins on the forward and return links. The ISS use of Reed-Solomon (RS) helps to extend this performance even further. Although not a required mode, testing also included the Coherent Mode. The S-band audio analysis was performed and was acceptable, but the Motorola Modified Residual-Excited Linear-Predictive (MRELP) algorithm can make some female voices difficult to understand. The ISS Program is assessing this audio condition.

The test team conducted over 30 hours of SN/TDRSS RF testing on the Ku-band subsystem evaluating 50, 75, and 150 Mbps data using an ISS test set located at WSC. Both digital TV and payload data were tested. All coded data was recorded at WSC and video was sent to GSFC for analysis by the GSFC TV lab.

With the completion of yet another significant ISS prototype test, the GSFC ISS Test Team sets its sights on verification of the ISS flight models, which are scheduled to begin testing early this summer at the KSC Space Station Processing Facility (SSFP). On-orbit operation of the ISS S-band and Ku-band system is currently planned to begin in mid 1999.

This test team must be commended for its hard work, dedication, and team spirit as it continues to meet the challenges of verifying the critical communication systems of the ISS.

Article by Doug Lumsden/Lockheed Martin/GSFC Code 451 and Ted Sobchak/GSFC Code 451

For additional information, check out the Human Spaceflight Web site at http://tip.gsfc.nasa.gov/hpshuttl/hsd/hsd.html, or contact Ted Sobchak/GSFC Code 451 at (301) 286-7813 or via email at Ted.Sobchak@gsfc.nasa.gov.

Additional Activities of Note

GSFC Engineers Enable Students to View Eclipse

The Exploratorium Science Museum in San Francisco, CA recently invited NASA to participate in a unique educational partnership opportunity. The objective was to obtain real-time video data of a total solar eclipse from the optimum viewing site in Aruba, and make the video accessible to students worldwide. NASA engineers decided to implement a portable, TDRS-compatible terminal that could accept real time video from on-site cameras, relay the data through TDRS, and then to the Exploratorium via an Internet terminal at the White Sands Complex that was recently constructed for the South Pole TDRS Relay. The Exploratorium would then post the data on the World Wide Web for distribution to schools, enabling students to observe the total solar eclipse as it was actually happening.

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The eclipse occurred on Feb. 26,1998 and although it was rainy and overcast (early in the morning, it cleared as eclipse time approached. There was actually a backup plan to move the equipment onto a cruise ship that would search for a clear viewing site if the weather continued to be unfavorable. Fortunately, that contingency was not needed — no one was overly confident that all of the equipment could be relocated to the ship and made to work in the few short hours that would have been available.) All went well during the exciting event, and millions of schoolchildren (and some adults) who were fortunate to access the Exploratorium web site got to see an eclipse as it happened.

NASA's contribution to this effort consisted of supplying the hardware and the engineering team that traveled to Aruba for the event. Dave Israel (GSFC Code 567) was the lead engineer who assembled and tested the terminal equipment, and traveled to Aruba with a team from both GSFC and the Exploratorium. Essentially all of the equipment was either already functional or was borrowed from various groups at GSFC. If you managed to get on the Exploratorium web site during the event, you would have seen Dave peering out from the equipment sporting sunglasses and a hat!

This entire effort was a demonstration of how NASA can contribute its talents and resources to an educational outreach program, positively impacting the educational experience of a large number of youngsters in school. Surely there is a future Edison or an Einstein among them, and perhaps we played a major part in sparking his/her interest in science. Now we can look forward to the eclipse next year in Turkey!

Article by Frank Stocklin/GSFC Code 450.4

For more information regarding this effort, please contact the author via email at Frank.Stocklin@gsfc.nasa.gov

TDRS Support for Range Safety... The Possibilities Explored

The concept of Space Network (SN) support for Range Safety (RS) has undergone an interesting evolution. When the concept was introduced at the Second TDRSS Workshop in June 1996, there were many skeptics. However, the GSFC RS Team members investigating the support possibilities have been optimistic from the beginning. "We know the SN/TDRSS is a reliable resource. In fact, TDRSS telemetry services to Expendable Launch Vehicle launches have been very successful to date — proven capabilities. Our team just needed to document the technical potential of the S-Band Forward services, then convince NASA Management and the Range Community," says Ted Sobchak, NASA Code 451.1, Range Safety Mission Manager.

The GSFC RS Team has completed a significant amount of work since the TDRSS Workshop: presentations to the Range Commanders Council – Range Safety Group and GSFC Code 450 Management; documents such as RS Strategic Guidelines, RS Preliminary Business Case; and most recently, a detailed working copy of the NASA SN Support for Range Safety – Concept and Feasibility Study, which focuses on potential RS service for the U.S. Air Force (USAF) Eastern Range (ER) and Western Range (WR).

NASA and USAF ER personnel have expressed serious interest in the SN/TDRSS concept. A presentation was given to Space Operations Management Office (SOMO) personnel and was well received. In addition, a USAF letter from the ER to USAF Space Command was written in January 1997, stating the potential for S-Band Command Destruct services and touting key aspects of the SN/TDRSS.

The cornerstone to this overwhelming interest in the SN/TDRSS services has been the USAF Range Standardization and Automation (RSA) Program. The program will define the USAF range upgrades into the next century. Within this program, the idea of converting range launch-head systems from the UHF frequency to the S-Band frequency is under consideration, as is the closure of downrange stations due to maintenance costs and technological advancements. Enter TDRSS and the Space Network, possibly providing lower range safety costs for services and maintenance, world-wide coverage capabilities, and "seamless" transition of services from an S-band launch-head to Over the Horizon (OTH) support through insertion — a rather appealing concept!

Interest in the SN/TDRSS for Range Safety services continues to grow. As stated in the November 1997 issue of *The Integrator*, there are three entities investigating the use of a space-based platform to provide RS services — ER, GSFC, and Lockheed Martin (LM) RSA Phase 2 Team (WR). Each element agrees the concept for a space-based platform has huge potential.

The ER team has developed a white paper concerning space-based system RS command and control. The ER study provides a comparison between Low Earth Orbiting (LEO), Medium Earth Orbiting (MEO), and Geosynchronous Earth Orbiting (GEO) relay satellite systems for providing space-based command destruct. SN/TDRSS is used as the example in the GEO system analysis. The conclusion of the paper specifically states that, although the LEO and MEO offer many benefits for space-based RS command and control, the GEO (such as TDRSS) is the most promising.

The GSFC study focuses on the SN/TDRSS concept and technical feasibility. Preliminary results indicate the SN/TDRSS to be a definite candidate in the newly evolving RS environment. The LM RSA Team is investigating

several space-based systems. At last check, the SN/TDRSS was a forerunner in this study, the results of which will be presented to the U.S. Space Command at completion. Very recently, personnel from the Aerospace Corporation RSA have expressed serious interest in the SN/TDRSS, for downrange services in particular.

This is an exciting time for this endeavor. Timing could not be better. *Space News* has documented several stories concerning the RSA program and the benefits of upgrading the circa 1960 systems to a more technically advanced system. The ER has increased interest in using the SN/TDRSS for range safety, and has discussed with GSFC team personnel the possibilities of developing a test program to include TDRSS. Most exciting for the GSFC RS team are discussions with RS launch vehicle equipment vendors that are proposing development of S-Band RS equipment to test with the SN/TDRSS in the near future.

No doubt this concept will be further investigated. What was once considered to be a "pipe dream" by nay-sayers is now showing huge potential. Will SN/TDRSS be the Range Safety mode of the future? Only time will tell.

Article by John Smith/LMSC/GSFC Code 451

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TDRSS On-line Information Center

Have a question about TDRSS or the Space Network? Check out the TDRSS On-line Information Center! New information about TDRSS Support for Expendable Launch Vehicles, Demand Access, and NCC 98 is now included. Try out our new interactive Link Budget Calculators. A new Javascript search engine will help lead you directly to the information you are looking for. Still need help or have a question? Use our feedback form, and we'll get the appropriate expert to answer your question and email the response directly to you. The web site is updated twice monthly to ensure the information is current and accurate.

The web site can be found at *http://nmsp.gsfc.nasa.gov/tdrss/*

Detailed information is currently available on:

* The Tracking and Data Relay Satellites (including TDRS H, I, J)
* The White Sands Complex
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Announcing...

The N&MSP Logo Contest

The **N&MSP Team** is looking for a **New Logo** to fit their new organization.

*So, get out your **pencils** and put those **creative minds** to work.*

Please submit entries to:
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Greenbelt, MD 20771
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Deadline to submit ideas - August 1, 1998.

Electronic files or paper drafts welcome.

New Networks and Mission Services Project Schedule Provided

Please note that a new chart, the "Networks and Mission Services Integrated Schedule," is included as an insert in the center of this issue of *The Integrator*. This new chart depicts the schedules of many current and future activities of the new Code 450 organization, and will be updated and provided as needed in future issues.

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The Integrator can be found online at *http://nmsp.gsfc.nasa.gov*

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