EXPERIMENT REPORT
UNITED STATES ARMY SPACE EXPERIMENT 601

TERRA SCOUT

Space Requirements Branch
Space Division, Directorate of Combat Developments
United States Army Intelligence Center and Fort Huachuca
Fort Huachuca, Arizona

29 July 1992

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EXPERIMENT REPORT
PREFACE

1. This Experiment Report is intended to accomplish the following:

a. Evaluate results of the TERRA SCOUT experiment as they relate to experiment objectives defined by the United States Army Intelligence Center and Fort Huachuca, (USAIC&FH) Fort Huachuca, AZ.

b. Determine the suitability of the primary and back-up optical equipment to (mission) objectives.

c. Provide a project history detailing how the experiment evolved, the Military Man in Space (MMIS) concept review process, and other ancillary data relevant to the history of the experiment.

d. Through review and analysis of mission data collected, and participation of the payload crew, describe results of the experiment.

2. The Terra Scout experiment was born out of a suggestion by the first Army astronaut, Brigadier General Bob Stuart. During a visit to Fort Huachuca in 1985, BG Stuart relayed his observation experiences to the personnel from Space Division, USAIC&FH, with the suggestion that what he had observed on orbit was worthy of further investigation. The decision was made early in the development of the experiment to use an experienced imagery analyst as it was this perspective that was desired. Since this was a skill that was not resident in the astronaut corps, it was the Intelligence Center's responsibility to select an analyst who could be trained as a Payload Specialist (PS) for a mission aboard a future space shuttle flight.

Despite the fact that the Air Force concurred that the experiment met the currently agreed to guidelines between the Air Force and NASA (as the guidelines pertain to flying a PS), neither seemed anxious to honor this agreement. Eventually, pressure at the service Secretary level, prompted from the Principal Investigator (PI) level, broke the "log jam" thereby delaying the final experiment approval cycle by only 18-24 months. We believe and hope that this unfortunate set of circumstances should not arise again for future experimenters who have a valid requirement to employ a PS.

St-A per telecon Mr. Huth, Army Intelligence Ctr. Ft. Huachuca/ ATZS-CDA-S, Ft. Huachuca, AZ 85653.
2-17-93 JK

During the almost seven years from the initial concept to launch, the project evolved through the tenure of three Principal Investigators: each who endured the political roller coaster along with other key players. Our opinion after experiencing many Military-Man-in-Space Review and Prioritization Boards is that we, the Army, need to have more senior leaders with education and/or experience in the area of space operations and related activities. Although we are grateful for the consideration and support given to us by many of the Board members, there is a need to have personnel with the technical and operational knowledge in space operations and experimentation. We gained an immeasurable amount of experience by forging the path with Terra Scout. However, this experience needs to be used and built upon if we are to move ahead (and not repeat errors which may have been made).

The five key Terra Scout team members during the final three years of the project were CPT John Huth, CW3 John Hawker, CW3 Tom Hennen, MSG Mike Belt, and Mr. Jerry Ramage who has been key to moving the experiment toward success from the beginning. The two previous PI's who passed the experiment to us were MAJ (Ret) Dave Bales and CPT Ed Apgar. There are many other people within the Army, Air Force, NASA, DIA, and the Australian government who helped make this experiment a success . Finally, we are grateful to COL Fred Gregory for accepting our PS as a crewmember,and the STS-44 crew for making this experiment a success.

I. INTRODUCTION.

1. Purpose of Experiment.

The original purpose of the Terra Scout experiment was to collect data which could be used to determine the ability of a specialist, in this case an Imagery Analyst (IA), on-board an orbiting platform, to collect valuable information in real time. During seven years of development, the experiment evolved and expanded in scope to include a variety of research and developmental issues described later in this report.

2. Rationale.

a. Military Man in Space/Space Test Program.

(1) The Military Man in Space (MMIS) program is a component of the Department of Defense (DoD) Space Test Program (STP) and is intended to provide opportunities to determine military applications in space. Relevance of experiments to DoD requirements is stressed. After approval and prioritization by a Joint Board, these programs provide no cost launch services for military experimenters.

(2) To conduct Terra Scout, an astronaut who was a trained expert in ground site analysis (such as an Imagery Analyst (IA)), was required. This expertise was not resident within the National Aeronautics and Space Administration (NASA) astronaut corps. In accordance with DoD MMIS program requirements, an Army IA was selected to receive training and subsequent NASA designation as astronaut/Payload Specialist (PS) for Terra Scout.

b. Results of Terra Scout will provide information to assist analysis of the following:

(1) Feasibility of observations made from low Earth orbit and reported to ground commanders in real time.

(2) Flexibility of an expert in-the-loop to conduct varied on-orbit activities..

Terra Scout will help determine if the expert analyst has the ability to adjust from pre-planned target observation sites to other locations and provide reports in real time based on his knowledge of Essential Elements of Information (EEI) and key activity indicators.

(3) Utility of a permanent (manned) presence in space to satisfy DoD research and development (R&D) requirements or to support the combined arms commander.

(4) Capabilities required to cue or augment other national capabilities.

(5) Insight to observables from space which impact Operations Security (OPSEC).

3. Objective.

To determine the potential of having a trained IA Payload Specialist (PS), to conduct real time analysis from a low Earth orbiting platform.

a. Issues.

(1) Real Time Analysis. Can a trained Imagery Analyst perform real-time ground site analysis while on board a low Earth orbiting platform?

(2) Spaceborne Direct View Optical System (SpaDVOS). Is the Spaceborne Direct View Optical System suitable as primary optical and video/audio recording equipment for this experiment?

(3) Operations Security (OPSEC). Do Earth observations from a manned orbiting platform impact Operations Security?

(4) Coloristics[I-1]. Are there sights observable from Earth orbit by the human eye that can not be reproduced through photographic and related technology?

(5) Army Requirements. Is there potential for satisfying Army requirements through real time analysis from space? Is the Space Shuttle a viable platform for conducting research, development, and experimentation in related Earth observation concepts?

b. Data collected as a result of Terra Scout could help determine if the analytical skills of a specialist who is a professional expert in his field, provides a significant or measurable advantage over those of a professional astronaut who is not a expert/specialist in that field. Evaluating this data serves to benefit future space missions.

c. Evaluating past training and experience of either Imagery Analysts' or Astronauts' is not an objective of this experiment.

4. Procedure.

Terra Scout observation sites were recorded on video tape simultaneously with PS observations. Audio capability was included on the tape to record the PS verbal dissemination of results and characterization of the SpaDVOS. The primary purpose of video recordings was to verify acquisition of the observation site.

I-1 The term given to investigation of human color vision during space flight, the development of instruments for measuring it, the development of improvement of visual and automatic remote-sensing spectrometers, the study of the color attributes of natural objects and phenomena and the study of radiation spectrums and errors in perception of spectral characteristics.

After landing, the PS written and verbal reports were compared with ground truth provided primarily by on-site personnel or by other means.

After landing, other expert IAs were to perform detailed analysis of the recorded video and determine if there was a difference in PS reports and information available. Detailed analysis was not accomplished due to the poor quality of the video recording. An explanation is provided later in this report

5. Scope of Experiment.

An Imagery Analyst, trained and qualified as a space shuttle crew member, attempted to visually acquire, track and record observations and analysis of fifty-five (55) planned, ad hoc, and bonus target ground site locations from an orbiting space shuttle. The SpaDVOS was the primary observation equipment and the shuttle video tape recorder (VTR) was the primary recording equipment. In addition to video recording, the IA made a voice recording during each ground site analysis event. He also entered results of his analysis in separate target folders for each site. Current weather and other ground truth observations were recorded by personnel at the ground sites. Most ground sites were photographed by other means at approximately the same time as the orbiting analyst passed overhead. All data collected was returned to the USAIC&FH after the experiment concluded. The data was analyzed by subject matter experts (SME) with results described in Section III of this report.

The experiment was planned for a 160-200nm orbit, providing a total viewing time of approximately 70 seconds per site. Only 45 seconds of the total time was expected to be usable due to target site locations, target site incidence angle, and the time required to acquire, track, zoom, and focus on the site.

6. Background.

a. Justification and Military Relevance.

(1) The tactical commander on the modern battlefield is pressured by limited time and space, and sophisticated weapons systems. These constraints require him to "see" deeper in all directions and receive information and intelligence in a more timely manner than ever previously required. One important source of this information is Imagery Intelligence (IMINT).

For several years, the Intelligence Electronic Warfare Mission Area Analysis process repeatedly identified inadequate IMINT collection capabilities at echelons from Division through Echelons Above Corps (EAC) and Joint Command. The new Branch Planning Analysis (BPA) process continues to identify these same deficiencies (in the area of imagery intelligence). The complete prioritized list of deficiencies is published in the U. S. Army Training and Doctrine (TRADOC) Battlefield Development Plan (BDP).

It was believed that experimentation using an Imagery Analyst (IA), performing real time observation and reporting from an orbiting platform, could provide data which would contribute to correcting these deficiencies and provide support to AirLand Operations doctrine. Thus, Terra Scout was conceived to address Army deficiencies.

(2) Space platforms are not restricted by national boundaries, and are useful throughout the spectrum of conflict from contingency operations to support of the deep battle, and especially for support to emerging AirLand Operations. The imagery targets chosen for Terra Scout included a cross-section throughout the spectrum. of conflict It is important to emphasize that the objective is not just to see these targets, as has been marginally done in previous experiments, but to use the techniques and order of battle experience of the IA to interpret their importance and note any current significant activity.

b. Imagery Analysis (IMINT) Description.

Ground site analysis (imagery analysis) is in large part a process of elimination. The primary interest of the military analyst is in military activity and includes the entire military environment. The analyst can evaluate natural features such as terrain, vegetation, bodies of water and ground mobility, and determine types of military activity that could be conducted within the observed environment. He then separates natural features from the man-made using a variety of analytical tools and observation skills. These include size, shape, shadow, shade, and relation to surrounding objects or areas. This is why the National Imagery Interpretation Rating Scale (NIIRS) rating of a particular image , although important, is somewhat insignificant to an imagery analyst. The higher the NIIRS, the more one can see. However, even when an image has a low NIIRS rating, an experienced imagery analyst can derive information from that image that would require a higher NIIRS rating (better resolution) for the untrained or inexperienced person to see the same thing. Usually, background information is available to provide the analyst a basic state of "normalcy" for the area or object. The following examples are provided to describe how the trained expert accomplishes analysis, and to give rationale for using an expert analyst.

(1) An analyst is tasked to analyze an airfield. The analyst will mentally sort through the man-made/natural features and initially identify the airfield as military, civilian, or joint use. This is accomplished by looking at the primary runway(s), their orientation, composition, and whether ammunition storage, or other underground/ground covered facilities exist. Next, he will focus attention on the hangars (size and type), taxiways and parking areas (size, type, revetments, separation, parking). Size and location of hangars are indicators as to size and number of aircraft the airfield can accommodate. Parking facilities provide strong indicators of the type aircraft normally accommodated i.e., small revetted aprons indicate fighter aircraft.

These observations are normally completed very quickly and help the analyst establish the type activity likely to be seen. The IA then identifies specifics of facilities or objects observed, with special attention to support capabilities such as fuel storage capacity, rail service, supporting road networks and electrical service. Through training and experience the analyst knows traditional and evolving methods for construction, concealment, disbursement, and protection of these facilities. The IA makes a determination of defenses through direct observation and by analysis of revetments or other patterns not associated with airfield activity. The IA also knows specific patterns of deployment used by different types of air defense systems.

(2) Another example, might likely be the observation of an item of equipment organic to an Air Defense Battalion subordinate to an Army or Front which can be used to protect a high value target such as an airfield, supply depot, etc. Whereas a similar item of equipment may be organic to a lower level organization and therefore protecting a less significant target. The equipment may represent threats to our assets, but perhaps even more important questions are, why are they there and what are they protecting? Where one item of equipment may be protecting a nuclear storage area, a high level command post, or some other semi-fixed high value target; the other item of equipment may be providing protection for a river crossing operation. An IA knows this, and upon locating items of equipment or patterns on the ground, will naturally search for the significant activity or target likely to be associated with that observation.

c. Joint Service Interpretation Standards.

(1) Each of seventeen (17) mission/target categories are described in *RADC-TR-90-370, Imagery Interpretation Requirements for Reconnaissance Systems,*, along with standing EEI and a representative image for each category. The categories are as follows:

01	Airfield
02	Missile System
03	Electronic Installations
04	Barracks/Camps/Headquarters
05	Storage and Repair Facilities
06	Military Activity
07	River Crossings/Ferries
08	Shipping
09	Route Reconnaissance
10	Terrain Reconnaissance
11	Coastal Strip
12	Bridges
13	Water Control Facilities
14	Ports/Harbors
15	Rail Facilities
16	Industrial Installations
17	Electrical Power Installations

(2) Each category is further broken down into specific EEI. such as the example provided below:

Mission/Target Requirement - Cat 01 - Airfield

TARGET EEI - Airfield
1. Type
Military/Civil/Joint
2. Status
a. Serviceable/Unserviceable
b. Operational
c. Status of Construction/Being Modified/Type of Mod.
d. Hardened
3. Activity
a. Aircraft - Number, Type, Location
b. Other Activity, If Significant
- Include Troop Concentration
- Supply Stocks
4. Defenses - Number, Type, Location
a. Anti-Aircraft
b. Ground
5. Combat Operation Facilities - Number, Type, Location
a. Operations Centers/Bunker
b. ATC - Facilities
c. Auxiliary Power Supply
d. Communications/Electronics
6. Infrastructure
a. Runways/Taxiways - Orientation, Dimensions, Material
b. Dispersals/Shelters
c. Other Main Buildings Including Hangars - Purpose, Location, Hardening
7. Support Facilities - Permanent/Temporary
a. Weapons Storage
b. POL
c. Power Facilities
d. Supply
e. Other

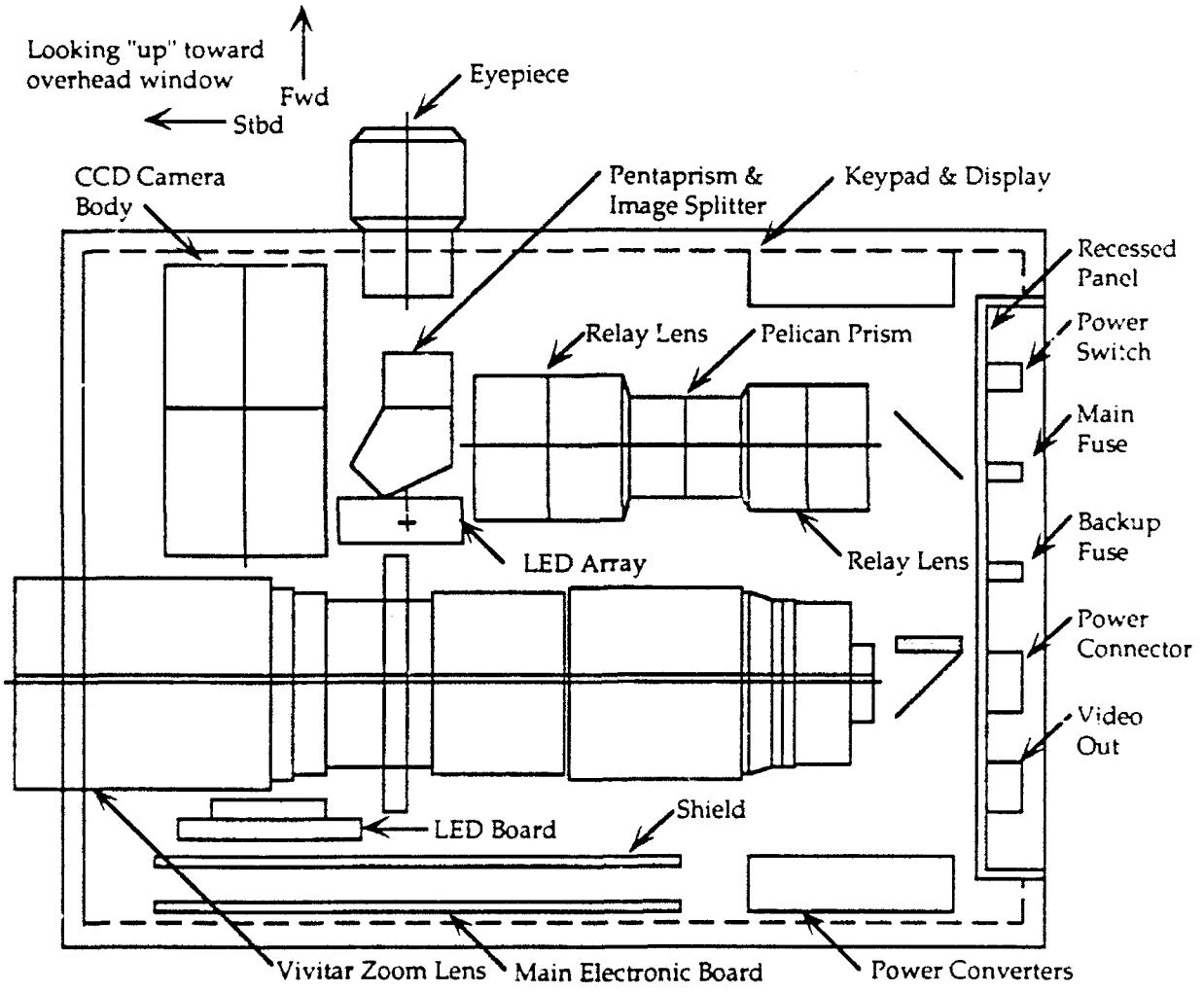
7. Experiment Equipment Requirements and Acquisition.

a. Primary Optical Equipment: Spaceborne Direct-View Optical System (SpaDVOS).

(1) SpaDVOS is a telescopic folded optical device which is capable of having its magnification changed from 4X to 60X, using removal eyepieces. Additionally, it was designed to simultaneously transmit video images to a video recorder at the same time the object is being observed. It was built to conform to all NASA space flight

qualification requirements and to accommodate single-person mounting, operation and removal from the space shuttle aft flight deck overhead windows without the need for special tools. SpaDVOS was designed and built by the USAF Armstrong Aerospace Medical Research Lab (AAMRL) at Wright-Patterson AFB, OH with contract support from the University of Dayton Research Institute. It was conceptually designed by Dr. Lee Task of AAMRL for human factors experiments proposed for the space shuttle.

Figure I-1 SpaDVOS Configuration Diagram



(2) Two SpaDVOS' were funded jointly by the Army and Air Force. One of these will be placed in the Post museum at Fort Huachuca, while the other will remain with AAMRL. A summary of pertinent SpaDVOS characteristics is in Appendix B.

b. Back up Optical Equipment.

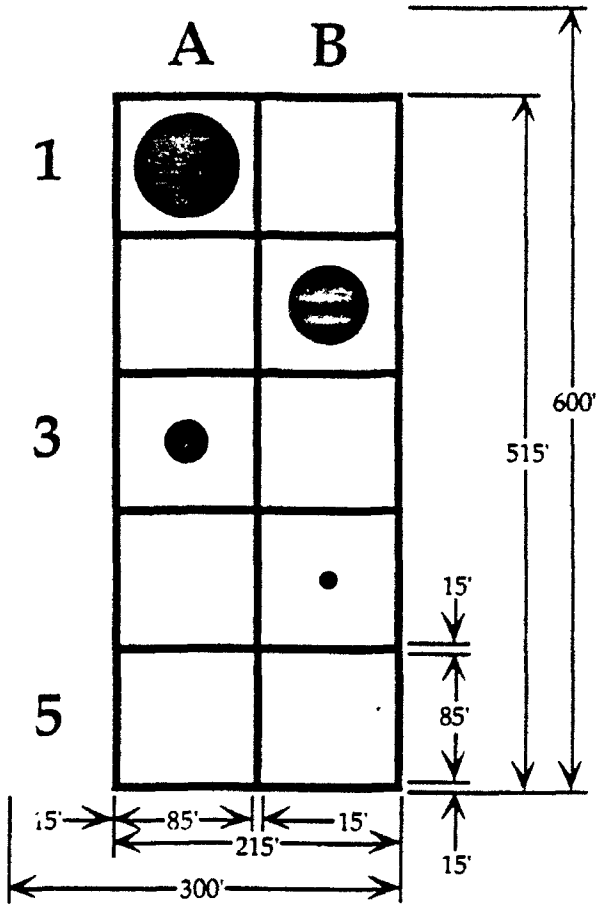
(1) Fujinon binoculars, 14x70. Experiments carried out on board the space shuttle should have back-up hardware and are required to have alternative plans for completing their objectives if unforeseen problems arise after launch. These binoculars were expected to provide minimum resolution required for the imagery analyst to complete experiment objectives if SpaDVOS malfunctioned. In addition, they could be used to assist locating targets and scanning target areas by other crew members. As a result of performance during STS-44, NASA is considering the addition of these binoculars as standard Shuttle equipment.

(2) Bausch & Lomb Discoverer spotting telescope, 15-60x. The spotting scope was manifested for the same purpose as the binoculars above. However, they were not used on orbit.

c. Optical Resolution Panels.

The United States Army Electronic Proving Ground (USAEPG), supported by Georgia Tech Research Institute (GTRI) provided optical resolution panels and test and evaluation (T&E) support to USAIC&FH for Terra Scout. USAEPG/GTRI support included logistical support and technical preparation; pre-test simulation definition; and design, development, and test of the Optical Resolution Panels; and on-site assistance. These panels were positioned at four locations for the experiment: Cape Canaveral, FL; Barbers Point, HI; and two sites in Australia. Australian locations were manned by U.S. Army personnel with assistance from local organizations. Test support direction and control was accomplished at Fort Huachuca, AZ by USAEPG, supported by COR, Inc., Sierra Vista, AZ. An example of the Optical Resolution Panels is provided below. Additional information on purpose, site data and results of using the Optical Resolution Panels is in Appendix C.

Figure I-2 Optical Resolution Panel



8. Experiment Limitations.

The original experiment design was constrained by a variety of factors. The first constraint was that the experiment was designed for only one on-orbit analyst because of the difficulty getting a Payload Specialist on the shuttle. An increase in the number of on-orbit analysts would not likely have been approved for flight. The current Space Test Program and Space Transportation System (STS) was designed to accommodate experimentation if there was space available on the shuttle after meeting all requirements of a primary payload. Military-Man-In-Space (MMIS) experiments requiring a Payload Specialist were a low priority for manifesting on the shuttle by NASA. Payload Specialists were not a common element of the STS subsequent to the catastrophic CHALLENGER accident in January, 1986 and required additional effort for planning, training and integrating with the crew.

a. Based on having only one on-orbit analyst and the need to ensure a measure of statistical validity, approximately 20 (target) observation sites were determined to be the minimum required. This is listed as a constraint because there was no guarantee the PS would be able to complete the minimum number of observations during a shuttle mission which was originally scheduled for only four days. As Terra Scout evolved, personnel of the U. S. Air Force Operating Location at Johnson Space Center recognized this as a valid concern and provided strong DoD support to the NASA offices desiring to extend the flight to 10 days in order to accomplish medical and extended duration orbital flight studies.

b. The primary hardware limitation was that the shuttle aft flight deck windows were not designed for observations of the type desired during Terra Scout. However, during the process of developing Terra Scout, the optical quality of the windows was evaluated by Aerospace Corporation and AAMRL. Results of these evaluations showed that the aperture designed for the SpaDVOS was near optimum considering the poor optical quality of the windows. Appendix B contains a summary of the Shuttle Window Optical Test Results.

c. SpaDVOS was the choice of optics for Terra Scout for a variety of reasons described elsewhere in this report, and because of its high priority within the Space Test Program. However, SpaDVOS was primarily designed for human factors experiments to determine man's visual capability from low Earth orbit, and not originally intended to provide the resolution desired for Terra Scout. Additionally, it was not originally designed to accommodate "through the lens" video recording. The decision to use SpaDVOS was made specifically because: 1) there was no other capability available considering the limited funds provided by the Army for hardware development; 2) SpaDVOS did provide a satisfactory tool to use for a proof of concept experiment such as Terra Scout; 3) Lessons learned from Terra Scout would provide information that could be used to further improve SpaDVOS's capability as an earth observation and recording device if desired.

d. During the mission there were no direct communications with the Payload Specialist (PS1) by the secondary payload/experiment support teams (described in Section II). Communications were routed through Mission Control because NASA does not traditionally permit direct communications between and the shuttle.

e. Support for Terra Scout was provided by a variety of organizations including the Secretary of the Army for Research, Development and Acquisition (SARDA), U. S. Army Training and Doctrine Command, and the Army Space Program Office. An approximate breakdown of costs over a seven year period is as follows:

- Hardware Development and Training:	$520K.
- Training Plan Development:	$10K.
- TDY for Training and Management:	$160K.
- Resolution Target Fabrication and Deployment:	$250K.
Army/USAIC&FH sub-total:	$940K

- Payload Specialist Training: (paid by DoD)	$250K
DoD total:	$1.19M

II CONDUCT OF EXPERIMENT.

1. General.

The Terra Scout Space Shuttle Experiment was organized and completed as a proof of concept in accordance with U. S. Army TRADOC policies. The basic process for development, submission, approval and prioritization of experiments for the Space Test Program are described in Appendix G. Some of the steps required to complete specific actions for experiment development are dependent upon type, purpose, scope and requirements, on a case by case basis for each experiment. Some of the steps taken in development of Terra Scout were done in sequence, while many were done simultaneously, and a few were updated continuously throughout the entire process. An outline of major phases of development and selected summaries are provided below. Additional information is provided in appendices to this report.

2. Experiment Phases.

a. Payload Specialist (PS) Selection. (see Appendix F)

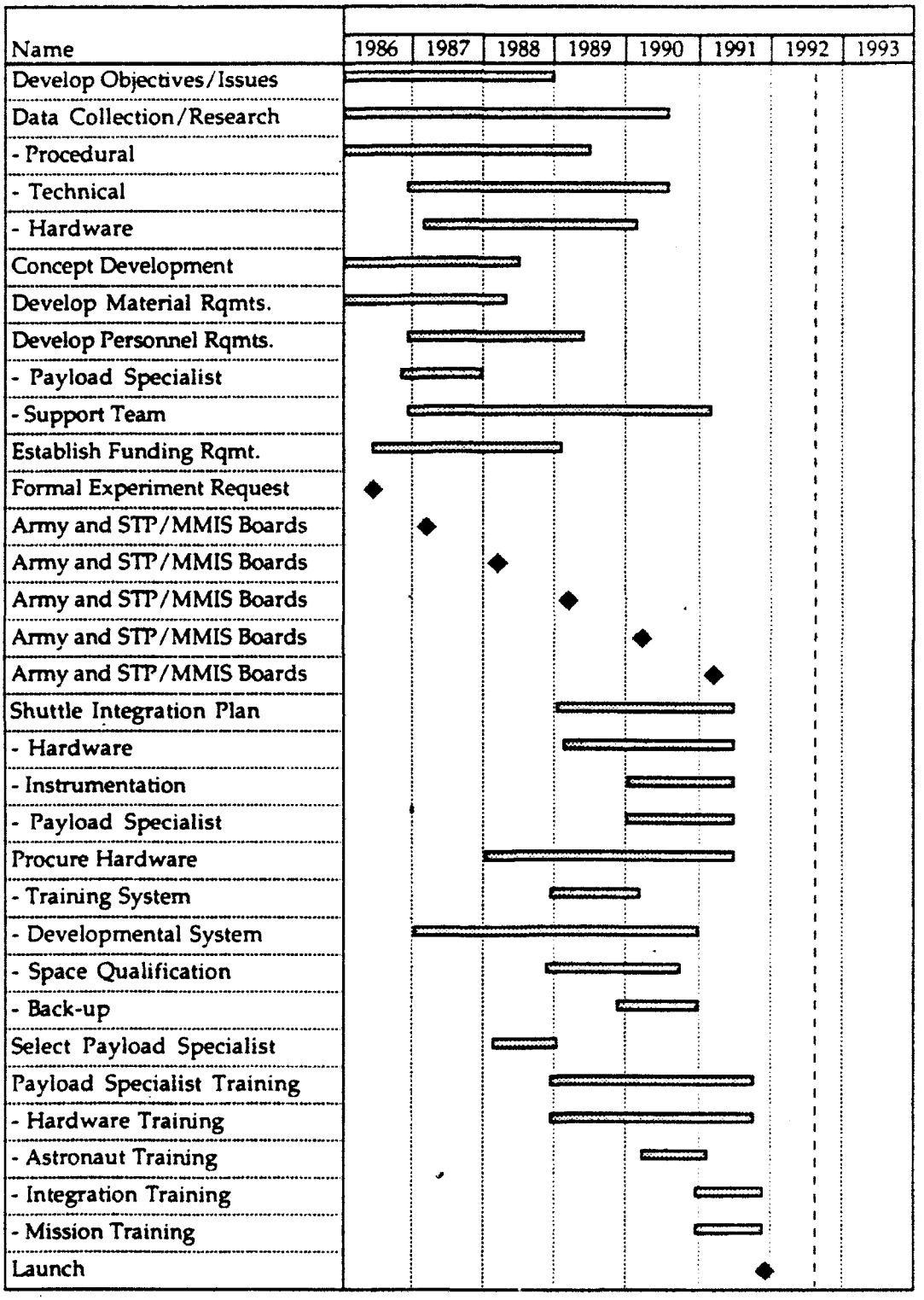
Selecting a PS from among qualified personnel was a major effort. The Army is not manned to accommodate positions for personnel not approved and authorized by the Service Secretary, Secretary of Defense, or Congress. There are few positions for Army personnel at NASA, and no positions for Payload Specialists. Support from senior leadership of the Army is required. In 1988, MG Parker, then Commanding General of USAICS[II-1], and LTG Weinstein, then DCSINT of the Army, provided this support for Terra Scout. They requested approval of General Thurman, the Vice Chief of Staff of the Army. MG Parker directed the Army Military Intelligence Branch to conduct an Army-wide screen of all warrant officer (WO) and senior non-commissioned officer (NCO) Imagery Analyst[II-2] records. In the Army, the bulk of expertise in imagery analysis resides within the WO and senior NCO ranks. Selection criteria established by USAIC&FH required one WO and one NCO be selected, versus the best two overall from among the warrant and non-commissioned ranks. After the Army-wide records screen, four PS candidates were selected for interviews and physical examinations.

The final determination of payload specialist candidates for Terra Scout was made by a selection board held in August, 1990 at USAIC&FH. CW3 Thomas Hennen was selected as the primary, MSG Michael Belt was selected as the alternate/back-up, and a third candidate, CW3 John Hawker was selected as an alternate and retained to serve as part of the experiment design and execution team. The fourth candidate was eliminated as a result of the NASA physical examination.

II-1 United States Army Intelligence Center and School, re-designated United States Army Intelligence Center and Fort Huachuca in 1991.

II-2 Army Military Occupational Specialty (MOS): 350D (962A until 1988) for Warrant Officer and 96D for non-commissioned officer.

Figure II-1 Phase History



b. Training. (Additional information in Appendix F)

Training for Terra Scout was based on eight instructional areas taught during the 19 months prior to the launch of STS-44. These include the following:

(1) Imagery Analysis and Review: This training was designed to enhance skills in searching, acquiring, tracking, and reporting on targets from space.

(2) Target imagery simulation and testing: Training accomplished two objectives; (a) familiarization for each PS with the speed at which the earth will move beneath the shuttle; and (b) establishing the difference in the imagery analysis abilities of the two IA's prior to experiment execution.

(3) Flexible Image Generation System (FIGS) training: See paragraph c (2).

(4) Generic space instruction: Addressed the orbital environment and space vehicle subsystems common to all spaceflight.

(5) Aircraft overflight simulation training: Provided confidence and realism in observing comparable targets utilizing a rudimentary telescope arrangement.

(6) SpaDVOS training: Included assembly/disassembly, care, and operation, and flights on NASA Lear Jets and microgravity simulation aircraft using the actual flight hardware telescope.

(7) Physical training: Provided necessary physical and mental fitness for spaceflight.

(8) Payload Specialist Training: See paragraph c.(3).

c. Training Locations.

(1) Fort Huachuca, AZ. (March 89-continuous) Although the PS candidates had significant expertise in imagery analysis, additional imagery training for the experiment was conducted at Fort Huachuca. This training primarily involved thorough familiarization with pre-planned target sites[II-3]. Target files were made for each pre-planned target, which included a narrative description of the area, imagery of the area, and a sequence of images representing how the approach to the ground site would appear from space. Their performance during this training was also used as a factor in determining which candidate would be selected as the primary PS based on demonstrated retention of target information.

II-3 A small number of ad hoc targets were passed to the IA while in orbit but the majority of targets were pre-planned because each observation opportunity had to be programmed with the shuttle primary mission.

(2) Wright-Patterson Air Force Base, Dayton, OH. (Sep 89-continuous) Approximately twelve training sessions were conducted on the Flexible Image Generation System (FIGS) simulation device at Wright-Patterson AFB, beginning in September, 1989. FIGS replicates the operation of a space-borne telescope system which is focused on terrestrial targets. Specifically, the simulator teaches each candidate to search, acquire, track, and observe targets which are in range for approximately 70 seconds. The simulator presents examples of target types which will be used during Terra Scout. This simulator does not replicate a weightless environment but is operated by means of the same type of manual controls as SpaDVOS.

-During the training and development process SpaDVOS was mounted in a NASA Lear jet where training and system tests were conducted in flight.

-Several training sessions and system tests were also completed with SpaDVOS mounted in a NASA KC-135 microgravity environment training aircraft. Each session was conducted while the aircraft flew approximately 50 successive arching parabolas where the trainees experience a microgravity environment for 20-25 seconds per parabola

(3) Johnson Space Center (JCS), Houston, TX. (Oct 90-launch)

-Astronaut crew training was conducted at JSC for both primary and back-up PS candidates beginning nearly one year prior to launch. Although only the primary PS received complete "hands on" training, the back-up received the same classroom training and observed all of the hands on training with the crew. Crew and experiment integration training began nine months prior to launch. The PS was integrated with the crew members, extensively training together for the specific mission. Emphasis was on shuttle operational requirements and individual crewmember responsibilities. Once manifested for flight, the primary PS/IA was given the call sign/designation of PS1.

-Programs for astronaut training, crew integration and mission training are established and conducted by NASA.

3. Concept of Employment and Operation.

a. The SpaDVOS was developed, built and space qualified for use as the primary optical equipment for the experiment. SpaDVOS was not designed to provide optimum resolution but was low cost, provided a video recording capability, and was determined to provide sufficient resolution for experiment purposes. Of considerable concern to the Terra Scout experiment team was the fact that flight deck shuttle windows are not designed to provide high optical quality. However, tests conducted on the shuttle windows showed that the SpaDVOS aperture was very near optimum for the non-optical quality windows used during the experiment. SpaDVOS was operated in both a manual mode and partially automated mode using an along-track motion motor drive.

b. Approximately ninety ground target sites were selected by SME's. Target sites were selected considering shuttle orbital parameters and were based on terrain, activity, and equipment or objects representative of typical military-related areas of interest. Optical Resolution Panels were also placed at four ground target sites with the intent of accurately measuring observable resolution and contrast values. These panels were configured differently for each observation opportunity (orbit) in an attempt to perform ground resolution measurements. The analyst, PS1, attempted to report observation of the sites as many times as possible during the mission i. e., observation of the same site was attempted during each orbit the site was observable and time required for observation was scheduled within the flight plan.

c. Target folders were prepared for each site. Folders included overhead images (large and medium scale), photographs, maps, EEI and general information, and space for recording observations.

d. The (daily) morning Text and Graphics (TAGS) message (delivered to the crew on-orbit) included site information for that day[II-4]. The SpaDVOS was built with the capability for PS1 to input site information for up to four targets at a time. SpaDVOS could then provide PS1 acquisition assistance during observation attempts by displaying cross-track and along-track reference to the target.

e. After achieving orbit and deployment of the STS-44 mission primary payload, PS1 removed the SpaDVOS optical equipment from the stowage locker and mounted it to the aft flight deck overhead window.

f. Several minutes prior to overflight of each site, PS1 completed checks on the SpaDVOS, reviewed the respective target folder, and prepared to acquire the site and record observations.

g. During the mission, another crew member (frequently the pilot, referred to as PLT) positioned himself in the forward portion of the flight deck to assist PS1's acquisition of the prescribed site. PLT provided confirmation of off-track angle to the site and apparent weather at the site.

h. PS1 primarily used pre-selected geographic features to acquire and track the target. The previously described SpaDVOS acquisition assistance was through LED indicators, viewable through the optics, which provided along-track and cross-track information on the target. When the LED display was "zeroed", the target was within the SpaDVOS field of view. As the site emerged into view PS1 manually acquired it and continually tracked, focused and zoomed the optical equipment to accomplish his observation. PS1 verbally recorded actions taken to acquire and track the site, and each observation event.

II-4 The TAGS message represents a daily situation and information report from Mission Control to the shuttle crew. It is normally prepared and transmitted each morning and can include messages for individual crew members, activity changes, weather for areas to be observed, and any other information.

i. Initially the video recording of observations was to be transmitted to the ground where another IA, who was not limited by time, would analyze the imagery to see if there were differences in what was reported by PS1. Further, more detailed analysis of the video was to be accomplished after the mission. This part of the experiment was changed because recorded images did not accurately reflect what was seen through the eyepiece of SpaDVOS and there was no means on this flight to transmit the imagery to the ground. Instead, the video was used to later confirm target area acquisition. Recordings of observations made by on-site observers and imagery provided through national technical means were also used as ground truth for verification of PS1's observations.

j. After launch, support operations were activated in the Secondary Payload Support Room (SPSR), Johnson Space Center (JSC), Houston, TX. The SPSR is a facility co-located with the Mission Control Center - Houston (MCC-H) and is provided by NASA to accommodate secondary payload and experiment support personnel during DoD shuttle missions. The support team consisted of the back-up PS, other members of the USAIC&FH Space Division and AAMRL who are the principal investigators and developers of Terra Scout and SpaDVOS. The team established a schedule for around the clock operations and communication (through mission control) to PS1. The primary objective of the experiment team was to perform troubleshooting activities for the SpaDVOS, collect in flight target data to the extent possible, and to conduct planning for changes to the target list and immediate tasking to PS1 if necessary. A limited number of observations were passed from PS1 to the support team during the mission. All communication between the support team and PS1 were routed through the MCC-H, with the support team able to monitor transmissions between PS1 and MCC-H.

h. After the mission, all data collected was returned to USAIC&FH for analysis and reporting by Space Division.

4. Experiment Control.

a. Factor and Conditions. The following factors, conditions and controls were in effect during the experiment.

Factors and Conditions	Control	Levels
Range	Controlled	By Orbit ~200nm
Light Conditions	Controlled	Varied - Predominantly Daylight
Target Movement	Controlled	No Movement
Target Arrays	Varied	Optical Resolution Panels - Controlled Other - Uncontrolled
NBC	N/A	–
Terrain	Systematically Varied	Predominantly Level or Gentle, Rolling
Threat	N/A	–

Factors and Conditions	Control	Levels
Obscuration	Uncontrolled	As Occurred
Personnel	Held Constant	Specific Criteria
Organization	Held Constant	NASA/USAICS/AAMRL
Environment (PS)	Held Constant	Shuttle Environment
Environment (Targets)	Uncontrolled	Same as Obscuration
Communications	Uncontrolled	Limited/Restricted by NASA Policy
Weather	Uncontrolled	As Occurred
Systems Operational Status	Uncontrolled	Limited Backup Capability On Board

b. Ground site targets.

(1) Optical Resolution Panels. (see Appendix C)

(2) Pre-planned and ad hoc sites.

Conditions for pre-planned and ad hoc sites were not controlled. An attempt was made to select ground target sites thought to provide acceptable viewing conditions of prevailing weather and obscuration limitations, and sites were scheduled for observation during periods of acceptable sun angle.

5. Data Collection and Reduction.

The original data collection plan is described in detail in the Terra Scout Experiment Plan developed by ***Dr. George W. Lawton, Army Research Institute for the Behavioral and Social Sciences, January, 1989.*** The plan includes data collection requirements for preflight, on-orbit, and post-flight phases of the experiment. Significant modifications to the original plan were necessary due to a number of planning and execution variables which were unknown or unconfirmed until launch. These are generally included below.

a. Preflight.

During the preflight phase, testing of the primary and back-up PS was conducted approximately Launch minus one month (L-1). Testing consisted of each analyst having one minute to look at each of approximately 30 photos. For preflight test purposes, one minute corresponds approximately to the maximum time the analyst was expected to have on orbit to analyze each site. After one minute the analyst was given 15 minutes to generate a report on the observation. Reports were based on the EEI for that site based on Mission/Target Category, and included time of report, subjective estimate on atmospheric haze, and an estimate of the NIIRS rating. Not all of the sites used during the preflight phase were among those actually planned for the experiment. Exact target sites could not be selected prior to this phase because the actual orbital track for the

shuttle mission was dependent on actual launch time. Therefore, the ability to select imagery of all eventual pre-planned sites was not feasible. Regardless of this, imagery used for training included sites similar in type and variety as those desired for observation by the on-orbit analyst during any shuttle mission.

b. On Orbit.

During the on-orbit phase, PS1 followed essentially the same procedure for site analysis and reporting as during the preflight phase. One difference was that the analysis was by direct view through SpaDVOS rather than analyzing film. Another difference was the requirement to manually track, zoom and focus while performing analysis in the microgravity environment of space. The SpaDVOS also allowed for simultaneous video taping of the general area during analysis. During this phase PS1 was dynamically tasked by ground support personnel in MCC-H to attempt acquisition, tracking, analysis and reporting on ad hoc ground sites, and report observations of bonus sites not scheduled as primary but within the primary target area. On-orbit data collection was divided into two parts: pre-planned and ad hoc sites, and resolution sites.

(1) Pre-planned and ad hoc (non-resolution) site data collection was accomplished by the SpaDVOS video and audio recording while PS1 observed ground sites in real time using the SpaDVOS optics for acquisition, tracking, and analysis. Sites included a variety of locations and activities, primarily areas representative of possible military interest. Ground truth imagery was provided for some sites through other sources.

(2) Resolution site data collection. In addition to the SpaDVOS recordings, weather and the resolution grid panel configurations (ground truth) were recorded by on site personnel.

c. Post flight.

(1) For ad hoc and pre-planned, non-resolution panel sites, imagery SMEs of Space Division, USAIC&FH accomplished data reduction manually. Data reduction consisted of comparing the target files used by PS1, the INFLIGHTREP completed by PS1 while on orbit, ground truth imagery provided through national technical means, and in a few cases, the SpaDVOS video. Additional data was derived from NASA post mission crew debriefings and questionnaires completed by crewmembers of STS-44.

The SpaDVOS video was expected to provide imagery of target sites acquired by PS1. The video would provide one tenth of the area visible to PS1 and at least an order of magnitude less resolution. Video frames extracted from the SpaDVOS recording would be analyzed by SMEs following normal Reconnaissance Exploitation Reporting (RECCEXREP) procedures and timelines (approximately 15 minutes). They would not have the constraints of PS1 in terms of time, microgravity, and the requirement to manually acquire, track and focus. A comparison of differences between PS1 and the unconstrained SMEs was intended. Finally, these results were to be combined and compared with other ground truth in the final report.

It was suspected during the mission that analysis of the vide recording would be impossible. For most target sites, as the aperture on SpaDVOS was adjusted for optimum observation by PS1, it prevented enough light from passing through the optics onto the CCD array of the SpaDVOS, therefore not providing enough light for video capture. Post flight analysis of the SpaDVOS video confirmed this suspicion. Short, marginally viewable portions were compared to PS1's observations to the extent possible. However, the audio track on the tape did provide significant site and characterization data.

(2) For optical resolution panel sites, ground truth was recorded by on-site support personnel at the four world wide locations. Data included current weather and visibility, and specific pattern layout within the resolution panel grids. This data was analyzed and provided to USAIC&FH by USAEPG. (Appendix C)

d. According to STS-44 crew debriefing and post flight analysis, atmospheric obscuration was severe during STS-44 and a distinct detriment to the experiment. The lack of a sufficient number of clear weather sites prevented accurate statistical measurement. Analysis of upper atmospheric conditions and obscurants was performed by NASA and provided in a Darkest Object Identification Report. This report is included as Appendix D to this report.

III EXPERIMENT RESULTS.

The Terra Scout space experiment took place on board the space shuttle ATLANTIS, Space Transportation System (STS) mission 44. STS-44 was launched from Kennedy Space Center (KSC), FL, 23:44:00 Greenwich Mean Time (GMT), 24 November 1991. The mission was planned to orbit approximately 200 nautical miles at an inclination of 28.5 degrees for 10 days and return for landing at KSC. Due to a malfunction in the shuttle back-up navigation equipment the mission was terminated three days early and ATLANTIS landed at Edwards Air Force Base, CA 22:34:42 GMT, 1 Dec 1991.

1. Experiment Issues.

a. Issue 1. Real time Analysis. Real time analysis of ground sites can be accomplished by a trained Imagery Analyst on board a low Earth orbiting platform.

(1) Review and analysis of mission data collected, and results of payload crew debriefing, indicates a significant degree of success for the United States Army Space Shuttle Experiment, Terra Scout. Although not easily quantified, there is sufficient data to state that the objectives of Terra Scout were met. With improvements in optical and recording capability, an analyst/expert could provide a distinct advantage in Earth observation from future orbiting platforms if real time analysis of military activity is desired from that platform.

(2) Acquisition and tracking of pre-planned, ad hoc, and ground site targets of opportunity can be accomplished using SpaDVOS from a low-earth orbiting platform. Due to the shuttle windows, SpaDVOS does not provide resolution necessary for detailed analysis and provides marginal resolution for limited terrain analysis and situation development.

b. Issue 2. Space-borne Direct View Optical System. (SpaDVOS)

The SpaDVOS is suitable as primary optical (telescope) equipment for this experiment, but inadequate for recording with its current CCD array.

(1) As stated elsewhere in this report, the Terra Scout team's use of SpaDVOS was advantageous for both the USAIC&FH and AAMRL. SpaDVOS was not originally designed specifically for Terra Scout, and thus did not provide the high quality video recording output desired for post-mission analysis. As previously identified in Section I, Limitations, the aft flight deck overhead windows in the space shuttle are not optical quality windows and thus do not accommodate larger aperture optics or high resolution, detail viewing or video recording optics. Although these factors are significant, they were considered to be within satisfactory limits for a proof of concept experiment to determine if a trained analyst could provide usable information through

ground site analysis from an orbiting platform. With development and design of specific optical equipment for this purpose, the trained analyst would provide a distinctly new capability.

(2) SpaDVOS is capable of providing resolution to 24 feet[III-1], the best resolution recorded during Terra Scout. Due to the poor optical quality of the shuttle windows, atmospheric conditions of weather and other obscurants, and other factors impairing contrast, the best resolution that could be routinely expected should be considered as 50 to 80 feet. The field of view is adequate. The along- and cross-track ability is limited but it is very easy to aim, acquire and track a ground target with SpaDVOS, when the along- and cross-track cueing function is operating correctly. Although there were malfunctions during the experiment, SpaDVOS should not be considered prone to malfunction. The recording capability is poor and should not be relied upon unless significant improvements are made.

c. Issue 3. Operations Security. There is an impact on Operations Security resulting from Earth observation from a manned orbiting platform.

PS1 was able to acquire and track specific target sites accurately and, if desired, would be able to observe activity that could impact operations security.

d. Issue 4. Coloristics. There apparently are sights observable from Earth orbit by the human eye that can not be reproduced through photography and related technology.

(1) Based on the survey of astronauts and PS1's comments, color, patterns, and shades of color or light are observable during orbit but not accurately reproducible by mechanical means. These are among the most commonly cited phenomena by astronauts. While on orbit and during post-mission debriefing, PS1 indicated that color greatly assisted in target acquisition and identification. Although Terra Scout did not provide measurable data for an absolute determination of this issue, the experiment served to increase awareness of the need for further study.

(2) The former Soviet Union has for years used their Salyut and Mir orbital stations to accumulate vast amounts of information concerning effects of space and atmosphere on observation of earth from orbit. They have determined that there are many sights (phenomena) that cannot be reproduced by mechanical imaging systems and have developed coloristic experiments as part of their studies in the advantages of earth observation from space by the human eye. A significant finding is described as the constancy of eyesight. There are many kinds of constancy, such as that of the relative depth and orientation of objects. The most significant constancy is of color perception that prevails even when the light spectrum changes. This property makes it

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III-1 PS1 was able to see the 15-foot-wide grid lines on the resolution panels. However, these are linear features and do not represent true resolution capability.

possible for observers to overcome obscuring phenomena such as atmospheric haze, blotting shadows and patches of sunlight[III-2]. Based on responses provided by former astronauts and PS1, these ideas appear to hold true and validate the need for in-depth experimentation.

e. Issue 5. Army Requirements. The Space Shuttle is not a viable platform for operational application of real time Earth observation and analysis. However, it is well suited for conducting research, development (R&D), and experiments in related Earth observation concepts. This is another area which our Soviet counterparts have been capitalizing on for years.

(1) The utility of the current shuttle program for conducting real-time Department of Defense observations is marginal at best. As previously stated, the shuttle's primary missions are to place and repair satellites in orbit, conduct R&D and experimentation. Given these missions, observation of specified or ad hoc ground sites is serendipitous. Considering coincidence of normal shuttle orbital inclination, and international Defense requirements, there is little opportunity for the PS or astronaut to observe and report requisite ground site observation data on a regular or dependable basis.

(2) The major advantage in using the current shuttle program for earth observation appears to be in research and development from the payload bay. In the areas of Earth observation and remote sensor development the Shuttle provides the following:

- A controllable platform in many attitudes and configurations.

- More easily returnable payloads. The shuttle is based on the concept of returnable and recoverable payloads and in-space repair or refueling of payloads.

- Actual space environment instead of theory or lab simulation. Duration can be varied for experiment purposes.

- During research, development and engineering check-out, the shuttle is cost effective compared to numerous large, expendable boosters, and can accommodate engineers or technicians who can perform on-the-spot corrections or modifications if needed.

f. Additional data contribution. The analytical skills of a Payload Specialist (PS) who is a professional imagery analyst provides advantages over those of a professional astronaut who is not a trained IA.

III-2 Excerpts from an article in V Mire Nauki, the Russian language edition of Scientific American, reprinted in the English edition, Scientific American, July 1989.

(1) The authors of this report believe Terra Scout provides evidence of advantages in using a trained IA for Earth observation experiments with objectives similar to that of Terra Scout. The advantages for specific experiments are significant when a particular skill is needed. A PS is selected as the best person for the task. Therefore, he is better and more intensively trained on the experiment specific tasks. He is more available for feedback and provides feedback to the experimenters in a common language, which makes it easier to relate his experiences.

(2) There has not been a previous experiment or test of an astronauts' ability to perform ground site analysis of the type, purpose, and level of detail of Terra Scout. It is clear to the authors that follow-on experimentation should be accomplished to quantify advantages or differences in perception of ground observables from space.

(3) There have been no military analysts on board the shuttle who are comparable to PS1. The majority of astronauts are pilots, or scientists who have some measure of Earth observation experience, but they do not have the in-depth training and experience as PS1 in Earth observation for purposes of situation and target development or operational planning.

A pilot is trained to look for objects on the ground primarily to aid navigation or targeting, and occasionally to report activity. An imagery analyst is trained to perform a systematic, detailed, in-depth analysis, deriving much more than object recognition and location. An analyst is trained to develop a complete picture of who, what, why, for what purpose, then report his results in militarily relevant terms. Frequently, contrasting shades and shadows on the ground are more significant to an Imagery Analyst than the ability to clearly see objects. Looking at objects on the ground from a pilot's perspective, (as targets or as points of reference for navigation), should not be compared to the approach taken by an imagery analyst. To a pilot, a large petroleum tank farm is a target or a commonly used reference point. To an analyst it represents an entire network of roads, equipment, communications and other activity, and can convey through analysis the intentions of the controlling unit or organization.

2. Summary of Experiment Data.

The following chart shows ground site observation attempts by PS1. They are listed in order of orbit number and MET[III-3] . PS1 observations are listed in the "PS1 Report" column. Confirmation of both weather and PS1 Reports was made by on-site personnel, National Technical Means, review of the SpaDVOS video, and National Oceanographic and Atmospheric Administration weather information.

III-3 MET is the time scale used for space shuttle missions and is based on time of launch. It begins at launch and includes the day of the mission and elapsed time since launch. For example, 0:02:01:01 is launch day, 2 hours, one minute and one second after launch. MET is occasionally preceded by the orbit number i.e., 2/0:02:01:01.

Orbit/Location/MET	WX/Remarks	PS1 Report
17/Learmonth, AUS 01/01:30		Acquired resolution grid and circles.
18/Ford Island, HI 01/01:56	Equipment Malfunction	Not acquired.
20/Pretoria City, S. Africa 01/06:02	9mm lens Hazy	Not acquired.
20/Diego Garcia 01/06:14	21mm lens	Airport active, serviceable. Five possible large swept wing aircraft on main concrete parking ramp. NIIRS 3. During tracking, clouds began to obscure main parking ramp.
21/Kampong, Thailand 01/06:26	9mm lens	Airport active, occupied, serviceable.
*Helicopter Assembly Building		No abnormal activity.
*Quay/Rail Siding		Normal activity.
*Ship Activity		Normal merchant ship activity
21 /Usakos, Namibia 01/07:37	Re-planned, replaced Harare, S. Africa	Acquired/identified.
30 /Brisbane, AUS 01/21:18	Hazy	Haze too dense for clear observation.
30 /Cape Canaveral, Fl	Cloud Cover	Not acquired.
35 /Anderson, Guam 02/03:45	Typhoon Yuri	Not acquired.
35 /Maputo City, Mozambique 02/04:56	Hazy	Atmosphere too bad for analysis.
*Naval Base		Pier was visible.
*Naval Headquarters		Acquired/identified.
*Training Facility		Acquired/identified
36 /US Embassy Manilla, Philippines 02/05:22	Hazy	Obscured by haze. (SpaDVOS video viewable)
*Mt. Pinatubo		Obscured by clouds.
*Subic Bay	Minimum zoom	Acquired/identified.
*Manilla Bay	Minimum zoom	Acquired/identified.
*Cavite Navy Base	Minimum zoom	Acquired/identified.
36 /Bulawayo, Zimbabwe 02/06:33	Hazy/Cloud cover	Acquired late due to weather Located intersecting runways.
45 /Brisbane, AUS 02/20:12	Overcast, storm	Not acquired.
46 /Christmas Island 02/21:55	Input error	Not acquired.
47 /Useless Loop, AUS 02/23:17		No significant activity.
*Airstrip		Acquired/identified dirt airstrip.
*Pier		Acquired/identified. No activity noted.
51 /Gabarone Airport, Botswana 03/05:21	Cloud cover	Observed major NE road to Gabarone through break in clouds.

Orbit/Location/MET	WX/Remarks	PS1 Report
52 /Sattahip, Thailand 03/05:47	Hazy	Acquired/identified
61 /Managua 2, Cuba 03/19:39	Cloud cover	Not acquired.
*Managua 1, Cuba		Acquired/identified.
62/Cape Canaveral, Fl 03/21:18		Acquired resolution grid and circles
62/Alice Springs, AUS 03/22:10		Acquired/identified.
63 /Learmonth, AUS 03/23:47		Acquired visually with binoculars. Resolution grid and circles.
64 /Ford Island, HI 04/00:13	Cloudy	Acquired/identified. Clouds covered east end of runway. Could not see resolution targets.
*Lualualei	Cloud cover	Not acquired.
*Hickam Airbase	Cloudy	Acquired/identified.
*International Airport		Acquired/identified.
*Barber's Point		Acquired/identified.
66 /Pretoria City, S. Africa 04/04:13	Low sun angle/ Hazy.	Roads visible in/around area. Airfield not visible.
76 /Brisbane AUS 04/19:34	Cloudy	Acquired
77/Cape Canaveral, Fl 04/20:10		Acquired resolution grid and circles.
78/Cape Canaveral, Fl 04/21:47	Cloud cover	Acquired/identified.
*Tampa Int'l Airport		Acquired/identified.
*MacDill AFB		Acquired/identified.
*Melbourne Airport		Acquired/identified.
*Patrick AFB		Acquired/identified
81 /Spratly Islands 05/03:26	Cloud cover	Added Opportunity
82 /US Embassy, Manilla Philippines 05/03:37	Hazy	Acquired/identified.
*Manilla Bay		Acquired/identified.
91 /Santiago, Cuba 05/17:26		Acquired/identified.
*SAM-2 site		Acquired/identified.
*Guantanamo Airfield		Acquired/identified.
92/Cape Canaveral, Fl 05/19:02	Cloud Cover	Acquired/identified.
92 /Baurefield, New Hebrides 05/20:08	Cloud cover	Acquired/identified.
93 /Christmas Island 05/20:19	Light cloud cover	Airport unoccupied. Usable for small aircraft. Building off edge of large concrete apron.
93/Cape Canaveral, Fl	Cloud cover	Not acquired.

a. Pre-planned ground sites, including optical resolution panel sites.

For the planned ten day mission of STS-44, forty-two (42) acquisition attempts were scheduled. Due to early return of the shuttle, 31 of those planned were actually attempted. PS1 was able to positively acquire, identify and track 24 of 31 planned ground sites, representing 77.4%.

(1) Of the 31 planned sites attempted, 2 were unsuccessful due to equipment malfunction and input errors.

18/Ford Island, HI
46/Christmas Island

(2) Of the 31 planned sites attempted, 5 were unsuccessful due to cloud cover or obscuration such that the area could not be acquired/identified.

20/Pretoria City, S. Africa
30/Cape Canaveral, FL
35/Anderson, Guam
45/Brisbane, AUS
61/Managua 2, Cuba

(3) Of the 31 planned sites, 24 were acquired/identified. Cloud cover and haze severely impaired detailed analysis, however, conditions at 8 sites allowed limited analysis.

17/Learmonth, AUS (resolution panel)
20/Diego Garcia
21/Kampong, Thailand
47/Useless Loop, AUS
62/Cape Canaveral, FL (resolution panel)
63/Learmonth, AUS (resolution panel)
64/Ford Island, HI
77/Cape Canaveral, FL (resolution panel)

(4) The remainder of sites were positively acquired, identified and tracked but conditions combined with resolution of optical equipment did not allow detailed analysis.

b. Ad hoc and bonus ground sites[III-4].

III-4 Bonus targets are additional targets picked up in the area of a primary site when the primary site was cloud covered or as time allowed after PS1 completed analysis of the primary site on that pass.

Twenty-three (23) attempts to acquire bonus and ad hoc sites were recorded. Three of these were tasked as ad hoc targets by the support team during the experiment and were successfully acquired by PS1 with no prior notice and without the aid of a target folder. Nineteen (19) of the 23 were acquired and identified, representing 82.6%.

Planned	Bonus
21/Kampong, Thailand	1. helicopter assembly building 2. rail siding at the quay
35/Maputo City, Mozambique	3. naval base 4. naval headquarters (NA*) 5. training facility (NA*)
36/US Embassy, Manilla	6. Mt. Pinatubo 7. Subic Bay 8. Manilla Bay 9. Cavite navy base
47/Useless Loop, AUS	10. airstrip 11. pier
61/Managua 2, Cuba	12. Managua 1, Cuba
64/Ford Island, HI	13. Lualualei (NA*) 14. Hickam Airbase 15. International Airport 16. Barber's Point
78/Cape Canaveral, FL	17. Tampa International Airport 18. MacDill AFB 19. Melbourne Airport 20. Patrick Airfield
82/US Embassy, Manilla	21. Manilla Bay
91/Santiago, Cuba	22. SAM-2 site 23. Guantanamo Airfield

*NA = not acquired

c. A combined total of 57 ground site observation attempts were recorded. Acquisition, tracking and positive identification was recorded for 37 sites, representing 64.9%. Another 10 site locations were acquired and tracked, but not positively identified due to obscuring phenomena. Therefore, a total of 47 of the 57 sites were acquired and tracked, representing 82.5%

d. Optical resolution panel sites.

There were 10 passes over the four resolution panel sites including two passes each over Brisbane and Ford Island which were weathered out. There were four passes over the site at Cape Canaveral; two of these were weathered out, one was a very low sun angle, and one was near the maximum cross-track capability of the SpaDVOS. Despite these conditions, the resolution grid and 80 foot disk were identified in their correct orientation. There were two passes over the site at Learmouth. The first pass was the first Terra Scout target of the mission and the grid and 80 foot disk were properly identified. There was an equipment problem on the second pass and the site was acquired late. The grid was seen and reported by another crew member and described with some accuracy down to the 24 foot disk. Based on data collected, 80 foot resolution is attainable using the mission optical equipment under a variety of conditions, while resolution to 24 feet is occasionally possible.

(1) The effect of weather conditions and haze present a distinct impact. (See Appendix D for NASA study on impact of atmospheric effects.)

(2) The relatively small sample size of resolution panel observations does not allow for determination of the exact percentage of observability that could normally be expected by target, or by typical shuttle mission..

3. **Conclusion.**

The objective of Terra Scout was accomplished, but more importantly, results show several issues need further research and follow-on experimentation.

a. Improvement in optical quality of the shuttle windows should be a part of any future experiment if high resolution Earth observation or photography from the aft flight deck are of interest.

b. PS1 demonstrated that a trained analyst is capable of earth observation and analysis and flexibility of the man-in-the-loop was demonstrated on several occasions. PS1 was able to report bonus targets based on his experience and judgment of their value without being tasked. He was able to observe and report on ad hoc sites tasked to him with little advance notice. He was able to independently compensate for hardware failures and provided a significant value added level of control over experimental hardware, techniques, and data gathering.

c. It is the conclusion of this report that Terra Scout was an overall success and related follow-on experimentation, research and development should be pursued. However, continued funding for technologies supporting programs such as "Light Sats" and Unmanned Aerial Vehicles (UAV) is the recommended path for satisfying current Army requirements and solving expected future deficiencies. There is no current Army plan or program for dedicated manned, low-earth orbit platforms for earth observation.

IV FUTURE EXPERIMENTATION.

1. Terra Scout was an excellent start for the Army in the Department of Defense Military Man in Space Program. The MMIS program was established to provide opportunities for experimentation and determination of techniques, technologies and capabilities supporting military and civilian requirements from space. A review of the history for development and completion of Terra Scout provides insight to Army participation in STP/MMIS programs but describes a long and difficult process. The Army has always been deeply involved with responsibilities for space and related ballistic missile defense but has begun to recognize other potential space operation applications. There are many concepts to pursue.

2. The affect of adverse weather and atmospheric conditions during Terra Scout hampered the collection of data to support all objectives. The SpaDVOS resolution and recording capabilities were satisfactory for proof of concept but inadequate for detailed data collection or operational capabilities. Experimentation should be conducted using other imaging sensors and technologies such as Synthetic Aperture Radar (SAR) and Multi-spectral and Hyper-spectral Imaging (MSI and HSI). These technologies are not generally as effected by weather and atmospheric obscuration.

3. Much has been written on related concepts and studies in coloristics from earth orbit. Data obtained from the Terra Scout experiment serves to act in support of some of the previous hypothesis and findings in this area. Operational utility of live color scene data from the shuttle is marginal due to factors of mission and orbital geometry, but further experimentation in methods of earth observation is warranted.

4. A follow-on experiment, **Terra Scout II** (TSII) is under development by USAIC&FH, and was rated number 10 of 26 experiments by the 1992 Joint Military Man in Space (MMIS) board. Terra Scout II is a complex secondary payload in that the PS will control a payload bay sensor from the mid-deck. Analysis will be performed on both pre-selected targets and ad hoc targets cued via an air-ground voice communications link. A higher inclination flight is highly desired but not required. The payload equipment margin required will be approximately 150-200 kg in addition to a PS.

Terra Scout II will have broad military applications based on requirements identified by each of the services. The potential to show how these requirements may be satisfied warrants giving it the highest rating.

In support of USAIC&FH, team of government and civilian scientists and subject matter experts are in the process of detailed experiment design, equipment selection and development. Team members include the following: Jet Propulsion Laboratory (JPL), Pasadena, California; MIT/Lincoln Laboratory, Lexington, Massachusetts; Army Space and Technology Research Office, Topographic Engineering Center, Fort Belvoir, Virginia; and Aerospace Corporation, Los Angeles, California.

Most of 1992 has been used to gather information on existing databases and hardware prototypes for Terra Scout II which is planned to be ready for launch in 1995. Terra Scout II represents a quantum leap in technology, depth of experimental design, objective, purpose, and data gathering capability. The shuttle provides an excellent platform to conduct this experiment in support of remote sensing system research and continued development of emerging sensor technology.

APPENDIX A

NASA Mission STS-44 Flight Crew Report

U.S. Gov.

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas
77058

NASA

Reply to Attn of CB-92-196

July 14, 1992

TO: CA/Director, Flight Crew Operations
THRU: CB/Acting Chief, Astronaut Office

FROM: CB/Commander, STS-44

SUBJECT: STS-44 Flight Crew Report

The STS-44 flight crew report is herewith enclosed.

Frederick D. Gregory

cc:
See attached list

CB/FDGregory:jmg:7/13/92:32796

CC:
NASA Headquarters
M/J. W. Pearson III

NASA Ames Research Center
O/D. L. Compton

NASA Kennedy Space Center
CD/R. L. Crippen
MK/B. H. Shaw, Jr.
TM/J. F. Honeycutt

NASA Marshall Space Flight Center
DA01/T. J. Lee

NASA Johnson Space Center
AA/A. Cohen
AB/P. J. Weitz
AC/D. A. Nebrig
AC5/J. W. Young
CA/D. R. Puddy
CA2/A. C. Beall
CA3/D. H. Finney
CA4/S. G. Andrews
CA4/C. N. Major
CA4/R. A. Mastracchio
CA44/O. J. Bertrand
CB/D. C. Brandenstein
CB/All Astronauts (95)
CB/K. P. Colgan
CB/H. E. Ream
CB/M. J. Sanchez
CC/R. J. Naughton
CC5/C. F. Hayes
DA/E. F. Kranz
DA/J. W. O'Neill
DA2/T. W. Holloway
DA3/S. G. Bales
DA8/B. R. Stone
DF/J. Knight
DG/J. A. Wegener
DH/E. L. Pavelka
DK/K. W. Russell
DM/J. C. Harpold
EA/H. O. Pohl
EC/W. E. Ellis
GA/L. S. Nicholson
IA/W. J. Huffstetler
KA/J. W. Aaron
MJ/T. R. Loe
NA/C. S. Harlan
PA/R. L. Berry
SA/C. L. Huntoon
SP/C. D. Perner
TA/C. H. Lambert, Jr.
TC/D. S. Grissom
TC2/F. W. Brizzolara
TC3/D. D. DeAtkine
TC4/R. M. Swalin
VA/D. M. Germany
VP/C. E. McCullough
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WG/S. N. Hardee

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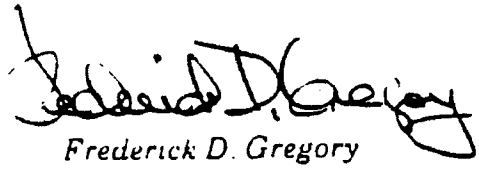

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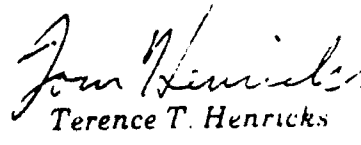
Colonel, U. S. Air Force
Commander



Terence T. Henricks
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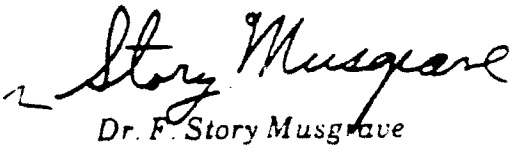
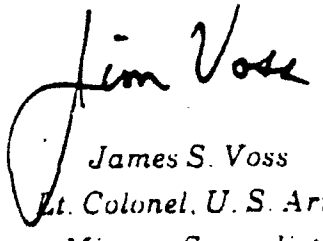
Pilot



Dr. F. Story Musgrave
Mission Specialist



James S. Voss
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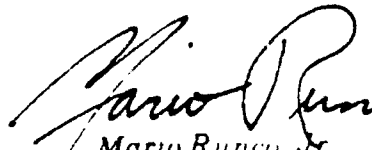
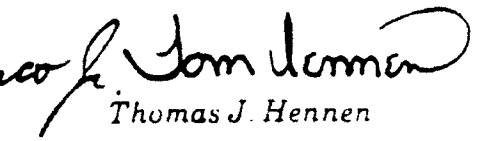


Mario Runco, Jr.
Lt. Commander, U. S. Navy
Mission Specialist



Thomas J. Hennen
CW3, U. S. Army
Payload Specialist

I. INTRODUCTION

The Space Shuttle ATLANTIS, on Mission STS-44, was launched from Pad 39A at the Kennedy Space Center (KSC), Florida, on November 24, 1991, at 6:44 p.m. EST, for a scheduled ten-day mission. Atlantis was flown into a 195-nautical mile (NM) circular orbit, at an inclination of 28.5 degrees, using a direct insertion to apogee followed by an Orbital Maneuvering System (OMS) burn for circularization. This was the forty-fourth flight of the Space Shuttle Program, and the tenth flight of the Orbiter Atlantis. The mission was declared a Minimum Duration Flight (MDF) following the failure of Inertial Measurement Unit (IMU) 2. The mission ended, three days earlier than scheduled, on December 1, 1991, at 2:34 p.m. PST, after 110 orbits, with a landing at Edwards Air Force Base (AFB), California, on lakebed Runway 05. Mission duration was 6 days, 22 hours, 52 minutes, and 27 seconds. The six crew members on board were:

Frederick D. Gregory, Colonel, United States Air Force
Commander (CDR)

Terence T. Henricks, Colonel, United States Air Force
Pilot (PLT)

James S. Voss, Lieutenant Colonel, United States Army
Mission Specialist 1 (MS1)

Story Musgrave, MD
Mission Specialist 2 (MS2)

Mario Runco, Jr., Lieutenant Commander, United States Navy
Mission Specialist 3 (MS3)

Thomas J. Hennen, Chief Warrant Officer 3, United States Army
Payload Specialist (PS)

Atlantis was successfully launched on the second launch attempt. The first launch attempt, on November 19, 1991, was scrubbed because of a Redundant Inertial Measurement Unit (RIMU) failure on the Inertial Upper Stage (IUS). This RIMU was removed and replaced.

The primary objective of STS-44 was the deployment of the Defense Support Program (DSP) satellite. Numerous other secondary experiments, Development Test Objectives (DTOs), and Detailed Supplementary Objectives (DSOs) were conducted. These are listed below.

Payload Bay Experiments

Interim Operational Contamination Monitor (IOCM)

Middeck Experiments

Terra Scout
Military Man in Space (MMIS/M88-1)
Air Force Maui Optical System (AMOS)
Cosmic Radiation Effects and Activation Monitor (CREAM)

Shuttle Activation Monitor (SAM)
Radiation Monitoring Experiment-III (RME-III)
Visual Function Tester-1 (VFT-1)

Detailed Supplementary Objectives

DSO 316	Bioreactor/Flow and Particle Trajectory in Microgravity
DSO 463	In-flight Holter Monitoring
DSO 472	Intraocular Pressure
DSO 478	Lower Body Negative Pressure (LBNP)
DSO 603	Orthostatic Function During Entry, Landing and Egress
DSO 604	Visual-Vestibular Integration as a Function of Adaptation (OI-1&3)
DSO 605	Postural Equilibrium Control During Landing and Egress
DSO 608	Metabolism/Exercise testing
DSO 611	Air Monitoring Instrument Evaluation and Atmosphere Characterization
DSO 613	Endocrine Regulation
DSO 614	Head and Gaze Stability During Locomotion
DSO 901	Documentary Television
DSO 902	Documentary Motion Picture Photography
DSO 903	Documentary Still Photography

Development Test Objectives

DTO 242	Entry Aerodynamic Control Surface Test
DTO 301D	Ascent Structural Capability Evaluation
DTO 3070	Entry Structural Capability
DTO 312	External Tank (ET) Thermal Protection System Performance
DTO 520	Edwards Lakebed Runway Bearing Strength and Rolling Friction Assessment for Orbiter Landing
DTO 645	Combustion Products Analyzer
DTO 649	Shuttle Extended Duration Orbiter (EDO) Rehydratable Food Package Evaluation
DTO 797	Star Line Maneuver Validation

In this report, only pertinent comments, observations, and recommendations concerning the mission, relative to either training or flight, will be discussed. If a topic is not mentioned, it was nominal or had been debriefed by previous crews and did not warrant further comment.

II. PREFLIGHT

A. Training

The training provided by the Shuttle Mission Simulator (SMS) training team was excellent, extremely professional, and thorough. Support by the Training Division to accommodate preparation for the mission, including non-Crew Training Catalog activities, was superb. The crew scheduled extra time for non-cataloged nominal activities in the SMS, the Crew Compartment Trainer (CCT) trainer, and the Single System Trainer.

1. Schedule/Workload

The flight crew was assigned to STS-44 in May 1990 for a scheduled March 1991 launch. The mission slipped until July 1991 and subsequently to November 1991. A payload specialist to support the military experiment Terra Scout was added to the crew in July 1990. The mission was extended from four days to ten days in November 1990 with the addition of the EDO associated DSOs. The crew commenced full-time training in February 1991 following the "standard" training template. With the launch slip from July until November, "standard" training was temporarily suspended for three months and during that time the crew training was reduced to a minimum or "maintenance" level, returning to the "standard" in August 1991. Even though the crew took five one-week vacations during the period July 1990 to August 1991, it was still on or ahead of the Catalog training schedule.

Considerable effort was expended in arranging the schedule to prevent a "bow wave" of activities in the last several weeks prior to launch. The "bow wave" was reduced but the actual hours spent in training during the last four months before flight were excessive. The crew believed that the following Catalog requirements could be completed earlier in the flow as part of "pilot pool" training:

Photography/Television (TV) equipment
Intravehicular Activity (IVA) training
Extravehicular Activity (EVA) pre/post training
In-Flight Maintenance (IFM) training
Launch and Entry Suit (LES) familiarity
Crew escape systems training
Vertical Orbiter reach and visibility with LES introduction
Crew systems/habitability equipment and training
Post Insertion/De-orbit Preparation familiarity

If this training were received prior to mission assignment, only refresher or proficiency training would be required during the mission-specific training flow.

RECOMMENDATION: Accomplish as much training as possible before crew assignment.

The Catalog includes requirements that support normal Orbiter activities. These include but are not limited to ascent, post insertion/deorbit preparation, orbit, entry, malfunctions, aborts, and primary payload operations. Little if any listing, recognition, or accounting for secondaries, DSOs, DTOs, Earth observation, flying proficiency, Shuttle Training Aircraft training, or briefings and training at other locations, is identified in the Catalog. There is no Catalog time scheduled for Astronaut Office activities such as the Monday morning all astronaut meeting, attending previous mission debriefings, or doing routine office administrative work. All of these activities require recognition in the Catalog and should be scheduled by the Training Managers.

RECOMMENDATION: Expand the Catalog to include all training required to accomplish the mission. Have all training coordinated by the Training Manager.

2. Training Objectives

Because of the importance of on-orbit activities other than those designated to support the primary payload, crew training should have increased emphasis on all other mission objectives: DTOs, DSOs, and secondaries. Scheduled stand-alone training in the simulators, earlier crew access to training hardware, software, procedures, and integrated simulations should be the rule, not the exception.

RECOMMENDATION: The SMS training team should include a person to ensure the correct level of crew proficiency on DTOs, DSOs, and secondaries.

Training should be prioritized. Training must emphasize the things that the crew will do. This would include on-orbit operations and secondary payload training. They now get little training emphasis but they occupy much of the actual work time on orbit. Secondly, we need to train for those procedures which we might realistically do for the most likely failures that will be catastrophic if not acted on in a timely manner. This is necessary and can be quantified somewhat through use of the extensive Failure Effects and Mode Analysis/Critical Item List research that has been done to characterize the likelihood of failures. Last priority should be those unlikely catastrophic failures or more likely failures that are less severe.

RECOMMENDATION: Prioritize training with emphasis on training for tasks that we will do, on probability of failure and level of severity. Do not limit the majority of training to the primary mission or improbable failure scenarios.

RECOMMENDATION: At least one session in the SMS is needed from crew ingress through lift-off. Communication checks and other crew actions which need to be trained for exist within this period. Likewise, at least one postlanding session needs to be run all the way through crew egress. Emphasis should be placed on actual Orbiter configuration and on non-standard, flight-specific configurations including crew member instrumentation supporting DSOs.

The majority of crew training is accomplished stand-alone. Stand-alone training simulates a loss of communication with Mission Control. When integrated training begins, the crew must immediately change their failure response process and normal operating methods to accommodate Mission Control's advice and expertise. Integrated training should begin much earlier in the crew training flow to better develop the total team concept and remove the loss of communication malfunction that is always present. Adequate integrated training should be scheduled to accommodate both severe failure scenarios and the anticipated normal operations that would ensure that the crew, Mission Control, and the customers are thoroughly prepared for the flight. Joint integrated simulations must include all mission objectives.

RECOMMENDATION: Increase the number of and participation in integrated training.

3. Inertial Upper Stage/Defense Support Program

The individual training sessions conducted by the IUS instructors were excellent but the overall approach to IUS training is not efficient. The initial classes were spread over many weeks, requiring topics and information to be repeated. This resulted in a slow learning process with the overall picture clear only after months of training.

RECOMMENDATION: Increase frequency of initial IUS training to improve overall training efficiency.

Training on IUS display indications was often confusing because of changes to what was expected to be seen on the Communications Interface Unit (CIU). Display indications for the IUS are not always consistent because of the complicated nature of the data flow, but the system is mature and the most likely indications are known, and these most likely indications should be used.

RECOMMENDATION: Emphasis should be placed on the most likely CIU indications during training.

4. Extended Duration Orbiter/Detailed Supplementary Objectives

While the medical DSOs were manifested at L-90 days, the formal training on most did not start and had not been planned to start until L-60 days. It is preferable to be fully trained on DSOs at L-60 days and use the remaining time for refreshers and data takes. With eleven DSOs, a lot of training was delayed until the most demanding period of preparation close to launch. With DSOs a major part of the flight plan, orbit operations, and de-orbit preparation could not be realistically trained for or visualized until the crew was trained on the individual experiments.

RECOMMENDATION: DSO training should be conducted earlier and should be included and managed within the "standard" training template.

5. Detailed Test Objective

Training for entry Programmed Test Inputs (PTIs) was inadequate. The cue card was not correct nor was it suited for use as a cue card during dynamic flight. Change requests (482s) were submitted to correct the card too late to be incorporated other than by pen and ink. The crew should be included during the development of mission-specific cue cards, especially if used during dynamic flight. The sequence/timing of the auto PTIs varied depending on the landing site. A training team cannot be expected to train a crew when given late and/or incorrect procedures. During SMS training, Orbiter malfunctions often precluded enabling PTIs, especially during integrated simulations.

RECOMMENDATION: The PTI sponsors must ensure the crew is trained properly. The crew and control team should be exposed to entry PTIs for the primary and secondary landing sites.

6. Military Man-In-Space/M88-1

No formal training plan existed. However, the M88-1 team effectively conducted the necessary training. They were also very responsive to crew requests for information and hardware. A simple scene simulation would have been helpful to enhance training. Scenes looking out a +XVV window and a ZLV overhead window oriented as they would be in the Orbiter would be very helpful. Two types of scenes would be desired: one that would track a given ground target from front to rear windows and one that would show rate-of-scene-passage across the windows. This would enable a potential user to become familiar with how fast a scene passes and what to do to photograph that scene. In addition, our flight readiness would also have been enhanced if we had had the opportunity to fly the M88-1 equipment on board an aircraft specifically to practice communication and observation operations over designated ground sites. Lastly, the level of detail participating crew members desired for Tethered Electronics Module (TEM) training varied. The M88-1 payload support should be prepared to accommodate this variability, possibly by having a set of briefing materials available and using a combination of these to meet crew member dependent objectives.

RECOMMENDATION: Since the training for M88-1 was, for the most part, effective, a formal training plan is not necessary. Document the actual time the crew spent in preparing for the M88-1 so that the total crew training workload can be managed.

RECOMMENDATION: Develop a simple scene simulation of ground target passage using actual on-orbit, out-the-window camcorder scenes; fly the M88-1 equipment on board an aircraft at least once prior to flight to conduct practice observation runs.

7. Terra Scout

All Terra Scout training was provided by the U. S. Army Intelligence Center. This included both training in hardware specific operations, as well as imagery analysis training. Hardware training was conducted at the Aero Medical Research Laboratory located at Wright Patterson Air Force Base. This training was provided to both the primary and back-up PS on a routine basis. Addi-tionally, five training sessions were provided to the CDR and PLT for equip-ment familiarization purposes. The hardware training was sufficient to effectively operate the Terra Scout hardware on-orbit.

8. Air Force Maui Optical Station

The crew was first exposed to the procedures when the Orbit Operations Flight Supplement was published. Several change requests (482s) were written to correct the Reaction Control System jet test procedures. However, due to the late initiation of the 482s close to flight, the crew never trained to the final flight procedure. Crews should be involved in procedure development early enough so that they can train to them. Not having crews train for a procedure until the procedures are published in the Flight Data File (FDF) results in too little training, too late.

RECOMMENDATION: Train early and often on those procedures you will normally perform. Involve the crew in procedure development of secondaries.

9. In-Flight Maintenance

Training was excellent with all sessions using hands-on experience to meet the training objectives. The training benefit of seeing the actual flight hardware, tools, and access during the Crew Equipment Interface Test (CEIT) is invaluable.

RECOMMENDATION: Retain the IFM training as part of CEIT.

Du.ing on-orbit simulations, IFM activities are usually not performed due to hardware limitations.

RECOMMENDATION: Construct an IFM training panel in the middeck on the fixed base simulator to allow real-time IFM training tasks to be performed.

10. Wireless Communication System

The Wireless Communication System (WCCS) system works well in the real vehicle but not in the SMS. The loud squeals in the SMS, limited battery life, and unreliable operation limit the WCCS use and give the system an undeserved bad reputation. There are, however, two problems that exist within the system that should be corrected. Two crew members share one wall unit. When one crew member transmits, the microphones of both crew members are keyed, even if they are in the Push To Talk (PTT) configuration. This results in unwanted transmissions that could be avoided only by announcing on the intercom one's intentions of transmit-ting to the ground. Then it still limits the other crew to no talking during the transmission or it would be picked up by the second microphone causing a garbled transmission. The second problem was the shortage of batteries. Two batteries failed and some of the others did not have as long a lifetime as expected, so by flight day six there were no fresh batteries remaining.

RECOMMENDATION: Modify the WCCS so that when in the PTT mode, microphones associated with a leg unit are keyed only when the PTT switch is pushed for the leg unit.

RECOMMENDATION: Manifest enough batteries to last for the expected mission duration. Include margin for battery failures and shortened battery life based on reported operational use during flights.

B. Flight Data File

All of the support personnel in DH433 did an outstanding job supporting the STS-44 flow.

RECOMMENDATION: Post insertion and on-orbit operations would be enhanced if a generic Reference Data stowage list was provided for training early in the training flow.

C. Sleep Shift

The crew shifted their normal wake-up from approximately 6:30 a.m. to 2:00 p.m. to accommodate a 6:30 p.m. lift-off. The shift was begun at L-7 days and continued until L-2 days waking approximately 1 hour 20 minutes

later each day, and sleeping eight hours the night before. From L-2 days until actual lift-off, including the four-day launch delay, the crew was stabilized at the shifted awake time. Subjectively, all crew members felt rested and "sleep-shifted" on launch morning. The melatonin assay verified that our physiological rhythms had in fact shifted.

RECOMMENDATION: A natural sleep-shift should be considered as an option.

III. LAUNCH COUNTDOWN AND ASCENT

The Terminal Count Demonstration Test (TCDT) conducted several weeks before the scheduled launch prepared the crew for actual launch operations, requirements, and responsibilities. It was noted by all STS-44 crew members that the strapped down body position in the Orbiter was different from the accustomed body positions while training in the SMS or the CCT trainer. Specifically, the crew members' final body positions in the Orbiter were different from their positions during training. The crew observed that when strapped down in the Orbiter they were significantly higher up the seat back, perhaps 2-3 inches, and that the seat-back position was more heads down, perhaps 15 degrees, than simulated during training. Reach and visibility, control stick/rudder position, visibility of recessed gauges and talkbacks, and switch access were all different. During TCDT and the launch countdown, the crew had to relearn the cockpit. Because of the different seating position, the crew's capability to respond to real Orbiter malfunctions would be reduced.

RECOMMENDATION: Change the simulated launch attitudes of the SMS and the CCT trainers to better replicate the Orbiter.

RECOMMENDATION: Until the SMS and CCT trainers' seat positions are corrected, all CDRs, PLTs, and MS2s should determine their correct seated positions while suited in an Orbiter on the launch pad, and then adjust their seats and body positions appropriately in the trainers during training sessions.

The LESs are extremely uncomfortable and severely restrict the crew members' movements, field of view, and capabilities. The tight neck dams on the LES are unacceptable. Some crew members spend about an hour on the pad in the white room area waiting to ingress the Orbiter. The LES zipper design, however, makes it nearly impossible to urinate except into a diaper. The LES is hot and humid, bulky and heavy, and is unacceptable for space flight. The risk versus comfort/capability trade off during ascent, however, continues to make the wearing of the LES mandatory.

RECOMMENDATION: Continue modification/replacement efforts to create an LES acceptable for launch countdown and ascent.

Prelaunch, all of the windows except the payload bay windows were dirty from rain-spotting and streaking. Dirty windows restrict visibility, increase glare, and degrade photographic documentation.

RECOMMENDATION: Clean exterior window surfaces prelaunch and keep the windows covered until the pad support technicians depart.

Orbiter loads and oscillations during ascent appeared normal. During second stage, a low frequency oscillation developed and remained until Main Engine Cutoff. Approximately three minutes after lift-off, all flight deck crew members saw bright flashing lights through the forward windows. MS2, using a wrist mirror, verified that the flashing was the same frequency as that of the plumes from the Space Shuttle Main Engines.

There was an extremely loud metallic banging sound and vibration at Eternal Tank (ET) separation. This was unexpected and not simulated during SMS training.

RECOMMENDATION: The SMS visual and aural cues should simulate as accurately as possible actual mission sounds and sights.

Most of the crew members of STS-44 commented on the discomfort, severely limited mobility, and reduced logistics capabilities during the high-g segment of the ascent. All commented that the training that the crew had received gave them a false and exaggerated indication of their capabilities to respond to Orbiter malfunctions during this phase of the flight. They unanimously agreed that only the most critical crew or Orbiter-saving activities could and should be done during this ascent phase. The crew members also agreed that training should be changed to reflect these restrictions and the community should be aware of the crew's concerns.

RECOMMENDATION: Re-evaluate training objectives and modify, if required, to reflect actual crew capabilities during ascent, especially during the high g phase.

Centrifuge training at Brooks Air Force Base was worthwhile, especially for crew members flying for the first time, although there are some comments worth noting. The g profile for the training matches the actual flight-g loading but the feel of the real vehicle is somewhat different. In the Orbiter the acceleration feels higher and it is more difficult to move and reach around. The difference could be due to the vibration of the Orbiter which is absent in the centrifuge or could be because of the apparent difference in the direction of the acceleration vector. The vector is perpendicular to the chest in the centrifuge, but seems to be pointed 10-20 degrees more toward the head in the Orbiter. Another possibility is the length of time spent on one's back strapped to the seat before lift-off. The crew thinks this causes fluid shift and fatigue. The centrifuge training is the best we have to simulate ascent loads and also has apparent worth by assuring a good LES and harness fit.

RECOMMENDATION: Centrifuge training should be continued for non-flown astronauts and should be added as a recommended activity for previously flown astronauts for the simulation of the ascent g loading and to assure a good LES and harness fit.

The STS-44 crew carried temperature sensing strips with them to monitor area environment temperatures during ascent and entry. During ascent the area around the CDR and the PLT was approximately 92 degrees Fahrenheit (F); around MS1 and MS2 approximately 85 degrees F; and around MS3 and the PS approximately 75 degrees F.

IV. ON ORBIT

Orbit activities went smoothly only because of the excellent training and the flexibility of the SMS training team, the training manager, each customer representative, and the major support of the Training Division. Most of the on-orbit activities supporting secondaries and DSOs were not included in the Crew Training Catalog. The STS-44 crew, Mission Control, and customer proficiency was achieved only by scheduling additional sessions including a Joint Integrated Simulation specifically for secondaries.

RECOMMENDATION: It is imperative that to guarantee mission success, the team must thoroughly prepare and train for the real mission.

The payload bay and the crew module were extremely clean and free of debris.

A. Significant On-Orbit Anomalies

The STS-44 crew responded to three significant systems anomalies and executed one avoidance maneuver. Two of the Orbiter problems were corrected, the third resulted in the declaration of an Minimum Duration Flight (MDF). The avoidance maneuver was accomplished with no impact. The significant anomalies and the avoidance maneuver are listed below.

1. On MET Flight Day (FD) 3, after the cabin temperature controller reconfiguration from the primary to the secondary controller, and before the humidity separators had been switched from B to A, we observed that the equivalent of several cups of water had accumulated around the humidity separator screen and that the separator was flowing free water into the Lower Equipment Bay (LEB) below the middeck. When humidity separator B was turned off, the flow stopped. The crew accomplished several IFM activities including a free water clean-up and the covering of the separator B screen with a bag and towels to prevent another free water spill. Humidity separator A was activated with no problems and the mission continued. The humidity separator problem, as of this writing, is unknown but it has been noted that when the cabin temperature actuator link was switched from the primary to the secondary controller, the primary was controlling to full hot while the non-activated secondary controller was positioned to full cold.

2. A supply water dump valve leak was identified on FD3. Indications of a leaking dump valve were seen after the second and fourth supply water dumps. An IFM to purge supply water from the dump line was performed twice. The first attempt indicated blockage, the second attempt produced air flow. The work-around was to continue the mission, dumping by means of the Flash Evaporator System.

3. On FD5, twelve hours after IMU 2 was powered up, the Z axis accelerometer channel and redundant gyro showed excessive outputs. The IMU was taken to standby, then to operate, and then power-cycled, but the failure was still present. An MDF was declared with an intended de-orbit to Edwards Air Force Base on FD6.

4. On FD3 the crew executed a retrograde burn to increase the separation distance from a COSMOS rocket body casing. This was no impact on the mission.

B. Post Insertion

The timeline was followed with no problem. MS3 and the PS were responsible for configuring the middeck for orbit operations and also for doffing and stowing the crew's LESs and boots. MS3 and the PS doffed and stowed their suits immediately after MECO. MS2 doffed his suit immediately after the OMS 2 burn. When he returned to the flight deck, MS1 doffed his LES. The CDR and the PLT remained in their LESs until a "go" for Orbit Operations was given. During this transition time, each flight deck operation had verification by two crew members.

New stowage areas were used on this flight to save volume in the airlock and on the middeck. One LES was stored, without the mesh bag, forward of the window shade rack, to the left of the lockers. If done carefully, you could get two suits stored head-to-feet in the same volume. All white headrest cushions, orange parachute support cushions, and some of the seat cushions were stored behind the window shade cover rack. There was just enough room to slide these items in and enough friction to hold them there. There was additional storage above the galley on the overhead above where the trays are stored.

RECOMMENDATION: Unstow a camcorder and bracket early in the post insertion time line to document middeck post insertion activities for future flight crews to review during training.

C. *Defense Support Program*

After Payload Bay Door opening, IUS ground personnel investigated an apparent failure of the IUS Converter Regulator Unit (CRU) whose voltage dropped unexpectedly. This anomaly was explained when it was determined that the DSP satellite solar panels received enough sunlight reflected from the Earth to completely power the spacecraft, making the CRU output voltage drop to the regulation set point. The only other hardware anomaly was the IUS radio frequency amplifier output power which dropped unexpectedly from 27 to 22 watts. The power returned to 27 watts, remained nominal, and had no impact on the mission.

Payload panel activation and checkout started late due to the aft station mission clock being in the Greenwhich Mean Time (GMT) configuration instead of the desired Mission Elapse Time (MET). There was a 16-minute difference between GMT and MET. After the pre-deploy check times were read to the ground controllers, the cause of the time difference became clear and was resolved by switching to MET. All operations were nominal with no mission impact resulting from the time difference.

RECOMMENDATION: The aft station mission clock switch should be set in the MET configuration during prelaunch switch reconfiguration.

All deploy operations were nominal but, as was the case during training, the last 20 minutes before deploy were harried. With the many activities during

this period and their criticality to mission success, any problems encountered could result in a late deploy or errors. This is a time for methodical, careful actions, not a time to hurry.

RECOMMENDATION: If the IUS battery margins allow, the deploy countdown should be lengthened, with the IUS transfer to internal power occurring at 30 minutes before deploy.

D. Detailed Supplementary Objectives

Even though all objectives were met and all procedures and operations went smoothly, earlier crew exposure to hardware and procedures would significantly enhance the collection of data. Data is being analyzed and summary results will be available from the principal investigators. Only exceptions or significant comments are noted by DSO below.

1. DSO 316 Bioreactor

The bioreactor would be greatly enhanced if downlink capability was routinely provided and the flexibility for human interaction was included. This would allow for real-time observation of results by both the crew and the investigators and the real-time modification of chamber specifications such as control of rotations and flows.

2. DSO 472 Intraocular Pressure

As designed and as intended, the tone indication of a valid reading is an important aid to the operation of the tonometer. The tone could not always be heard in flight because of the crew module background noise making the procedure more difficult and forcing a change in technique.

RECOMMENDATION: The tone on the pen should be made louder to be more discernible over the normal Orbiter background noise.

3. DSO 478 Lower Body Negative Pressure (LBNP)

Several modifications to the LBNP preflight crewman-specific fit adjustments had to be made during the mission. To avoid this for future flights, more attention to detail should be given to this on the ground.

The LBNP can be conveniently stowed as temporary stowage by removing only the controller and placing it within the LBNP bag. No other connections need be broken.

Some useful work such as housekeeping, maintenance, or Earth observation photography can be performed during an LBNP soak even in the device's present configuration. During an LBNP soak, MS1 evaluated a crew member's ability to perform normal operations while confined in the LBNP device. All normal activities that were attempted were performed successfully. The tasks done were stowing and de-stowing items in lockers, filling drink containers, preparing food, replacing bolts in the LiOH box as part of an IFM, recording data in an FDF book, Earth observation photography, and movement throughout the crew compartment. All areas of the crew compartment could be reached, but movement through the interdeck access was slow because of the small

clearance between the deck and the LBNP controller. The cables and vacuum line did not tend to pull on the bag or cause any problems, but one had to be aware of their presence to avoid becoming entangled. The length and bulk of the device take up a lot of space, which could be a problem when working around other crew members. The LBNP seat and waist seal were comfortable for the entire five-hour soak and could have been worn much longer. MS1 felt that any normal task could be accomplished while in the LBNP device with the only minor detriment being the inability to use one's legs for restraint while working.

RECOMMENDATION: Reduce the size of the LBNP device and the profile of the controller to allow easier movement while wearing the device during soak operations.

RECOMMENDATION: Evaluate LBNP "pants" with legs to further reduce the operational impact of soak operations.

The LBNP soak was done the day before landing because of the shortened mission. The preliminary postflight data show great promise for the use of the LBNP as an effective aid to orthostatic tolerance on re-entry. Subjectively, MS1 felt very well on entry with no orthostatic intolerance.

RECOMMENDATION: Highly recommend continuing research with the LBNP, including operational use; that is, working in the device and using it the day before entry to obtain operationally relevant data.

4. DSO 608 Metabolism/Exercise Testing

Exercise is a time-consuming but valuable task. The current treadmill is not acceptable for flights where a lot of exercise is required (long flights, large crews, extensive exercise DSOs). The treadmill was noisy and took up a lot of space in the middle of the middeck. It jammed and could not be repaired. Exercises were developed that allowed us to continue the DSO.

RECOMMENDATION: Replace the treadmill with an alternate means of exercise.

E. Development Test Objectives

DSO 649 Shuttle EDO Rehydratable Food Package Evaluation. The EDO food packages were an acceptable substitute for the hard plastic food containers. While eating, the food access using the EDO packages is a little less convenient, but the trade-off between convenience and trash management--especially for long missions and large crews-- is worth it.

RECOMMENDATION: Manifest the EDO rehydratable food packages.

F. Terra Scout

The purposes of the Terra Scout experiment and the Army PS were to demonstrate the:

1. Utility of real-time observations to the Department of Defense (DOD).

2. Flexibility of the man-in-the-loop (expert system).

3. Usefulness of live-color imagery.

4. Utility of the Orbiter as a viable research and development platform for the design of future remote sensing systems.

The on-board equipment included the Spaceborne Direct-View Optical System (SpaDVOS), voice recorders, 14X70 mm binoculars, and a telescope.

With the coincidence of the DOD's informational requirements and the orbital inclination of a mission, real-time observations could be conducted from the Orbiter. However, improvements need to be made in current optical systems employed by crew members. The addition of other remote sensing systems (i.e., infrared, radar, spectral, etc.) to collect data would greatly enhance the capability from the Orbiter in this area.

The experiment demonstrated the flexibility of the man-in-the-loop on a number of occasions, specifically during SpaDVOS hardware failures. It added a significant value level of control over experimental hardware, techniques, and data-gathering requirements. SpaDVOS suffered software and hardware problems during the mission. The cause of the damage is unknown as of this writing. As an alternate resource for Terra Scout, the binoculars were outstanding, providing (subjectively) 20 to 30-foot resolution while tracking a site. The telescope was unusable because of its small field of view.

RECOMMENDATION: No secondary experiment should be manifested with SpaDVOS as a primary sensor until it demonstrates greatly improved performance and resolution.

RECOMMENDATION: The binoculars flown as part of the Terra Scout equipment should be procured and manifested as standard Orbiter flight crew equipment.

The effect of adverse weather and atmospheric conditions during the mission hampered the collection of data to support all Terra Scout objectives. Much has been written on the subject of color definition from Earth orbit and the data obtained from the Terra Scout experiment serves to not only to support previous findings but to expand the discussion of the usefulness of "live-color" scene data to military operational requirements. The observations on board more than justify the continuance of live-color scene transmission from orbiting reconnaissance and surveillance platforms.

The Orbiter continues to prove invaluable in satisfying the research and development activities of the DOD. In the case of Terra Scout, specifically in the area of remote sensing technology development, the Orbiter provided the following:

1. A controllable/returnable payload.

2. A comparison of "real environment" versus laboratory.

3. Significant cost-reduction during system R&D and check out.

4. Utility of the human observer if enhancements in optical and the addition of remote sensing systems are made.

Terra Scout was an important step in the OOD's Military Main in Space (MMIS) program, targeted at the utilization of space assets to further technologies, techniques, and capabil-ities supporting both military and civil requirements.

The Orbiter provided an excellent platform to conduct future remote sensing system research as well as the continuing development of current technologies.

Terra Scout II should be conceptually planned to make a quantum leap in technology, depth of experimental design, objectives, purpose, and data-gathering capability (spectral versus optical). Maintain the man-in-the-loop. Fly the next experiment in the payload bay, eliminating window and field of view impairments. Manifest the follow-on flight on a high inclination mission with 24-hour operations.

RECOMMENDATION: Pursue the development of Terra Scout II.

G. Military Man in Space/M88-1

M88-1's purpose was to determine the ground resolution obtainable by the human observer from low Earth orbit using out-the-window optics. The second part of the evaluation was to evaluate the feasibility of making tactically significant observations and reporting these observations to tactical commanders in near real-time.

Prior knowledge of the target site allowed a more thorough interpretation of the Charge Couple Device (CCD) imagery.

The optical equipment included: Nikon F3 camera body, 300mm lens with 1.2 and 2.0x extenders providing an effective focal length of 960mm, Kodak CCD camera-back for digital imagery, Kodak TEM for digital data storage, and a Sony model PVM 91-5 high resolution (850 lines) 13-inch black and white monitor for real-time imagery display.

RECOMMENDATION: The matte finish focusing prism installed on the Nikon F3 limited useful through-the-lens observations. Replace the matte finish viewfinder on the camera with a clear non-obstructed viewfinder to allow better through the lens observations.

The communications equipment included: for the network mode, the Orbiter Air to Ground Loop 1 (A/G-1); and for the direct mode (UHF line-of-sight) an LST-5B radio transceiver, KY-57 cryptological unit, and an overhead window mounted antenna (non-opaque).

For each observation site, a pre-pass briefing was received providing weather over the target and what to observe. Initial target acquisition was done using the windows pointing into the velocity vector on the side which would provide the best view to the target. Useful observations were made through the overhead window when the target was within approximately 15-20 degrees to nadir. A spotter, using velocity vector viewing windows would acquire the target, begin making observations using the Terra Scout-provided binoculars,

and vector the CCD camera operator positioned at the overhead window onto the target. The CCD operator would then commence photographing the target while in view near nadir. The spotter would also transition to the overhead window to continue binocular-assisted observations. Post pass, the imagery would be reviewed by both observers as quickly as possible and then relayed to awaiting ground personnel using either network or direct communications or a combination of both. Initial acquisition of the target would have been more simple if a geolocation capability was provided.

RECOMMENDATION: Add geolocation capability to instantaneously locate target image.

Imagery obtained showed a maximum resolution of 20 to 30 feet under the best contrast, lighting, and shadow conditions; however, the lower limit to identify specific features in the images was 80 to 100 feet depending on its particular shape and position on the ground. In addition, National Imagery Interpretability Rating Scale (NIIRS) utility was rated at approximately an NIIRS 3 to 4 (scale of 1 to 10, with 10 being the best). The synergism between the spotter/observer and the photographer/observer allowed for a significantly increased observation capability upon review of the obtained imagery after the pass. The following recommendation could enhance an observer's capability to identify and evaluate a target.

RECOMMENDATION: Increase the focal length of the lens to 1200-1500 mm. Increase the CCD pixel resolution as high as possible.

RECOMMENDATION: Add color capability.

RECOMMENDATION: Add capability to transfer digital images from TEM storage device to an on-board laptop computer equipped with image processing software to allow for on-board image enhancement.

The direct communications aspect of the experiment was not tested due to an equipment failure. This failure, a continuous off-scale high received signal, prevented reception of normal ground transmissions. Broadcast signals worked nominally as our transmissions were received at several ground sites. The failure as of this writing is unexplained. Network communications via A/G-1 worked well and extended the communication time significantly over what would have been the direct signal acquisition period. This allowed for a longer and more detailed review of obtained imagery and, therefore, better more accurate information relayed to the ground.

Militarily useful observations by the human observer in low Earth orbit are feasible as a supplement to other sources which gather observational data. This is not to say that the Orbiter would be used primarily for this purpose, but if an Orbiter is in an appropriate orbit at the right time (then with modest improvements to the low cost equipment used on STS-44) these human observations from low Earth orbit could prove valuable for tactical use in times of national crises.

The CCD camera only afforded a maximum ISO of 200 which limited the shutter speed to approximately 1/250 seconds. With the near 1000mm lens a shutter of speed of 1/1000 seconds was needed to freeze an image considering only the human steadiness factor. Given the speed of advance of the Orbiter over the

ground, a shutter speed of at least 1/2000 seconds would be needed to obtain a very sharp image. The faster shutter speeds would allow more reliable imagery acquisition and therefore less time would be spent acquiring images. This would allow more time to review and report on the imagery which in turn would make the UHF direct communications window useful.

RECOMMENDATION: The technology already exists to increase the ISO of the CCD camera which would allow for the faster shutter speeds required. This technology should be vigorously pursued.

Therefore to obtain useful images, a series of images (up to 40) were taken for a given target. A large rubber bumper mounted on the front end of the lens allowed the operator to plant the lens against the window thus steadying the camera (or the lens), and to track targets manually. When the disk in the TEM was not very full, the CCD/TEM equipment allowed rapid fire picture taking (2-3 images per second). This technique would produce several sharp images per target.

With the limitations of the optical equipment which forced us to take several images per target, we rapidly filled up the available disk space. This slowed the CCD/TEM's ability to take additional images and therefore prevented capture of sharp imagery. In addition, the time to find and review the best imagery of the several images taken would have hampered the ability to use direct communications to best advantage. Network communication allowed the extra time to find and review the best images but did not allow talking in the clear. Encryption of network communications would have allowed more explicit reporting as would have been possible with direct communication.

RECOMMENDATION: Improve CCD to TEM input/output capability to allow for rapid acquisition of images at a minimum of 2-3 images per second under all disk storage capacity conditions.

RECOMMENDATION: Improve TEM utility by allowing for storage of images by specific numbers, and by allowing for shifting of images to lower numbered slots which become available after non-desireable images are deleted.

RECOMMENDATION: Develop a communication plan so that when it is required, the Orbiter uplink and downlink can be encrypted to allow pre-pass briefings, post-pass voice reporting, and downlink of images to be accomplished via network communications.

RECOMMENDATION: Add downlink capability so imagery can be relayed directly to tactical commanders in the field.

H. Payload Bay Experiments

There was no on board crew monitoring devices for the payload bay experiments. Data will be available from the principal investigators.

Interim Operational Contamination Monitor (IOCM)

This secondary experiment was given little attention because the only crew interface was a powerdown postlanding. Onorbit, during Orbiter night and with the payload bay lights off, the crew noticed a bright light coming from the IOCM illuminating the payload bay, degrading night visual observations from the aft windows. This light could also be seen by the ground sensors during the AMOS tests. The light may not have been necessary or could have been shaded.

RECOMMENDATION: Crews should investigate each secondary experiment for its impact on other mission activities.

I. Middeck Experiments

All experiments worked well. Data is being analyzed and will be available from the principal investigators. Significant comments are listed below.

1. Radiation Monitoring Experiment-III

The first memory module used during activation did not respond properly when the time was updated. This module was replaced and not needed due to the early mission termination.

2. Shuttle Activation Monitor

The cassette tape recorder used for data storage was located on the middeck next to the escape pole. This made it susceptible to impact during normal middeck activities. The record buttons were unprotected and were bumped out of record resulting in the loss of about 40 minutes of data. The practice of stowing cassette tapes without the tape case resulted in the tape unwinding in microgravity. On orbit, one cassette was unstowed and it was found that not only had it unspooled but it also had tangled and had become unusable.

RECOMMENDATION: Data acquisition/stowage devices should remain in lockers to prevent loss of data due to inadvertent impacts. Power and venting should be provided.

RECOMMENDATION: A method of holding tension on cassette tapes prior to and after use should be provided.

J. Earth Observations

The Earth in November 1991 when compared with the Earth seen in November 1989 during the flight of STS-33, was far more extensively cloud-covered. The atmosphere appeared more purple or lavender than blue when viewed obliquely with the sun at your back. The short term atmospheric effects of Mount Pinatubo and the oil fires in Kuwait appear to be clearing and the effects of local phenomena, such as burning and pollution, were again becoming predominant.

Orbiter window #10, the port aft window looking into the payload bay, was streaked with two heavy white lines shaped like a horizontal "V" each about

ten inches in length. These marks appear in all the photographs taken from this window.

The atlas and slider map are very useful documents. They should continue to be manifested on each mission. The Earth Observation Preflight Training Manual is also an excellent source document and should also be manifested.

RECOMMENDATION: The STS-44 crew recommends that we continue to manifest the atlas and slider map and begin manifesting the Earth Observation Preflight Training Manual.

K. Photography/Television

In addition to the standard Earth observation photographic documentation the crew of STS-44 carried a dual Hasselblad camera mount so that comparison photographs could be taken and later evaluated. Side-by-side comparisons were to be made of film types and polarization. When the mission was shortened because of the IMU 2 failure, only the film comparison was completed. The ground evaluation of the film comparison, as of this writing, has not been completed. The following are comments and recommendations relative to the comparison activities.

Dual camera polarization studies require extensive set up and waiting time for optimum sunglint.

RECOMMENDATION: If extensive dual-camera mount operations are required, at least a third Earth observation camera should be flown.

Most of the camera lenses, lens covers, filters, and other pieces of photographic equipment were not equipped with velcro. In-flight time was used to cut and place velcro on each piece of photo equipment.

RECOMMENDATION: Every piece of camera equipment should be launched with at least one patch of hook velcro.

The crew was presented with a complex matrix of photographic experiments ten days prior to launch. We were defining, developing, and learning these procedures until the crew left for KSC three days before launch. This evaluation was not documented as part of DSO-903, Documentary Still Photography.

RECOMMENDATION: Extensive or significant photo requirements should be planned and trained for at least a month or two before launch. They should be included in the formal flight plan to optimize the availability of crew, windows, Orbiter attitudes, Earth views, and camera hardware.

The in-flight configuration of the polarization filters was different than expected.

RECOMMENDATION: The training in polarization techniques should involve not only lectures but also training with the hardware as it will be configured for flight. Training should also involve actual practice on reflected sunlight such as viewed from aircraft.

The fulfillment of OSO-903 for Earth observations went smoothly with excellent photographic results. The crew used the Minolta Spotmeter. The f-stops provided by the Payload General Support Computer (PGSC) are forecasted approximations. Rules of thumb needed to be applied to each approximation before a successful photograph could be attempted. The real-time biasing of these approximations based on the photographic objectives was a very involved process to be used on a quickly passing objective.

RECOMMENDATION: Training for the exposure of Earth observation photographs should include not only PGSC derived settings but also use of metering devices such as the Minolta Spotmeter.

The color Closed Circuit Television (CCTV) monitors flew for the first time and were a complete success. The monitors were a significant improvement over the old black and white monitors. The preflight detents for contrast brightness, etc., were optimal, and could not be improved in flight. An informal evaluation showed that the monitors' color quality were excellent. Camcorder views of objects on the flight deck were compared with the actual objects. The colors on the monitors were the same as the actual object's color.

RECOMMENDATION: Continue to fly the color CCTV monitors.

RECOMMENDATION: When new equipment flies for the first time, an official documented test of the equipment should be conducted. The test should be scheduled in the flight plan.

The 16mm Ariflex camera mode switch was intermittent throughout this flight and previous flights. The Ariflex camera has not been reliable.

RECOMMENDATION: The Ariflex should be modified, upgraded, or replaced.

The Orbiter Video Tape Recorder (VTR) jammed on FD2. The jam was cleared but the tape insertion mechanism would not seat properly without pushing on the top of the mechanism each time a tape was loaded. The VTR is old and has limited capabilities. It should be replaced.

RECOMMENDATION: Replace the VTR with a recorder with current capabilities.

L. Orbiter Systems, Flight Crew Equipment, and other Miscellaneous Observations

The compaction of trash will be a requirement on EDO missions. The trash compactor was fully capable of compressing an average of six man-days of trash into a volume less than 0.75 cubic feet. It was simple to operate, had no noticeable odor, and only allowed a small amount of liquid to escape one time.

We encountered a number of minor difficulties with the compactor and these should be corrected before it flies again.

1. The handles released from the compactor too easily, probably because of the minimum force required to compress the ball plungers.

2. The "finger lid" fingers tore.

3. The door latch began sticking after three days. This problem was easily remedied by applying Chapstick to the latch mechanism.

4. A screw in the right handle fell out, perhaps due to a defective locking method.

5. The metal outer ring and bag assembly repeatedly floated out of place. The entire assembly must fit more snugly in the compactor cylinder.

6. The handles began to go out of sync after FD4. When you placed both left and right retraction/compaction switches in the compaction mode and began moving the handles inward and outward in unison, the left handle would eventually stick in the inward position. The operator would then be required to place the compactor in the retraction mode, move the left handle outward and then place the machine back into the compaction mode to resume normal operations.

7. The velcro straps intended to secure the trash in its compacted state, did not work very well. Gray tape was used to ensure the completely compacted bag did not expand.

RECOMMENDATION: The compaction of trash is a necessity on EDO missions. After the required mechanical fixes, the compactor should, if feasible, be flown on every mission.

The Orbiter electrical Group B powerdown was executed after the DSP deploy. This was an effective way to save and manage cryogenic fluids. The Group B powerdown allows only three middeck lights to be on.

RECOMMENDATION: Group B powerdown should allow more lighting on the middeck.

The Orbiter temperature and humidity control was outstanding. STS-44 was the first mission to position the H2O loop 2 bypass mode in "automatic." The crew also flew in the automatic temperature control mode with the temperature controller rotated to the 2:30 position.

For some missions, stowage of food by crew member versus by meal greatly facilitates food preparation.

RECOMMENDATION: Stowing food by crew member should be an alternative if requested.

When either annunciator bus was selected on panel A6U, a buzz was heard. The buzz was loud enough to be distracting, and because of that the bus was left off except when required.

RECOMMENDATION: Eliminate the buzz associated with the panel A6U annunciator bus select switch.

During scheduled maintenance the vacuum cleaner attachment for cleaning Data Display Unit filters broke. A more flexible plastic tube is needed to vacuum hard-to-access filters.

The vacuum cleaner was powered once from an AC outlet using a Y-cable from a secondary experiment. The cable was two-phase only, and although the vacuum cleaner worked there was potential for damaging equipment.

RECOMMENDATION: Clearly label all non-standard cables to avoid improper use. Include in training a caution against use of "extension" cables that are not three-phase when they are manifested.

A humidity separator discharged several cups of water into the LEB requiring access to the area to clean up the water and bag the end of the humidity separator so that it could be used if needed. An attempt to access the humidity separator by removing the LiOH box was not successful. The IFM checklist call out for fasteners was not correct, so the box could not be removed. Postflight information revealed that each Orbiter is different. Access to the LEB was successfully made through Volume H, under the interdeck access ladder. This access path was on the port side and had one narrow point with only 8-9 inches of clearance between hardware. Water was on all the structure, wires, and lines from the humidity separator outlet to the outboard hull. All water was wiped up with towels, then the IFM to bag the end of the humidity separator outlet was completed.

RECOMMENDATION: Correct the IFM checklist to include differences in Orbiter LiOH box fasteners.

The voice reproduction characteristic of the flight deck and middeck speakers within the speaker/microphone system was unacceptable. In all instances, the crew member had to position himself directly in front of the speaker to understand what was being broadcast.

RECOMMENDATION: Replace the speaker with a voice reproduction system that can be easily heard and understood.

The method used for crew option TV downlinks seemed to work nicely and was well received by Public Affairs. Each day, available crewmen videotaped footage on a topic of interest designated by the CDR. A crew member acted as the director/producer to plan, organize, and ensure timely completion of the video. Scenes were discussed and then rehearsed if needed before filming. The video was reviewed as the filming was done and retakes were made as required. The crew member who would later broadcast the downlink would then review the finished video and rehearse his commentary. At the appointed time of the live downlink the prerecorded video was sent down and simultaneously played on the CCTV monitor while the crew member added live audio commentary.

M. On Orbit Assessment and Planning with MCC

Communication between the Atlantis crew and Mission Control were generally good. The crew, however, could not hear nor could they participate in discussions between the flight controllers, discussions that would ultimately affect the Flight Plan. The crew also did not, except by self-assessment,

receive a direct indication of how it had performed nor what, if any, changes might be necessary to improve efficiency. A daily tag up between the Flight Director and the CDR, similar to the private medical conference, could be included as a daily scheduled activity to ensure adequate crew assessment and anticipated future planning coordination.

RECOMMENDATION: Schedule a daily private or open discussion between the Flight Director and the CDR for crew performance assessment and future planning coordination.

V. DE-ORBIT PREPARATION AND ENTRY

The first de-orbit opportunity was "no-go" because of high winds at Edwards Air Force Base. The next opportunity, the second of three daylight opportunities at Edwards, had acceptable winds and the crew was given a "go" for de-orbit and for a landing on lakebed Runway 05.

There were five crew members who wore instrumentation for medical DSOs during entry. Each of these crew members required extra time during LES donning to prepare and put on the instrumentation. This resulted in de-orbit preparation activities still being worked after entry interface. These DSOs should be done because of their scientific importance to the manned space program and time should be allocated to ensure they are done properly.

RECOMMENDATION: Allow extra time in the de-orbit prep timeline for medical DSO instrumentation checkout and donning.

The entry profile and Orbiter characteristics were typical with anticipated buffets between Mach 24 and 22. The Mach 1 buffet was impressive and, as always, generated crew comments.

Cockpit temperatures increased and, similar to ascent, higher temperatures were measured on the flight deck then on the middeck. Temperatures in the area around the CDR and the PLT were approximately 96 degrees F decreasing by 10 degrees F in the MS1 and MS2 seating areas. The middeck, similar to ascent, experienced temperatures of approximately 75 degrees F.

The comments made concerning the currently configured LES during launch countdown and ascent are all applicable during entry. The risk during entry, however, is considered significantly less and the probability of bailout is minimal. An appropriate helmet that would provide breathing air or oxygen to the crew member in the unlikely case of loss of Orbiter pressurization should be worn. Five of the six members of the STS-44 crew recommend that the LES not be donned for entry because it would severely limit and restrict the crew's capability to quickly egress from the Orbiter following a more probable landing mishap.

RECOMMENDATION: Do not wear the current LES during entry and landing.

RECOMMENDATION: Provide a helmet for each crew member that, in case of loss of Orbiter pressurization, would provide air or oxygen for survival.

The sixth member of the crew disagrees. The following is his statement of concern:

"The assessment that the risk of bailout is minimal on entry may be valid; however, the LES offers protection not only for bailout but also for loss of cabin pressure at high altitudes and for exposure protection. Every launch has new anomalies that were previously not within our experience. If such a problem does occur on entry where the LES may mitigate the degree of severity of the failure on the crew, it would be unacceptable to not have the needed protection. The total protection that the LES provides is worth retaining; it is the current LES that is unacceptable. Before we make a precedent-setting decision to not wear the LES for entry, we should make every endeavor to either fix the current suit or fully explore alternatives that would be acceptable to retain the protection afforded by the suit. Only then should we consider abandoning this protection."

DTO 520 Edwards Lakebed Runway Bearing Strength Assessment for Orbiter Landings. The declaration of an MDF and the requirement to land at a lakebed complex because of the IMU failure, gave us the opportunity to complete DTO 520. An uneventful landing was made and Atlantis was allowed to roll out with no brake application until 15 knots groundspeed (KGS). Directional rollout stability was excellent, though MS2 commented that the rollout was rougher than he recalled from his last lakebed landing on Runway 23 in 1985.

VI. POSTLANDING

Standard full convoy operations began after wheel stop. The Crew Transport Vehicle (CTV) was rolled to the Orbiter hatch and, after postlanding activities were completed, the crew exited directly into it. Three of the crew members, the CDR, MS3, and the PS, exited the CTV immediately for an Orbiter "walk around." A second vehicle stood by for their transportation. The remaining crew members immediately began DSO data-takes within the CTV. The CTV and the second vehicle subsequently carried the crew back to the medical facility for family greetings, postlanding medical examinations, and the continuation of postlanding DSO activities.

The postlanding medical activities and all DSO evaluations were completed on time. DSO 472 Intraocular Pressure Measurement required crew member participation to take measurements on a second crew member. We recommend that a returning crew member should not be expected to be operators of DSOs such as 472 in the immediate postflight period. Eye-hand coordination skills cannot be expected to be normal at this time.

RECOMMENDATION: Do not use returning crew members as operators for DSOs in the immediate postflight period.

VII. SUMMARY OF RECOMMENDATIONS

RECOMMENDATION: Accomplish as much training as possible before crew assignment. (P. 3)

RECOMMENDATION: Expand the Catalog to include all training required to accomplish the mission. Have all training coordinated by the Training Manager. (P. 3)

RECOMMENDATION: The SMS training team should include a person to ensure the correct level of crew proficiency on DTOs, DSOs, and secondaries. (P. 4)

RECOMMENDATION: Prioritize training with emphasis on training for tasks that we will do, on probability of failure and level of severity. Do not limit the majority of training to the primary mission or improbable failure scenarios. (P. 4)

RECOMMENDATION: At least one session in the SMS is needed from crew ingress through lift-off. Communication checks and other crew actions which need to be trained for exist within this period. Likewise, at least one postlanding session needs to be run all the way through crew egress. Emphasis should be placed on actual Orbiter configuration and on non-standard, flight-specific configurations including crew member instrumentation supporting DSOs. (P. 4)

RECOMMENDATION: Increase the number of and participation in integrated training. (P. 4)

RECOMMENDATION: Increase frequency of initial IUS training to improve overall training efficiency. (P. 5)

RECOMMENDATION: Emphasis should be placed on the most likely CIU indications during training. (P. 5)

RECOMMENDATION: DSO training should be conducted earlier and should be included and managed within the "standard" training template. (P. 5)

RECOMMENDATION: The PTI sponsors must assure the crew is trained properly. The crew and control team should be exposed to entry PTIs for the primary and secondary landing sites. (P. 5)

RECOMMENDATION: Since the training for M88-1 was, for the most part, effective, a formal training plan is not necessary. Document the actual time the crew spent in preparing for the M88-1 so that the total crew training workload can be managed. (P. 6)

RECOMMENDATION: Develop a simple scene simulation of ground target passage using actual on-orbit, out-the-window camcorder scenes; fly the M88-1 equipment on board an aircraft at least once prior to flight to conduct practice observation runs. (P. 6)

RECOMMENDATION: Train early and often on those procedures you will normally perform. Involve the crew in procedure development of secondaries. (P. 6)

RECOMMENDATION: Retain the IFM training as part of CEIT. (P. 7)

RECOMMENDATION: Construct an IFM training panel in the middeck on the fixed base simulator to allow real-time IFM training tasks to be performed. (P. 7)

RECOMMENDATION: Modify the WCCS so that when in the PTT mode, microphones associated with a leg unit are keyed only when the PTT switch is pushed for the leg unit. (P. 7)

RECOMMENDATION: Manifest enough batteries to last for the expected mission duration. Include margin for battery failures and shortened battery life based on reported operational use during flights. (P. 7)

RECOMMENDATION: Post insertion and on-orbit operations would be enhanced if a generic Reference Data stowage list was provided for training early in the training flow. (P. 7)

RECOMMENDATION: A natural sleep-shift should be considered as an option. (P. 8)

RECOMMENDATION: Change the simulated launch attitudes of the SMS and the CCT trainers to better replicate the Orbiter. (P. 8)

RECOMMENDATION: Until the SMS and CCT trainers' seat positions are corrected, all CDRs, PLTs, and MS2s should determine their correct seated positions while suited in an Orbiter on the launch pad, and then adjust their seats and body positions appropriately in the trainers during training sessions. (P. 8)

RECOMMENDATION: Continue modification/replacement efforts to create an LES acceptable for launch countdown and ascent. (P. 8)

RECOMMENDATION: Clean exterior window surfaces prelaunch and keep the windows covered until the pad support technicians depart. (P. 9)

RECOMMENDATION: The SMS visual and aural cues should simulate as accurately as possible actual mission sounds and sights. (P. 9)

RECOMMENDATION: Reevaluate training objectives and modify if required to reflect actual crew capabilities during ascent, especially during the high g phase. (P. 9)

RECOMMENDATION: Centrifuge training should be continued for non-flown astronauts and should be added as a recommended activity for previously flown astronauts for the simulation of the ascent g loading and to assure a good LES and harness fit. (P. 9)

RECOMMENDATION: It is imperative that to guarantee mission success, the team must thoroughly prepare and train for the real mission. (P. 10)

RECOMMENDATION: Unstow a camcorder and bracket early in the post insertion time line to document middeck post insertion activities for future flight crews to review during training. (P. 11)

RECOMMENDATION: The aft station mission clock switch should be set in the MET configuration during prelaunch switch reconfiguration. (P. 11)

RECOMMENDATION: If the IUS battery margins allow, the deploy countdown should be lengthened, with the IUS transfer to internal power occurring at 30 minutes before deploy. (P. 12)

RECOMMENDATION: The tone on the pen should be made louder to be more discernible over the normal Orbiter background noise. (P. 12)

RECOMMENDATION: Reduce the size of the LBNP device and the profile of the controller to allow easier movement while wearing the device during soak operations. (P. 13)

RECOMMENDATION: Evaluate LBNP "pants" with legs to further reduce the operational impact of soak operations. (P. 13)

RECOMMENDATION: Highly recommend continuing research with the LBNP, including operational use; that is, working in the device and using it the day before entry to obtain operationally relevant data. (P. 13)

RECOMMENDATION: Replace the treadmill with an alternate means of exercise. (P. 13)

RECOMMENDATION: Manifest the EDO rehydratable food packages. (P. 13)

RECOMMENDATION: No secondary experiment should be manifested with SpaDVOS as a primary sensor until it demonstrates greatly improved performance and resolution. (P. 14)

RECOMMENDATION: The binoculars flown as part of the Terra Scout equipment should be procured and manifestec as standard Orbiter flight crew equipment. (P. 14)

RECOMMENDATION: Pursue the development of Terra Scout II. (P. 15)

RECOMMENDATION: The matte finish focusing prism installed on the Nikon F3 limited useful through-the-lens observations. Replace the matte finish viewfinder on the camera with a clear non-obstructed viewfinder to allow better through the lens observations. (P. 15)

RECOMMENDATION: Add geolocation capability to instantaneously locate target image. (P. 16)

RECOMMENDATION: Increase the focal length of the lens to 1200-1500 mm. Increase the CCD pixel resolution as high as possible. (P. 16)

RECOMMENDATION: Add color capability. (P. 16)

RECOMMENDATION: Add capability to transfer digital images from TEM storage device to an on-board laptop computer equipped with image processing software to allow for on-board image enhancement. (P. 16)

RECOMMENDATION: The technology already exists to increase the ISO of the CCD camera which would allow for the faster shutter speeds required. This technology should be vigorously pursued. (P. 17)

RECOMMENDATION: Improve CCD to TEM input/output capability to allow for rapid acquisition of images at a minimum of 2-3 images per second under all disk storage capacity conditions. (P. 17)

RECOMMENDATION: Improve TEM utility by allowing for storage of images by specific numbers, and by allowing for shifting of images to lower numbered slots which become available after non-desireable images are deleted. (P.17)

RECOMMENDATION: Develop a communication plan so that when it is required the Orbiter uplink and downlink can be encrypted to allow pre-pass briefings, post-pass voice reporting, and downlink of images to be accomplished via network communications. (P. 17)

RECOMMENDATION: Add downlink capability so imagery can be relayed directly to tactical commanders in the field. (P. 17)

RECOMMENDATION: Crews should investigate each secondary experiment for its impact on other mission activities. (P. 18)

RECOMMENDATION: Data acquisition/stowage devices should remain in lockers to prevent loss of data due to inadvertent impacts. Power and venting should be provided. (P. 18)

RECOMMENDATION: A method of holding tension on cassette tapes prior to and after use should be provided. (P. 18)

RECOMMENDATION: The STS-44 crew recommends that we continue to manifest the atlas and slider map and begin manifesting the Earth Observation Preflight Training Manual. (P. 19)

RECOMMENDATION: If extensive dual-camera mount operations are required, at least a third Earth observation camera should be flown. (P. 19)

RECOMMENDATION: Every piece of camera equipment should be launched with at least one patch of hook velcro. (P. 19)

RECOMMENDATION: Extensive or significant photo requirements should be planned and trained for at least a month or two before launch. They should be included in the formal flight plan to optimize the availability of crew, windows, Orbiter attitudes, Earth views, and camera hardware. (P. 19)

RECOMMENDATION: The training in polarization techniques should involve not only lectures but also training with the hardware as it will be configured for flight. Training should also involve actual practice on reflected sunlight such as viewed from aircraft. (P. 19)

RECOMMENDATION: Training for the exposure of Earth observation photographs should include not only PGSC derived settings but also use of metering devices such as the Minolta Spotmeter. (P. 20)

RECOMMENDATION: Continue to fly the color CCTV monitors. (P. 20)

RECOMMENDATION: When new equipment flies for the first time, an official documented test of the equipment should be conducted. The test should be scheduled in the flight plan. (P. 20)

RECOMMENDATION: The Ariflex should be modified, upgraded, or replaced. (P. 20)

RECOMMENDATION: Replace the VTR with a recorder with current capabilities. (P. 20)

RECOMMENDATION: The compaction of trash is a necessity on EDO missions. After the required mechanical fixes, the compactor should, if feasible, be flown on every mission. (P. 21)

RECOMMENDATION: Group B powerdown should allow more lighting on the middeck. (P. 21)

RECOMMENDATION: Stowing food by crew member should be an alternative if requested. (P. 21)

RECOMMENDATION: Eliminate the buzz associated with the panel A6U annunciator bus select switch. (P. 21)

RECOMMENDATION: Clearly label all non-standard cables to avoid improper use. Include in training a caution against use of "extension" cables that are not three-phase when they are manifested. (P. 22)

RECOMMENDATION: Correct the IFM checklist to include differences in Orbiter LiOH box fasteners. (P. 22)

RECOMMENDATION: Replace the speaker with a voice reproduction system that can be easily heard and understood. (P. 22)

RECOMMENDATION: Schedule a daily private or open discussion between the Flight Director and the CDR for crew performance assessment and future planning coordination. (P. 23)

RECOMMENDATION: Allow extra time in the de-orbit prep timeline for medical DSO instrumentation checkout and donning. (P. 23)

RECOMMENDATION: Do not wear the current LES during entry and landing. (P. 23)

RECOMMENDATION: Provide a helmet for each crew member that, in case of loss of Orbiter pressurization, would provide air or oxygen for survival. (P. 23)

RECOMMENDATION: Do not use returning crew members as operators for DSOs in the immediate postflight period. (P. 24)

VIII. LIST OF ABBREVIATIONS

A/G	Air to Ground
AC	Alternating Current
AFB	Air Force Base
AMOS	Air Force Maui Optical Station
CCD	Charge Couple Device
CCT	Crew Compartment Trainer
CCTV	Closed Circuit Television
CDR	Commander
CEIT	Crew Equipment Interface Test
CREAM	Comic Radiation Effects and Activation Monitor
CRU	Converter Regulator Unit
CTV	Crew Transport Vehicle
DOD	Department of Defense
DPS	Data Processing System
DSO	Detailed Supplementary Objective
DSP	Defense Support Program
DTO	Detailed Test Objective
EDO	Extended Duration Orbiter
EST	Eastern Standard Time
ET	External Tank
F	Fahrenheit
FD	Flight Day
FDF	Flight Data File
g	Gravity
GMT	Greenwich Mean Time
H2O	Water
IFM	In-Flight Maintenance
IMU	Inertial Measurement Unit
IOCM	Interim Operational Contamination Monitor
ISO	International Standards Organization
IUS	Inertial Upper Stage
KEAS	Knots Equivalent Air Speed
KGS	Knots Groundspeed
KSC	Kennedy Space Center
LBNP	Lower Body Negative Pressure
LEB	Lower Equipment Bay
LES	Launch and Entry Suit
LIGHTSAT	Light Satellite
LiOH	Lithium Hydroxide
MDF	Minimum Duration Flight
MET	Mission Elapsed Time
mm	Millimeter
MMIS	Military Main in Space
MS	Mission Specialist
NIIRS	National Imagery Interpretability Rating Scale
NM	Nautical Miles
OMS	Orbital Maneuvering System
PGSC	Payload General Support Computer
PLT	Pilot
PS	Payload Specialist
PST	Pacific Standard Time
PTI	Programmed Test Input

PTT	Push to Talk
RCS	Reaction Control System
R&D	Research and Development
RIMU	Redundant Inertial Measurement Unit
RME-III	Radiation Monitoring Experiment-III
SAM	Shuttle Activation Monitor
SMS	Shuttle Mission Simulator
SpaDVOS	Spaceborne Direct View Optical System
TCDT	Terminal Count Demonstration Test
TEM	Tethered Electronics Module
TV	Television
U.S.	United States
UAV	Unmanned Aerial Vehicle
UHF	Ultrahigh Frequency
VFT	Visual Function Tester
VTR	Video Tape Recorder
WCCS	Wireless Communication System

APPENDIX B

Optical Equipment and Results of Shuttle Overhead Window Tests

1. SpaDVOS Description Summary.

a. Optical System:

Light rays from the ground site pass through the shuttle overhead windows and are reflected by the front surface mirror. To permit pointing and tracking of ground sites, the mirror rotates about two axes: one in the plane of the mirror and the other coincident with points left and right of the ground track. Rotation of the mirror about the optical axes is used to point in or opposed to the direction of travel.

The mirror position is controlled by a mechanical system consisting of gears, belts, and a control handle. Movement of the control handle in the fore/aft direction with respect to the shuttle causes the entire mirror assembly to rotate about the optical axis on the double loaded bearings upon which the assembly is mounted. This action causes the along track pointing angle of the optical system to change one degree for every degree that the handle is rotated.

Movement of the control handle in the side-to-side direction causes the mirror to rotate around the axis in the plane of the mirror. This is accomplished by a gear and belt system. The axis to which the control handle is rigidly attached is connected to a gear on the side of the mirror head assembly. This gear drives a second gear by means of a chain belt, achieving a 4:1 reduction in rotation. The position of the mirror changes four degrees for every degree that the handle is rotated in the side-to-side direction.

Rays from the external scene are reflected by the pointing mirror into the zoom objective lens. This lens is a Vivitar telephoto zoom, 120 to 600 mm focal length, f/#5.6-8.0, 82 mm diameter; changeable lenses provide f/# to 22.0. The lens has its object focus fixed at infinity since only distant targets will be observed. The focal length and aperture of the objective lens are set by the position of levers mechanically attached to the focal length selection ring and f-stop ring respectively. After a 90 degree reflection from a front surface mirror, a real image of the external scene is formed at the back focal plane of the lens. A 60 mm focal length field lens is also located at the back focal plane of the objective lens. This lens has no optical power with respect to the image, but increases light throughput by collecting the chief rays of the image forming bundles so more rays pass through the exit pupil of the system.

After the field lens, another from surface mirror is used to reflect the rays 90 degrees. A pair of lenses then relay and magnify the intermediate image. The first lens, focal length 135 mm, collimate the incoming rays. These parallel rays pass through the pechan prism located between the two lens. The prism is mounted in a rotating assembly which is mechanically connected to the rotating mirror head. Because of the

mirror rotation system, the incoming image is rotated one degree for every degree of mirror rotation about the principal optical axis. The pechan prism causes an image rotation of two degrees for every one degree of prism movement. Thus by rotating the pechan prism one degree clockwise for every two degrees of counterclockwise mirror rotation, the observed image retains its orientation.

The second lens of the relay pair, 180 mm focal length, causes the collimated rays to converge. These rays pass through a penta-prism, which changes the optical path 90 degrees without inverting or reversing the parity of the image. The light then enters a cube beamsplitter which is cemented to the penta-prism. Some of the light is transmitted through the cube and forms a real image, which is viewed with the eyepiece. The remainder of the light is reflected upward, where is reflected again by a right-angle before forming an image at the CCD array of the video camera.

b. Electronic System.

The SpaDVOS 's electronic system has two functions: to acquire data and to cue the observer to the location of ground sites. These functions are performed by a microprocessor based circuit consisting of : a 65C02 microprocessor, a 2048 by 8 bit static ram, a 32K EPROM, a vertical interval data inserter, a video multiplexer, optical encoders. optical interrupters, a CCD array video camera, a LED display, a LCD, and a data entry keypad.

First, two 1024 pulse optical encoders (BEI No. E513-900-HD) interface directly with the MPU to monitor the position (pointing angles) of the tracking mirror. Second, the encoders are calibrated by two opto-interrupters (Marktech No. MTSS-12000) which transmit position reference signals to the MPU. The third input to the MPU is from the data entry keypad (Grayhill No. 86-BA2-001). The keypad allows the user to set the MET and to enter ground site cueing information. The final input to the MPU is the video signal generated by the CCD array camera (Sony model DXC-1011).

Information output by the MPU goes to the LED display, the LCD, and the video signal. The LED display is internal to the SpaDVOS main unit. This display shows the along track and cross tracking pointing angles when the system is in the run mode, and the time to the target site.

c. Technical Parameters:[B1]

Size	18.3 x 14.5 x 7.6 inches
Weight	36.52 pounds
Magnification	4x -67x (using changeable eyepieces)
Field of View	1-8 degrees
Field of Regard	+/- 25 x +/- 45 degrees
Eyepieces	9mm, 21mm, 32mm and 40mm
Objective Lens	120-600mm, f/5.6-22.0, 82mm diameter
Microprocessor	65C02
Mirror Size	5 x 6 x 3/4 inches

2. (Summary of *Space Shuttle Overhead Windows, Optical Tests, Final Report*, Aerospace Report No. TR-0091(6508-21)-1, dated June 1991)

"On 1-2 August 1989, the optical quality of the space shuttle overhead windows was tested at the Corning Glassworks plant in Canton, New York. The tests were conducted by Karen P. Scott, David W. Warren, and Michael C. Wanke of the Aerospace Corporation. The tests were in support of the Military Man in Space program and were funded by the U. S. Air Force. The purpose of the tests were to characterize the optical quality of the overhead windows, especially when they are used in conjunction with different aperture telescopes. This report first provides a simple review of the optical theory involved when windows are present in an optical system. Next, a review of the hardware used for the test is presented along with a full procedure on the photographic, visual, and interferometric tests that were conducted. Next, the results are presented with accompanying photographs that were taken during the test...." A review of tests performed concurrently by the Armstrong Aeromedical Research Laboratory are also presented in the report.

a. Visual photographic, and interferometric tests were performed on the space shuttle overhead windows to characterize the optical quality of these windows. An Air Force tri-bar target was viewed with an 8-in. telescope and a 5-in. telescope for the photographic and visual tests. A Zygo Mark IV interferometer was used for the interferometric tests. Results showed that the windows significantly degraded the performance of both telescopes. At least a 160% degradation in resolution was seen. The results of tests by Armstrong Aeromedical Research Laboratory were reviewed and found to corroborate the Aerospace Corporation results.

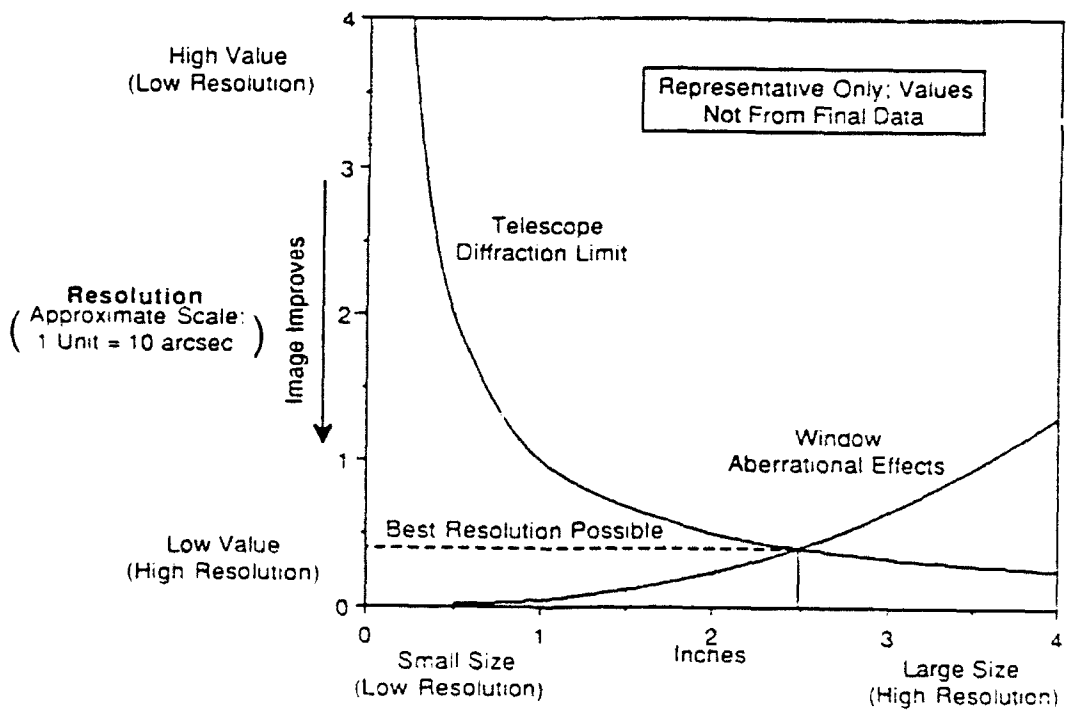
b. The tests made it clear that the shuttle overhead windows were not designed to be used in conjunction with medium aperture telescopes. Corning did not use its optical grade glass, and no optical surface finish was specified. Both telescopes used in the test were affected by aberrations induced by the windows which were evident as multiple overlapping images and severe astigmatism. The AAMRL tests conducted concurrently with the Aerospace test found that the window aberrations become

[B1] The expected best resolution of SpaDVOS was 10-15 feet (NIIRS 3).

apparent for aperture diameters greater than 2 inches. At an aperture of 3 inches, the resolution of the optics was degraded moderately, but the AAMRL results still found that this aperture yielded the best resolution. The cutoff point, at which increasing the aperture fails to increase resolving power, still is unclear.

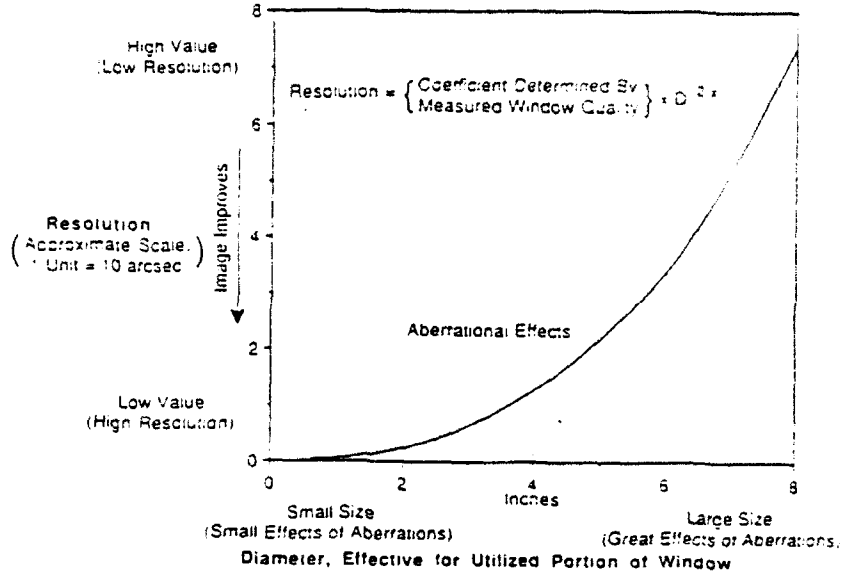
c. Test conclusions state, when an optical system is used in conjunction with a window port, the window must be designed for that use. Space Station Freedom, the Space Shuttle, Spacelab, and Spacehab have the facilities to hold high optical quality windows. For future experimentation or programs that require the use of high-resolution optical systems within one of the above facilities, it is critical to design suitable windows to specifically meet these needs.

BEST APPROXIMATE TELESCOPE DIAMETER FOR ORBITER OVERHEAD WINDOWS

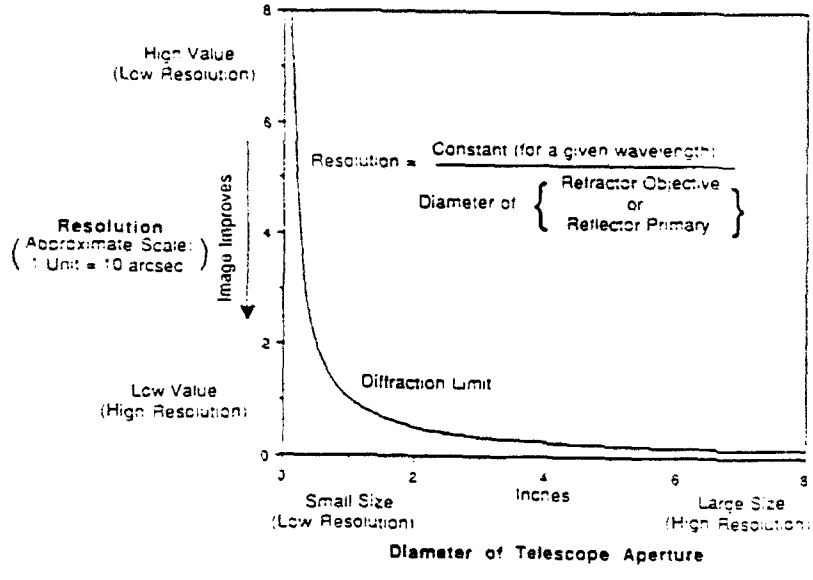


Diameter, Effective, for Utilized Portion of Orbiter Overhead Window

WINDOW ABERRATIONAL EFFECTS CURVE



TELESCOPE DIFFRACTION LIMIT CURVE



3. The following pages are reproduced from the *Cargo Systems Manual: SpaDVOS, dated 1 October 1991, prepared by the National Aeronautics and Space Administration, Payload Operations Branch, Operations Division, JSC.* The extract of this manual is included in this Appendix because it provides descriptive information on the design of the SpaDVOS and its interfaces with the shuttle orbiter. It is the single authoritative source of information on the Space-borne Direct View Optical System for use by JSC space shuttle planning and operations support personnel. Schematic diagrams reflect the current information available at time of publication and are constructed in accordance with the Mission Operations Directorate Drafting Standards, Rev C, dated April 1987.

CONTENTS

FIGURES

SECTION 1
INTRODUCTION

1.1 OBJECTIVE

The Spaceborne Direct View Optical System (SpaDVOS) payload will be used to investigate man's capability to acquire and extract information from Earth-based sites in real time using a direct view optical system in the orbiter.

1.2 PAYLOAD BACKGROUND

The SpaDVOS consists of a manually controlled zoom telescope, a charge coupled device (CCD) array camera, a small microcontroller for programming targets and driving internal and external displays, and supporting electronics enclosed in an aluminum housing. The system requires two standard middeck lockers during the ascent and entry phases of flight. During on-orbit operations, the flightcrew will unstow and assemble the SpaDVOS equipment. The unit is then mounted to the aft flight deck (AFD) overhead windows and secured by the sunshade latches. The mounting system incorporates the inboard sunshade clamps of windows W7 and W8.

1.3 PAYLOAD SYSTEMS DESCRIPTION

The SpaDVOS is powered from the orbiter 28 V dc power system via the Space Shuttle Program (SSP)-supplied standard 28 V dc power harness and contains a 1-amp fuse in the SpaDVOS main power circuit. The SpaDVOS video camera signal is routed to the orbiter video tape recorder (VTR) via an SSP-supplied VTR cable. The SpaDVOS has a control weight of 54 pounds. The main housing has dimensions of 15-1/4 by 12-1/8 by 7-5/8 inches.

Figures 1-1 through 1-3 show the various crew and orbiter interfaces. When SpaDVOS is mounted to the AFD overhead windows, figure 1-1 is a view looking aft which shows the eyepiece, data entry keypad, and associated liquid crystal display (LCD). The tracking mirror assembly is located on the left side of the unit. Figure 1-2 shows a view of the bottom side of the SpaDVOS. The controls located here are the f-stop, focal length, and tracking mirror lever. Figure 1-3 is a view of the port side which includes SpaDVOS interfacing jacks for orbiter 28 V dc power, video signal output, hand controller (interfacing connector not shown, J3), power switch, and operational and spare fuses.

1.3.1 Front Surface Tracking Mirror

Figure 1-4 shows the internal layout of the SpaDVOS.

The front surface tracking mirror is contained in an aluminum housing which is attached to the SpaDVOS main housing during on-orbit experiment setup. The mirror is manufactured of 98 percent silica and 2 percent proprietary material. The mirror is glued to an aluminum plate and is also held with four clamps. A transparent mirror cover provides mirror protection and allows inspection for mirror damage/breakage during on-orbit assembly of the experiment.

1.3.2 Charge Coupled Device Color Camera

The CCD color camera is a Sony DXC-101 TV color camera. This camera produces a standard 525 RS 170 video signal. Digital information containing tracking mirror position and current mission elapsed time (MET) is written onto lines 14 and 15 of the video image. The observed sites are recorded with the CCD, and the images are transferred to the orbiter VTR via an SSP-provided VTR interface cable. The camera is powered by 12 V dc and consumes 4.2 W.

1.3.3 Zoom Telescope

The manually controlled zoom telescope (fig. 1-4) is manufactured by Vivitar and provides a 120-600mm focal length, an aperture range of f5.6-f32, and a diameter of 82mm. The lens has its object focus fixed at infinity since only distant targets will be observed. The focal length and aperture of the lens are set by the position of levers mechanically attached to the focal length selection ring and f-stop ring, respectively. A transparent cover on the SpaDVOS housing allows for inspection of the scope lens for damage during on-orbit assembly of the experiment.

1.3.4 Prisms/Lenses/Eyepieces

The prisms and lenses used in the SpaDVOS are off-the-shelf items provided by various vendors. The eyepieces are also standard off-the-shelf Tele-Vue eyepieces. Excluding the zoom lens, there are three other lenses: 60mm, 135mm, and 180mm (fig. 1-5). The 60mm lens is used to increase the light flow through the system. After the 60mm lens, a 135mm lens is used to collimate the light rays before passing them through the pechan prism. The pechan prism is used to retain an upright orientation of the image. The 180mm lens is used to converge the image rays. These rays then pass through a penta prism which is used to change the optical path without inverting or reversing the image. The final component is a beam splitter which passes the image to the observer and also to the CCD camera.

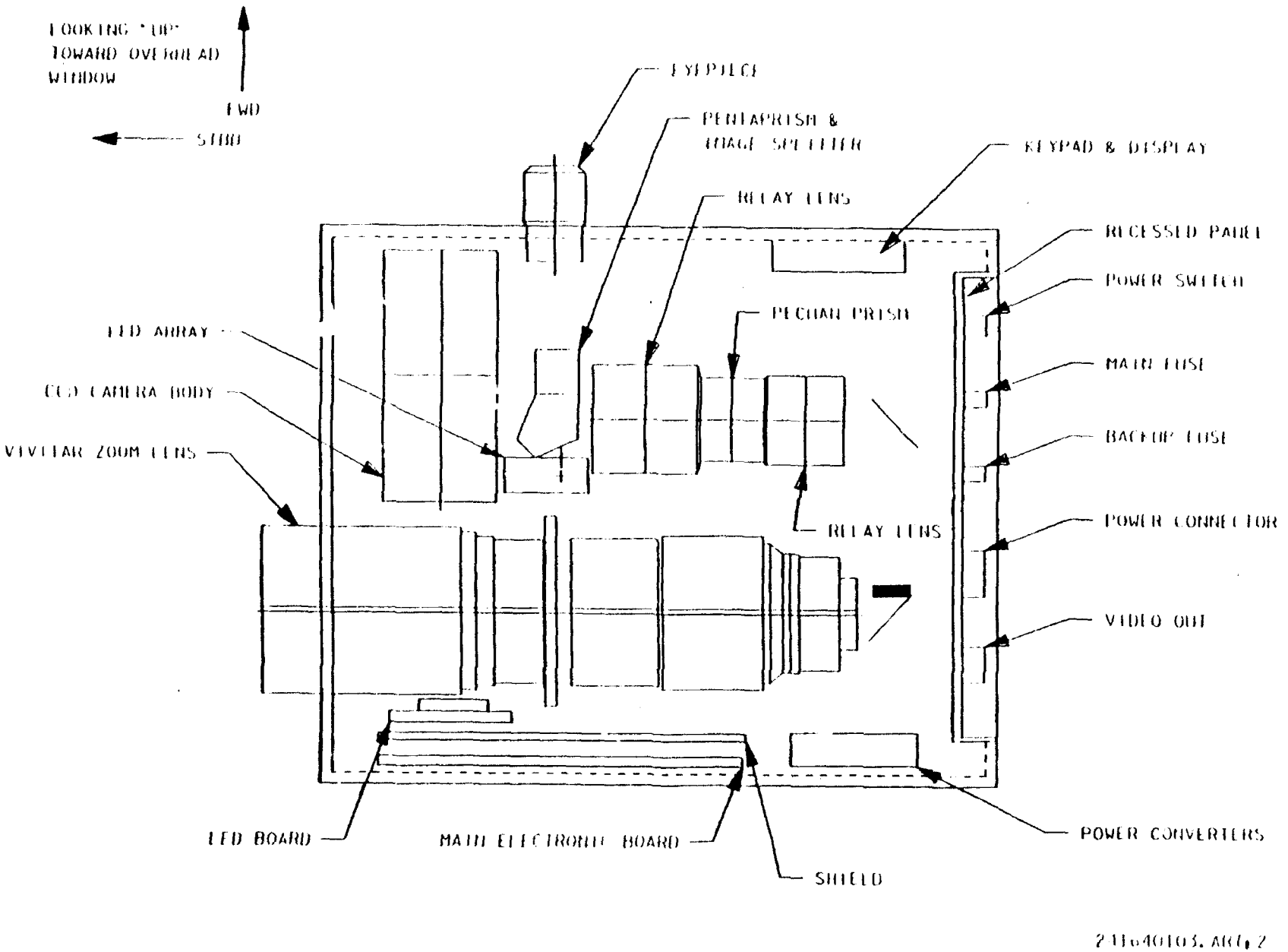


Figure 1-4.- SpaDVOS configuration diagram.

JSC-24164

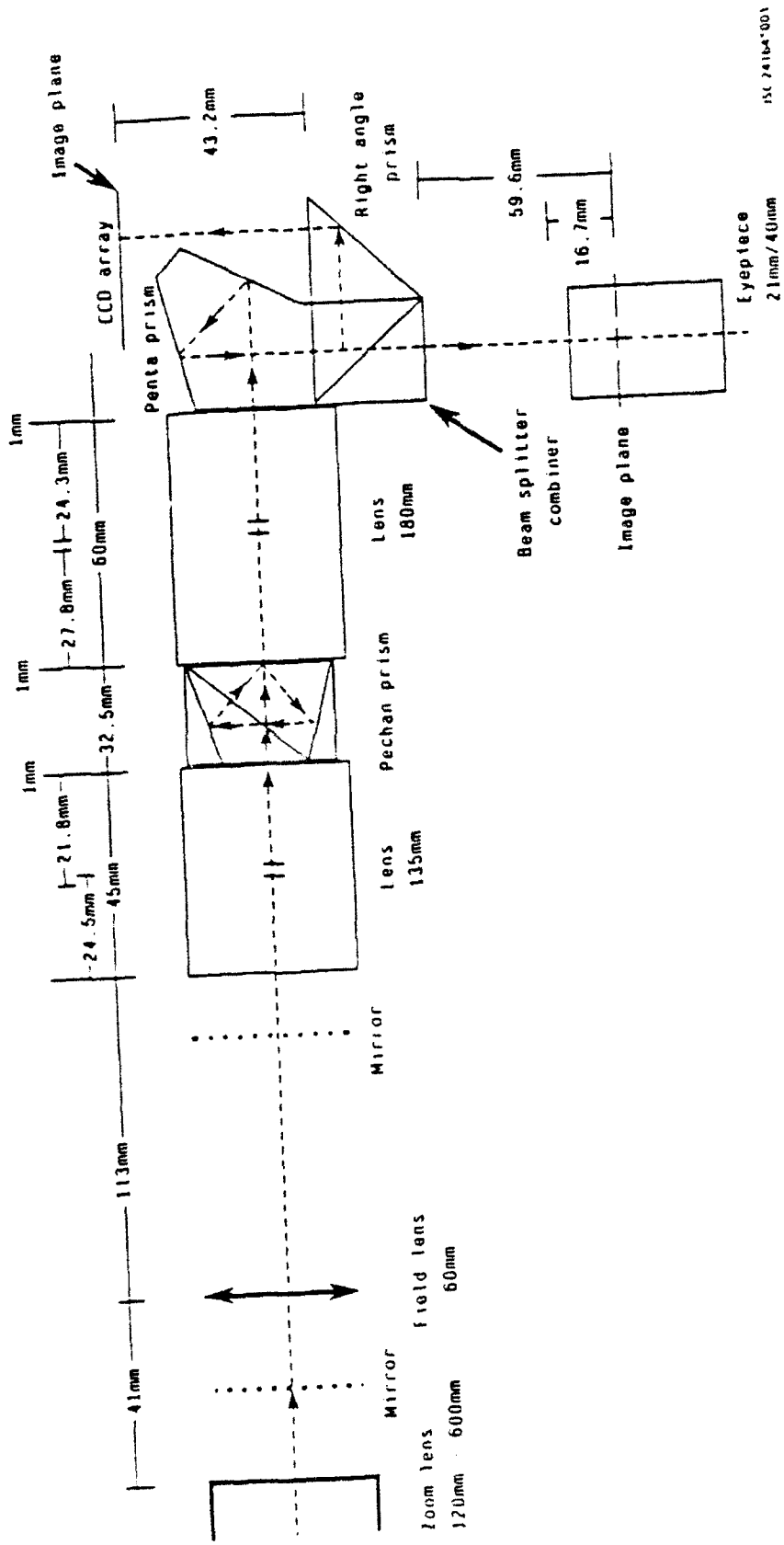


Figure 1-5.- Shuttle telescope.

Four eyepieces (9, 20, 32, and 40mm) are available to be flown. The eyepiece is threaded for insertion into the SpaDVOS unit and is held in place with a set screw located on the underside of SpaDVOS.

1.3.5 Mounting Extensions

The SpaDVOS uses a combination of extension legs to mount to the overhead windows. Figure 1-1 shows the assembled extensions once attached to SpaDVOS. Figure 1-6 shows details of extension legs and the overhead window interface.

1.3.6 Electronics

The SpaDVOS electronics provide dc/dc down-conversion of orbiter-supplied 28 V dc to -5 V, +5 V, and +12 V dc for use by the CCD camera, light-emitting diode (LED) display, and keyboard electronics. The SpaDVOS electronic system is controlled by a microprocessor unit (MPU), which receives inputs from four sources. First, two 1024-pulse optical encoders interface directly with the MPU to monitor the position of the tracking mirror. Second, the encoders are calibrated by two opto-interrupters which transmit position reference signals to the MPU. The third input to the MPU comes from the data entry keyboard. The final input to the MPU is the video signal generated by the CCD array camera.

Information output by the MPU goes to the LED display, the LCD, and the video signal. The video signal output by the MPU is identical to the input signal except that mirror pointing angles and the MET are written on lines 14 and 15 by the vertical interval data inserter and the video multiplexer circuitry.

The electronic system is fused using a 1-amp fuse and has 16-gauge wire upstream of the fuse and 22-gauge wire downstream. The wire is Teflon coated. (In section 2, see figure 2-2.)

1.3.7 Tracking Mirror Hand Controller

A dc motor has been added to aid the crewmember in tracking the site in the along-track axis. This motor is internal to the SpaDVOS unit and is controllable via a modified aircraft hand controller. The controller, figure 1-7, has three switches which control: (1) on/off switch, (2) attitude switch to select between orbiter -XVV or +XVV, and (3) motion switch that, when activated, will drive the mirror assembly in the along-track direction from target acquisition of signal (AOS) until target loss of signal. This mechanism diminishes erratic tracking motions that can be induced when tracking in a manual configuration.

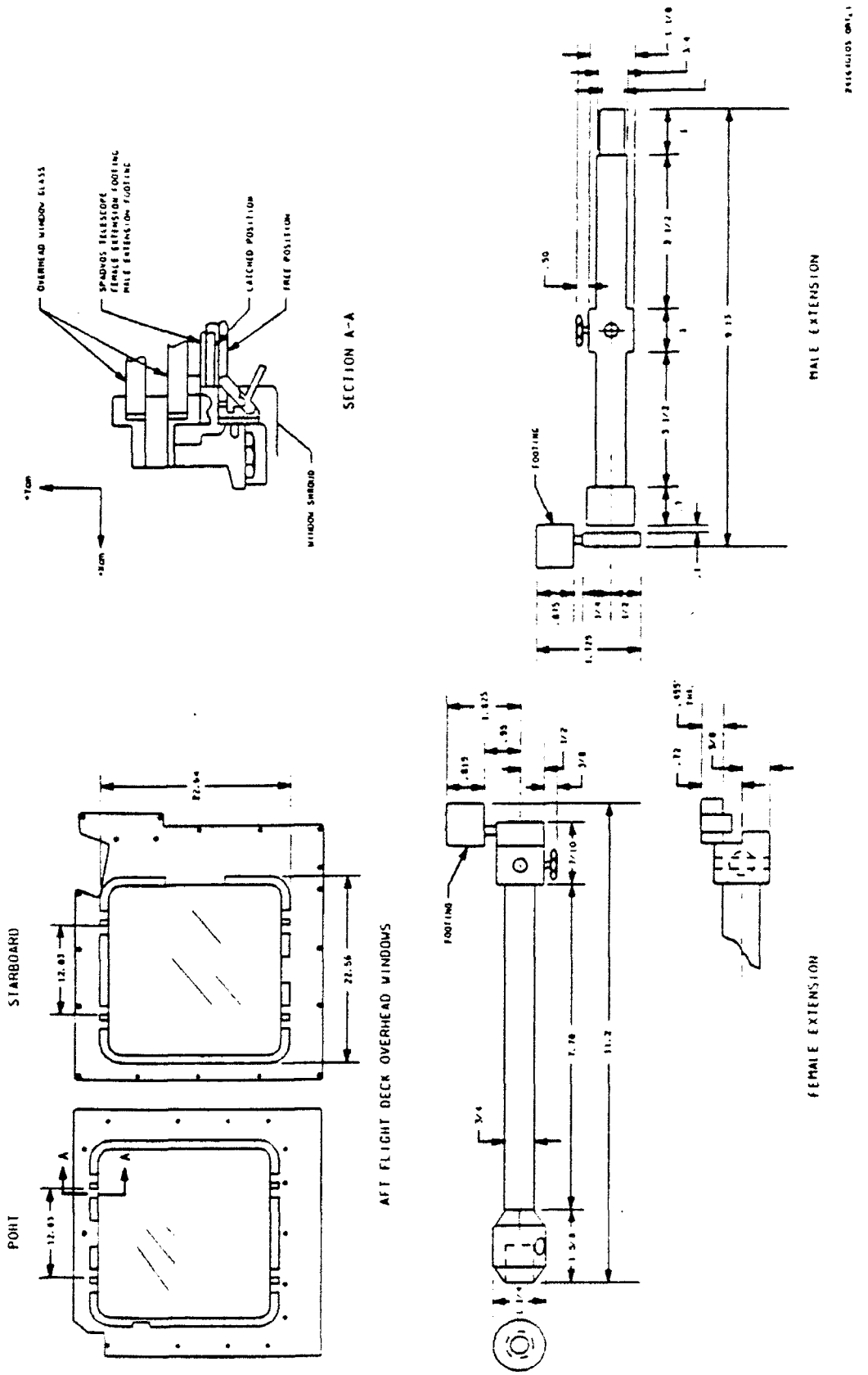


Figure 1-6.- Mounting extensions to AFD window interface.

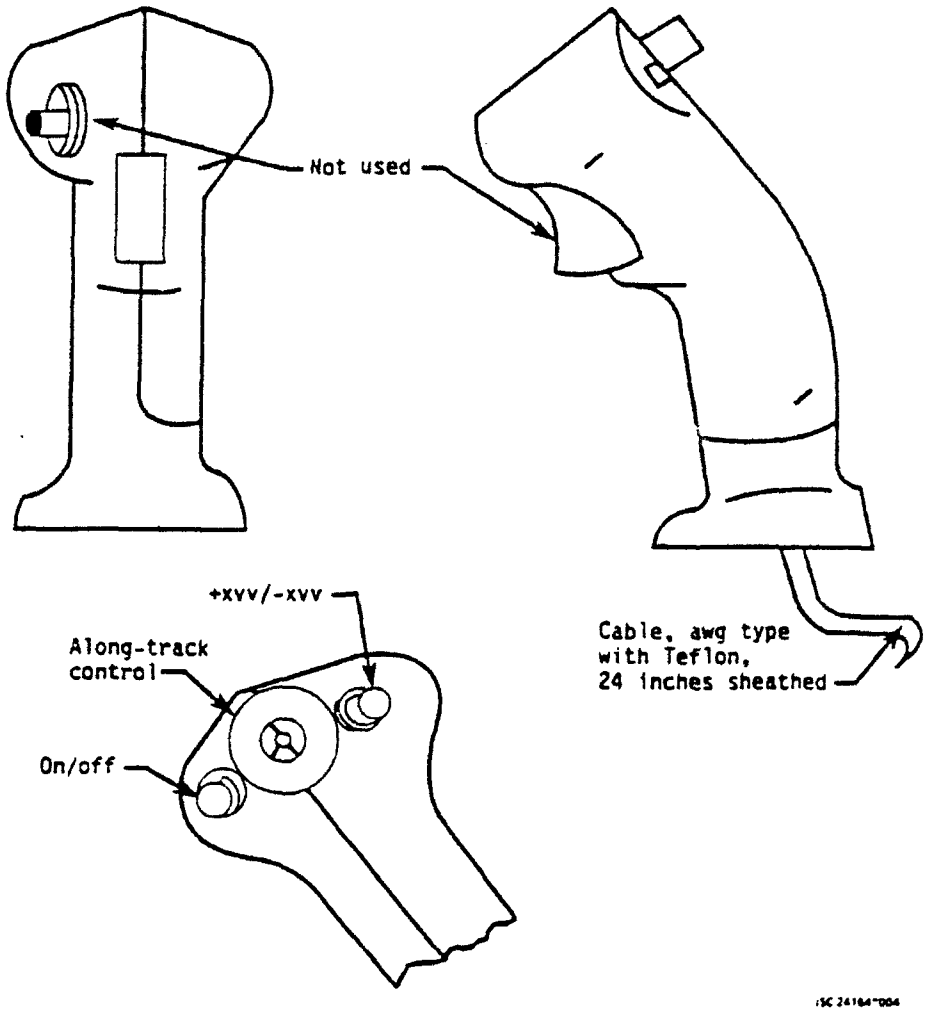


Figure 1-7.- Tracking mirror hand controller.

1.4 ORBITER/SPADVOS INTERFACES

The SpaDVOS-to-orbiter interfaces consist of a 28 V dc power interface, a VTR interface, and a mechanical mounting to the AFD overhead windows. The dc power and video interfaces are on panel O19. The video signal interfaces with the TV jack, and the power is provided by 28 volts MN A. The mechanical mounting consists of the inward sunshade clamps on windows W7 and W8. In section 2, see figure 2-1.

SECTION 2
OVERVIEW

2.1 PHYSICAL OVERVIEW

Figure 2-1 shows the assembled SpaDVOS system when it is mounted to the AFD overhead windows. The inset illustrates the system in detail.

2.2 ELECTRICAL OVERVIEW

SpaDVOS uses 28 V dc from the orbiter AFD panel O19. The system uses 18.2 W nominally and 18.2 W peak. Figure 2-2 details the electrical interface with SpaDVOS and the orbiter.

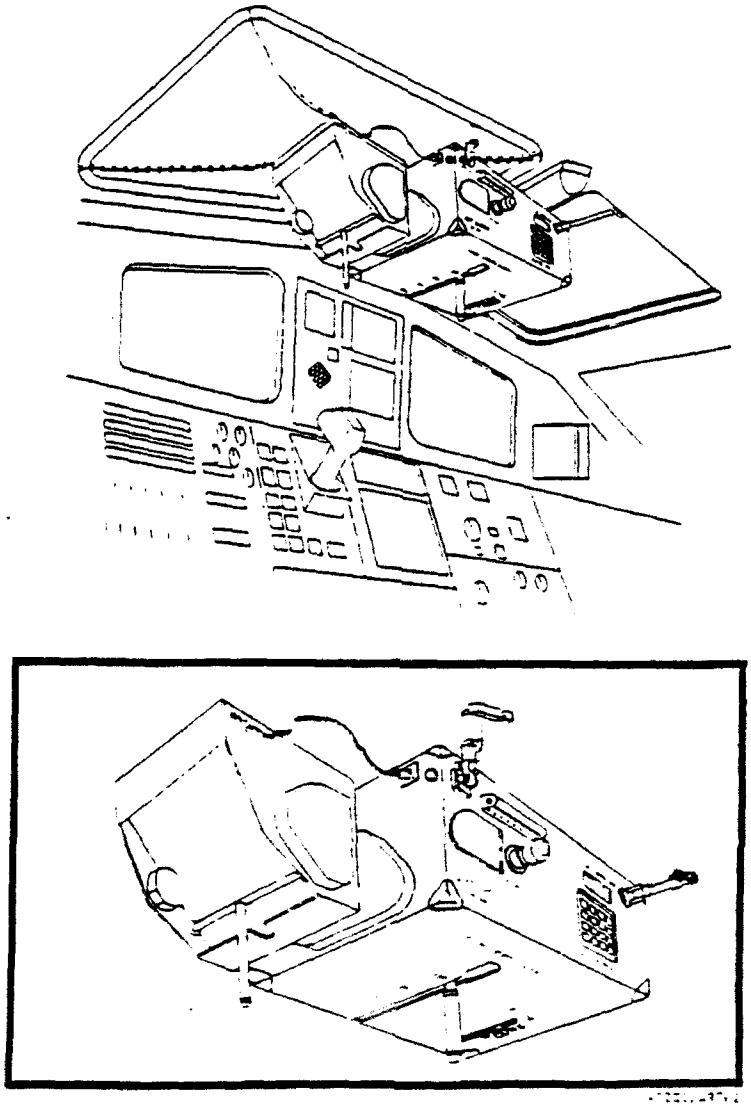


Figure 2-1.- SpaDVOS system mounted to AFD overhead windows.

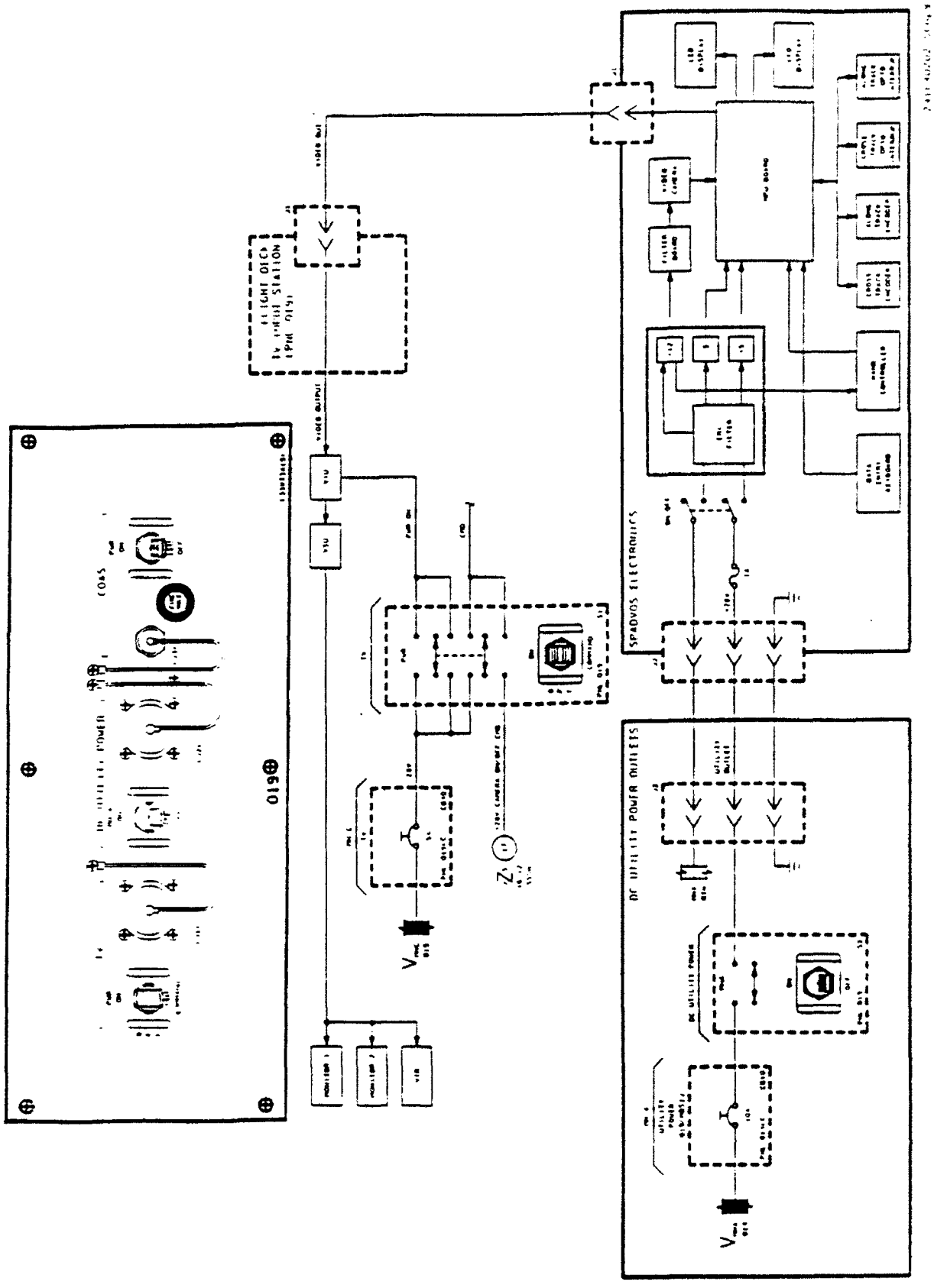


Figure 2-2.- Electrical interface with SpaDVOS and orbiter.

SECTION 3
DISPLAYS AND CONTROLS

3.1 FUNCTION DESCRIPTION

A crewmember will acquire and track both preselected and opportunity target areas while making a video/audio recording. The preselected target areas will be uplinked for programming into SpaDVOS. When the orbiter passes these preselected targets, SpaDVOS will use internal displays to direct the crewmember where to point the mirror. Table 3-1 lists the functional description of the crew interfaces to SpaDVOS.

TABLE 3-1.- FUNCTIONAL DESCRIPTION

Item	Type device	Function
J0 Mirror encoder	Connector port	Output connector port for mirror encoder cable. Feedback of mirror angle system cue
J1 Video out	Connector port	Output connector port for interfacing with the closed-circuit television (CCTV) interconnect cable supplying video signal to orbiter video switching unit (VSU) for video recording
J2 28 V dc	Connector port	Input connector port for interfacing with dc power cable supplying 28 V dc power
J3 Hand controller	Connector port	Input connector port for hand controller. Feedback information includes tracking motor direction, speed, and ON/OFF control
Fuse 1-amp SLO-BLO SPARE	1-amp fuse	Protects system from excessive voltage
S1 POWER ON-OFF	Two-position toggle switch (maintain-maintain)	ON - Supplies 28 V dc power to the SpaDVOS system OFF - Removes power from the SpaDVOS system
Data entry keyboard	12-key pushbutton keyboard	Used to input MET, target MET, and target crosstrack angles
Liquid crystal display	6-digit liquid crystal display	Displays information input through keyboard
Focal length	Push-pull handle	Used to adjust focal length of optical system. Capable range of 125-600mm
f-stop	Push-pull handle	Used to adjust f-stop of optical system. Capable range of f5.6-f32
Hand controller power-ON/OFF	Two-position switch	Supplies power to a dc motor to drive the tracking mirror in the along-track direction
Hand controller attitude switch	Two-position switch	Selects proper attitude for mirror assembly tracking. Selects between +XVV and -XVV
Hand controller motion switch	Momentary switch	Drives the mirror assembly from target AOS through LOS at crewmembers' discretion

3.2 SPADVOS KEYPAD

The crewmember will input the preselected targets into SpaDVOS via a keypad (see fig. 3-1). The crewmember will input the time of closest approach (TCA) in hour, minute, and second and then the crosstrack angle to the nearest 10th degree. There are also specialty keys on the keypad to perform the following functions:

1. +/- key: Toggles between allowable attitudes, either nose first (-ZLV +XVV) or tail first (-ZLV -XVV). Also used to enter ± degrees of cross-track angle.

2. ENTER key: Used to enter the MET, altitude, TCA, velocity, and cross-track angles into the microcontroller.

3. SETUP key: Toggles between the RUN and PROGRAM modes of operation.

4. LED key: Used to adjust brightness of the internal displays. The internal displays can be adjusted to three levels of brightness.

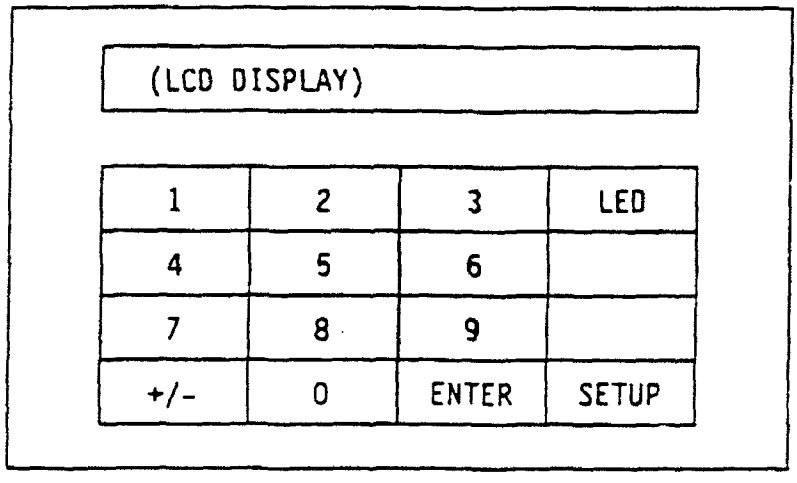


Figure 3-1.- Keypad and external LCD display.

SECTION 4
SPADVOS OPERATIONS

4.1 ON-ORBIT OPERATIONS

SpaDVOS has three modes of operation: programming, run, and cue.

4.1.1 Programming Mode

This mode is entered during activation. The program mode is active when entering the following parameters:

a. Orbiter attitude

b. Setting the SpaDVOS clock to current MET

c. TCA

d, Target crosstrack angle

e. Orbiter altitude

f. Orbiter velocity

Note: If an error is made when inputting parameters b through f, the reprogramming procedure must be run to correct the improper value. If an error is made upon inputting parameter a, power cycle SpaDVOS and begin again.

4.1.2 Run Mode

Once the above parameters have been input, the crewmember should press the SETUP key. This action will transition SpaDVOS to the run mode. In this mode the external display will show a number (1-4) corresponding to the upcoming target site that was programmed into SpaDVOS during the program mode. Also appearing will be a time (HR:MN:SEC) which will be counting down to that site's TCA.

In the run mode, the internal display will show the along-track pointing error (top LED) and the crosstrack pointing error (bottom LED) in degrees. See figure 4-1.

Note: While in the run mode, pressing the SETUP key will toggle SpaDVOS between the program and run modes of operation. This toggling is required to change any parameters that were incorrectly entered during the programming mode.

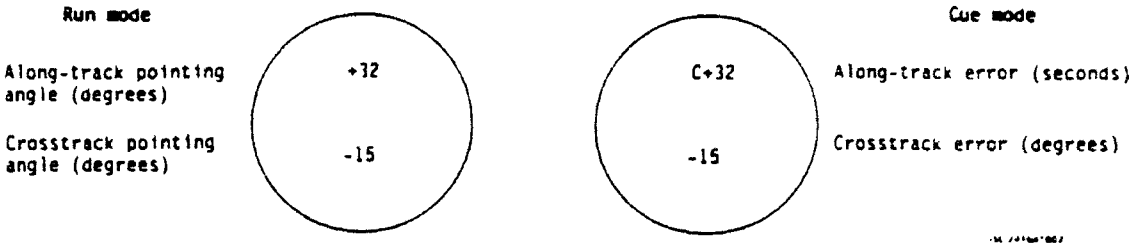


Figure 4-1.- Example SpaDVOS internal display.

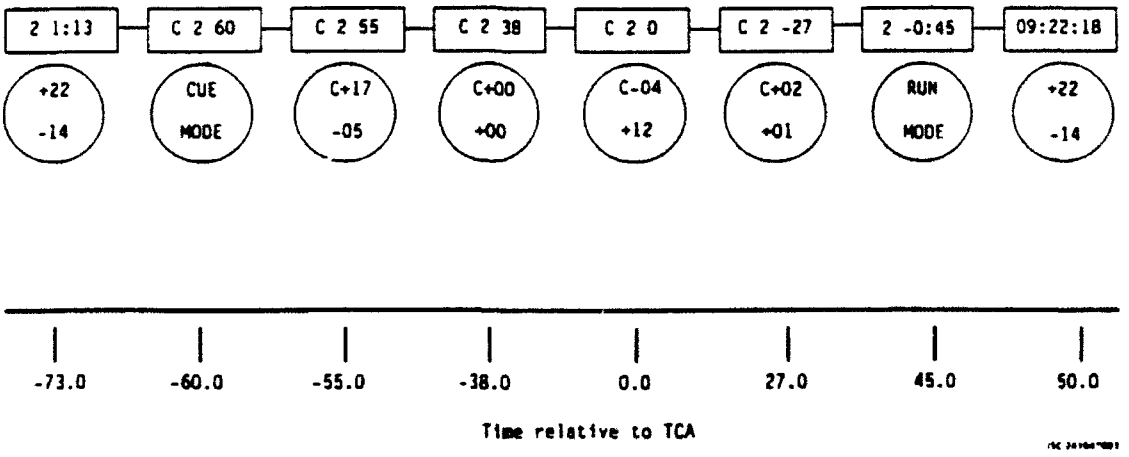


Figure 4-2.- Cueing system operation.

4.1.3 Cue Mode

Sixty seconds before the TCA of the upcoming ground site, the system will automatically display CUE MODE on the internal LED's for 5 seconds, indicating that the cue mode has been entered. The top LED will then display the along-track pointing error in seconds. This error is the difference between the TCA of the upcoming ground site and the TCA for the area that is in the instantaneous field-of-view (FOV). The bottom LED will display the crosstrack pointing error, which is the difference between the present crosstrack pointing angle and the crosstrack pointing angle required to place the desired ground site within the FOV (fig. 4-1). By manipulating the mirror control handle such that both LED's display "0," the user will, in theory, be placing the desired ground site in the center of his FOV. Upon entering the cueing mode, the external LCD will display a "C" followed by the number of the ground site and the time until its TCA. Forty-five seconds after TCA, both the LED's and LCD will return to the run mode.

Figure 4-2 shows the cueing mode operation for a second programmed site as related to the TCA.

Note: If additional targets are programmed into SpaDVOS, the LCD will display the next site number (2-4) and TCA. If the last programmed target was just viewed, the LCD will display the MET.

4.2 RESOLUTION CHART

Normally, two continental United States (CONUS) ground sites will be set up to include a resolution chart to help in quantifying image clarity and resolution. This chart will have two columns and five rows which will contain varying sizes of circles in each cell. Using the orbiter VTR, the crewmember will then annotate any difficulties that are observed while trying to locate each circle. See figure 4-3 for an example of the resolution chart.

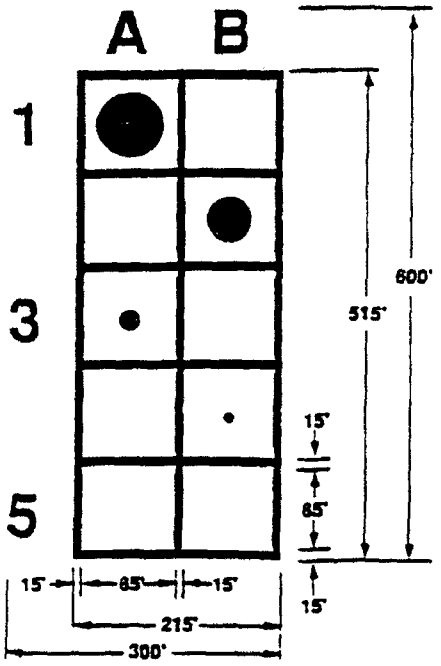


Figure 4-1.- SpaDVOS resolution chart.

4.3 SAFETY

SpaDVOS must be temporarily stowed after viewing the designated targets. The targets will be scheduled for successive orbits so that, once these targets have been viewed, SpaDVOS may be temporarily stowed for an extended period of time before the next viewing opportunity.

In case of emergency deorbit, the SpaDVOS can be stowed in less than 20 minutes.

4.4 ATTITUDE CONSTRAINT

For SpaDVOS to properly compute and display crosstrack and longitude angles on the internal display, operations are limited to orbiter attitudes of ±XVV-ZLV. A deadband of 1° is also required to support SpaDVOS operations.

4.5 POSTFLIGHT ANALYSIS

To accurately correlate SpaDVOS data with geophysical location, the Air Force requires orbiter navigation and position data throughout the SpaDVOS activity. THRIFT format 3317 is required. This format includes state vector and attitude data.

APPENDIX A
ACRONYMS AND ABBREVIATIONS

AFD	aft flight deck
AOS	acquisition of signal
CCD	charge coupled device
CCTV	closed-circuit television
CONUS	continental United States
FOV	field of view
LCD	liquid crystal display
LED	light emitting diode
LOS	loss of signal
MET	mission elapsed time
MPU	microprocessor unit
SpaDVOS	spaceborne direct view optical system
SSP	Space Shuttle Program
TCA	time of closest approach
V dc	volts direct current
VSU	video switching unit
VTR	video tape recorder
±XVV	±X axis into velocity vector
-ZLV	-Z axis perpendicular to Earth radial vector

APPENDIX C

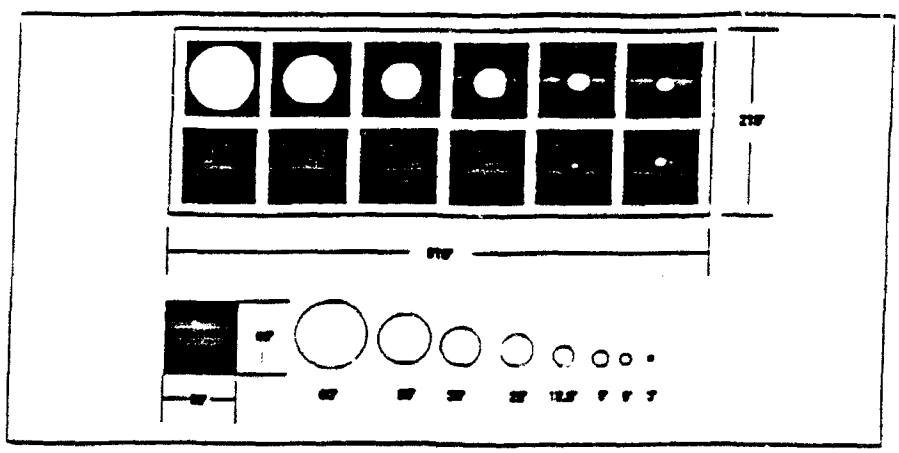
Optical Resolution Panels

The following information is a summary of from the *After Action Report For The Terra Scout Experiment on the STS-44 Shuttle Mission*, dated December 31, 1991, prepared by Georgia Tech Research Institute. Analysis described in the complete report attempts to consider realistically the sizes of targets that can be observed from space using the SpaDVOS. The analysis looked at the problem from the points of view of the minimum target size and minimum target contrast that an observer can be expected to be able to detect using SpaDVOS under suitable atmospheric conditions.

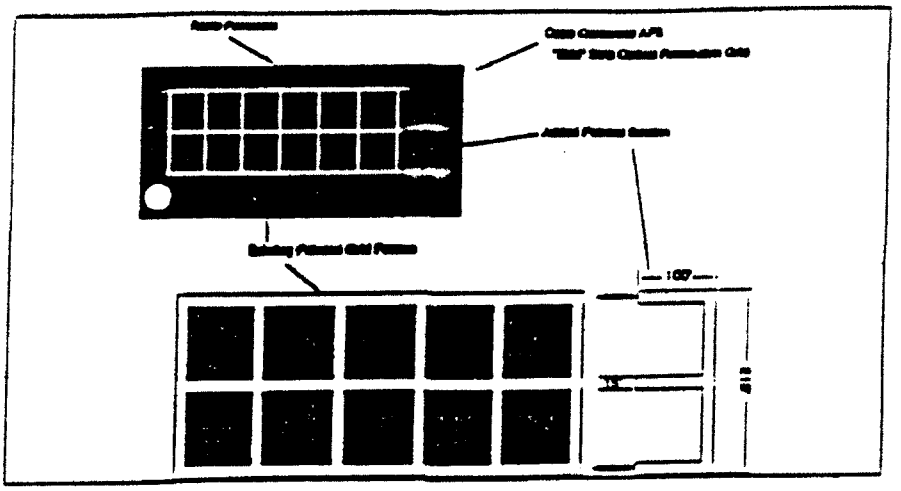
1. Ground Resolution Sites.

a. Physical Description:

Figure C-1 depicts a typical configuration for either the Optical Resolution Panels used in Australia and Hawaii or the Optical Resolution Grid Circles deployed at Cape Canaveral AFS, FL. The relative positions of each white circle on the Optical Resolution Panel could be changed as required to fit the test plan deployment pattern sets developed for the experiment. The Optical Resolution Panels are transportable and are fully contained so that sufficient ground space to deploy them is all that is required. In the case of the Optical Resolution Circles, a painted surface "grid", such as that shown in Figure C-2 is required. At Cape Canaveral AFS, a painted grid, which was used for other earlier experiments, was expanded for Terra Scout and used as the background for the Optical Resolution Circles.

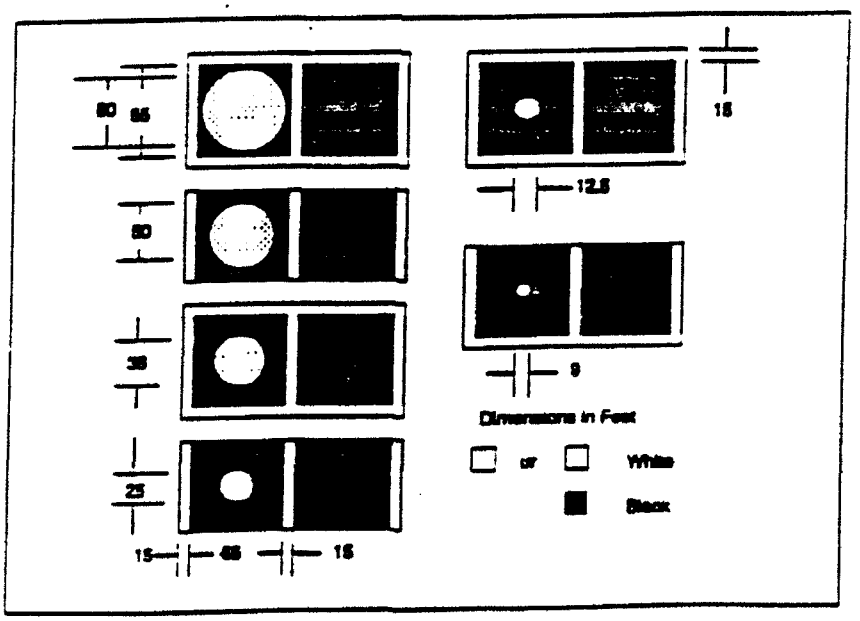


C - 1 Optical Resolution Panel Configuration



C-2 Optical Resolution Panel Circles at Cape Canaveral AFS, FL.

Each Optical Resolution Panel consists of an array of white circles fastened to black squares, surrounded by a white border. Figure C-3 shows the configuration of an Optical Resolution Sub-Panel. It is designed so that with the exception of the bottom panel, the individual panels can be turned by 180 degrees to place the circle on either the right or left side of the panel. The bottom panel has a detachable circle that can be moved from one side to another and attached by velcro. The panels are fastened together by velcro, with alternate mating snap-connectors. Velcro is affixed along the long sides of every panel to allow for 180 degree rotation. With the exception of the bottom panel, the circles are permanently sewn to the contrasting square background, and the borders are sewn to the panels in the same manner. To save weight, the larger circles were not sewn over the squares. but sewn into the squares so that two thicknesses of material would not be required. The smaller circles (nine-, six, and three-foot) are removable and can be placed on any vacant black square within the Optical Resolution Panel. More information on specifications, materials, construction, packaging and shipping is available in the After Action Report referenced above.



C-3 Sub-Panel Configuration.

b. Predetermined Optical Resolution Panel configurations were deployed at each of the respective ground sites. These configurations were chosen so that the Shuttle Observer would not be presented with repetitive patterns during successive orbits. The patterns at each site were generally changed for different orbits, except when successive orbits over a site provided optimum conditions for viewing and there would not be enough time to rearrange the patterns.

2. Ground Measurements.

Measured contrast data was obtained from each deployment sight for each specified orbital viewing time. The measurements were made with photometers at the approximate same angles (determined by x-track and Max El. angle data provided by NASA) from which the Shuttle Observer would view the Optical Resolution Panels at the maximum elevation angle over the site. A minimum of three measurements were to be made at each site at the time when the Shuttle was to pass overhead, This was deemed sufficient to quantify overall Optical Resolution Panel contrast since the construction of the panels is homogeneous throughout (same materials, etc.) and the deployment sites were relatively flat.

Multiple measurements were accomplished at all locations except Amberly, Australia and the reason for only taking one set of measurements there is unknown. However, the measurements taken at Amberly are believed to be representative of overall panel contrast at each particular viewing time. Since conditions at Cape Canaveral AFS, FL were different from those of the other deployment sites (fabric on a painted strip), multiple measurements were made of several circles and areas of pavement during the viewing times.

The resulting contrast measurements were generally consistent within one or two percent, and indicate a reasonably good contrast ratio at the times of viewing. It can also be seen from some of the measurements that the absolute level of measured luminance decreased during the measurement times. This was attributed to the time of day when the sun angle was extremely low and the sun was rapidly disappearing behind the horizon.

Figures C-4, C-5 Paint Contrast Tests

C-4 TERRA SCOUT Paint Contrast Tests

Weather-Worn Painted Surface — 20 June 91 2:30 p.m. EDT

	Concrete Surface			Asphalt Surface		
	White	Black	Contrast	White	Black	Contrast
G*	(1) 80.8	3.4	91.9%	(1) 79.0	3.8	90.9%
B*	(2) 69.0	4.8	86.9%	(2) 65.8	4.2	88.0%
W*	(3) 36.3	5.6	73.0%	(3) 51.9	6.6	77.0%

*G = Good
*B = Bad
*W = Worst

C-5 *TERRA SCOUT Paint Contrast Tests (2nd Coat)*

2nd Coat Full-Coverage Painted Surface — 21 June 91 10:50 a.m. EDT

	Concrete Surface			Asphalt Surface		
	White	Black	Contrast	White	Black	Contrast
C*	48.0	1.8	92.7%	54.0	2.1	92.5%
S*	56.4	2.3	92.2%	51.2	2.1	92.0%

*C = Cloudy
*S = Partial Sun

Reduction in contrast due to an optical instrument such as a telescope or a pair of binoculars is caused by a decrease in the modulation transfer function (MTF) of the instrument with increasing spatial frequency. This statement simply means that as objects are placed closer and closer together, it becomes more and more difficult to tell where one object ends and another begins. The actual physical parameter that is reduced is the modulation contrast function (MCF) which is simply related to the MTF and may be considered to be almost the same for most applications.

3. Expected Camera Resolution Limits.

The Sony DXC-101 camera has 510x492 resolution elements, and each pixel is 13 microns vertical x 17 microns horizontal. This arrangement gives an imaging area of 8.67mm x 6.40mm. In the image plane of SpaDVOS corresponding to the TV camera cathode, one cycle therefore occupies 4.69×10^{-2} mm, so that there are 21.3 cycles/mm. The area occupied by each of the various circles of the Optical Resolution Panels varies on the TV camera cathode. If this area is less than one pixel, it will not be possible to resolve that particular circle using the TV camera. The cut-off occurs for a circle 36 feet in diameter, so that only 80, 50, and 36 foot circles would be resolved with the camera. As a practical matter, it is unlikely that the 36 foot circle would be resolved, because it would appear to be modulated by the relative motion of the spacecraft and the resolution panel on the ground. A careful observer might be able to discern that a circle is present, but might not be able to tell on which side of the overall panel it lies because of this modulation. The telephoto lens of the camera imposes additional limitation on the ability of the TV camera to resolve the individual sub-panels. Considering this limitation and that imposed by the resolution of the TV cathode, together with contributions by the MTFs of the intervening optical elements and atmospheric degradation, it must be concluded that only the 80 and 50 foot circles would be resolved by the TV camera, and that resolution of the latter circle will be marginal.

4. Expected Observer Resolution Limits.

The parameter which determines whether or not an object can be detected from a given range is the contrast of the object. Contrast C is defined as the brightness of the stimulus B_S minus the brightness of its background divided by this background brightness (B_O [1], $C=B_S-B_O / B_O$). In designing an experiment such as that proposed for the SpaDVOS, one would begin with evaluation targets which have 100% contrast, if possible. Practically, such targets are not available, so that reasonable contrasts are in the range 80-95%. To determine whether or not an object can be detected, the effects of other parameters on the contrast must be considered. The atmosphere has a given contrast transmission because of scattering by aerosols and molecular attenuation. Atmospheric turbulence also affects contrast. Perhaps the most important factor affecting contrast of a target as viewed by an observer is the modulation transfer function of the optical system. Considering all of these contributions to image degradation, the modulation transfer function (MTF) of the SpaDVOS is the MTF due to atmospheric turbulence, and the contrast degradation due to atmospheric attenuation. The overall degradation for the Terra Scout experiment is a combination of these factors plus other optical components in the system, the space shuttle window, and other immeasurable factors such as reflections and back-lighting of the observer's station. Additional technical analysis of the SpaDVOS can be obtained from the referenced After Action Report or by contacting AAMRL.

5. In conclusion, analysis was attempted to consider realistically the sizes of targets that can be observed from space using the SpaDVOS. The analysis looked at the problem from the points of view of the minimum target size and minimum target contrast that an observer can be expected to be able to detect using the SpaDVOS under suitable atmospheric conditions, Based on these calculations, it is concluded that the smallest of the deployed targets that can be seen by an observer using SpaDVOS from an altitude of 200 nautical miles is 36 feet in diameter. The smallest of these targets that can be discerned using the TV camera is 50 feet in diameter because of the limitation of the TV cathode pixel spacing. The 36 foot circle might actually be detectable with the TV camera, but it would not be possible to tell on which side of the resolution panel the circle lies because its intensity would be modulated by the relative motion of the spacecraft and target.

It also becomes obvious that the resolution limitation of this experiment is the Vivitar lens used on the SpaDVOS. A lens designed for photographic applications cannot be expected to have outstanding resolution because the camera performance is limited by granularity of the film. The balance of this instrument seems to be carefully and thoughtfully designed, and would probably be capable of excellent performance if the Vivitar were replaced with a custom designed lens with the same specifications. Such lenses can be obtained which approach diffraction-limited performance. It is possible to obtain such a lens, but the cost might be several thousands of dollars. Analysis shows that a 9 foot circle could be detected with SpaDVOS at 60X and a 12.5 foot circle at 40X using the lens under the same conditions of altitude and atmosphere. The performance of the TV camera would be unaffected, however, because the limit on its performance is given by the granularity of the camera cathode and not by the resolution of the optical instrument.

APPENDIX D

The following is the NASA STS-44 Brightness Value Study:

ENVIRONMENT REMOTE SENSING ANALYSIS FACILITY (ERSAF)
STS-44 Brightness Value Study

GOAL:

This study was undertaken to estimate the atmospheric influence to viewing conditions as observed from the Space Shuttle during STS-44. In most experiments that attempt to measure instrument spatial resolution, the atmosphere has been considered to be "clean" in clouds-free regions when viewing targets from the Space Shuttle. Recent study results have demonstrated that by studying the cloud free pixels from the visible channel of geostationary satellites, we can determine the potential variability of light to penetrate the atmosphere and its contribution/degradation to Earth observations in the visible wave length (400 - 740A). From these data, estimates of viewing conditions are presented in this report.

THEORY:

As the contrast of a scene increases, the minimum brightness value (darkest object) will decrease in the visible wavelength. This implies that there is less path radiance occurring in the scene and imagery of the scene will have a better overall resolution. Light reflecting off objects on the earth will have a "truer" path with less scattering. In this study a limited sample set (2-3 weeks) of satellite data were used to determined the cloud-free minimum and mean brightness (radiance) for Brisbane, Darwin (Learmouth), Hawaii (Ford Island), and Florida (Cape Canaveral).

METHODOLOGY: "Data with constant viewing angles, constant sun angle, homogeneous background"

The Bureau of Meteorology (BoM), in Australia and the University of Wisconsin gathered geostationary satellite data for three weeks for post-mission analysis at ERSAF. A 64 x 64 array study area was selected from each of the four sites. Study areas were selected based on homogeneous cover (ocean sea surface) and based on minimal sun glint contribution to the total reflected visible energy that the satellite imaged. Brightness thresholds were selected for each of the sites to filter out the clouds in the arrays (cirrus/cumulus). The cloud detection filter was a single pass on the visible data (no IR used) so it is possible for thin cirrus to be included in the cloud-free pixels evaluated. Samples that were excessively cloudy were excluded from the statistics (if > 90% of pixels in the sample had brightness values above the threshold). The solar angle is assumed to be constant as the samples were taken with two weeks of each other during the winter solstice and at the same time of day for each site as close to the over-flight time as possible.

CLASSIFICATION OF Overflight OBSERVATIONS:

The viewing condition classification for each pass is based on which standard deviation category the mean brightness value for that day had compared with the mean of the entire sample. The standard deviation (s) categories were:

Daily Mean	Viewing Conditions
>+1s	poor
0 -> +1s	marginal
-1s -> 0	good
<-1s	very good

were "s" is the standard deviation.

For example, the mean brightness value (BV) for a observation period was 45.0 and the standard deviation was +/- 2.0 BV and the recorded mean BV for the overflight was 42.0, then the viewing conditions would be "very good"

RESULTS:

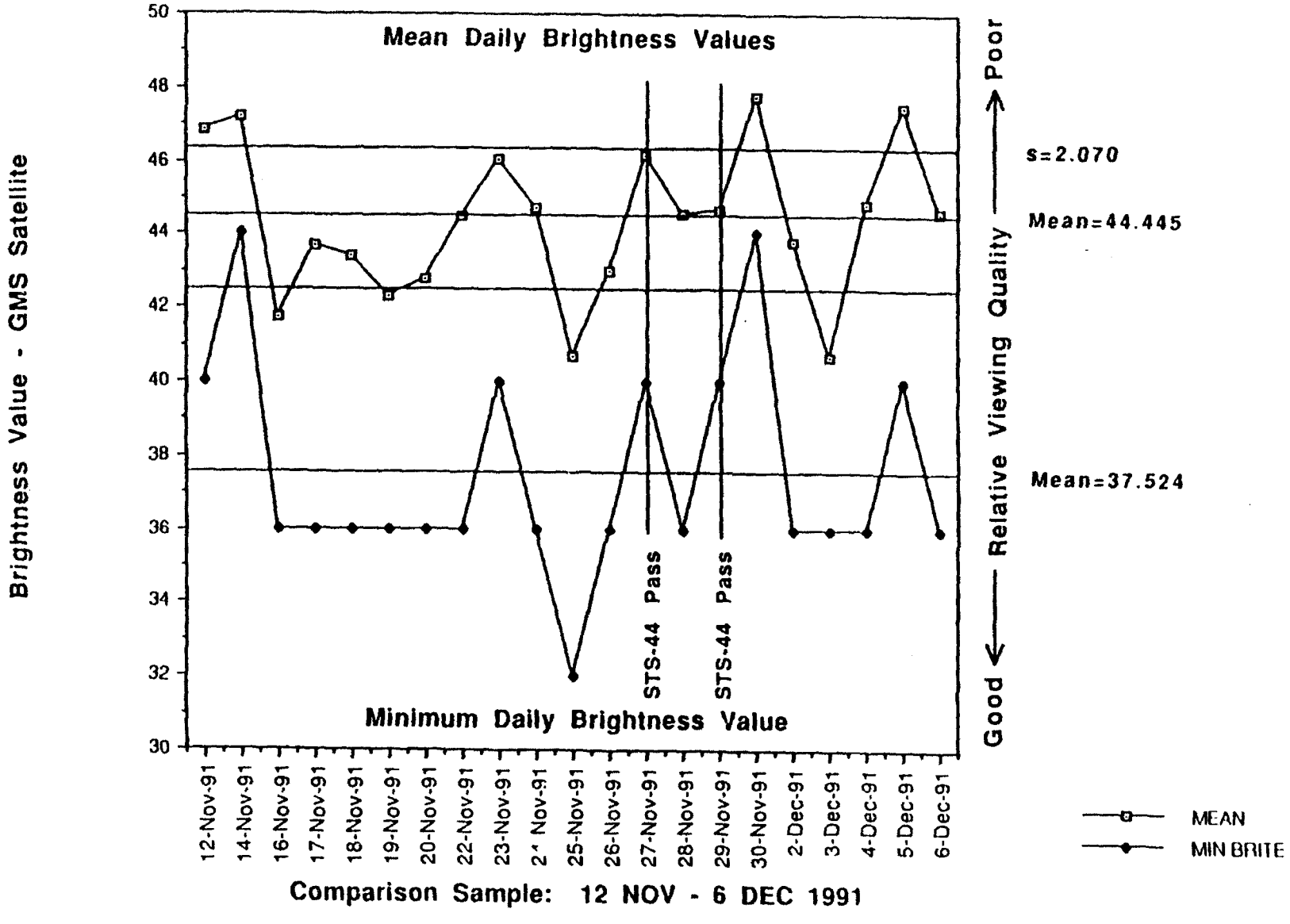
1. **BRISBANE:**
   - o Threshold Brightness Value: 48.00
   - o Mean Brightness Value **44.45**
   - o Standard Deviation of Daily Mean Brightness Values 2.07
   - o Mean Minimum Brightness Value **37.52**

   STS-44 Mission Comparisons:

   * **27 NOV 91 Overflight Sample (AREA1146 - 27 NOV 1991/21:31GMT)**
     - MEAN Brightness Value **46.15**
     - MIN Brightness Value **40.00**
     - STANDARD DEVIATION CLASSIFICATION **Marginal Viewing Conditions**

   * **29 NOV 91 Overflight: Sample (AREA1149 - 29 NOV 1991/21:31GMT)**
     - MEAN Brightness Value **44.65**
     - MIN Brightness Value **40.00**
     - STANDARD DEVIATION CLASSIFICATION **Marginal Viewing Conditions**

STS-44 Viewing Conditions - Brisbane Brightness Value Curves



Comparison Sample: 12 NOV - 6 DEC 1991

Brisbane Statistics Matrix

Site	Date	Area	Max	Min	Nsamp	Std Dev	Mean	Prcnt
Brisbane	12-Nov-91	area1130	48	40	1191	1.957	46.828	29.077
Brisbane	14-Nov-91	area1132	48	44	315	1.603	47.2	7.69
Brisbane	16-Nov-91	area1134	48	36	2808	2.905	41.722	68.555
Brisbane	17-Nov-91	area1135	48	36	1406	2.83	43.687	34.326
Brisbane	18-Nov-91	area1136	48	36	2762	3.13	43.415	67.432
Brisbane	19-Nov-91	area1137	48	36	3110	3.53	42.286	75.928
Brisbane	20-Nov-91	area1138	48	36	2507	3.153	42.763	61.206
Brisbane	22-Nov-91	area1140	48	36	1261	3.085	44.498	30.786
Brisbane	23-Nov-91	area1141	48	40	674	2.479	46.006	16.455
Brisbane	24-Nov-91	area1142	48	36	912	2.937	44.697	22.266
Brisbane	25-Nov-91	area1143	48	32	3282	3.049	40.717	80.127
Brisbane	26-Nov-91	area1144	48	36	2396	3.014	43.003	58.496
Brisbane	27-Nov-91	area1146	48	40	1817	2.232	46.151	44.36
Brisbane	28-Nov-91	area1147	48	36	2112	2.778	44.564	51.563
Brisbane	29-Nov-91	area1149	48	40	2925	2.582	44.647	71.411
Brisbane	30-Nov-91	area1150	48	44	49	0.969	47.755	1.196
Brisbane	2-Dec-91	area1152	48	36	2827	3.02	43.784	69.019
Brisbane	3-Dec-91	area1153	48	36	4058	3.077	40.693	99.072
Brisbane	4-Dec-91	area1154	48	36	3430	2.631	44.801	83.74
Brisbane	5-Dec-91	area1155	48	40	1120	1.399	47.45	27.344
Brisbane	6-Dec-91	area1156	48	36	2138	2.922	44.616	52.197
				788			933.353	
			min mean=	37.524		mean mean	44.445	
						std dev mean	2.070	

2. LEARMOUTH (DARWIN)

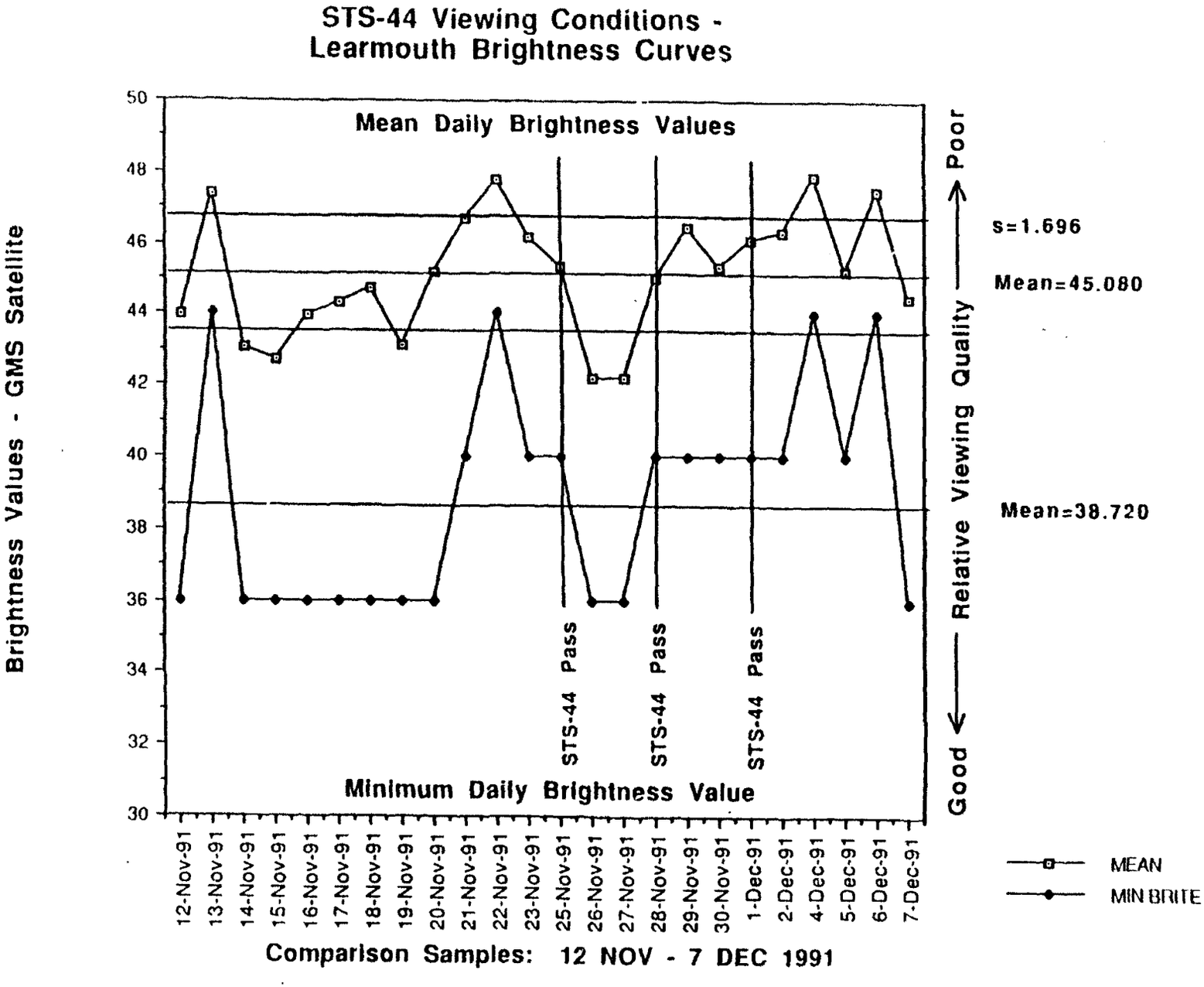
- o Threshold Brightness Value: 48.00
- o Mean Brightness Value **45.08**
- o Standard Deviation of Daily Mean Brightness Values 1.70
- o Mean Minimum Brightness Value **38.72**

STS-44 Mission Comparisons:

* **26 NOV 91 Overflight:**
  Sample (AREA1114 - 25 NOV 1991/23:31GMT
  MEAN Brightness Value **45.36**
  MIN Brightness Value **40.00**
  STANDARD DEVIATION
  CLASSIFICATION **Marginal Viewing Conditions**

* **29 NOV 91 Overflight:**
  Sample (AREA1118 - 28 NOV 1991/23:31GMT)
  MEAN Brightness Value **44.98**
  MIN Brightness Value **40.00**
  STANDARD DEVIATION
  CLASSIFICATION **Marginal Viewing Conditions**

* **1 DEC 91 Overflight:**
  Sample (AREA1123 - 1 DEC 1991/23:31GMT)
  MEAN Brightness Value **46.11**
  MIN Brightness Value **40.00**
  STANDARD DEVIATION
  CLASSIFICATION **Marginal Viewing Conditions**


STS-44 Viewing Conditions -
Learmouth Brightness Curves
Mean Daily Brightness Values
Minimum Daily Brightness Value
Brightness Values - GMS Satellite
Relative Viewing Quality
Poor
Good
s=1.696
Mean=45.080
Mean=38.720
STS-44 Pass
STS-44 Pass
STS-44 Pass
50
48
46
44
42
40
38
36
34
32
30
12-Nov-91
13-Nov-91
14-Nov-91
15-Nov-91
16-Nov-91
17-Nov-91
18-Nov-91
19-Nov-91
20-Nov-91
21-Nov-91
22-Nov-91
23-Nov-91
25-Nov-91
26-Nov-91
27-Nov-91
28-Nov-91
29-Nov-91
30-Nov-91
1-Dec-91
2-Dec-91
4-Dec-91
5-Dec-91
6-Dec-91
7-Dec-91
Comparison Samples: 12 NOV - 7 DEC 1991
MEAN
MIN BRITE

Learmouth Statistics Matrix

Site	Date	Area	Max	Min	Nsamp	Std.Dv	Mean	Prcnt
Learmouth	12-Nov-91	area1101	48	36	2275	2.865	43.984	55.542
Learmouth	13-Nov-91	area1102	48	44	104	1.486	47.346	2.539
Learmouth	14-Nov-91	area1103	48	36	3875	2.697	43.071	94.604
Learmouth	15-Nov-91	area1104	48	36	4091	2.374	42.697	99.878
Learmouth	16-Nov-91	area1105	48	36	2334	3.15[illegible]	43.966	56.982
Learmouth	17-Nov-91	area1106	48	36	1440	3.000	44.339	35.156
Learmouth	18-Nov-91	area1107	48	36	3043	2.680	44.724	74.292
Learmouth	19-Nov-91	area1108	48	36	3991	2.466	43.110	97.437
Learmouth	20-Nov-91	area1109	48	36	3562	2.712	45.154	86.963
Learmouth	21-Nov-91	area1110	48	40	673	2.07[illegible]	46.686	16.431
Learmouth	22-Nov-91	area1111	48	44	851	0.984	47.741	20.776
Learmouth	23-Nov-91	area1112	48	40	2010	2.326	46.163	49.072
Learmouth	25-Nov-91	area1114	48	40	2820	2.539	45.356	68.848
Learmouth	26-Nov-91	area1116	48	36	4096	2.104	42.206	100.000
Learmouth	27-Nov-91	area1117	48	36	4096	2.106	42.185	100.000
Learmouth	28-Nov-91	area1118	48	40	2527	2.580	44.978	61.694
Learmouth	29-Nov-91	area1120	48	40	2801	2.154	46.445	68.384
Learmouth	30-Nov-91	area1121	48	40	3289	2.417	45.330	80.298
Learmouth	1-Dec-91	area1123	48	40	2977	2.227	46.105	72.681
Learmouth	2-Dec-91	area1124	48	40	1565	2.118	46.334	38.208
Learmouth	4-Dec-91	area1126	48	44	364	0.686	47.879	8.887
Learmouth	5-Dec-91	area1127	48	40	1962	2.611	45.240	47.900
Learmouth	6-Dec-91	area1128	48	44	1078	1.365	47.462	26.318
Learmouth	7-Dec-91	area1129	48	36	362	3.524	44.508	8.838
				968			1126.993	
			min mean=	38.720		mean mean=	45.080	
						std dev means	1.696	

3. **HAWAII (FORD ISLAND):**

- o Threshold Brightness Value: 55.00
- o Mean Brightness Value **51.53**
- o Standard Deviation of Daily Mean Brightness Values 1.34
- o Mean Minimum Brightness Value **43.76**

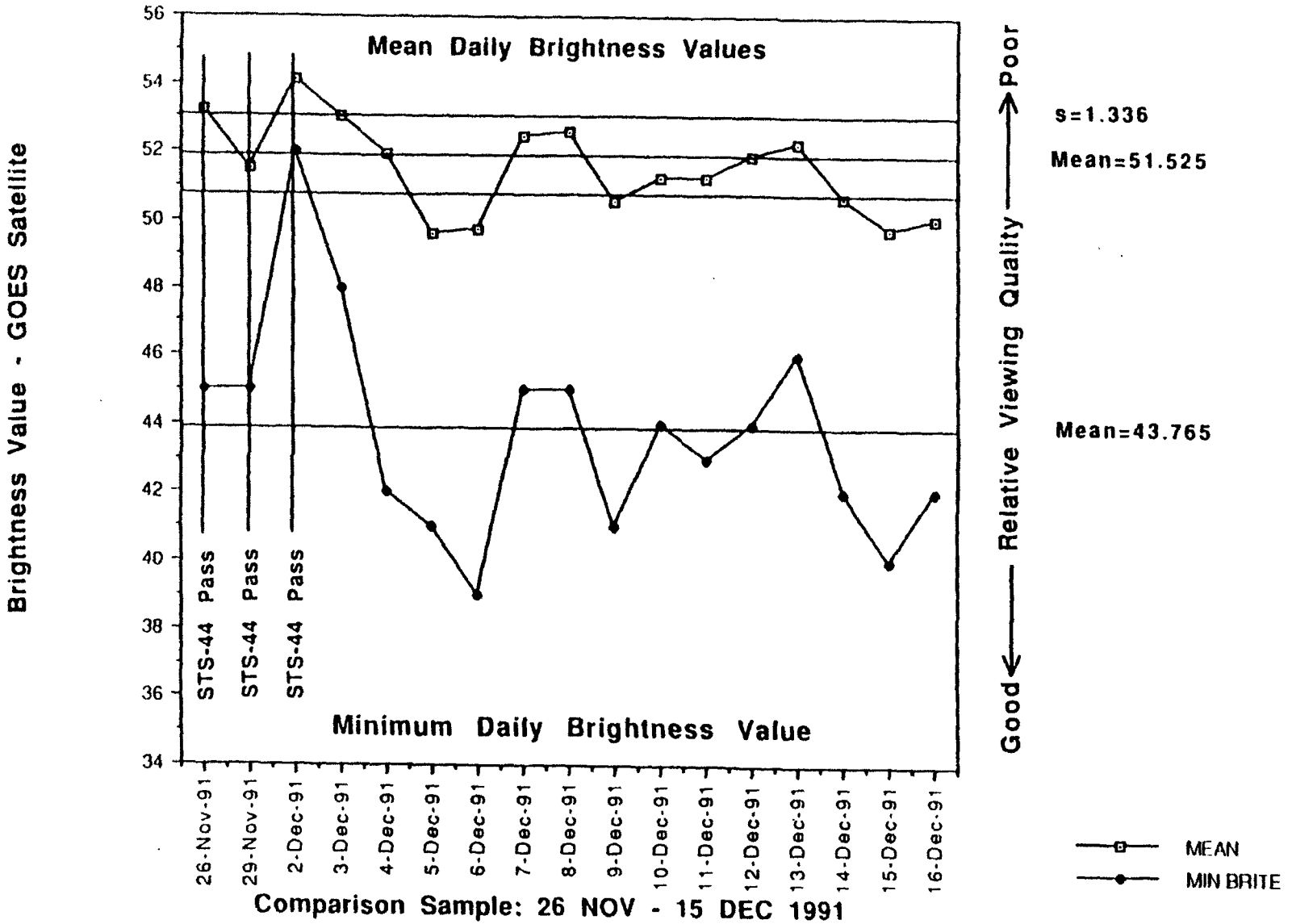
STS-44 Mission Comparisons:

- **26 NOV 91 Overflight:**
  Sample (AREA5071 - 26 NOV 1991/00:01GMT)
  MEAN Brightness Value **53.23**
  MIN Brightness Value **45.00**
  STANDARD DEVIATION
  CLASSIFICATION **Marginal-Poor Viewing Conditions**

- **29 NOV 91 Overflight:**
  Sample (AREA5072 - 29 NOV 1991/00:31GMT)
  MEAN Brightness Value **51.63**
  MIN Brightness Value **45.00**
  STANDARD DEVIATION
  CLASSIFICATION **Good-Marginal Viewing Conditions**

- **1 DEC 91 Overflight**
  Sample (AREA5056 - 2 DEC 1991/00:01GMT)
  MEAN Brightness Value **54.10**
  MIN Brightness Value **52.00**
  STANDARD DEVIATION
  CLASSIFICATION **Poor Viewing Conditions**

STS-44 Veiwing Condition -
Ford Island Brightness Value Curves



Ford Island Statistics Matrix

Site	Date	Area	Max	Min	NSamp	Std Dev	Mean	Prcnt
Ford Island	26-Nov-91	area5071	55	45	164	1.901	53.232	4.004
Ford Island	29-Nov-91	area5072	55	45	1358	1.940	51.531	33.150
Ford Island	2-Dec-91	area5056	55	52	53	0.925	54.094	1.294
Ford Island	3-Dec-91	area5057	55	48	234	1.708	53.034	5.713
Ford Island	4-Dec-91	area5058	55	42	841	2.595	51.951	20.532
Ford Island	5-Dec-91	area5059	55	41	544	3.223	49.638	13.281
Ford Island	6-Dec-91	area5060	55	39	870	3.880	49.724	21.240
Ford Island	7-Dec-91	area5061	55	45	729	2.126	52.440	17.798
Ford Island	8-Dec-91	area5062	55	45	522	2.024	52.592	12.744
Ford Island	9-Dec-91	area5063	55	41	666	3.268	50.560	16.260
Ford Island	10-Dec-91	area5064	55	44	102	2.466	51.235	2.490
Ford Island	11-Dec-91	area5065	55	43	535	2.698	51.284	13.062
Ford Island	12-Dec-91	area5066	55	44	332	2.592	51.883	8.105
Ford Island	13-Dec-91	area5067	55	46	468	2.222	52.256	11.426
Ford Island	14-Dec-91	area5068	55	42	1052	2.810	50.660	25.684
Ford Island	15-Dec-91	area5069	55	40	425	3.552	49.739	10.376
Ford Island	16-Dec-91	area5070	55	42	673	3.213	50.067	16.431
				744			876	
			min mean	43.765		mean mean	51.525	
						std dev mean	1.336	

4. **FLORIDA (CAPE CANAVERAL AFS):**

- o Threshold Brightness Value: 44.00
- o Mean Brightness Value **40.00**
- o Standard Deviation of Daily Mean Brightness Values 1.20
- o Mean Minimum Brightness Value **34.33**

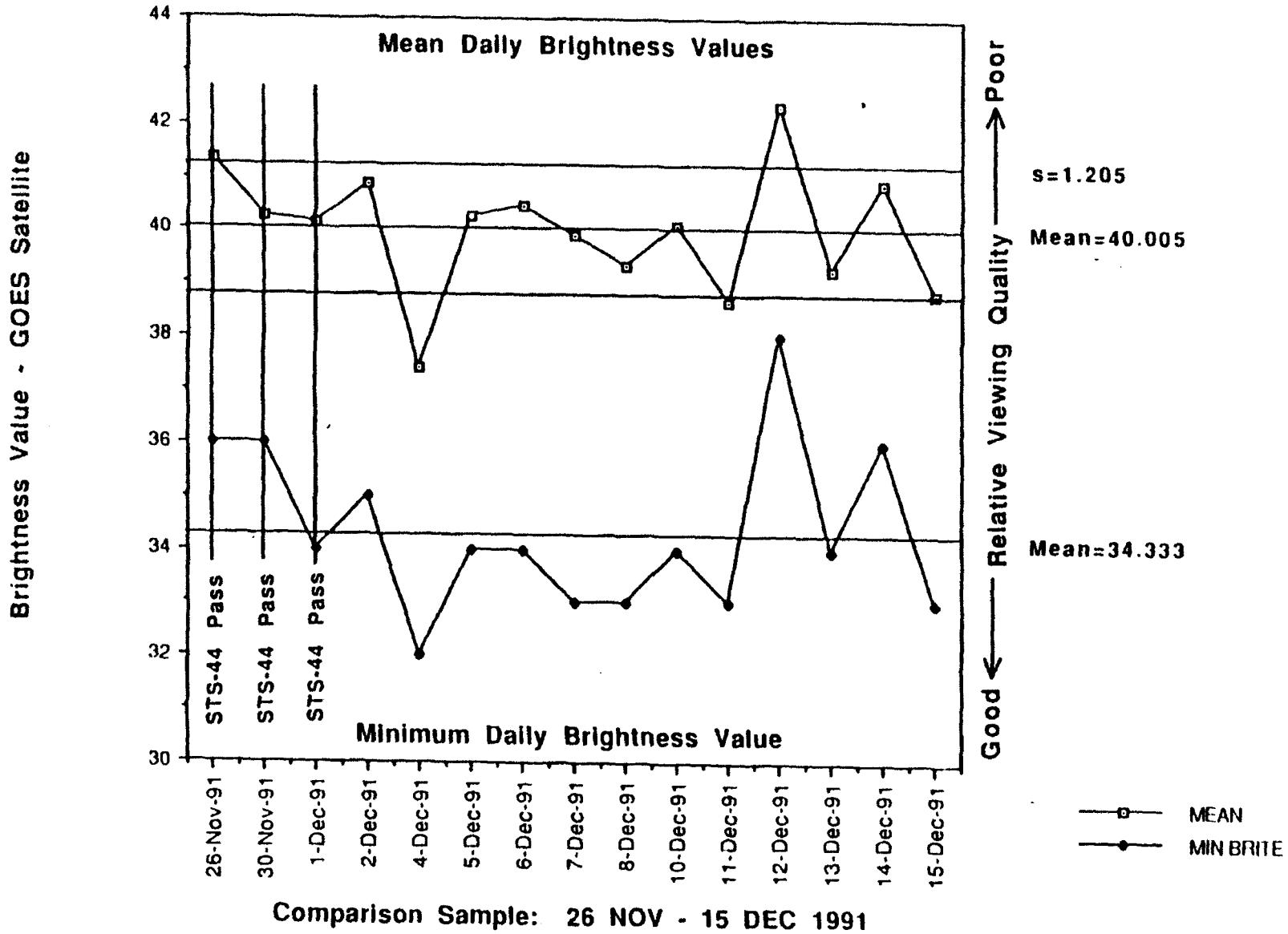
STS-44 Mission Comparisons:

- **26 NOV 91 Overflight:**
  Sample (AREA5021 - 26 NOV 1991/21:01GMT)
  MEAN Brightness Value **41.35**
  MIN Brightness Value **36.00**
  STANDARD DEVIATION CLASSIFICATION **Poor Viewing Conditions**

- **30 NOV 91 Overflight:**
  Sample (AREA5022 - 30 NOV 1991/21:01GMT)
  MEAN Brightness Value **40.25**
  MIN Brightness Value **36.00**
  STANDARD DEVIATION CLASSIFICATION **Marginal Viewing Conditions**

- **1 DEC 91 Overflight:**
  Sample (AREA5006 - 1 DEC 1991/21:01GMT)
  MEAN Brightness Value **40.14**
  MIN Brightness Value **34.00**
  STANDARD DEVIATION CLASSIFICATION **Marginal Viewing Conditions**

STS-44 Viewing Conditions - Florida Brightness Value Curves



Comparison Sample: 26 NOV - 15 DEC 1991

Florida Statistics Matrix

Site	Date	Area	Max	Min	Nsamp	Std.Dv	Mean	Prcnt
Florida	26-Nov-91	area5021	44	36	574	1.974	41.345	14.014
Florida	30-Nov-91	area5022	44	36	1605	1.989	40.250	39.185
Florida	1-Dec-91	area5006	44	34	2525	1.961	40.141	61.646
Florida	2-Dec-91	area5007	44	35	1097	2.001	40.861	26.782
Florida	4-Dec-91	area5009	44	32	3530	2.207	37.414	86.182
Florida	5-Dec-91	area5010	44	34	1124	1.966	40.255	27.441
Florida	6-Dec-91	area5011	44	34	1213	2.251	40.457	29.614
Florida	7-Dec-91	area5012	44	33	813	2.396	39.913	19.849
Florida	8-Dec-91	area5013	44	33	846	2.183	39.330	20.654
Florida	10-Dec-91	area5015	44	34	1514	2.336	40.114	36.963
Florida	11-Dec-91	area5016	44	33	1220	2.502	38.656	29.785
Florida	12-Dec-91	area5017	44	38	605	1.455	42.370	14.771
Florida	13-Dec-91	area5018	44	34	3370	2.031	39.240	82.275
Florida	14-Dec-91	area5019	44	36	1029	1.796	40.917	25.122
Florida	15-Dec-91	area5020	44	33	1957	2.195	38.811	47.778
				515			600.074	
			min mean	34.333		mean mean	40.005	
						std dev means	1.205	

CONCLUSION:

The initial findings of this study indicate that the atmosphere may have negatively impacted most of the TerraScout/M88-1 targets during STS-44. The summary shows that 2.5 overflights were classified "poor", 8.0 "marginal", 0.5 "good", and 0.0 "very good". The impact of atmospheric scattering effectively reduced the resolving power of the experiment based on these data alone. These results are based on a limited sample and more data points would increase the reliability of the conclusions.

Additionally, these results imply that the target acquisition from TerraScout/M88-1 may be improved by increasing the number payload observations over a greater time period thereby reducing the impact of transitory atmospheric hazy events such as the situation during STS-44.

In conclusion, the results of this study appear to be valid as a cyclitory improvement and degradation of estimated viewing conditions occurred with the same period as with the passage of macro-scale meteorological systems. Further testing and automation of the estimated viewing conditions should be investigated for application in the operational space environment.

David R. Helms 7/16/92

David R. Helms, Lockheed Engineering and Sciences Company
for Victor S. Whitehead, NASA
ERSAF, Johnson Space Center

APPENDIX E

Human Factors Data

1. Earth Observation Survey of U. S. Astronauts.

Astronauts may be broadly considered subject matter experts in general earth observation from space, they are not trained and should not be considered subject matter experts in ground site (target) analysis. Therefore, an important preliminary task for design of Terra Scout was elicitation and analysis of astronaut knowledge regarding earth observation from on-board a space vehicle. This task was accomplished by *Dr. Beverly G. Knapp, U.S. Army Research Institute.* Dr. Knapp's complete report is available through the Fort Huachuca Field Unit, Army Research Institute, Fort Huachuca, AZ 85613-7000, telephone (602) 538-4704, (DSN 879-4704). The following paragraphs summarize the report and comments from the Terra Scout experiment Team.

a. Survey Design (summarized).

A survey instrument was developed consisting of 5 knowledge categories based on a model of earth observation functions derived from recordings and comments of shuttle astronauts. The model consists of a number of separate although related considerations proceeding from gross orientation to object tracking, as well as accounting for the effects of factors which might impinge on observation (optical distortion, vibration, speed). Four functions comprise the model:

(1) Orientation to the geographical area (recognizing where you are, and what stands out in a salient way).

(2) Recognition of specific features (rivers, irrigation patterns, coastlines, mountain ranges) structures and objects (road nets, built up areas, etc.).

(3) Detailed recognition of specific features (erosion, silting, volcanic eruptions, bridges, vehicles).

(4) Tracking features, structures, or objects (following its course as viewing window and angle change).

The survey was developed using a checklist and rating approach to prompt for the top three cues in each area, as well as a fifth multi-part item to determine the role of factors affecting the four visual observation functions of the model. A copy of the complete survey is at TAB A to this Appendix.

Twenty-two astronauts who had flown on one or more shuttle flights were administered the survey.

b. Analysis and Results.

Each survey question for the four observation functions contained a checklist of prompt items as well as an "other" category to determine the top 3 or 4 cues that provided the most useful information pertaining to the function. In some cases, respondents applied a 1 to 3 ranking for three items, others simply checked items they thought applied. Therefore, the top three items were determined using a "point index" system, determined by combining the items most selected by one third or more respondents, or top three selected) and the point value assigned (if checked only a "1" was assigned) and then divided by the total number selecting that item. Thus, the lowest point index would be obtained by an item being selected by many respondents and also being assigned many "1" values; the lower the index the more salient the cue.

(1) Orientation. The top three cues that best oriented to an area of observational interest:

-Shuttle On-board Portable Computer (SPOC)(Index value=1.27; N=21)
-Other (Index value=1.78; N=19)
-Colors (Index value=2.27; N-11)

Write-in ("other") items included large geographical formations (4), coastlines (8), sound regional knowledge, pre-orientation, pre-flight study (7), and specific geographical features (2). Also, "major landmarks such as rivers, mountains", "color intensity and colors play together", "texture of mountains and water allow depth perception", "deserts characterized by specific colors".

(2) Recognition. The three best cues were:

-Preferred pattern (river meanders, etc.) (Index=1.5: N=18)
-Regular geometric shape (Index=1.8; N=10)
-Colors (Index=2.25; N=12)

The "other" category received an index value of 1.0 since 7 respondents chose it with a rank of 1 each. This is marginal since this is just less than one third of the respondents.

(3) Detailed Recognition. Features contributing to detailed recognition were divided into natural and man-made categories.

Those that stood out for natural features:

-Lakes/seas (Index value=1.33; N=15)
-Mountain ranges (Index value=1.5; N=14)
-River patterns (Index value=1.55; N=9)
-Storms (Index value 1.77; N=9)

Those that stood out for man-made features:

-Agriculture/irrigation patterns (Index value=1.15; N=20)
-Built up area (Index value=1.73; N=15)
-Road network (Index value=2.54; N-11)

(4) Tracking. This function elicited fewer responses on the formal checklist of suggested cues.

-River pattern (Index value=1.50; N=8)
-Road net (Index value=2.6; N=5)

Voluminous comments indicated that specific cues are not as critical as the observer being cued in advance to the upcoming target, **and to be keenly trained** so that the reference objects will be familiar. Several individuals felt that SPOC was the best cue since it can tell when and where you are, so that you are then able to use predetermined reference objects made familiar to you by extensive pre-flght training and flight experience.[E-1] Some respondents felt tracking could not be done without the aid of a second crew member who could cue to the upcoming area or feature.

c. Summary.

Astronaut knowledge of earth observation has pointed out a number of salient cues related to specific functions of orientation, recognition, detailed recognition, and tracking from an orbiting platform. The extensive use of the "other" category during the survey indicates that further detailed interviewing is needed. It is clear from an astronauts point of view, and in the words of one astronaut, earth observation from space allows a "large, synoptic view, very quickly, which allows someone to quickly notice elements that are unusual and worth closer attention"[E-2]. It is the pursuit of further detail and specification of the nature of this viewing capability that follow on efforts need to address.

2. Evaluation of Payload Specialist Candidates for Terra Scout using Psychological Indicators.

The following is a reproduction of evaluations done by Dr. Beverly G. Knapp, Army Research Institute for Behavioral Sciences.

[E-1] This is one area the Terra Scout experiment team feels is not understood. Trained and experienced imagery analysts have extensive abilities for locating, tracking, and analyzing ground observations.

[E-2] Again, this is from an astronaut perspective. Terra Scout offers the next logical step by placing a recognized expert in Earth ground site analysis from an overhead perspective, in an orbiting platform.

a. Introduction.

Candidates for payload specialist for USAICS project Terra Scout were evaluated using three psychometric instruments which, in combination, provide general personality characteristics, ways of viewing the world and responding to situations, and general anxiety and stability levels. All three individuals tested demonstrated indicators in the normal ranges with not evidence of unusual personality attributes or pathology.

b. Evaluation Instruments.

Anxiety level was measured using the Anxiety Scale Questionnaire (ASQ) (Krug, Scheier, and Cattell, 1976). The ASQ was developed following years of factor analytic research into personality traits by Cattell in order to derive clinically meaningful anxiety information in a rapid, objective, and standard manner. Output scores from the ASQ are typically converted to normalized or sten scores which range from 1-10. This score can then be viewed in relation to general adult population norms. Generally a sten score of 4,5,6, or 7 indicates an average level of anxiety. Scores or 1,2, or 3 are typically found in unusually relaxed, secure, phlegmatic individuals. A score of 8 indicates a person whose anxiety level would be getting serious, while stens of 9 or 10 are found in only about 1 of 20 cases.

Emotional stability was measured using the Eysenck Personality Inventory (EPI) (Eysenck, 1960), which measures personality in terms of two pervasive, independent dimensions: extroversion-introversion and neuroticism-stability. Briefly, extroversion as opposed to introversion, refers to the outgoing, uninhibited, impulsive and sociable inclinations of a person. Neuroticism refers to the general emotional over-responsiveness and liability to neurotic breakdown under stress.

Perception, judgment and social inclinations were measured using the Myers-Briggs Type Indicator (MBTI) (Myers and McCaully, 1985). The main objective of the MBTI is to identify four basic preferences on four independent scales, which then allows sixteen possible combinations called "types" denoted by the four letters of the scales:

EI: The Ei index is designed to reflect whether a person is an extrovert or an introvert. Extroverts are oriented primarily toward the outer world; they tend to focus their perception and judgment on people and objects. Introverts are oriented toward the inner world; they tend to focus their perceptions and judgment upon concepts and ideas.

SN: The SN index is designed to reflect a person's preference between two opposite ways of perceiving-one relies primarily upon the process of sensing, which reports observable facts or happenings through one or more of the five senses; the other relies more on the less obvious process of intuition, which reports meanings, relationships, and possibilities that have been worked out beyond the reach of the conscious mind.

TF: The TF index is designed to reflect a person's preference between two contrasting ways of judgment. One may rely primarily on thinking to decide impersonally on the basis or logical consequences, another may rely mostly on feeling to decide primarily on the basis of personal or social values.

JP: The JP index is designed to describe the process a person uses primarily in dealing with the outer world; that is with the extroverted part of life. A person who prefers judgment has reported a preference for using a judgment process (either thinking or feeling) for dealing whit the outer world. A person who prefers perception has reported a preference for using a perceptive process (either sensing or intuiting) for dealing with the outer world.

c. Results of Testing.

Anxiety Scale Questionnaire

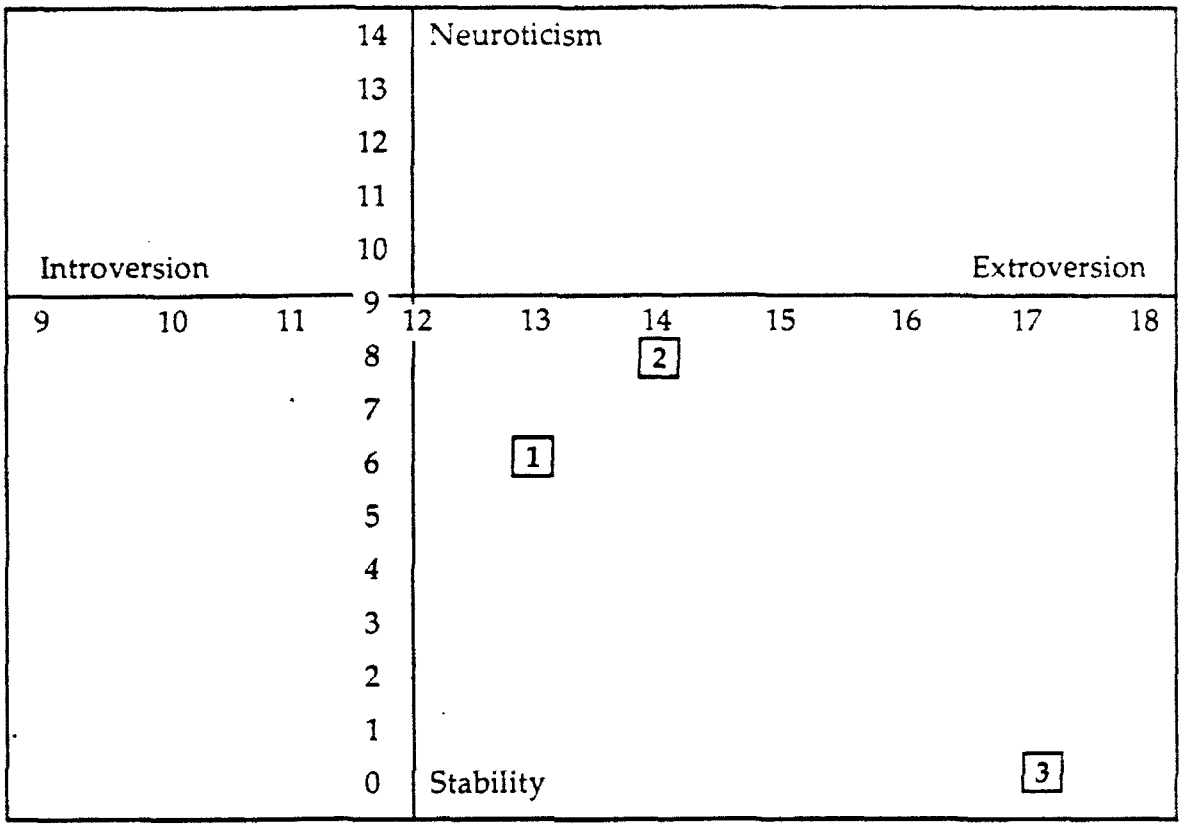
Candidate	Sten Score	Percentile
1	3	11
2	5	40
3	3	11

Results: All three are low on anxiety with subjects one and three being unusually relaxed, calm and secure, relative to a normal population. Subject two is within the normal range, toward the low anxiety scale.

Eysenck Personality Inventory

Candidate	Extroversion	Neuroticism
1	13 (62%tile)	6 (27%tile)
2	14 (70%tile)	8 (41%tile)
3	17 (91%tile)	0 (1%tile)

Figure E-1 Psychological Indicators



Results: All subjects tend to be stable. Subject three is extremely extroverted and stable. Subject one tends to be balanced between extroversion and introversion and very stable. Subject two is also more stable than the norm and has a tendency toward extroversion.

Myers-Briggs Type Indicator

Candidate	Preferences
1	INTJ
2	ESTJ
3	ENTJ

Each of the three candidates tested came out a different "type" although certain similar preferences were reported. All three are "TJ" sometimes called "logical decision makers" characterized by use of the thinking-judgment functions, and are described as tough-minded, executive, analytical, and instrumental leaders. Reportings on the EI and SN indices showed differences. Candidates two and three are extroverted by differ in sensing and intuition and candidates one and three are aligned in sensing and intuition but one is introvert and three is extrovert.

INTJ: Usually have original minds and great drive for their own ideas and purposes. In fields that appeal to them, they have a fine power to organize a job and carry it through with or without help. Skeptical, critical, independent, determined, sometimes stubborn. Must learn to yield less important points in order to win the most important.

ESTJ: Practical, realistic, matter-of-fact, with a natural head for business or mechanics. Not interested in subjects they see no use for, but can apply themselves when necessary. Like to organize and run activities. May make good administrators, especially if they remember to consider others' feelings and points of view.

ENTJ: Hearty, frank, decisive, leaders in activities. Usually good in anything that requires reasoning and intelligent talk, such as public speaking. Are usually well informed and enjoy adding to their fund of knowledge. May sometimes appear more positive and confident than their experience in an area warrants.

d. Discussion.

None of the candidates should be eliminated on the basis of the test data alone, due to the limitations of the test battery. The scores indicate that all individuals are stable and have low anxiety. This means that all are probably capable of dealing with stressful and challenging circumstances.

The slight differences in the scores on the three tests provides some information usable for distinguishing between the three candidates. However, there are not test norms for payload specialists, thus there is no way to know if the differences are meaningful. The selection panel should consider the tests results in relation to the job to be performed and the environmental and social context in which it will be carried out. This procedure could provide a realistic interpretation of the scores for consideration in selection.

3. STS-44 Crew Debriefing on Payload Operations.

A preliminary post flight debriefing with crew members was completed upon landing. The portion of that debriefing concerning Terra Scout follows.

Q: What resolution did Tom 2 (PS1) and the crew believe was achieved (i.e., spatial resolution)?

A: NIIRS 3/25

Q: What impact did current atmospheric conditions have on your observation/analysis abilities?

A: Cloud covered and hazed over targets.

Q: What did color, sun glint, and time over target add to tour ability to locate/identify objects?

A: Ability to (with more confidence) locate and identify the target and analyze as much as resolution would allow.

Q: Could you ever detect object motion?

A: No. Could detect ship wakes (but not the ship) with binoculars.

Q: Do binoculars provide any additional advantages?

A: Two crewmember operations/excellent backup optical manual tracking device.

Q: Did you notice any physiological effects (visual or otherwise) which may have impacted your analyst skills?

A: None.

Q: Was SpaDVOS/FIGS training useful? What was most useful? What can be improved?

A: Yes. Equipment familiarization and locating targets at orbital velocity. Using actual planned targets or general areas.

Q: Did FIGS simulate what was observed in flight?

A: Fairly accurate, less the jitter caused by TAC tracking mechanism on orbit.

Q: Were the target folders effective?

A: Not as good as they could be. Better maps (color), larger overviews.

Q: We expected at least an order of magnitude better resolution through the eyepiece than observed on the recorded acquisition. Was this valid?

A: Definitely.

Q: How much difficulty did the PS have acquiring Ad Hoc targets, and did he add/record targets we are not aware of?

A: None. No.

Q: Did PS1 perform non-military analysis (i.e., geological) with SpaDVOS?

A: Limited.

Q: How often did PS1/PLT/CDR use alternate optics? Which alternate optics were used?

A: Virtually every target acquisition opportunity with both alternate optics.

Q: The Terra Scout PIs consider this a very successful experiment, despite the early landing. Is that your feeling also?

A: Yes.

APPENDIX F

Payload Specialist (PS) Selection and
Training of Experiment Personnel

1. Payload Specialist Selection.

a. In addition to astronaut criteria established and provided by NASA, personnel of USAIC&FH Space Division developed requirements of training and expertise believed necessary to successfully conduct Terra Scout. Also, candidates were required to have sufficient time remaining on their military commitment to complete Army and NASA post mission reporting, analysis and other follow-up actions. Basically, the only requirement of NASA was that the Payload Specialist successfully pass an astronaut physical examination and interview. Information concerning forms and requirements for a NASA physical examination is not provided with this report but may be obtained by requesting support through any military Flight Surgeon's office.

b. Specific selection criteria, including military background and imagery analysis training and experience were developed by Space Division, USAIC&FH. The final candidates were interviewed by Space Division and given a test of their imagery analysis skills to determine which would be the primary and back-up Payload Specialist. Finally, the candidates were given a psychological evaluation by the Army Research Institute for Behavioral Science.

c. All candidates were school trained and qualified Imagery Analysts (IA). The current sixteen week training course for qualification as an IA at Skill Level 1 includes the following:

(1) Imagery analysis organizations and equipment.
(2) Document security.
(3) Map reading.
(4) Photogrammetry.
(5) Imagery analysis procedures.
(6) Imagery analysis reports.
(7) Lines of communication analysis.
(8) Identification of military equipment (U.S., NATO, and potential adversaries).
(9) Ground order of battle analysis.
(10) Radar imagery analysis.
(11) Infrared imagery analysis.
(12) Low intensity conflict analysis.
(13) Digital imagery analysis and exploitation.

d. A summary of qualifications of the final three Payload Specialist candidates is as follows:

(1) CW3 Thomas Hennen: 18 years total imagery analysis experience. Unique qualification and experience:

-tactical and national level exploitation
-certified instructor
-extensive research and development
-USAICS Representative for imagery intelligence within the Tactical Exploitation of National Capabilities (TENCAP) Program at the Army Space Program Office.
-college educated

(2) SFC Michael Belt: 15 years total imagery analysis experience. Unique qualifications and experience:

-tactical and national level exploitation
-certified instructor
-500 flight hours as private fixed wing pilot
-private business as aerial photographer
-college educated

(3) CW3 John Hawker: 17 years total imagery analysis experience. Unique qualifications and experience:

-tactical, strategic, and national level exploitation
-6 1/2 years analysis with Domestic and Foreign Special Operations Forces
-250 flight hours as military observer and photographer
-128 flight hours in rotary wing aircraft
-90 military parachute jumps (70 as primary jumpmaster)
-extensive research and development
-college educated

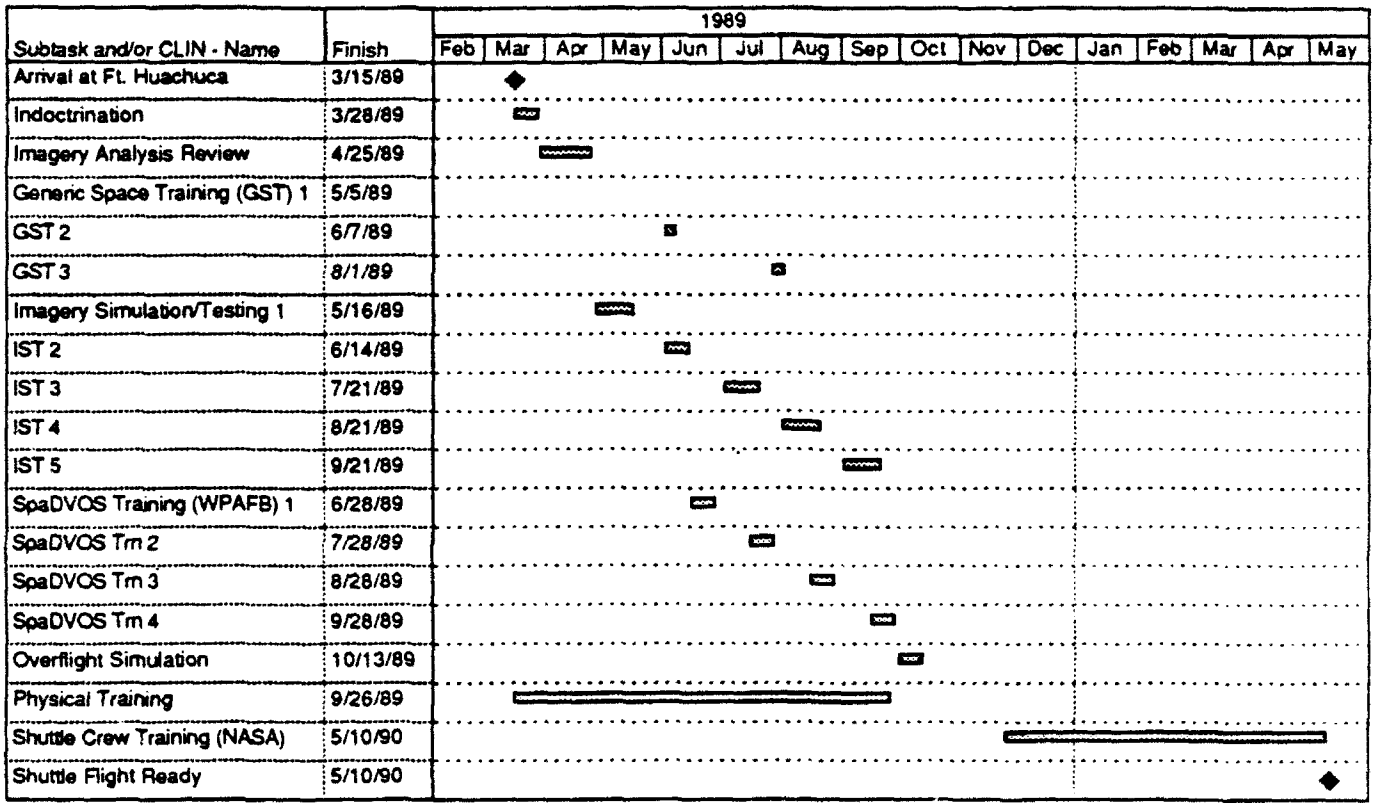
2. Training of Experiment Personnel.

a. Refresher/specific imagery training and target folder development were done at Fort Huachuca, AZ. These activities were done, as time permitted, from mid-1988 until a few weeks prior to launch. A training plan was developed and used by the experiment team but keeping rigidly to the planned time schedule proved impossible due to shuttle mission slippages and rescheduling. The Department of Surveillance Systems Maintenance (DSSM), USAICS, provided equipment, imagery and occasionally instructional assistance for in-depth experiment specific training. This included current doctrinal and tactical order of battle information on both US/NATO and non-NATO

observation sites. Most of the groundwork for target folder development was accomplished during this training phase, supported by DSSM as required.

The following figure is the training plan schedule used as a guide in preparation for Terra Scout. Several listed activities were conducted for a longer period than planned to ensure proficiency would be maintained continuously until the actual launch (21 November 1991).

Figure F-1 Training Plan Schedule



b. Flexible Image Generation System (FIGS) Training.

(1) Several training sessions were conducted on the FIGS simulation device at Wright-Patterson AFB, beginning in September, 1989. FIGS replicates the operation of a spaceborne telescope system which is focused on terrestrial targets. Specifically, the simulator teaches each candidate to search, acquire, track, and observe targets which are in range for approximately 70 seconds. The simulator shows examples of targets which will be used during Terra Scout. This simulator does not replicate a weightless environment but is operated by means of the same type manual control as SpaDVOS.

-During the training and development process SpaDVOS was mounted in a NASA Lear jet where training and system tests were conducted in flight.

-A combined training and proof of concept demonstration flight was conducted on board an Air Force KC 135 at Fort Irwin, California during ground force exercises there. Participants in this flight included one of the imagery analyst/payload specialist candidates, one NASA astronaut, two Air Force/NASA flight engineers, an Air Force-Space Division/STP engineer, and two other Air Force observers/analysts. Training and lessons learned during the flight are as follows:

--In general, participants who were not trained analysts had more difficulty acquiring and tracking specified tactical-size ground targets than the analyst.

--Participants who were not intelligence trained could not report what they observed i.e., echelons, maneuver elements, style of attack ongoing, identity of forces (friendly vs. enemy, follow-on forces and militarily significant inconsistencies in the ground force activities.

-Several training sessions and system tests were also completed with SpaDVOS mounted in an Air Force C-135 microgravity environment training aircraft. Each session was conducted while the aircraft flew approximately 20 successive arching parabolas where the trainees experience a microgravity environment for 20-25 seconds at a time.

(2) The first three sessions with FIGS were primarily for familiarization with the FIGS device, SpaDVOS flight hardware, and the 1-g mock-up of the aft flight deck of the shuttle. These sessions were also used to assist determination of the two candidates' ability to use the SpaDVOS in all aspects of acquisition, tracking and visual analysis of target sites.

(3) Following thorough training with the FIGS, and upon delivery of the first SpaDVOS, several additional training sessions were completed in the NASA KC-135 zero g simulator aircraft. These sessions were usually $2^{1/2}$ to 3 hours in duration and consisted of a flight profile where the aircraft performed approximately 50 parabolas (zero/low g arcs), each of approximately 20-30 seconds duration. The SpaDVOS was mounted on the floor of the aircraft where the candidates could perform simulated earth observation using the actual SpaDVOS controls while in a weightless environment.

4. The following is an outline of the Payload Specialist portion of training for Terra Scout. The majority of this training is directed and conducted by NASA.

TERRA SCOUT - PS TRAINING PLAN 6/14/90
Lesson Description

L-12 to L-9 months

A01:	THIS IS JSC	Video	21 minutes
A02:	TOUR OF JSC BY PSO	Tour	4 hours
A03:	MCC OVERVIEW	Video	45 minutes
A04:	MCC TOUR	Tour	2 hours
A05:	TECH LIB TOUR (optional)	Tour	2 hours
A06:	ELLINGTON OPS 1103 (opt)	Video	24 minutes
A07:	ELLINGTON TOUR	Tour	4 hours
A08:	CST/SST TOUR	Tour	1 hour
A10:	WETF TOUR	Tour	2 hours
A12:	MDF TOUR	Tour	1 hour
A13:	CCT/FFT TOUR	Tour	1 hour
A14:	SMS TOUR 1103	Video	18 minutes
A15:	SMS TOUR	Tour	1 hour
A16:	SES TOUR (optional)	Tour	1 hour
A17:	SAIL TOUR (optional)	Tour	1 hour
OV-211/LSC	PL BAY & AFT COMPT	Video	15 minutes
OV-289/LSC	ORB CREW MODULE ACC	Video	15 minutes
QG-101/KSC	FIRE PRO SAFETY	Video	33 minutes
QG-102/KSC	TOXIC PROP SAFETY	Video	36 minutes
QG-150/KSC	FLT VEH SAFETY	Video	32 minutes
QG-250/KSC	HYPREGOL FIRE SUPP	Video	20 minutes
QF-39X/KSC	SLF-OPF-Pad-RPSF VAB-MLP FAM	Video	
QS-205/LSK	HOW CLEAN IS CLEAN	Video	
QF-28X	INDUSTRIAL AREA SAFETY WALKDOWN	Video	34 minutes
A33:	NASA...THE 25TH YEAR (opt)	Video	1 hour
A34:	LEGACY OF GEMINI (opt)	Video	29 minutes
A35:	THE TIME OF APOLLO (opt)	Video	29 minutes
A36:	FLIGHT OF APOLLO 11 (opt)	Video	32 minutes
A37:	APOLLO XIII (opt)	Video	28 minutes
A38:	SPACE SHUTTLE (optional)	Video	31 minutes
A44:	CAIT/REGENCY FAM 1101	Briefing	1 hour
C01:	VOICE COMM TR 1103	Video	24 minutes
C03:	FRONTLINE 1103	Video	1 hour
C04:	FLT OV 1103	Video	1 hour
C05:	FLT OV 1203	Video	1 hour
C06:	FLT OV 1303	Video	1 hour
C08:	KSC TURN OPS 1103	Video	15 minutes
C11:	ENVIRON FAM & PHYSIO TRNG	Chamber	8 hours
C23:	EXTRACTION AND SURVIVAL - WATER SURVIVAL TRAINING		24 hours
S01:	SPACE SHUTTLE FAM 1107	Text	4 hours
S23:	FDF 2101	Workbook	4 hours
S25:	DPS OV 2102	Workbook	4 hours
S26:	CSI 2102	Workbook	3 hours
S27:	CSI 2105	CST	1 hour
S28:	DPS HW/SW 2102 (optional)	Workbook	10 hours
S29:	GNC OV 2102 (optional)	Workbook	2 hours
S30:	GNC HS OV 2102 (optional)	Workbook	6 hours

S31:	C&W 2164	Regency	2 hours
S32:	C&W 2102	Workbook	3 hours
S33:	SM TM 2102	Workbook	3 hours
S34:	DPS 2105	CST	2 hours
S35:	C&W OPS 2104	SST	1 hour
S65:	SPOC 2102	Workbook	2 hours
S66:	SPOC FPH 2107 (optional)	Text	1 hour
S70:	CCTV OPS 2102A	Workbook	1 hour

L-9 to L-7 months

A31:	PHOTOS AND BIOGRAPHY		8 hours
A32:	PRESS & PAO ACTIVITY		16 hours
C24:	IN/EG 2102A	Workbook	2 hours

L-8 months

A40:	STS PRESS INFO (optional) SECTION ON SRB, ET	Text	2 hours
S04:	LOC CODE 2102	Workbook	2 hours
S05:	LIGHTING 2102	Workbook	2 hours
S06:	CREW SYS EQ 2102	Workbook	2 hours
S07:	CS OV 1103	Video	1 hour
S08:	C STA DSN 1103 *	Video	2 hours
S10:	WCS 2102C	Workbook	2 hours
S11:	FOOD SYS 2102B	Workbook	1 hour
S14:	MED EQ 2102 (optional)	Workbook	2 hours
S15:	CREW CABIN FAM 2120	CCT	2 hours

*Replace with "Living & Working in Space" video

L-6 months

A28:	MED PHYSIOLOGICAL BRF	Briefing	4 hours
A29:	CLOTHING FIT		4 hours
A30:	FOOD SAMPLING		1 hour
A41:	MOD ORIENTATION MANUAL (opt)	Text	8 hours
A42:	MOD TRAINING DIV OV 2107	Text	4 hours
A45:	FCOD ORIENTATION	Briefing	4 hours
A46:	ROLMPHONE 1103 (optional)	Video	22 minutes
C37:	ADV ORBIT SKILLS 3112	SMS	2 hours
S12:	WCS 2164	Regency	2 hours
S16:	HAB EQ/PROC 2120	CCT	4 hours
S23:	FDF 2102	Workbook	4 hours
S24:	FDF 2120	CCT	1 hour
S36:	EPS 2102	Workbook	4 hours
S37:	EPS 2164 (optional)	Regency	2 hours
S38:	ECLSS 2102	Workbook	3 hours
S41:	ECLSS 2164 (optional)	Regency	2 hours
S42:	MECH SYS 2102 (optional)	Workbook	4 hours
S43:	MECH OV 1103	Video	1 hour
S44:	COM/IN INTRO 2102	Workbook	2 hours
S45:	COMM OV 2164	Regency	2 hours
S46:	COMM/IN 2102	Workbook	6 hours
S47:	COM/IN OPS 2106A	SST	2 hours
S48:	AUDIO 2106	SST	1 hour

S49: AUDIO 2120	CCT	2 hours
S50: MPS 2102 (optional)	Workbook	4 hours
S51: MPS 2164 (optional)	Regency	1 hour
S64: ORB MEC 2164 (optional)	Regency	2 hours
S69: ASC/ABORTS FPH 2107 (opt)	Handbook	8 hours
S73: BASIC PHOTO 2101	Briefing	2 hours
S74: PHO 35 EQ 2102	Workbook	1 hour
S75: PHO 35 EQ 2101	Briefing	2 hours
S76: PHO 70 EQ 2102	Workbook	1 hour
S77: PHO 70 EQ 2101	Briefing	2 hours

L-5 months

C12: ENVR FAM 1152	T-38	8 hours
C13: ENVR FAM 1153	KC-135	8 hours
C23: EXTRACTION AND SURVIVAL -		
BAILOUT 2102	Workbook	1 hour
BAILOUT INTR 2101	Briefing	1 hour
C25: PI/PO PREP 3120	CCT	4+4 hours (+dry run)
S16: HAB EQ/PROC 2120	CCT	4 hours
S67: SPOC 2101 (opt)	Briefing	2 hours
S68: TELEPRINTER 2162 (opt)	Loose Eq	1 hour
S81: PHO OVERVIEW 2101	Briefing	3 hours
S82: PHO TECH 1 2101	Briefing	2 hours
S83: PHO TECH 2 2101	Briefing	1 hour
S84: PHOTO SKILLS 3162	Loose Eq	4 hours

L-4.5 months

C23: EXTRACTION AND SURVIVAL -		
BAILOUT 3120	CCT	3+3 hours (+dry run)
S12: WCS 2164	Regency	2 hours
S13: WCS PROC 2165	WCS trainer	2 hours
S21: IFM 2101 (optional)	Briefing	3 hours
S22: IFM PIN KIT 2101 (opt)	Briefing	1 hour

L-4 months

		1 hour
A30: FOOD SAMPLING	Meeting	4 hours
C18: MISSION RULES REVIEW	Exercise	3.5 hours
C20: FIREFIGHTING	SMS	4 hours
C37: ADV ORBIT SKILLS 3112	Meeting	1 hour
C40: TIMELINE REVIEW 3101		
(with the Commander)		

L-3.5 months

S18: FIRST AID 2101	Instruction	1 hour
S19: MED CPR 2101	Instruction	3 hours

L-12 weeks

S13: WCS PROC 2165	WCS trainer	2 hours

C45:	FLIGHT OPS REVIEW BOARD (splinter meetings in days preceeding)	Meeting	8 hours (+2 days)

L-9 weeks

C35:	SMS ASCENT SKILLS	SMS	2 hours

L-8 weeks

A30:	FOOD SAMPLING		1 hour
C23:	EXTRACTION AND SURVIVAL - BAILOUT 3127	WETF	3 hours (dry run)
C26:	ASC/CAP/DES 3120 (with crew)	CCT	8 hours
C40:	TIMELINE REVIEW 3101 (with the Commander)	Meeting	1 hour
C46:	BENCH REVIEW	Meeting	4 hours

L-7 weeks

C23:	EXTRACTION AND SURVIVAL - BAILOUT 3127	WETF	3 hours
C27:	PLD EG 3119	FFT	4 hours (dry run)
C28:	PRL IN/EG 3120	CCT	3 hours (dry run)
C32:	ASCENT BRF	Briefing	2 hours
C33:	ASCENT ABORT BRF	Briefing	2 hours
C35:	SMS ASCENT SKILLS	SMS	2 hours
C38:	PO INS 9112 (+ briefing)	SMS	6 hours
C39:	INTEGRATED ORBIT SIMS D/O PREP 9142	SMS	7 hours

L-6 weeks

C27:	PLD EG 3119	FFT	4 hours
C28:	PRL IN/EG 3120	CCT	3 hours
C34:	ENTRY BRF	Briefing	2 hours
S13:	WCS PROC 2165	WCS trainer	2 hours

L-5 weeks

C36:	SMS ENTRY SKILLS	SMS	2 hours
CEIT		KSC	8 hours

L-4 weeks

A32:	PRESS & PAO ACTIVITY (L-30 days press conference)		4 hours
C23:	EXTRACTION AND SURVIVAL - BAILOUT 3220	CCT	3 hours

L-3 weeks

A33:	PRESS & PAO ACTIVITY (TV Strategy meeting)		16 hours

L-2 weeks

C40: TIMELINE REVIEW 3101 (with the Commander)	Meeting	1 hour
S20: MED PROC 3101 (L-10 day physical included)	Briefing	3 hours
C41: TCDT (VITT BRF) (3 days tied up)	Briefing	30 hours

L-1 week

C36: SMS ENTRY SKILLS	SMS	1 hour
C38: PO INS 9212	SMS	4 hours
C42: FINAL SAFETY BRF	Briefing	1 hour
C43: FLT DIR/CAP COM MTG	Meeting	2 hours

As they occur: Optional

C14: ASCENT FLT TECHNIQUES	Meetings	4 hours
C15: ORBIT FLT TECHNIQUES	Meetings	16 hours
C16: ENTRY FLT TECHNIQUES	Meetings	4 hours
C17: POWG	Meeting	16 hours
C21: PAYLOAD SAFETY REVIEW	Meetings	40 hours
C29: MCC MONITOR - ASCENT	MCC	8 hours
C30: MCC MONITOR - ORBIT	MCC	24 hours
C31: MCC MONITOR - ENTRY	MCC	8 hours

APPENDIX G

Project History

1. General.

a. Terra Scout represents several "firsts" for the Army. These include:

(1). The first military-man-in-space experiment attempted by the Army.

(2). The first shuttle mission ever with a military crewmember who was not a senior officer/engineer.

(3). The first Warrant Officer ever to go to space.

(4). The first experiment based on determining military requirements satisfaction by a subject matter expert.

b. This Appendix is intended to provide a summary of the Space Transportation/Military-Man-in-Space Programs from the perspective of the Terra Scout Experiment team, and to show a brief chronology of events from initial concept to launch of Terra Scout.

2. Project History.

a. Terra Scout was conceived in 1985 during discussions between BG Bob Stewart, senior Army astronaut, MG Julius Parker, Commanding General of USAICS, LTC Paul Groskopf and CPT Dave Bales of Space Division, Directorate of Combat Developments, USAICS. BG Stewart described watching dust trails of what he though were armored forces moving through the desert in the Middle East. Use of binoculars did not provide enough magnification for confirmation. After the mission BG Stewart discovered that there were movements of large forces at the time and place in question. Because of this experience he believed a trained analyst aboard the shuttle might be able to derive useful information using optical equipment intended for that purpose. Coincidentally, the Secretary of the Air Force had recently circulated a memorandum to all services soliciting proposals for military-man-in-space experiments. Space Division, USAICS, was tasked to develop and submit an experiment proposal. Mr. Gerald Ramage and WO1 Dave Cole spent several months gathering technical and background information and, since this was new to the Army, CPT Bales determined the format, method, and chain of submission for approval. The final experiment proposal was written under SCI controls and hand carried to General Richardson, CG TRADOC, for signature and formal Army submission to DOD and NASA.

b. Support from the Army Chain of Command began with Major General Julius Parker, Commandant of the U. S. Army Intelligence Center and School (USAICS). Beyond USAICS, support from senior Army leadership was provided initially by General Thurman, Army Vice Chief of Staff (VCSA), General Richardson, Commanding General of TRADOC, and LTG Weinstein, Army Deputy Chief of Staff for Intelligence (DCSINT). From 1986 until late in 1988 Terra Scout was not well understood by the majority of Army leadership. It remained at a low level of development and a low priority for funding and manpower. Resources for the project were not authorized or provided and work was accomplished by USAICS primarily "out of hide".

c. The experiment was briefed before the first STP/MMIS Review and Prioritization Board and all subsequent Boards until launch. It was always placed among the top few out of all experiments submitted. Resources and support from Army leadership increased after Terra Scout received these high ratings from the first three annual Tri-Service Review and Prioritization Boards.

d. The SpaDVOS was already a high priority for flight on the shuttle but Dr. Task could not get enough support (funds) from the Air Force or NASA to build the system. Terra Scout provided a well defined plan, with minimal funding from TRADOC, but no engineering support (contract or military). After the first DOD Prioritization Board, Dr. Task agreed to support Terra Scout during subsequent Boards and other prioritization and approval processes. Eventually TRADOC provided funds to start building two systems.

e. Initially, the United States Army Topographic Engineering Center (USATEC), formerly Engineering Topographic Laboratory (USAETL) agreed to provide engineering support in developing the SpaDVOS and was given $115k by USAIC&FH. Due to internal problems at ETL, they withdrew their agreement to provide dedicated engineering support but agreed to assist development in an advisory capacity for the funds provided.

f. Additional funds were provided by the Army through the Concept Evaluation Plan (CEP) Systems Acquisition Review Council (SARC). Using these funds, Dr. Task established an agreement with Dayton University to build two systems. Captain Jim Whitely (USAF) of Dr. Task's division was designated the principal representative and action officer developing SpaDVOS. Today, AAMRL and USAIC&FH maintain an exceptional working relationship. **The Terra Scout-SpaDVOS team provided significant advantages during developmental stages of both experiments.**

3. Terra Scout Sequence of Key Events.

The sequence of events cannot include every step and accomplishment of the experiment team during the seven year effort to get Terra Scout on the Shuttle. It is provided to show the nature of effort required, and reveals the fact that the majority of effort is administrative and political-not technically oriented.

Jan 1986	Senior Army astronaut, BG (then COL) Bob Stewart visits USAICS as requested by Space Division to brief MI Officers Basic and Advanced Course classes and hold discussions about Space Division's idea for a shuttle experiment involving a trained imagery analyst.
Feb 1986	Concept briefing on space shuttle experiment to LTG Weinstein, DCSINT. First USAICS Working Group meeting.
Jun 1986	Space Division, USAICS formal submission to HQ TRADOC of Terra Scout as Army's first space shuttle experiment. Resume sheet to Test and Evaluation Division, DCD, USAICS for Concept Evaluation Program funds. Initial briefing to U. S. Army Intelligence and Security Command (INSCOM).
Jul 1986	Initial briefing to Defense Intelligence Agency (DIA).
Aug 1986	Experiment proposal approved by Secretary of the Army for Research and Development (SARDA). Forwarded to USAF Space Division for technical review, and SPACECOM for operational review. Briefed General Vuono, VCSA. Briefed LTG Bartlett, Commander, Combined Arms Center and Deputy Commander, TRADOC. Copy of experiment hand carried to Defense Advanced Research Projects Agency (DARPA).
Oct 1986	Briefing to USSPACECOM.
Dec 1986	Briefing to Space Division, USAF.
Jan 1987	Briefing to representatives of U. S. Army Space Office (USASO), DCSINT, TRADOC, DCSRDA, Secretary of the Air Force-Defense Support Program Office (DSPO), Army Space Program Office (ASPO).
Mar 1987	Briefing to DSPO. Briefing to DCSINT, and DCSOPS, USA. Army STP Prioritization Board (first held). Brief USAF Human Systems Division. Joint Military Man in Space Review and Prioritization Board. (Terra Scout #4, SpaDVOS #1) Agreement between AMRL and USAICS to discuss teaming. Briefing to several space system contractors for technical support (Boeing, E-Systems, Aerospace, etc.).
Mar 1987	Brief and coordinate experiment with Space Test Program Office, Tech Support.
Apr 1987	First meeting with Dr. Task, AAMRL concerning integrating Terra Scout and Space-borne Direct View Optical System (SpaDVOS).
Apr-May 87	First integration meeting with JSC, Det 2, USAF SD.
May 1987	Brief USAF Det 2, JSC.
Jun 1987	Army Development and Employment Agency (ADEA) offers $244K (never received) for Terra Scout.

	Begin development of experiment issues and criteria and tasks and skills analysis by New Systems Training Office, Department of Training and Doctrine, USAICS.
	Requested support from U. S. Army Engineering Topographic Engineering Labs (USAETL, now USATEC). Working group meeting to establish a Memorandum of Agreement.
Jul 1987	Space Experiment Working Group meeting at USAICS: DOTD, DCD, DSSM, OCMI, RMO, Scientific Advisor.
Sep 1987	Briefing to Honorable John O. Marsh, Secretary of the Army.
Nov 1987	Message from MG Parker to MI Branch directing records search of IAs for Payload Specialist candidates.
Mar 1988	U.S. Army Prioritization Board, 1988. Ranked number one.
	MMIS Prioritization Board, 1988. Ranked number four.
Oct 1988	Space Flight Medical Board certifies three PS candidates.
	SFC Belt flew in KC-135 over Fort Irwin, CA for experience on target approaches.
Dec 1988	Johnson Space Center Payload Integration Plan Draft completed.
	Formal (ARI) survey of astronauts on their Earth observations during past missions.
	Payload Integration Plan (PIP) draft
Feb 1989	Terra Scout (1628) briefed to NASA Scientific Support Group.
	SpaDVOS program review.
Mar 1989	Training simulation imagery from DIA.
	Two IA/PS's assigned to Fort Huachuca, AZ.
	U.S. Army Prioritization Board, 1989.
Apr 1989	SpaDVOS briefed to MMIS Prioritization Board.
Jun 1989	Payload Integration Plan completed by Johnson Space Center.
Sep 1989	SpaDVOS training begins at Wright-Patterson/Dayton, OH.
Dec 1989	T-38 simulator training.
	SpaDVOS flight on STS-38; proof of concept as Terra Scout mission equipment.
Jun 1990	**Terra Scout manifested for STS-44.**
Oct 1990	PS's move (TDY) to Johnson Space Center for training.
	PS mission integration training.
	PS Astronaut training
	DIA completed/shipped mission imagery packets
Nov 1990	SpaDVOS flew on STS-38 for data collection & characterization
Nov 1991	**Launch of STS-44.**

4. Space Test Program/Military Man in Space (STP/MMIS).

a. The Space Test Program (STP) is a Department of Defense (DoD) activity established to provide space-flight opportunities for DoD research and development (R&D) experiments. The Military Man in Space (MMIS) program is a component of the STP, intended to determine military applications of man's unique powers of observation and decision making in space. The STP/MMIS programs are described in Army Regulation 70-43/Air Force Regulation 80-2/Navy OPNAVINST 3913.1. These programs provide launch services for the Army space community at no cost to experimenters. The experimenter, of course, is responsible for developing and funding the experiment hardware.

In support of this program, HQDA will convene Army STP/MMIS Experiment Review Boards on a periodic (usually annual) basis to review and evaluate all Army requests for space-flight and to establish a priority list for Army space experiments. The Army Board is normally held approximately 60 days prior to the Tri-Service/Joint Board The Boards are usually held in the Washington, D.C. area, currently at Analytic Services Incorporated (ANSER), Crystal Gateway #3, Suite 800, 1215 Jefferson Davis Highway, Arlington, VA 22202. Sponsors/researchers who have experiments that require a space environment are strongly encouraged to submit their experiments for validation and prioritization to this Board. Experiments that receive a priority from the Board but are not manifested for flight prior to the next Board must compete again for prioritization at the following Board. Experiments selected by the Army Review Board are submitted to the Tri-Service STP/MMIS Experiment Review Board to compete with the other services for prioritization.

The STP/MMIS process has been streamlined into only two categories for all experiments: Free Flyer/Shuttle Bay (usually not requiring an astronaut) and MMIS/Middeck Locker (usually requiring an astronaut). The rating criteria will be the same for both categories and will include military relevance, quality of experiment, readiness for flight, and support and funding. All MMIS experiments must defend "mans utility" as part of the military relevance criterion. Proposed experiments, including those submitted in previous years but not manifested, must be submitted on DD Form 1721 and 1721-1 dated August 1990. A copy of these forms is included in this Appendix. Completed forms should be mailed to HQDA, SARD-TS, 3E474, the Pentagon, Washington, D.C. 20310-0103 and must be received approximately four weeks prior to the Board. Normal briefing requirements for the Board are included at the end of this Appendix.

Administrative instructions and meeting agenda are provided to experiment sponsors two to three weeks prior to the Board. **SECRET level clearances are required.** Questions concerning the Army STP/MMIS Experiment Review Board should be directed to Mr. Russ Edwards, (703) 695-1447 or DSN 225-1447. The Point of Contact (POC) for STP is SARD-TS; POC for MMIS is DAMO-SWX, (703) 695-0129 or DSN 225-0129.

b. Experiment sponsors are asked to make brief presentations at all Experiment Review/Prioritization Board meetings (Army and Joint/DoD). It is intended that these presentations be limited to 10 minutes and use only three vu-graphs. Standardized charts for these meetings are as follows:

Chart 1
Identification - Experiment Title and Number

Title - Concept

Content - Chart 1 is to contain statements about the experiment objective and description. give detailed values of performance parameters or measurements accuracies. Give sensor specifications. Compare performance to specific needs. Include a descriptive picture of the experiment, preferable in color. this chart is to provide the viewer with an understanding of what the experiment is and will do.

Chart 2
Identification - Experiment short Title and Number

Title - Justification

Content - Chart 2 is to present the justification for experiment space-flight. The three sections are to contain the following information: 1) the military relevance of the experiment, 2) a comparison of alternatives both inside and outside DOD, and 3) the detailed need for space test as opposed to ground test or previous space-flight experience. This chart explains why the experiment is important.

Chart 3
Identification - Experiment Short Title and Number

Title - Detailed Overview

Content - Chart 3 is a detailed overview of the experiment. Specifics on the experiment should be listed here under flight data such as: sortie or free flyer, type mission (secondary or primary), size, weight, availability constraints, the need for mission/payload specialist support. The experiment's priority must be stated as determined within its sponsoring agency or service. To be included is the rationale for this priority whether high or low. The status of the experiment must be identified by such factors as hardware readiness, funding, and production and delivery estimates.

5. NASA Documentation:

a. Payload Integration Plan (PIP) and Interface Control Document (ICD).

(1) The Payload Integration Plan (PIP) is a package of documentation in standardized National Space Transportation System (NSTS) format and is required for all payloads to be flown on the space shuttle. e PIP (NSTS 21147) represents the payload to Space Shuttle Program (SSP) agreement on the responsibilities and tasks which directly relate to the integration of the payload into the Space Shuttle, including the definitions of tasks which the SSP considers optional services.

-The following Orbiter accessories were provided by the SSP for Payload use on a shared basis:

Standard 35mm flight camera system
Lens/window cleaning kit
CCTV system
VTR system
microcassette recorder
very lightweight headset
lightshade assemble
voice microcassettes
28vdc power cables
35mm film cassettes
35mm film containers

-Applicable annexes to the PIP are as follows:

Annex 1-Payload Data Package
Annex 2-Flight Planning
Annex 3-Flight Operations Support
Annex 4-Orbiter Command and Data
Annex 5-Payload Operations Control Center
Annex 6-Orbiter Crew Compartment
Annex 7-Training
Annex 8-Launch Site Support Plan
Annex 9-Payload Verification Requirements
Annex 10-Intravehicular Activities (IVA)
Annex 11-Extravehicular Activities (EVA)

(2) The Interface Control Document (ICD) defines and controls the design of interfaces between the Shuttle Orbiter and the experiment payload. The interfaces are defined by direct reference to the corresponding sections and subsections of Part 1 of the standard the ICD. Unique and specific information related to an experiment payload are primarily described in subsequent sections of the ICD. In the event of conflict between Part 1 and subsequent unique, experiment specific data, the unique part of the ICD will take precedence.

(3) Relationship of ICD to PIP.

The ICD provides specific design data and defines engineering analysis applicable to the Orbiter/Payload interfaces and optional services identified in the PIP.

b. Flight Plan. (JSC-48000-44)

The STS Flight Plan is prepared by NASA and contains the on-orbit timeline. It is under configuration control of the Crew Procedures Control Board (CPCB) and the responsibility of the Mission Operations Directorate, Operations Division, NASA, JSC. The plan does not contain the detailed timelines that are covered in individual checklists for Ascent, Post Insertion, De-orbit Prep, and Entry Checklists, or detailed deploy procedures included in the Inertial Upper Stage (IUS) Deploy Checklist. However, the Flight Plan includes the entire flight and is illustrated as a timeline graph. The flight plan is considered a "living" document and is modified as necessary throughout the mission until the orbiter lands.

This on-orbit timeline displays times required and available for all actions by all crewmembers during a mission and satisfies NASA objectives specified in the Flight Definition and Requirements Directive and the requirements of the STS-44 Flight Requirements Document.

The flight profile used for the STS-44 Flight Plan was for a launch date of November 19, 1991, at 17:51 CST. Timeline formats used in the STS-44 Flight Plan are based on JSC-19933, Timeline Format Definitions and Standard Notes, Revision C, May 1990.

c. Attachments:

(1) Generic Middeck Payload Integration Schedule and Activities.

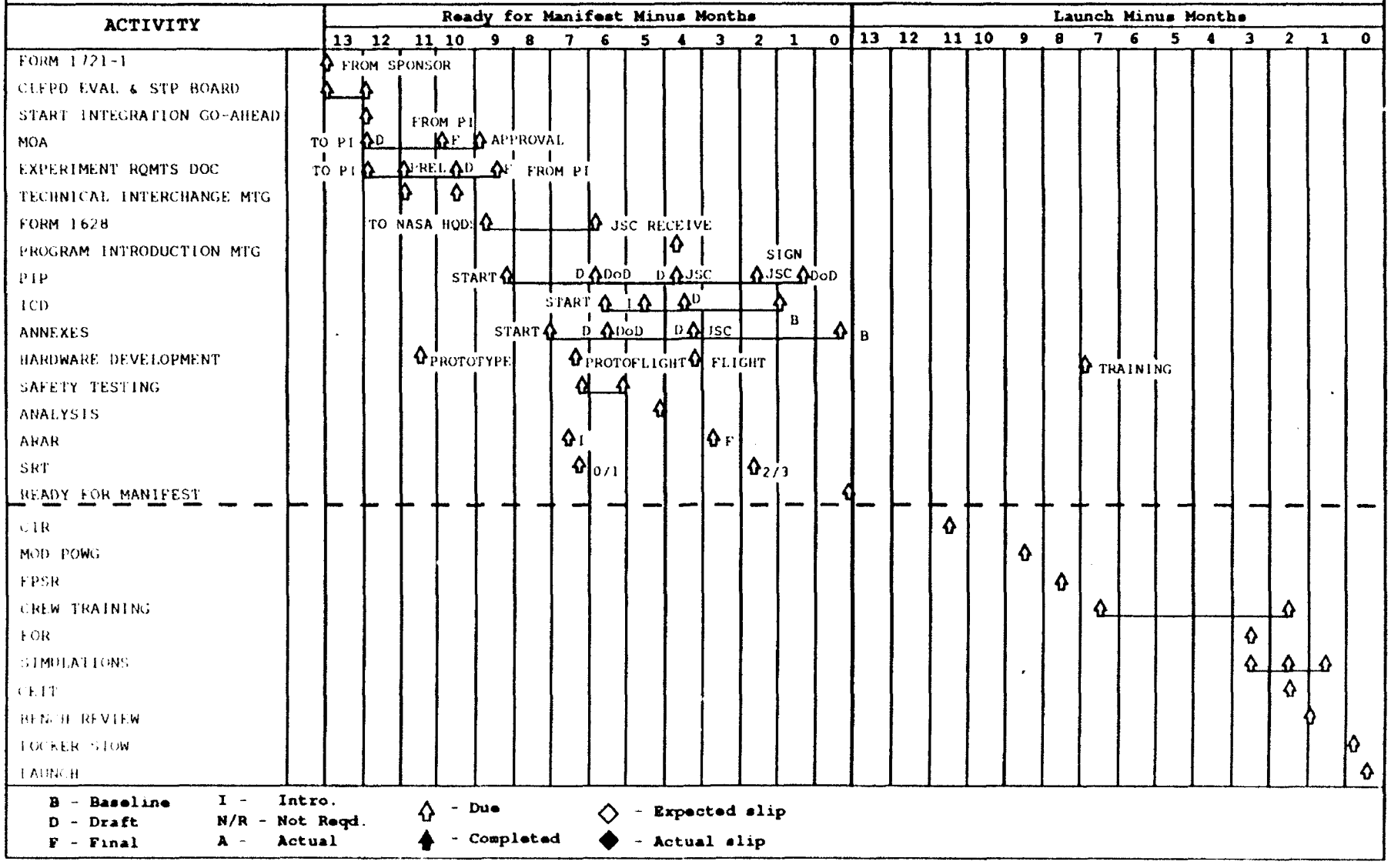
(2) Shuttle Capabilities and Payload Integration Briefing.

GENERIC MIDDECK PAYLOAD

INTEGRATION SCHEDULE

Date: 13 OCT 89

Sheet 1 of 1



TYPICAL DOD SECONDARY MISSION INTEGRATION ACTIVITIES

TRI-SERVICE BOARD	**L-24 MONTHS+**
FORM 1721 SUBMITTEL	L-24 MONTHS+
MOA DRAFT	L-24-18 MONTHS
INITIAL EXPERIMENT TIM	**L-24-18 MONTHS**
MOA APPROVAL	L-24-18 MONTHS
FINAL ERD DEVELOPMENT	L-24-18 MONTHS
DRAFT ARAR	L-24-18 MONTHS
FORM 1628 SUBMITTEL	**L-24-18 MONTHS**
DRAFT PAYLOAD INTEGRATION PLAN	L-18 MONTHS
INTERFACE CONTROL DOCUMENT SUBMITTEL	L-18 MONTHS
PHOTOTYPE HARDWARE TO JSC	L-18 MONTHS
PHASE 0/1 SAFETY REVIEW	**L-18-14 MONTHS**
ICD SIGNATURES	L-12 MONTHS
PIP INTRODUCTION MEETING	**L-18 MONTHS**
SECONDARY PAYLOAD POWG's	L-18-6 MONTHS
SECONDARY PAYLOAD GOWG's	L-18-6 MONTHS
PIP ANNEXES SUBMITTAL	L-16 MONTHS
PIP SIGNATURES	L-12 MONTHS
PIP ANNEXES SIGNATURES	L-12 MONTHS
CARGO INTEGRATION REVIEW	L-12 MONTHS
MOD PRE-FPSR ASSESSMENT POWG	**L-12-10 MONTHS**
FLIGHT PLANNING & STOWAGE REVIEW	**L-12-9 MONTHS**
EXPERIMENT TIM's	L-12-9 MONTHS
CREW FAMILIARIZATION BRIEFINGS	L-9 & 6 MONTHS
CREW TRAINING BEGINS	L-9 MONTHS
PHASE 2/3 SAFETY REVIEW	**L-12-7 MONTHS**
REVIEW BASIC FLIGHT PLAN	L-6 MONTHS
REVIEW BASIC PL OPS CHECKLIST	L-6 MONTHS
REVIEW BASIC PHOTO/TV CHECKLIST	L-6 MONTHS
REVIEW FOR DATA PACK/PREPARE FOR DN's	L-4 MONTHS
SAFETY CERTIFICATION LETTER FROM SSD/CLF	L-3 MONTHS
CEIT REQUIREMENTS TO NASA	L-3 MONTHS
SIMULATIONS BEGIN	L-3 MONTHS

FLIGHT OPERATIONS REVIEW	**L-3 MONTHS**
- FOR DN's due	FOR-2 weeks
- Prepare/Submit 482's	Post-FOR
REVIEW FINAL FLIGHT PLAN WITH FAO	L-2 MONTHS
REVIEW FINAL PL OPS CHECKLIST	L-2 MONTHS
REVIEW FINAL PHOTO/TV CHECKLIST	L-2 MONTHS
CREW EQUIPMENT INTERFACE TEST	**L-2 MONTHS**
- CEIT Hardware clean, bag and tag	CEIT-9 days
- CEIT Hardware to Boeing FEPC	CEIT-7 days
COFR's DUE TO NASA	L-2 MONTHS
ROLLOUT REVIEW	**L-2 MONTHS**
L-5 DAY LAUNCH SITE COORDINATION MEETINGS	L-1 MONTH
L-5 DAY LAUNCH SITE DRY RUN	L-1 MONTH
LANDING SITE COORDINATION MEETINGS	L-1 MONTH
LANDING SITE DRY RUN	L-1 MONTH
PERSONNEL LIST/SECURITY CLEARANCES SENT TO LANDING SITE	L-1 MONTH
BENCH REVIEW	**L-1 MONTH**
- Flight Hardware clean, bag and tag	BR-7 days
- Flight Hardware to Boeing FEPC	BR-5 days
CAPCOM DOD MIDDECK BRIEFING	L-1 MONTH
EST REVIEW WITH P/L AND FAO	L-1 MONTH
SPOM TEAM COORDINATION MEETING	L-1 MONTH
FLIGHT READINESS REVIEW	**L-14 DAYS**
LAUNCH READINESS REVIEW	L-10 DAYS
L-5 DAY LAUNCH SITE SECONDARY PAYLOAD ACTIVITY	L-5 DAYS
L-5 DAY LOCKER STOWAGE	L-5 DAY
LOCKER SHIP TO VAB	L-3 DAY
L-2 DAY MANAGEMENT REVIEW	L-2 DAYS
L-1 DAY PAYLOAD STATUS REVIEW	L-1 DAY
LAUNCH	
MISSION SUPPORT	**LAUNCH+**
DAILY SPSR REPORT ON SECONDARY PAYLOAD ACTIVITY	
LANDING	
POSTLANDING SECONDARY PAYLOAD ACTIVITY	LANDING+
PI CREW QUESTIONS DUE TO SPOM	LANDING +1 DAY
POST MISSION	
QUICK LOOK REPORT	LANDING + 1 WEEK
SECONDARY PAYLOAD CREW DEBRIEF	LANDING + 2 WEEKS

POST MISSION REPORT	LANDING + 30 DAYS
POST MISSION DATA COLLECTION/ANALYSES/REPORT	
FLIGHT HARDWARE RETURN TO JSC AND/OR PI	

Shuttle Capabilities & Payload Integration

Captain John R. Hennessey

SSD/CLPH (OL-AW)
Lyndon B. Johnson Space Center
Houston, TX 77058

May 1992

X200195M

Space Systems Division/CLPH
Space Test & Transportation Program

Operating Location - AW
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Houston, TX 77058

OVERVIEW

- **Shuttle Operating Environment**
- **Manifesting Process**
- **Space Test Program Support**
- **Upcoming Flights**
- **Space Station Freedom**

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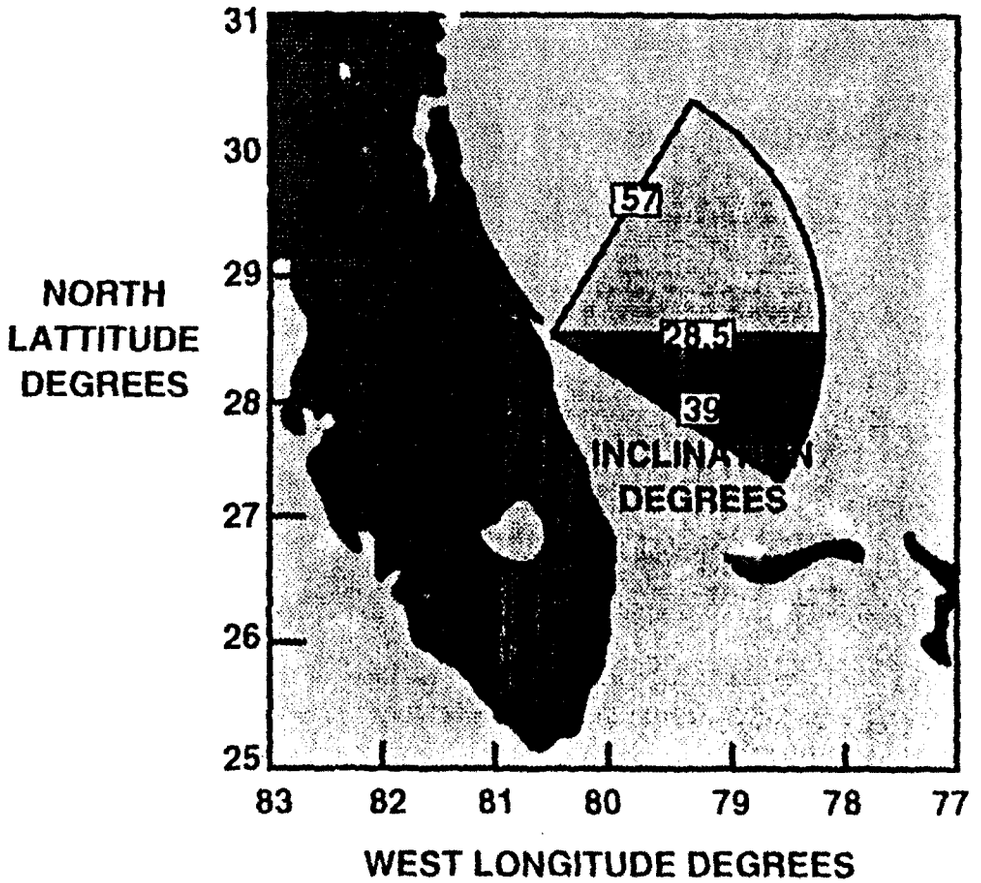
Shuttle Operating Environment

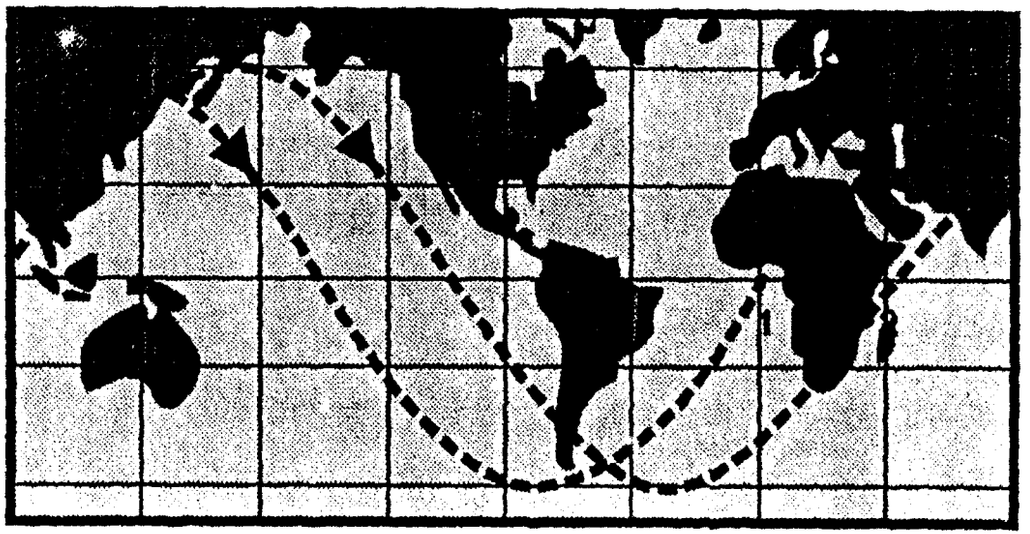
Altitude:	**120-~~130~~ 310 nm**
Orbital Period:	**89-95 min**
Orbit:	**Typically Circular**
Inclination:	**28.5 - 57 deg**
Ground Speed:	**4 nm/sec (17,550 mph)**
Regression:	**22.5 deg West/orbit**
Mission Duration:	**4-13 days (EDO - 30 days)**

Kennedy Space Center
Launch Inclination

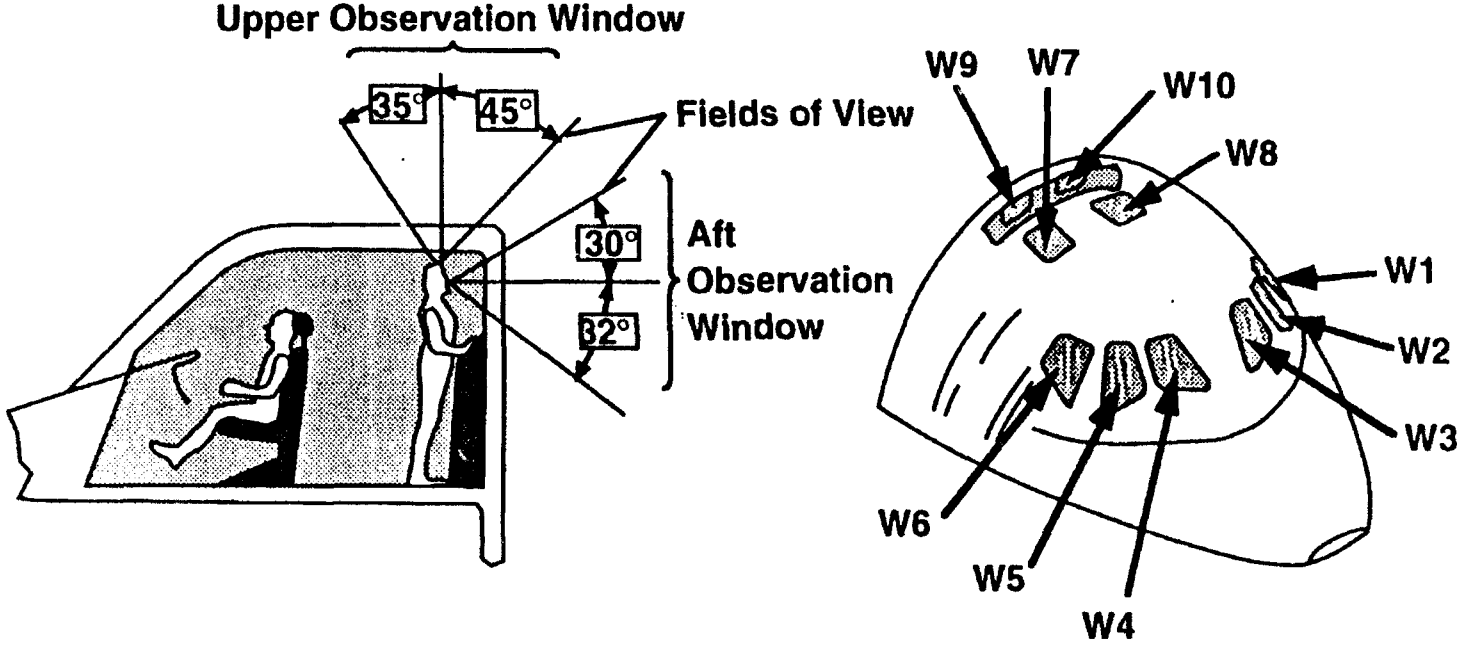


X200208M

Ground Track for Near Earth Satellite



STS Window Configuration



X200206M

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NASA Secure Operations

- **No secure air to ground**
- **Limited secure payload-related communications**
- **Classified documentation/conversations allowed in the FCR during SIMs and mission OPS**
- **Physical security/limited access for areas in CSR which have classified data in use**
- **Classified payload data packages may be stowed late**
- **Early destow of classified data products**

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Experiment Design Considerations

- **Stowage:**
  - **Each locker carries up to 54 lbs of payload**
  - **16 lbs reserved for packing materials and locker weight**
  - **Total volume is approximately 2 cubic feet**
  - **Limited control over how payload is stored**
  - **Payloads are allowed to replace lockers using standard locker mounting locations but must meet total allowable weight limits**

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Experiment Design Considerations

- **Power:**
  - **Orbiter Provided**
    - **Seven 28vdc outlets, 5 amps**
    - **Four 115vac outlets, 3 amps**
  - **Payload provided power:**
    - **Batteries previously flown include nickel-cadmium, alkaline-manganese, zinc-air, and lithium**
    - **All require safety certification**

** OL-AW should be contacted as early as possible in the design phase to preclude costly modifications and delays

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Manifesting Criteria

- **Suitable mission identified (ie: Altitude, Inclination, etc...)**
- **Experiment ranking by STP**
  - **STP payloads are included on the NASA Secondary Payload List**
- **Experiment readiness for flight**
- **Positive margin available**
  - **Shuttle performance**
  - **Prime payload growth**
  - **Secondaries**

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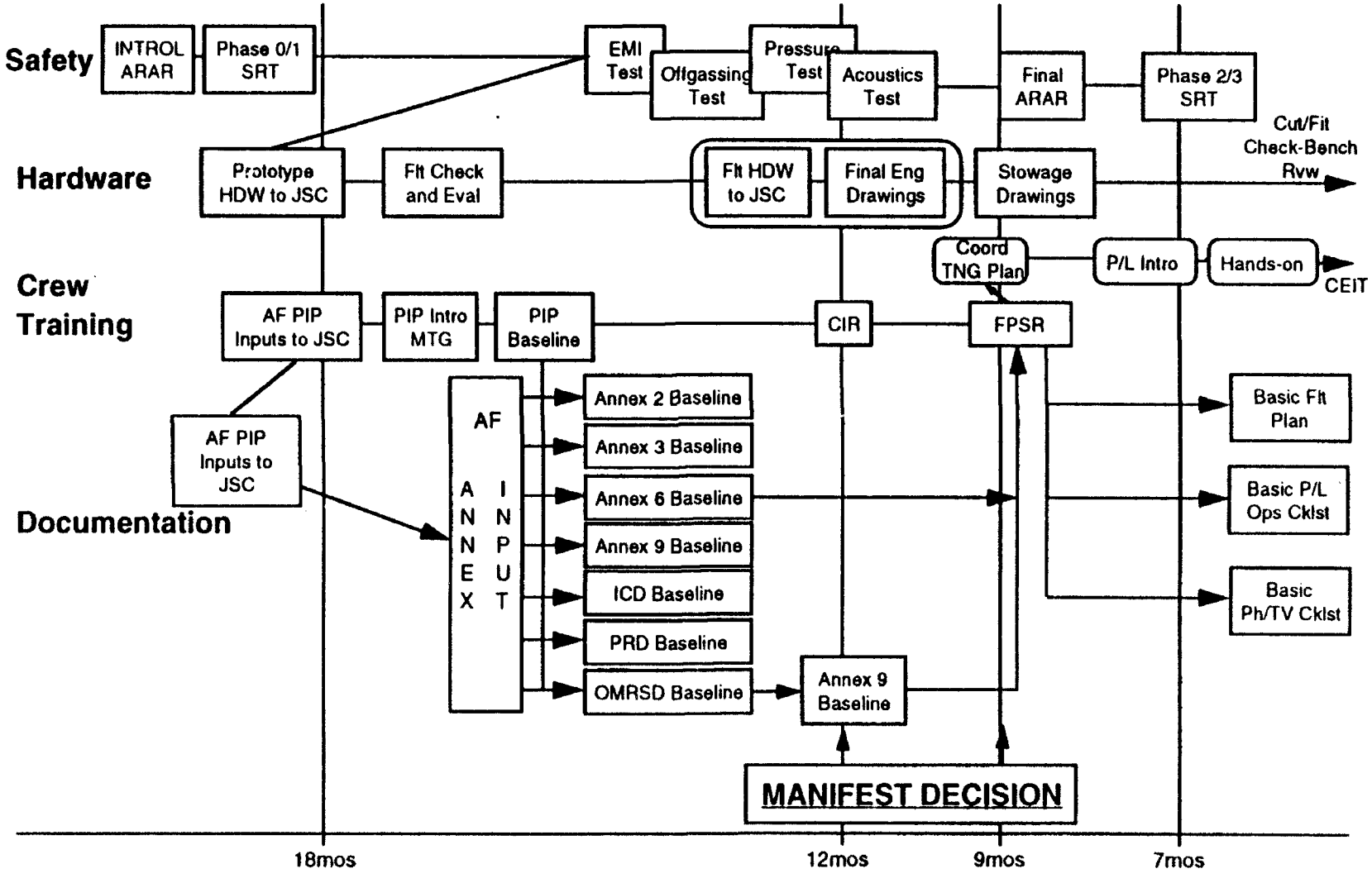
Secondary Payload Ground Rules

- **No (minimal) activity prior to primary payload activity**
- **Minimize requirements for attitude maneuvers**
- **No affect on launch date, time or mission orbital parameters**
- **Secondary payloads should be designed as flexible as possible**

Typical Middeck Secondary Payload Flow



Standard Timelines for Secondary P/Ls

X200201M

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Responsibilities of OL-AW

- **Assess experiment requirements and exercise STP programmatic control**
- **Pre-flight preparation**
  - **-Develop and coordinate MOAs and MOUs**
  - **-Prepare and forward requests for space flight (form 1628)**
  - **-Direct development of integration documentation**
  - **-Process payload hardware**
  - **-Perform safety certification actions**
  - **-Train Crew Members**
- **OPS Support**
  - **-Support mission operations during flight**
- **Post-flight**
  - **-Recover flight hardware and data**
  - **-Schedule/perform data takes**

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Mission Operations Support

- **Secondary Payload Operations Manager**
  - **DoD Mission Director Liaison**
  - **NASA Flight Control Team Interface**
- **Secondary Payload Mission Support Team**
  - **Payload technical expertise**
  - **Flight design system analysis**
  - **Coordination with remote locations**
  - **Realtime anomaly resolution and timeline replanning**

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Experiments Flown in 1991/92

STS-37	STS-39	STS-43	STS-48	STS-44	STS-42	STS-45
APM	APM	AMOS	APM	IOCM/APM	RME III	AMOS
AMOS	CLOUDS-1A	APE-B	RME III	TERRA SCOUT	AMOS	STL
RME III	RME III		AMOS	M88-1		RME III
	UVPI		CREAM	AMOS		CLOUDS-1A
			SAM	CREAM		UVPI
				RME III		
				VFT-1		
				UVPI		
				SAM		

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Projected Missions

- **Currently Manifested Experiments**

STS-53 (15 Oct 92)	HERCULES	CLOUDS-1A
	BLAST	CREAM
	RME III	MIS-1
	VFT-2	STL
	AMOS	UVPI
STS-49(5 May 92)	UVPI, AMOS	
STS-50 (3 Jun 92)	UVPI	
STS-46 (2 Jul 92)	UVPI, AMOS	
STS-47 (12 Aug 92)	UVPI, AMOS	
STS-52 (24 Sept 92)	RME III (Proposed), UVPI	
STS-54 (3 Dec 92)	HRSGS, RME III, VFT-2, UVPI (Proposed)	
STS-55, 51, 56 ('93)	Currently Under Review	

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Space Station Freedom Unique Capabilities

- **Lifetime of 30 years**
- **Internal and external payload accommodations in Micro-G and space environment**
- **Dedicated scientific laboratory**
- **Return/reflight of experiments**
- **Manned presence enhances experimentation process, allows for alteration of experiment operations, and maximizes capabilities**

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Space Station Freedom Mission Milestones

FY 96-97

First element launch to Man Tended Capability (MTC) in 6 assembly flights

FY 97-00

MTC to Permanently Manned Capability in 11 assembly flights

- 8 additional Utilization Flights (UF) scheduled (16 Days/UF)

FY 00- Beyond

PMC additions to accomplish eight man crew capability and increase laboratory elements

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Space Station Freedom and the DoD

- **DoD has made no commitment to fund, develop nor use the Space Station**

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Space Test & Transportation Program

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Summary

- **As an R&D platform, the Shuttle provides unique capabilities for experimentation**
- **Payload integration is an iterative process requiring close interaction between the experimenter, the integrating agency, and NASA**
- **Flight opportunities depend on the timely application of sponsor manpower, hardware development, and resource allocation**

New 1721 Forms

Both of the forms have been updated to reflect the current STP flight modes. References to obsolete modes (e.g., LDEF) were deleted, and new programs (e.g., CAP) were added.

Numerous items have been revised to make clear what data is required. This is particularly true for items where recent experience has shown that STP experimenters have not fully understood what information is required, or where the previous forms were ambiguous. For example, the new forms will allow the experiment power requirements and duty cycle to be stated more accurately. In addition, the new form allows the experimenter to more clearly state what experiment power is required from STP hardware and what will be provided by the experiment itself. This has been a source of confusion on numerous occasions in the past.

The new form allows the experimenter to describe what flight modes and orbit parameters would be acceptable. In addition, the telemetry and data handling sections were reworked. In the past, there was confusion about experiment data rates, real-time data rate, the amount of data storage needed, and so forth. Many PIs were making assumptions about the availability of ground station contacts in calculating these quantities and STP was unsure what assumptions they were making.

Items describing the program funding were changed to make more clear the funding needed for the experiment vs. what has actually been obtained.

The instructions were reworked to more clearly state what is needed and also to allow for easier reading than in the previous, sometimes terse, instructions. The layout of the forms were also changed to make it easier to read and easier to determine which sub-items belong under which major headings.

The forms now include spaces for items concerning individuals that have been needed, but not supplied, in the past. Mailing addresses, as well as office symbols, are now requested. Spaces for AUTOVON, as well as commercial, phone numbers are provided.

Finally, certain essential information, such as PI data, has been added to Form 1721-1, since this is the only form now required for many experiments

Points of contact for completion of these forms are MAJ Dan Cramer and CAPT Don Johnson, USAF Space Systems Division, SSD-CLPD, AV 833-6715, Commercial 213-363-6715.

SPACE TEST PROGRAM FLIGHT REQUEST EXECUTIVE SUMMARY

CLASSIFIED BY:

DECLASSIFY ON:

1. EXPERIMENT TITLE:

2. SHORT TITLE

3. EXPERIMENT NUMBER:

4. DATE OF SUBMISSION

5. DATE OF REVISION

6. OBJECTIVE

7. RELEVANCE TO SPECIFIC DOD REQUIREMENTS

8. REQUIREMENTS SUMMARY

a. FLIGHT MODE: (NOTE BY: 1-PREFERRED, 2-ACCEPTABLE, "BLANK"-UNACCEPTABLE)

☐ FREE-FLYER ☐ HITCH-HIKER ☐ SPARTAN ☐ STS LOCKER/ORSP
☐ G.A.S. ☐ C.A.P. ☐ SHUTTLE SORTIE
☐ OTHER (Specify)_____

b. HARDWARE FLIGHT READY DATE:

c. FLIGHT DURATION REQUIRED:

d. PAYLOAD SPECIALIST:
___ YES ___ NO ___ NOT APPLICABLE

e. WEIGHT (kg):

f. NOMINAL POWER (w):

g. DIMENSIONS (cm):
X X

h. VOLUME (cc):

i. STABILIZATION TYPE:

j. ORBIT REQUIREMENT (km):
APOGEE_____+_____-_____ PERIGEE_____+_____-_____

k. INCLINATION:

l. OTHER REQUIREMENTS:

9. PROGRAM SUMMARY

a. FUNDING STATUS

	PRIOR FISCAL YEARS	CURRENT FISCAL YEAR	FUTURE FISCAL YEARS	TOTAL
TOTAL NEEDED:				
SECURED TO DATE:				

b. DESIGN/FABRICATION STATUS

c. CONTRACTOR:

10. EXPERIMENTER AGENCY DATA

a. APPROVING OFFICIAL (Last, First, M.I.):

b. ACTIVITY:

c. POSITION:

d. MAILING ADDRESS:

e. TELEPHONE(S):
Com:
AV:

f. SIGNATURE:

g. PRINCIPAL INVESTIGATOR (Last, First, M.I.):

h. ACTIVITY:

i. POSITION:

j. MAILING ADDRESS:

k. TELEPHONE(S):
Com:
AV:

l. SIGNATURE:

Instructions For Completing DD Form 1721-1
Space Test Program Flight Request - Executive Summary

A. General

The Space Test Program Flight Request - Executive Summary requests information required by management for "quick look" understanding and evaluation of a proposed flight experiment. The Executive Summary will describe the objective(s) of the experiment and military value or relevance. It will also provide a summary of flight requirements, funding and hardware status.

B. Security

The form will be marked at the top and bottom with a security classification commensurate with the highest classification of any single entry on the page. For a classified form, the security classification of each block must be indicated such as (C) for CONFIDENTIAL). The downgrading block (Classified by: / Declassify On:) must also be completed.

C. Instructions for Form Items

1. *Experiment Title.* Select a title that describes the broad objectives of the experiment and uses one or more key words. Nicknames, equipment nomenclatures, acronyms, etc., should not be used. The title should be unclassified if possible.

2. *Short Title.* Nomenclature, acronyms, and nicknames are permissible, but should be unclassified if possible.

3. *Experiment Number.* Use up to five letters followed by a hyphen to identify the sponsor, then three numbers consisting of last digit of the the fiscal year (e.g. "9" for FY 1989) and the sponsor's log number in two digits.

4. *Date of Submission.* (Self-explanatory.)

5. *Date of Revision.* (Self-explanatory.)

6. *Objective:* Describe (in 50 words or less) what is to be accomplished. State the purpose/use of the expected results of the experiment. If there is more than one objective, treat each one separately. If the objective is classified, an unclassified version must be included, if possible.

7. *Relevance to Specific DoD Requirements:* Explain (in 50 words or less) why this experiment should be performed. Emphasize relevance to DoD as much as possible. Indicate potential improvement in military hardware or military operations.

8. *Requirements Summary:* Indicate by the notation scheme shown if the experiment is to be considered for the various flight means shown or explain other modes under "other." Hardware flight ready date (year-month-day) is the date on which the experiment could be delivered for integration with spacecraft or support equipment. Provide an estimate of the experiment's physical parameters, and the required orbital parameters. If technical requirements have not been fully determined, provide best estimate. Indicate any requirement for a payload specialist including the use of a payload specialist for free-flyer checkout before release.

9. *Program Summary:* Indicate funds previously obtained or expended to date, funds planned for the current fiscal year, and funds needed for future fiscal years. Distinguish between funds which are needed and those that have been secured. Total cost includes all costs supported by the experiment sponsor.

10. *Experimenter Agency Data:* Signature is required from the office that is authorized to transmit spaceflight requests to the Director of Space Systems and C^4, Headquarters SAF/AQS. The name block should include rank (if military) or title. Include full mailing address and commercial and/or Autovon phone numbers. Similar information should be provided for the Principal Investigator, who will be the primary contact to STP for the experiment.

SPACE TEST PROGRAM FLIGHT REQUEST

Preparation Date (YYMMDD) : Rev. ☐

CLASSIFIED BY:
DECLASSIFY ON:

PART I - REQUEST FOR SPACE FLIGHT

1. EXPERIMENT TITLE			2. SHORT TITLE
3. EXPERIMENT NUMBER	4. PROJECT NUMBER	5. TASK NUMBER	6. PROGRAM ELEMENT NUMBER
7. PROJECT OFFICE	8. MANAGEMENT OFFICE	9. SPONSOR	

10. PRINCIPAL INVESTIGATOR		
a. NAME (Last, First, M.I.)	b. ACTIVITY	c. POSITION
d. SIGNATURE	e. PHONE NUMBER(S) Com: AV:	f. DATE

11. STAFF APPROVAL		
a. NAME (Last, First, M.I.)	b. ACTIVITY	c. POSITION
d. SIGNATURE	e. PHONE NUMBER(S) Com: AV:	f. DATE

12. SPONSOR		
a. NAME (Last, First, M.I.)	b. ACTIVITY	c. POSITION
d. SIGNATURE	e. PHONE NUMBER(S) Com: AV:	f. DATE

13. PROJECT MANAGEMENT OFFICE		
a. NAME (Last, First, M.I.)	b. ACTIVITY	c. POSITION
d. SIGNATURE	e. PHONE NUMBER(S) Com: AV:	f. DATE

14. INTERMEDIATE ACTIVITY		
a. NAME (Last, First, M.I.)	b. ACTIVITY	c. POSITION
d. SIGNATURE	e. PHONE NUMBER(S) Com: AV:	f. DATE

15. DEPARTMENTAL APPROVAL		
a. NAME (Last, First, M.I.)	b. ACTIVITY	c. POSITION
d. SIGNATURE	e. PHONE NUMBER(S) Com: AV:	f. DATE

Instructions For Completing DD Form 1721
Space Test Program Flight Request

A. General

This DD Form 1721, Space Test Program Flight Request, solicits information needed to evaluate and select experiments proposed for spaceflight and enables STP to accomplish spaceflight planning analyses and payload integration studies prior to recommending assignments of experiments to spaceflights. Some general guidelines for completing this form are as follows:

1. Give actual information, if available; otherwise, use an estimate and so indicate. Dates will be shown (YYMMDD), which indicates year-month-day.

2. Submit a change when information previously submitted changes or when actual information becomes available to replace estimates. Fill in only those blocks necessary to identify the experiment and to note the change. In this case, be sure to check the "Rev." box in the date block at the top of page 1 of the form.

3. If the available space for any item is too small, use additional pages as needed. Although conciseness is desired, considerably more room may be required for specific items in individual cases.

4. It is important that the information on the form details all acceptable flight modes which would be considered. Clearly stating what flight modes would be acceptable increases the flight opportunities for a specific experiment.

5. For GAS (Get-Away Special), CAP (Complex Autonomous Payload) or QRSP (Quick Response Shuttle Payload) experiments, it is not necessary to complete Form 1721 (Form 1721-1 is sufficient). However, it may be desirable to complete Form 1721 to more clearly state the experiment requirements.

6. The form is in several parts. Parts I and III should be completed for all experiments. Part II is divided into separate sections for Shuttle payloads (Part II-A) and for free-flyer payloads (Part II-B). Fill out the section appropriate to the experiment. If it is desired that the experiment be considered for either means of flight, both Part II-A and Part II-B should be completed.

B. Security

The entire form will be marked with a security classification commensurate with the highest classification of any single entry. For a classified form, the security classification of each block must be indicated, such as (C) for CONFIDENTIAL. The downgrading block will be included on the first page of each 1721 submitted.

C. Instructions for Form Items

PART I - REQUEST FOR SPACEFLIGHT

1. *Experiment Title.* Select a title that describes the broad objectives of the experiment and uses one or more key words. Nicknames, equipment nomenclatures, acronyms, etc., will not be used. The title should be unclassified if possible.

2. *Short Title.* Nomenclature, acronyms, and nicknames are permissible, but should be unclassified if possible.

3. *Experiment Number.* Use up to five letters followed by a hyphen to identify the sponsor, then three numbers consisting of last digit of the the fiscal year (e.g. "9" for FY 1989) and the sponsor's log number in two digits. For example: the first experiment submitted by the

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

16. OBJECTIVE

17. RELEVANCE TO SPECIFIC DOD REQUIREMENTS

18. BACKGROUND

Geophysics Laboratory for FY 1989 would be GL-901. Once assigned, this number does not change.

4. *Project Number.* The experiment project number, or the number of the overall project of which the experiment is a part.

5. *Task Number.* The task number that the experiment is supporting.

6. *Program Element Number.* The DoD program element number of the program sponsoring the experiment.

7. *Project Office.* The activity to which the experimenter responsible for the experiment is assigned.

8. *Management Office.* The activity having management responsibility for the experiment.

9. *Sponsor.* The agency responsible for the program, project, or task being supported and controlling the resources to develop, fabricate and qualify the experiment.

10-15. *Approval as appropriate.* As a minimum, approval must include principal investigator, sponsor, and office having authority to forward request to SAF/AQS.

16. *Objective.* Describe what is to be accomplished. State the purpose/use of the expected results of the experiment. If there is more than one objective, treat each one separately in descending order of importance. If the objective is classified, an unclassified version must be included. Do not include the justification or description in this section. Note here possible modifications in the objectives and scope resulting from alternative flight options (sortie versus free-flyer and/or primary orbit versus alternate orbit).

17. *Relevance to Specific DoD Requirements.* Explain why this experiment should be performed. Emphasize relevance to DoD as much as possible. Multiagency relevance is particularly desirable. Consider the following questions as a guide in the development of your narrative, as applicable.

a. What is the relation to exploratory development or operational systems development programs?

b. For hardware developments and demonstrations, forecast results accruing through successful completion of this effort, including potential operational applications or improvements in present operational systems performance. What is the need for this hardware development? What will it do better? Why do it?

c. For exploratory development efforts, forecast the improvement in technology that is anticipated. Discuss how the proposed technology will be better than existing technology.

d. What is our present knowledge or capability in this area? What is the current state-of-the-art?

e. What are the technological alternatives? Why should this effort be made at this time?

18. *Background.* Provide a brief historical summary of the effort. If appropriate, include preliminary investigations in laboratories, ground facilities, aircraft, balloons, space probes, ballistic flights, and spaceflights. These may each be grouped with inclusive dates. References to documents or publications which summarize the history or current status of these efforts are desirable. List each historical flight, the results (i.e., success, failure), and the category of flight experiment (i.e., space probes, balloons, ballistic flights, and spaceflights). How does previous work make the proposed experiment practical? All experiments, not just those of your organization, should be reflected. Update this section as necessary with new developments.

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

19. ALTERNATIVES TO SPACEFLIGHT

20. FOLLOW-ON PLANS

19. *Alternatives to Spaceflight.* Explain why this experiment should be performed in space. Consider the following questions:

a. Why are ground, balloon, airplane, or space probe tests inadequate?

b. Why are existing data inadequate?

c. If similar or overlapping experiments are being performed by other agencies, explain how this proposal differs from (or is similar to) the other investigations, and comment on the following:

(1) Why should this DoD and similar or overlapping experiments should both be flown?

(2) How could either experiment be modified to suit the needs of the other?

(3) What efforts have been made to accomplish (2) preceding and with what results?

20. *Follow-on Plans.* What is the next step if this experiment is flown? Identify additional spaceflights anticipated. Does the present experiment require more than one flight? Indicate if the DD Form 1721 is to be used for justification for such flights.

21. *Description.* Tell how the experiment objectives are to be attained. Use the following as a guide, but include other relevant material.

a. Identify and discuss the technical approach or technique to be used.

b. Why is the proposed approach or technique better than others? Discuss in quantitative terms. What are the alternatives? What are the comparative advantages and disadvantages?

c. Identify and discuss the equipment to be used.

d. Discuss the risks involved.

22. *Pictorial.* Include a descriptive picture of the experiment.

PART II-A - TECHNICAL DETAILS, SPACE SHUTTLE SORTIE

Complete this section only if the experiment is to be considered for a Space Shuttle Sortie flight mode.

Otherwise, check the "not applicable" box and skip to Part II-B. In this case, the "required" category is checked on Item 49 of Part II-B.

23. *Orbiter Sortie Mode.* Check the item that describes if experiment is to be considered for sortie only, or if the sortie mode is an acceptable alternative (i.e., free-flyer as a first choice). Make sure that this block is consistent with Item 49 (Page 8).

24. *Standard Support Hardware Desired / Flight Options.* If experiment has been designed for a particular type of flight support equipment, describe that equipment. Also, note any mission peculiar flight options for this hardware. Describe briefly any nonstandard support required.

25. *Weight.* Provide the current best estimate of total experiment weight and expendable weight. "Expendables" include items that will be ejected from the Shuttle and/or consumed in the conduct of the experiment.

26. *Physical Dimensions.* List the physical dimensions of the hardware, making sure to note the way these dimensions are measured (for example: "W" for width, "H" for height, "L" for length, "D" or "DIA." for diameter, etc.).

27. *Total Volume.* Estimate the total volume of the experimental hardware.

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

21. DESCRIPTION

22. PICTORIAL

28. *Extension Beyond Bay Envelope.* If any portion of the experiment (excluding ejectables) extends outside the dynamic envelope of the Shuttle bay when fully deployed, check "yes."

29. *Power.* List the power requirement for each experiment mode. "Stand-by" denotes power needed when the experiment is not operating, but is drawing power ("keep warm" power). "Nominal" is the normal operating power. "Peak" denotes the highest power consumption level to be used. All entries should denote only the power that is to be provided to the experiment by the support equipment.

30. *Energy.* Provide the total energy requirement of the experiment under worst-case conditions. Do not include special processing undertaken in support of the experiment by the STP support hardware.

31. *Experiment Power.* If the experiment will provide some or all of its own power, note the experiment-provided power here. If the experiment will not contain its own power source, enter zero or "N/A".

32. *Typical Duty Cycle.* Enter the typical or nominal percentage of one day's operation for each of the power levels in Item 29.

33. *Maximum Duty Cycle.* Consider also a realistic maximum (most stressing) duty cycle.

34. *Mission Duration.* Express the mission duration requirements in days. Exclude from consideration time for ascent, descent, or deployment of host payload. "Nominal" denotes a typical mission. "Minimum" refers to the shortest time that could yield a successful experiment. "Maximum" might be dictated by battery life or other considerations; if there is no maximum, leave this item blank.

35. *Flight Date.* Indicate the quarter and calendar year of the preferred and latest date for flight. If no latest date can be provided at this time, write "open." The earliest date should be estimated based on the experiment delivery date, allowing a reasonable length of time for experiment integration. Best available information on subsequent flights required must be indicated.

36. *Orbital Parameters.* Consider the experiment requirements for orbit apogee, perigee, and inclination. Give most desirable nominal values and maximum plus/minus limits from these values. If no specific orbit is required, so state in "rationale." Include any other special requirements, such as circularity, sun synchronous orbits, etc. Acceptable alternative orbits should be noted in part "d." These orbits are to be considered alternatives to the primary orbit. If none are indicated, no consideration will be given to sortie flights for which the orbit parameters of parts a-c are not satisfied.

37. *Orbiter Orientation.* Use standard notation as much as possible to indicate Orbiter orientation requirements, if any. For example, Orbiter X, Y, and Z axes are standard airplane axes with origin at center of mass, X axis forward and Y axis out of right wing. LV denotes nadir or local vertical. POP denotes perpendicular-to-ecliptic plane. For example, +Z, LV denotes payload bay nadir oriented. Note any other attitude requirements needed to perform the experiment.

38. *Stabilization Requirements.* Provide experiment pointing accuracy and pointing knowledge requirements for line-of-sight and roll about line-of-sight. If special jitter or drift requirements are given, control duration should also be provided. If the experiment is to be mounted on an experiment-provided pointer, specifications on pointing, jitter or drift are not to be provided.

39. *Major Movements.* Discuss track or slew requirements. Indicate nature of targets and expected angular rates for pointing system, if known. Include under "other motions" requirements for instrumented booms, masts,

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

PART II-A - Technical Details, Space Shuttle Sortie

23. ORBITER SORTIE MODE
- ☐ NOT APPLICABLE (Skip to page 8)
- ☐ REQUIRED
- ☐ PREFERRED
- ☐ ACCEPTABLE

24. STANDARD SUPPORT HARDWARE DESIRED / FLIGHT OPTIONS

25. WEIGHT (kg) a. Total payload b. expendables

26. PHYSICAL DIMENSIONS (cm) x x

27. TOTAL VOLUME (cc)

28. EXTENSIONS BEYOND BAY ENVELOPE? ☐ YES ☐ NO

29. POWER (W) a. Nominal b. Max.Power c. Stand-by

30. ENERGY (WH)

31. EXP. POWER (W)

32. TYPICAL DUTY CYCLE (% of operation) a. Nom.Power b. Max.Power c. Stand-by

33. MAXIMUM DUTY CYCLE (% of operation) a. Nom.Power b. Max.Power c. Stand-by

34. MISSION DURATION (Days) a. Nominal b. Minimum c. Maximum

35. FLIGHT DATE (Quarter, Calendar Year)

a. PREFERRED | b. LATEST | c. EARLIEST | d. REFLIGHT | e. RATIONALE

36. ORBITAL PARAMETERS

	+(plus)	− (minus)
a. APOGEE (km)		
b. PERIGEE (km)		
c. INCLINATION (degrees)		

d. ALTERNATE ORBITS (acceptable if primary orbit is unavailable)

e. RATIONALE

37. ORBITER ORIENTATION REQUIREMENTS (comment where applicable)

a. X-AXIS

b. Y-AXIS

c. Z-AXIS

d. OTHER REQUIREMENTS

e. REMARKS

38. STABILIZATION REQUIREMENTS (pointing accuracy (degrees) /pointing knowledge (arc-sec.))

a. LINE-OF-SIGHT /

b. ROLL ABOUT LINE-OF-SIGHT /

c. JITTER OR DRIFT CONTROL

d. EXPERIMENT PROVIDED POINTER

e. REMARKS

RMS, or special field-of-view envelopes.

40. *Astronaut Participation.* Indicate by a check the functions an astronaut will be expected to perform. Provide an estimate of the astronaut duty cycle: how much crew time is required for set-up, checkout, operation, and stowage of the experiment. Summarize briefly the major tasks for the astronaut noting essential and desired functions.

41. *Ground Support Requirements During Flight.* Describe any coordinated ground support activities that will occur during the flight.

42. *Ephemeris Requirements.* Provide accuracy requirements in terms of a root sum square error or crosstrack, in-track, and radial errors; also indicate update requirements, if known. Indicate if the requirement is for real-time knowledge or post flight data.

43. *Telemetry And Data Handling.* Make best estimate of telemetry requirements. Acceptable delay times for ground reception should be indicated. Real-time downlink should be minimized to the extent possible. Consider astronaut monitoring and processing.

44. *On-Board Processing (Display & Control).* Special requirements, such as high speed processing or timeline-critical items, should be noted.

45. *Commands.* Estimate requirements for the different types of commands. Refer to "Guide to Standard Services." "Power on" and "power (for an item are considered separate commands. If it is determined that command storage is required, write "yes" in Item 45e.

46. *Experiment Complement/Package Data.* This section provides for a breakdown of the experiment into subassemblies based on packaging or modules, and/or in terms of separate experiments constituting the total experiment. Provide stowed and deployed (as applicable) dimensions in cm. The weight is to be provided in kg, and total weight for all items must agree with Item 25. Any ejected items such as sub-satellites or targets are to be noted. Any difference in the total weight of the "ejected" items here and the "expendables" in Item 25b are due to items consumed in in the experiment operations (e.g. cryogen). Indicate the status of final design drawings. Note the timetable of any critical specifications that are not presently determined.

47. *Space Shuttle Safety.* Indicate any radioactive, or hazardous materials and other safety considerations. Describe the status of any safety coordination activities with NASA that have been undertaken.

48. *Other Requirements.* Indicate here items not considered earlier, such as special contamination control requirements on Orbiter operations, experiment-support equipment, or other experiments. Note desirable correlative experiments (specific experiments or experiment classes) and unique temperature or thermal load requirements.

PART II-B - TECHNICAL DETAILS, FREE-FLYER MODE

Complete this section only if the experiment is to be considered for flight on a free-flying satellite. If this experiment must be flown as a Shuttle sortie, check the "not applicable" box and skip to Part III. The information in this box must be consistent with Item 23 (Page 5).

49. *Free-Flyer Mode.* Check items that describe if experiment is to be considered for free-flyer only, if a free-flyer is preferred, or if it is an acceptable alternative flight mode (i.e., Shuttle sortie as first choice).

50. *Experiment Class.* Check one of the following categories as follows:

Experiment Only - the experiment consists of one or more items requiring support from a spacecraft not provided as a part of the experiment.

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

39. MAJOR MOVEMENTS

a. TRACK

b. SLEW

c. OTHER MOTIONS

d. REMARKS

40. ASTRONAUT PARTICIPATION

a. TYPE

☐ MISSION SPECIALIST

☐ PAYLOAD SPECIALIST

b. FUNCTION

☐ MONITORING ☐ ANALYSIS

☐ COMMAND & CONTROL ☐ OTHER _____

c. ASTRONAUT DUTY CYCLE

d. DESCRIPTION OF ASTRONAUT DUTIES

41. GROUND SUPPORT REQUIREMENTS DURING FLIGHT

42. EPHEMERIS REQUIREMENTS

43. TELEMETRY & DATA HANDLING

a. DATA STORAGE REQUIREMENT (bits per orbit)

b. DATA OUTPUT RATE TO SPACECRAFT (bps)
(nominal) (maximum)

c. REAL-TIME DATA REQUIREMENTS (bps)

☐ REAL-TIME DATA NOT REQUIRED

☐ REAL-TIME DATA IS REQUIRED AT RATE _____

d. SPECIAL REQUIREMENTS

e. REMARKS

Complete Spacecraft - the experiment is to be supplied to STP as a self-contained spacecraft.

Piggyback Payload - the experiment is specifically designed as a piggyback payload for a specific spacecraft host.

51. *Weight.* Provide the current best estimate of total experiment weight and expendable weight. "Expendables" include items that will be ejected from the spacecraft and/or consumed in the conduct of the experiment.

52. *Physical Dimensions.* List the physical dimensions of the hardware, making sure to note the way these dimensions are measured (for example, "W" for width, "H" for height, "L" for length, "D" or "DIA." for diameter, etc.).

53. *Total Volume.* Estimate the total volume of the experimental hardware.

54. *Power.* List the power requirement for each experiment mode. "Stand-by" denotes power needed when the experiment is not operating, but is drawing power ("keep warm" power). "Nominal" is the normal operating power. "Peak" denotes the highest power consumption level to be used. All entries should denote only the power that is to be provided to the experiment by the support equipment.

55. *Energy.* Provide the total energy requirement of the experiment under worst-case conditions. Do not include special processing undertaken in the support of the experiment by the STP support hardware.

56. *Experiment Power.* If the experiment will provide some or all of its own power, note the experiment-provided power here. If the experiment will not contain its own power source, enter zero or "N/A".

57. *Typical Duty Cycle.* Enter the typical or nominal percentage of one day's operation for each of the power levels in Item 54.

58. *Maximum Duty Cycle.* Consider also a realistic maximum (most stressing) duty cycle.

59. *Mission Duration.* Express the mission duration requirements in months. Exclude from consideration time for ascent, or deployment of host payload. "Nominal" denotes a typical mission. "Minimum" refers to the shortest time that could yield a successful experiment. "Maximum" might be dictated by battery life or other considerations; if there is no maximum leave this item blank.

60. *Flight Date.* Indicate the quarter and calendar year of the preferred and latest date for flight. If no latest date can be provided at this time, write "open." The earliest date should be estimated based on the experiment delivery date, allowing a reasonable length of time for experiment integration.

61. *Orbital Parameters.* Consider the experiment requirements for orbit apogee, perigee, and inclination. Give most desirable nominal values and maximum plus/minus limits from these values. If no specific orbit is required, so state in "rationale." Include any other special requirements, such as circularity, sun synchronous orbits, etc. Acceptable alternative orbits should be noted in part "e." These orbits are to be considered alternatives to the primary orbit. If none are indicated, no consideration will be given to the experiment for missions in which the orbit parameters of parts a-c are not satisfied.

62. *Stabilization Requirements.* Indicate type of vehicle stabilization required, if any. For the spin stabilized case, additional information is required on the spin rate and spin vector. Indicate the relationship of the spacecraft major axis with the orbit plane. Provide experiment pointing accuracy and pointing knowledge requirements for line-of-sight and roll about line-of-sight. If special jitter or drift requirements are given, control duration should also be provided. If the experiment is to be mounted on an experiment-provided pointer,

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

44. ON-BOARD PROCESSING (DISPLAY & CONTROL)

a. NO. OF STANDARD DISPLAY FORMATS

b. TYPES OF FORMATS
☐ ALPHANUMERIC STATUS ONLY ☐ KEYBOARD
☐ HAND CONTROLLER ☐ OTHER (specify) _____

45. COMMANDS

a. NUMBER OF POWER COMMANDS

b. NUMBER OF DISCRETE COMMANDS

c. NO. OF SERIAL/DIGITAL COMMANDS

d. MAGNITUDE COMMAND WORD SIZE (bits)

e. COMMAND STORAGE

46. EXPERIMENT COMPLEMENT / PACKAGE DATA

a. ITEM	b. DIMENSIONS STOWED (cm)	c. DIMENSIONS DEPLOYED (cm)	d. WEIGHT	e. EJECTED?	f. RECOVERY?
≥					

g. OTHER PERTINENT DATA

h. DESIGN DRAWING SPECIFICATION STATUS

47. SPACE SHUTTLE SAFETY

a. POSSIBLE HAZARDS
- RADIOACTIVE DEVICES ☐ NO ☐ YES (if yes, material(s) _____, strength _____)
- HAZARDOUS MATERIALS ☐ NO ☐ YES (if yes, material(s) _____)
- OTHER ☐ NO ☐ YES (if yes, specify _____)

b. DESCRIBE SAFETY COORDINATION ACTIVITIES WITH NASA TO DATE (IF ANY)

48. OTHER REQUIREMENTS

specifications on pointing, jitter or drift are not to be provided.

63. *Major Movements.* Discuss track or slew requirements. Indicate nature of targets and expected angular rates for pointing system, if known. Include under "other motions" requirements for instrumented booms, masts, or special field-of-view envelopes.

64. *Ground Support Requirements During Flight.* Describe any coordinated ground support activities that will occur during the flight.

65. *Ephemeris Requirements.* Provide accuracy requirements in terms of a root sum square error or crosstrack, in-track, and radial errors; also indicate update requirements, if known.

66. *Telemetry and Data Handling.* Estimate the maximum amount of data to be taken on a typical orbit. Estimate the rates at which the spacecraft will be required to record the data. Make best estimate of telemetry requirements. Acceptable delay times for ground reception should be indicated. Real-time downlink should be minimized to the extent possible.

67. *Commands.* Estimate requirements for the different types of commands. "Power on" and "power off" for an item are considered separate commands. If it is determined that command storage is required, so indicate.

68. *Possible Hazards.* Indicate any radioactive, or hazardous materials and other safety considerations.

69. *Experiment Complement Package Data.* This section provides for a breakdown of the experiment into subassemblies, based on packaging or modules, and/or in terms of separate experiments constituting the total experiment. Provide stowed and deployed (as applicable) dimensions in cm. Provide weight in kg; the total weight for all items must agree with Item 51. Indicate the status of final design drawings. Note timetable of any critical specifications that are not presently determined.

70. *Other Requirements.* Provide any other information necessary to allow STP to meet the experiment requirements. Indicate here items not considered earlier, such as special contamination control requirements on the spacecraft or other experiments. Note desirable correlative experiments (specific experiments or experiment classes) and unique temperature or thermal load requirements. Indicate specific launch-window requirements, if any.

PART III - PROGRAM INFORMATION

71. *Funding Status.* (Self-Explanatory)

72. *Hardware Status.* (Self-Explanatory)

73. *Design-Freeze Date.* When the design has or will be "frozen." This normally occurs when detail drawings are released for hardware fabrication.

74. *Delivery Date.* When hardware could be delivered for integration into spacecraft or launch-vehicle system. Can be given in "months after flight assignment." Show as year, month, day when complete delivery date given.

75. *Funding Breakdown.* Total cost includes all funds expended by the sponsoring agency on the experiment or spacecraft. For future costs, estimates will be included. For each field in this item indicate the total funds needed for the item to the left of the slash, and the amount actually secured to the right.

76. *Budget/Program Authorization Number.* The budget and program authorization numbers approving the expenditure of funds for the experiment by the sponsoring agency or higher authority.

77. *Contractor.* Provide the name of the prime contractor.

78. *Geographical Location of Contractor Work.*

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

PART II-B - Technical Details, Free-Flyer Mode

49. FREE-FLYER MODE
- ☐ NOT APPLICABLE (Skip to page 11)
- ☐ REQUIRED
- ☐ PREFERRED
- ☐ ACCEPTABLE

50. EXPERIMENT CLASS
- ☐ EXPERIMENT ONLY
- ☐ COMPLETE SPACECRAFT
- ☐ PIGGYBACK PAYLOAD PREFERRED (HOST: _____)

51. WEIGHT (kg) a. Total payload | b. Expendables | c. spacecraft (if provided)

52. PHYSICAL DIMENSIONS (cm) x x

53. TOTAL VOLUME (cc)

54. POWER (W) a. Nominal | b. Maximum | c. Stand-by

55. ENERGY (WH)

56. EXP. POWER (W)

57. TYPICAL DUTY CYCLE (% of operation) a. Nom.Power | b. Max.Power | c. Stand-by

58. MAXIMUM DUTY CYCLE (% of operation) a. Nom.Power | b. Max.Power | c. Stand-by

59. MISSION DURATION (Months) a. Nominal | b. Minimum | c. Maximum

60. FLIGHT DATE (Quarter, Calendar Year)

a. PREFERRED | b. LATEST | c. EARLIEST

d. RATIONALE

61. ORBITAL PARAMETERS

a. APOGEE (km) +(plus) - (minus)

b. PERIGEE (km) +(plus) - (minus)

c. INCLINATION (degrees) +(plus) - (minus)

d. RATIONALE

e. ALTERNATE ORBITS (acceptable if primary orbit is unavailable)

f. AXIS/ORBIT PLANE RESTRICTIONS

62. STABILIZATION REQUIREMENTS (pointing accuracy (degrees)/pointing knowledge(arc-sec.))

a. STABILIZATION TYPE
- ☐ SPIN — SPIN RATE _____
- ☐ ANY
- ☐ 3-AXIS
- ☐ OTHER (specify)

b. ROLL /

c. PITCH /

d. YAW

e. JITTER OR DRIFT

f. OTHER REQUIREMENTS

g. REMARKS

Location of the hardware if already fabricated, or the design/manufacturing effort.

79. *Contract Number.* (Self-Explanatory).

80. *Planned Contract Obligation Date.* Indicate when contracts were or will be let to design, build, or support the experiment or spacecraft.

81. *Coordination.* Summarizes the coordination and concurrence obtained from other DoD agencies and/or NASA. Give names, offices and the phone numbers. As appropriate, indicate the result of this coordination. Give special consideration to the issue of similar and duplicative experiments in terms of objectives and/or techniques. Significant changes resulting from continuing coordination will be reported as appropriate. Attach additional pages if necessary with the new preparation dates.

In part "i", discuss similarities with other experiments, plans for consolidation, data exchange, etc. It is recommended that experimenters coordinate with SSD/CLPD to discuss experiment requirements, complexity, and compatibility with potential spacecraft opportunities.

82. *Plan for Data Processing & Dissemination of Results.* Describe how the data will be processed and results disseminated to potential users.

83. *Security Information.* Designate items "a" through "e" with the highest security applicable to this experiment by U (for UNCLASSIFIED), C (for CONFIDENTIAL), S (for SECRET), or T (for TOP SECRET). Under "other classified items" identify other classified elements of the experiment and show their classification.

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

63. MAJOR MOVEMENTS (explain and provide rates)

a. TRACK

b. SLEW

c. OTHER MOTIONS

d. REMARKS

64. GROUND SUPPORT REQUIREMENTS DURING FLIGHT

65. EPHEMERIS REQUIREMENTS

66. TELEMETRY & DATA HANDLING

a. DATA STORAGE REQUIREMENT (bits per orbit)

b. DATA OUTPUT RATE TO SPACECRAFT (bps)
(nominal) (maximum)

c. REAL-TIME DATA REQUIREMENTS (bps)
☐ REAL-TIME DATA NOT REQUIRED
☐ REAL-TIME DATA IS REQUIRED AT RATE _____

d. SPECIAL REQUIREMENTS

e. REMARKS

67. COMMANDS

a. NUMBER OF POWER COMMANDS

b. NUMBER OF DISCRETE COMMANDS

c. NO. OF SERIAL/DIGITAL COMMANDS

d. MAGNITUDE COMMAND WORD SIZE (bits)

e. COMMAND STORAGE

f. REAL-TIME COMMAND PROGRAMMING REQUIREMENTS (describe)

68. POSSIBLE HAZARDS

- RADIOACTIVE DEVICES ☐ NO ☐ YES (if yes, material(s)_____, strength_____)
- HAZARDOUS MATERIALS ☐ NO ☐ YES (if yes, material(s)_____)
- OTHER ☐ NO ☐ YES (if yes, specify _____)

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

69. EXPERIMENT COMPLEMENT / PACKAGE DATA

a. ITEM	b. DIMENSIONS STOWED (cm)	c. DIMENSIONS DEPLOYED (cm)	d. WEIGHT (kg)

e. OTHER PERTINENT DATA

f. EXPERIMENT EQUIPMENT MOUNTING RESTRICTIONS

g. DESIGN DRAWING SPECIFICATION STATUS

70. OTHER REQUIREMENTS

Experiment Number _____ Experiment Title _____ Preparation Date (YYMMDD): _____

PART III - Program / Security Information

71. FUNDING STATUS ☐ TOTAL ☐ PARTIAL ☐ UNFUNDED

72. HARDWARE STATUS ☐ FLT.READY ☐ UNDER CONST. ☐ BREADBOARD ☐ DESIGN ☐ CONCEPT

73. DESIGN-FREEZE DATE

74. DELIVERY DATE

75. FUNDING BREAKDOWN ($ NEEDED / $SECURED)

a. ITEM	b. PRIOR FY FUNDS	c. CURRENT FY FUNDS	d. FUTURE FY FUNDS	e. TOTAL COST
PROTOTYPE	/	/	/	/
HARDWARE	/	/	/	/
STAFF COSTS	/	/	/	/
DATA REDUCTION	/	/	/	/
TOTAL	/	/	/	/

76. BUDGET / PROGRAM AUTHORIZATION NO.

77. CONTRACTOR

78. LOCATION OF CONTRACT WORK

79. CONTRACT NO.

80. PLANNED CONTRACT OBLIGATION DATE

81. COORDINATION

a. NAME (Last, First, M.I.) | b. OFFICE | c. TELEPHONE

d. COORDINATION RESULTS

e. NAME (Last, First, M.I.) | f. OFFICE | g. TELEPHONE

h. COORDINATION RESULTS

i. COORDINATION SUMMARY

82. PLAN FOR DATA PROCESSING AND DISSEMINATION OF RESULTS

83. SECURITY INFORMATION (State Highest Levels)

a. EXPERIMENT OBJECTIVES | b. TIMELINE | c. EXTERNAL VIEW

d. EXPERIMENT DATA | e. INTERNAL FEATURES

f. OTHER CLASSIFIED ITEMS

APPENDIX H

Miscellaneous Documentation

1. Battlefield Development Plan.

The Battlefield Development Plan (BDP) is the Army Training and Doctrine Command's (TRADOC) assessment of the Army's ability to execute the approved umbrella concept. It provides a consolidated and prioritized listing of war fighting needs and helps TRADOC implement its mission to be the Architect of the Future Army. As one of the key products of the Concept Based Requirements System (CBRS), the BDP provides a basis for the identification and prioritization of solutions in the areas of doctrine, training, leader development, organization, and material.

a. The Branch Planning Analysis (BPA) process provides the basis for identification of war fighting needs in the BDP. The Combined Arms Command (CAC), with support from the Combined Arms Support Command (CASCOM), TRADOC schools and the Deputy Chief of Staff for Analysis (DCSA), conducted extensive analytical efforts from October 1988 through October 1990 which culminated in the current BDP. They considered historical perspective, doctrine, and Army missions. They also considered current and projected threats, war fighting environments, concepts, and friendly capabilities. They have analyzed our programmed forces' ability to defeat the projected threats in a variety of scenarios. CAC consolidated the resultant capability issues, prioritized them based on importance, and provided the prioritized list to centers and schools for branch-related analysis.

b. Branches reviewed the prioritized results and identified, from a branch perspective, any appropriate additional issues. Integrating centers then combined the branch capability issues. CAC staffed the draft BDP with Major Commands (MACOMs) and Commanders' in Chief (CINCs), incorporated appropriate recommendations, and obtained CG, TRADOC approval. Following this series of staff reviews the results were submitted in draft BDP 94-08 to HQ TRADOC.

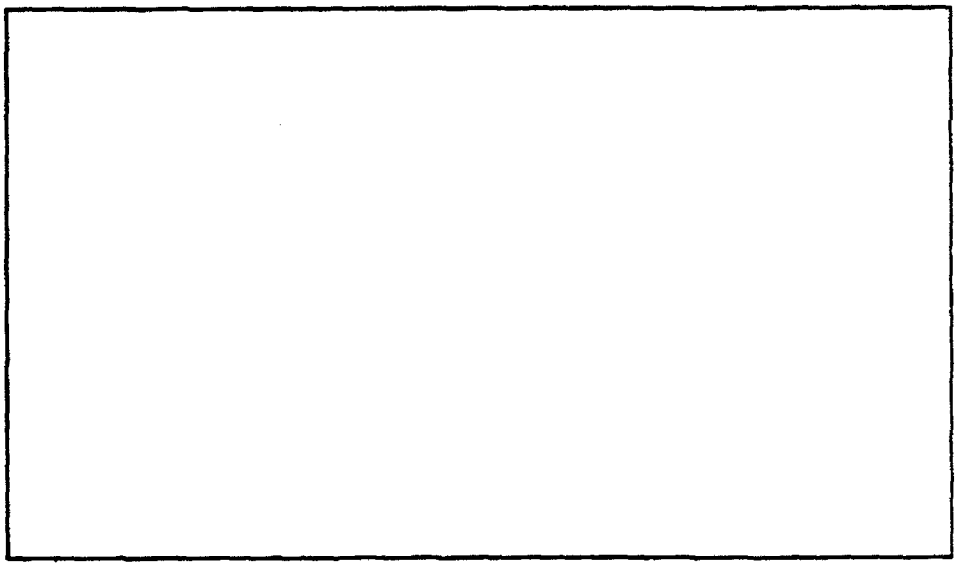
c. The BDP represents a multi-branch perspective of future Army war fighting needs and provides a logical basis for development of strategy for the future Army. The BDP will be used as the basis for developing the Army Modernization Memorandum, a follow-on document that will provide a recommended priority of solutions for input into the Army's Planning, Programming, Budgeting, and Execution Systems (PPBES).

d. Requirements applicable to both imagery and space technologies include the following:

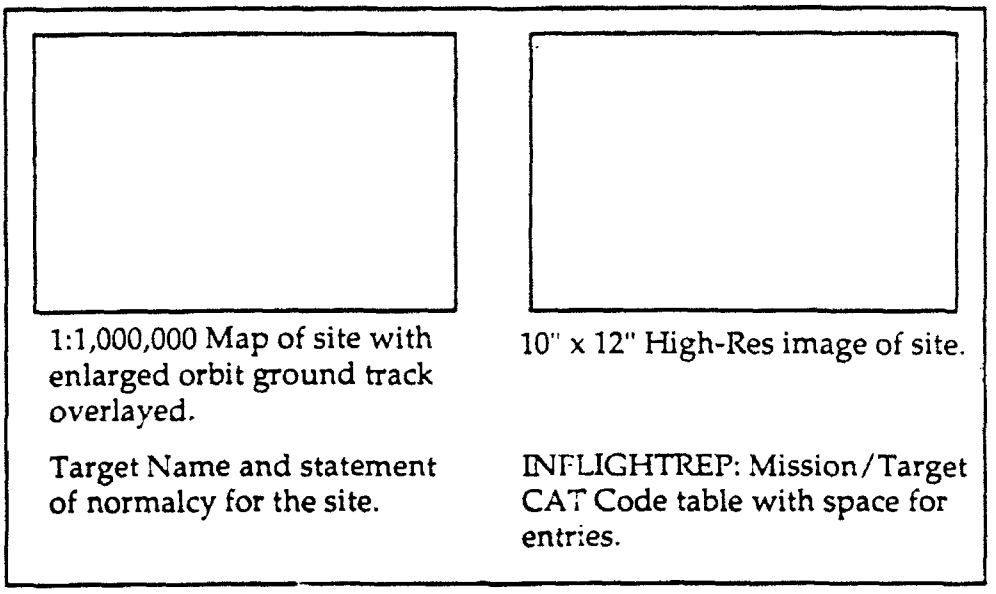
(1) Collecting threat information.
(2) Locating targets beyond line-of-sight.
(3) Imagery on deep targets.

(4) Target identification during periods of limited visibility.
(5) Detecting minefields.
(6) Identify nuclear weapons, storage and production areas.
(7) Detecting nuclear, biological, chemical (NBC) hazards.
(8) Information integration for battlefield decision-making.
(9) Exploitation of space capability to acquire target data.
(10) Timely target damage assessment (TDA) beyond line-of-sight.
(11) Map production.
(12) Cross-cueing from/to other sensors.

2. **Target Folder Example.**



Side 1 - 20" x 24" color photo taken from orbit during previous space mission. This photo provides a view of how the approach to the ground target site will appear from orbit.



Essential elements of Information (EEI) were not established separately for each target site. Guidance and required reporting items specified in the *Imagery Interpretation Requirements For Reconnaissance Systems, RADC-TR-90-370,* was used for all target sites.

3. Mission Ground Track. Graphic of actual ground track is included at the end of this appendix.

APPENDIX I

Abbreviations and Acronyms

AFS	Air Force Station
AAMRL	Armstrong Aerospace Medical Research Laboratory
ASQ	Anxiety Scale Questionnaire
BDP	Battlefield Development Plan
CCD	Charge Coupled Device
DARPA	Defense Advanced Research Projects Agency
DCSINT	Deputy Chief of Staff (for) Intelligence
DCSRDA	Deputy Chief of Staff for Research and Development (ARMY)
DE	Data Element
DIA	Defense Intelligence Agency
DR	Data Requirement
DSSM	Department of Systems Surveillance Maintenance
EEI	Essential Elements of Information
EPI	Eysenck Personality Inventory
FIGS	Flexible Image Generation System
FOV	Field of View
GTRI	Georgia Technical Research Institute
HQDA	Headquarters, Department of the Army
IA	Imagery Analyst
ICD	Interface Control Document
INSCOM	Intelligence and Security Command (Army)
IMINT	Imagery Intelligence
IPDS	Imagery Processing and Dissemination System, the Army system developed by the Joint Service Imagery Processing System (JSIPS)
JSC	Johnson Space Center (Houston, TX)
JSIPS	Joint Service Imagery Processing System
KSC	Kennedy Space Center (Cape Canaveral, FL)
L-1	(L-2,3,etc.) relates to launch time +/- number of hours, days, months, etc.
LED	Light Emitting Diode

MAA	Mission Area Analysis
MADP	Mission Area Development Plan
MBTI	Myers-Briggs Type Indicator
MET	Mission Elapsed Time
MI	Military Inteiligence
MMIS	Military Man in Space
MOS	Military Occupational Specialty
MPU	Microprocessor Unit
MS	Mission Specialist
MS1	Mission Specialist #1 on STS-44
NASA	National Aeronautics and Space Administration
NSTS	National Space Transportation System (usually shortened to STS)
NTM	National Technical Means
OPSEC	Operations Security
PIP	Payload Integration Plan
PS	Payload Specialist
PS1	Payload Specialist #1 on STS-44, The PS/IA conducting Terra Scout
RAF	Royal Air Force
SME	Subject Matter Expert
SpaDVOS	Space-borne Direct-View Optical System
SPSR	Secondary Payload Support Room
SSP	Space Shuttle Program
STS	Space Transportation System
TASIF	TENCAP Applications and Systems Integration Facility
TRADOC	Training and Doctrine Command (United States Army)
USAEPG	United States Army Electronic Proving Ground
USAETL	United States Army Engineering Topographic Laboratory (now USATEC, Topographic Engineering Center)
USAIC&FH	United States Army Intelligence Center and Fort Huachuca (Successor to USAICS in 1991)
USAF	United States Air Force