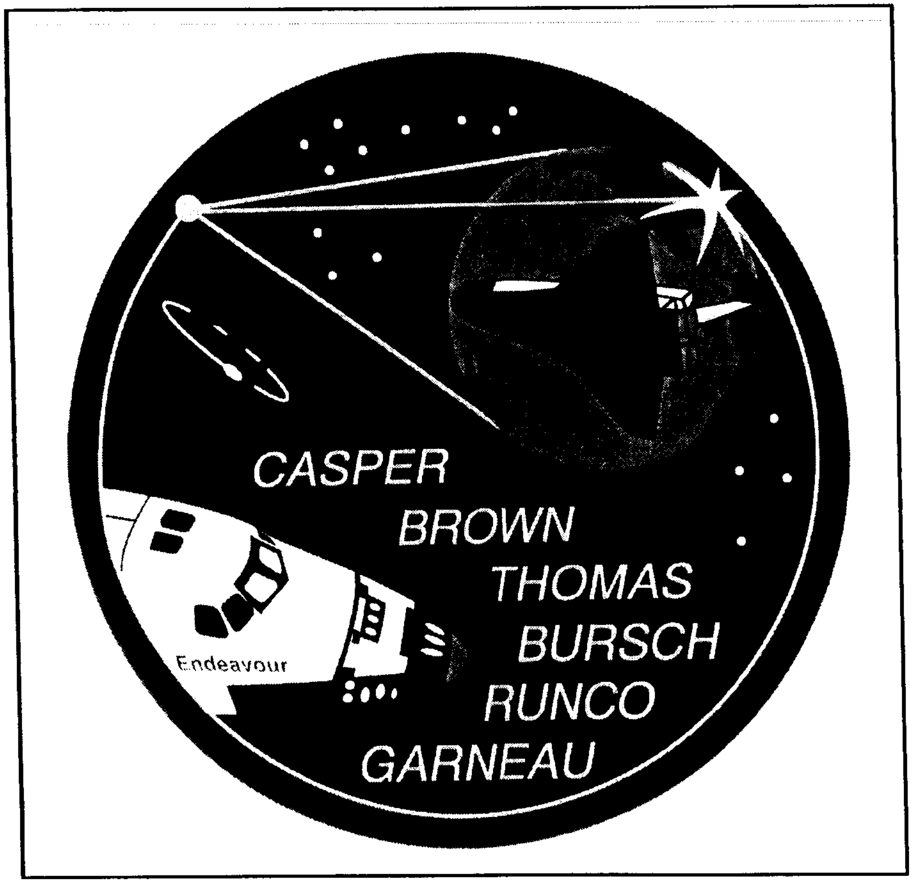


STS-77
PRESS INFORMATION AND MISSION TIME LINE

May 1996

Rockwell

Office of Media Relations
Space Systems Division

PUB 3546-V Rev 5-96

CONTENTS

MISSION OVERVIEW

This is the fourth space shuttle flight of 1996, the 11th flight of Endeavour, and the 77th mission for the space shuttle.

The flight crew for the ten-day STS-77 mission is commander John H. Casper, pilot Curtis L. Brown Jr., and mission specialists Daniel W. Bursch, Mario Runco Jr., Andrew S. W. Thomas, and Marc Garneau, a Canadian astronaut. The crew will work a single shift.

PRIMARY OBJECTIVES

Endeavour will be carrying three primary payloads on this mission: SPACEHAB-4, the SPARTAN 207 free-flying satellite, and four Technology Experiments for Advancing Missions in Space, or TEAMS.

This is the fourth flight for SPACEHAB, a pressurized laboratory in the orbiter's payload bay designed to support orbiter middeck experiments. The SPACEHAB complement of experiments includes 12 commercial space product development payloads in the areas of biotechnology, electronic materials, polymers, and agriculture as well as several experiments for other NASA payload organizations.

Among the SPACEHAB experiments are a study of advanced techniques for separating organic materials that may lead to improved medical products, investigations of various methods of growing high-quality crystals and gas-permeable membranes for use in contact lenses, an evaluation of tissue loss, and a study of plant growth. Many of the investigations are continuations of experiments that flew on previous shuttle missions.

The Goddard Space Flight Center's Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) satellite will be used to deploy and test an inflatable antenna. The experiment will lay the groundwork for the future development of inflatable space structures. SPARTAN will be deployed from the orbiter with the inflatable antenna attached for a 90-minute evaluation of the inflation and performance of the antennna. After the testing is complete, the antenna will be jettisoned and SPARTAN will be retrieved by the shuttle crew and returned to Earth.

The TEAMS payload consists of four experiments mounted on a Hitchhiker carrier in the payload bay. The Vented Tank Resupply Experiment will test improved methods of in-space refueling. The Global Positioning System Attitude and Navigation Experiment will determine how accurate the attitude information provided to space vehicles by the GPS constellation of satellites is. The Liquid Metal Thermal Experiment will evaluate the performance of liquid metal heat pipes. The Passive Aerodynamically Stabilized Magnetically Damped Satellite will be deployed from the orbiter to demonstrate aerodynamic stabilization in the upper atmosphere.

SECONDARY OBJECTIVES

The Aquatic Research Facility is a joint project of NASA and the Canadian Space Agency that will be used to study a wide range of small aquatic animals. Scientists will be able to use the facility to study fertilization, embryo formation, development of calcified tissue, and feeding behavior. This is the first flight of ARF.

The Brilliant Eyes Ten-Kelvin Sorption Cryocooler Experiment will seek to demonstrate that sorption coolers, which can quickly cool sensors to near absolute zero, can operate in the absence of gravity. Sorption coolers have practically no vibration, which interferes with pointing accuracy, and can operate reliably for more than ten years.

The Biological Research in Canisters payload, which carries investigations of the effects of space flight on small anthropod animals and plants, has flown on many shuttle missions. On this mission, BRIC will study pupae of the tobacco hornworm to clarify the mechanisms involved in the insect's endocrine system. Researchers hope this study will aid their study of endocrine systems in general, particularly those of humans in space.

Endeavour will also be carrying 12 getaway special payloads in the payload bay. These self-contained experiments include investigations of gamma ray bursts, the effects of high-energy particles on memory devices, the heat transport mechanism of boiling, and the processes involved in the formation of glass melts.

Nine development test objectives and eight detailed supplementary objectives are scheduled to be flown on STS-77.

MISSION STATISTICS

Vehicle: Endeavour (OV-105), 11th flight, 108th U.S. human space flight

Launch Date/Time:

5/19/96	6:30 a.m., EDT (day) 5:30 a.m., CDT 3:30 a.m., PDT

The original target date of May 16 was not available on the eastern range schedule.

Launch Site: Kennedy Space Center (KSC), Fla.—Launch Pad 39B

Launch Window: Two hours, 30 minutes (crew-on-back constraint)

Launch Period: Four hours. The launch period opens on the sunrise-at-KSC constraint and closes on the four-hour range constraint.

Mission Duration: 10 days, 37 minutes

The nominal duration is nine days. A highly desirable additional day cannot be guaranteed due to consumables but may be achievable. Planning will accommodate the longer duration wherever appropriate. The additional day will provide a second PAMS-STU stationkeeping opportunity.

The capability will be provided for two additional days for contingency operations and weather avoidance.

Landing: Nominal end-of-mission landing on orbit 161

5/29/96	7:07 a.m., EDT (day) 6:07 a.m., CDT 4:07 a.m., PDT

Runway: Nominal end-of-mission landing on runway 15, KSC, Fla.; alternates are Edwards Air Force Base (EAFB), Calif., and Northrup Strip (NOR), White Sands, N.M.

Transatlantic Abort Landing: Ben Guerir, Morocco; alternates: Moron, Spain, and Zaragoza, Spain

Return to Launch Site: KSC

Abort-Once-Around: KSC; alternate: EAFB

Inclination: 39 degrees

Ascent: The ascent profile for this mission is a direct insertion. Only one orbital maneuvering system thrusting maneuver, referred to as OMS-2, is used to achieve insertion into orbit. This direct-insertion profile lofts the trajectory to provide the earliest opportunity for orbit in the event of a problem with a space shuttle main engine.

The OMS-1 thrusting maneuver after main engine cutoff plus approximately two minutes is eliminated in this direct-insertion ascent profile. The OMS-1 thrusting maneuver is replaced by a 5-foot-per-second reaction control system maneuver to facilitate the main propulsion system propellant dump.

Altitude: 153 nautical miles (176 statute miles)

Primary Attitude: Various

Scheduled EVA: None

Crew provisions will support the performance of three two-crew member EVAs to accomplish the following unscheduled and contingency EVA requirements:

- Perform a contingency EVA to position the Ku-band antenna for stowing
- Perform a contingency EVA to close and/or latch the payload bay doors
- Perform an RMS contingency EVA to do an RMS joint alignment, an RMS shoulder brace release, an RMS tiedown, an MPM deployment and an MPM stow
- Perform one unscheduled EVA to retrieve and/or stow SPARTAN 207. An EVA may be performed to deploy SPARTAN 207 if a second EVA will not be required to retrieve/stow.
- Perform a contingency EVA to release/jettison SPARTAN 207 from the release/engage mechanism or SPARTAN 207/REM combination from the mission-peculiar equipment
- Perform a contingency EVA to disconnect the RMS end effector from SPARTAN 207

Payload Deployments: Shuttle Pointed Research Tool for Astronomy (SPARTAN) 207/Inflatable Antenna Experiment (IAE); Technology Experiments Advancing Missions in Space (TEAMS)/Passive Aerodynamically Stabilized Magnetically Damped Satellite (PAMS) Satellite Test Unit (STU)

SPARTAN 207/IAE deployment is scheduled on orbit 17 at MET 1/00:59.

TEAMS/PAMS-STU deployment is scheduled on orbit 48 at MET 2/22:48.

Payload Retrievals:

SPARTAN 207/IAE retrieval is scheduled on orbit 35 at MET 2/04:25.

Rendezvous:

TEAMS/PAMS-STU rendezvous on flight days 4 and 7 and, if on-orbit consumables allow, flight day 8

Space Shuttle Main Engine Thrust Level During Ascent: 104 percent

Space Shuttle Main Engine Locations:

No. 1 position: Engine 2037*
No. 2 position: Engine 2040*
No. 3 position: Engine 2038*

*Block I SSME

STS-77 is the first mission to fly three Block I SSMEs

External Tank: ET-78

Solid Rocket Boosters: BI-080

Redesigned Solid Rocket Motors: RSRM-047

Mobile Launcher Platform: 1

Cryo Tank Sets: 5 (fully loaded)

Software: OI-24 (ninth flight)

Editor's Note: The following weight data are current as of May 15, 1996:

Total Lift-off Weight: Approximately 4,518,947 pounds

Orbiter Weight, Including Cargo, at Lift-off: Approximately 254,538 pounds

Orbiter (Endeavour) Empty and 3 SSMEs: Approximately 174,766 pounds

Payload Weight Up: Approximately 26,971 pounds

Payload Weight Down: Approximately 26,149 pounds

Orbiter Weight at Landing: Approximately 221,382 pounds

Payloads—Payload Bay (* denotes primary payloads): Shuttle Pointed Research Tool for Astronomy (SPARTAN) 207/Inflatable Antenna Experiment (IAE);* Technology Experiments Advancing Missions in Space (TEAMS) 01 (TEAMS experiments include Vented Tank Resupply Experiment [VTRE], Global Positioning System [GPS] Attitude and Navigation Experiment [GANE] [RME 1316], Liquid Metal Test Experiment [LMTE] and Passive Aerodynamically Stabilized Magnetically Damped Satellite [PAMS] Satellite Test Unit [STU]);* SPACEHAB-4; Brilliant Eyes Ten-Kelvin Sorption Cryocooler Experiment (BETSCE); 12 getaway specials attached to a GAS bridge assembly (GAS 056, 063, 142, 144, 163, 200, 490, 564, 565, 703, 741 and the Reduced-Fill Tank Pressure Control Experiment [RFTPCE])

Payloads—Middeck: Aquatic Research Facility (ARF) 01; Biological Research in Canisters (BRIC) 07, Block III

Flight Crew Members:

Commander: John H. Casper, fourth space shuttle flight
Pilot: Curtis (Curt) L. Brown, Jr., third space shuttle flight
Mission Specialist 1: Andrew (Andy) S. W. Thomas, first space shuttle flight
Mission Specialist 2: Daniel (Dan) W. Bursch, third space shuttle flight
Mission Specialist 3: Mario Runco, Jr., third space shuttle flight
Mission Specialist 4: Marc Garneau, Canadian Space Agency, second space shuttle flight

Work Shift: Single shift

Ascent and Entry Seating:

Ascent:

Flight deck, front left seat, commander John H. Casper
Flight deck, front right seat, pilot Curtis (Curt) L. Brown, Jr.
Flight deck, aft center seat, mission specialist Daniel (Dan) W. Bursch
Flight deck, aft right seat, mission specialist Andrew (Andy) S. W. Thomas
Middeck, mission specialist Mario Runco, Jr.
Middeck, mission specialist Marc Garneau, Canadian Space Agency

Entry:

Flight deck, front left seat, commander John H. Casper
Flight deck, front right seat, pilot Curtis (Curt) L. Brown, Jr.
Flight deck, aft center seat, mission specialist Daniel (Dan) W. Bursch
Flight deck, aft right seat, mission specialist Marc Garneau, Canadian Space Agency

Middeck, mission specialist Andrew (Andy) S. W. Thomas
Middeck, mission specialist Mario Runco, Jr.

Extravehicular Activity Crew Members, if Required:

Extravehicular (EV) astronaut 1: mission specialist Mario Runco, Jr.
EV2: mission specialist Daniel (Dan) W. Bursch

Intravehicular Astronaut: Pilot Curtis (Curt) L. Brown, Jr.

RMS Operators: Mission specialists Marc Garneau, Canadian Space Agency; Mario Runco, Jr.; and Andrew (Andy) S. W. Thomas (backup)

Entry: Automatic mode until subsonic, then control stick steering

Flight Directors:

Ascent/Entry: Rich Jackson
Orbit 1: Bryan Austin
Orbit 2/Lead: Wayne Hale
Planning: Linda Ham

Notes:

- Among the equipment installed on Endeavour are the EDO nitrogen mission kit, middeck utility panel, port provisions stowage assembly, fifth cryo tank set, payload data interface panel, spare payload data interleaver, remote manipulator system and RMS display and control equipment, spare manipulator controller interface unit, TV interface panel, regenerable carbon dioxide removal system and lithium hydroxide canisters for minimum-duration flight plus two days, tools for the rendezvous and docking system, five aft flight deck stowage containers, 1,474 pounds of hard ballast located in the aft fuselage, and nine additional payload and general support computers above the core.

- The middeck accommodations rack and treadmill are not installed on Endeavour for this mission.

- Drag chute deployment will be per nominal flight rules unless the crosswind DTO is likely to be performed. If it is, drag chute deployment will be delayed until after nose gear touchdown to allow for pilot handling evaluation of the orbiter alone without any complications that drag chute dynamics may induce. For STS-77, the nominal touchdown speed is 205 KEAS in all cases with derotation performed using the beep trim switch at 185 kgs or manually (if beep trim fails) at 175 kgs (185 kgs on Edwards lakebed runway). Drag chute nominal deployment is immediately before the initiation of derotation. However, the drag chute DTO program has cleared drag chute deployment as early as 15 kgs before the initiation of derotation.

- Four tiles coated with toughened unipiece fibrous insulation (TUFI) are installed on Endeavour's carrier panel above window 3 to demonstrate the durability of TUFI coating in the orbiter flight/operational environment. TUFI was developed by Rockwell's Space Systems Division in conjunction with NASA's Ames Research Center.

- STS-77 will mark the first ascent controlled from JSC's new Mission Control Center (White Flight Control Room).

- Four rendezvous activities will be conducted during STS-77—a one-flight shuttle record.

- STS-77 will include the most stationkeeping time in shuttle program history.

- STS-77 is the first use of the SPARTAN payload for other than astronomy purposes.

- STS-77 is the first flight of three Block I space shuttle main engines.

- This is Endeavour's last flight before its first scheduled orbiter maintenance down period, which will be performed at Rockwell's Orbiter Maintenance and Manufacturing Facility in Palmdale, Calif. Endeavour is scheduled to be at the Rockwell facility for eight months for a complete structural inspection and numerous modifications and upgrades, including work to prepare it for its next mission, STS-88: the first space station assembly flight, currently scheduled for December 1997.

- NASA Television is available through Spacenet-2, Transponder 5, Channel 9, located at 69 degrees west longitude with horizontal polarization. The frequency is 3880.0 Mhz; audio is 6.8 Mhz.

MISSION OBJECTIVES

- Primary objectives
  - — Payload bay
    - Deployment, on-orbit operation and retrieval of the Shuttle Pointed Research Tool for Astronomy (SPARTAN) 207/Inflatable Antenna Experiment (IAE).
    - Technology Experiments Advancing Missions in Space (TEAMS) 01 operations [includes Vented Tank Resupply Experiment (VTRE), Global Positioning System (GPS) Attitude and Navigation Experiment (GANE) (RME 1316), Liquid Metal Test Experiment (LMTE) and deployment, stationkeeping and observations of the Passive Aerodynamically Stabilized Magnetically Damped Satellite (PAMS)—Satellite Test Unit (STU)]
    - SPACEHAB-04 operations
- Secondary objectives
  - — Payload bay
    - Brilliant Eyes Ten-Kelvin Sorption Cryocooler Experiment (BETSCE) operations
    - Operation of 12 getaway specials (GASs) attached to a GAS bridge assembly (GBA) [including the Reduced-Fill Tank Pressure Control Experiment (RFTPCE)]
  - — Middeck
    - Aquatic Research Facility (ARF) 01 operations
    - Biological Research in Canisters (BRIC) 07, Block III operations
- Nine development test objectives and eight detailed supplementary objectives

STS-77 CREW ASSIGNMENTS

Commander: John H. Casper

- Overall mission decisions
- Orbiter—rendezvous
- DSOs*

Pilot: Curtis (Curt) L. Brown, Jr.

- Orbiter—rendezvous
- Payload—GAS*
- DSOs
- Other—IV

Mission Specialist 1: Andrew (Andy) S. W. Thomas

- Payload—SPACEHAB-4, SPARTAN/IAE, TEAMS,* secondaries
- Other—Earth observations,* RMS*

Mission Specialist 2: Daniel (Dan) W. Bursch

- Orbiter—rendezvous*
- Payload—TEAMS (PAMS-STU)*
- Other—EV2

Mission Specialist 3: Mario Runco, Jr.

- Payload—SPARTAN/IAE,* TEAMS (including PAMS-STU)
- Other—Earth observations, EV1, RMS

Mission Specialist 4: Marc Garneau, Canadian Space Agency

- Payload—SPACEHAB-4,* secondaries,* GAS
- Other—RMS

NASA photo

STS-77 crew members are (from left) mission specialist Dan Bursch, pilot Curt Brown (seated), mission specialists Mario Runco and Marc Garneau, commander John Casper (seated), and mission specialist Andrew Thomas

FLIGHT ACTIVITIES OVERVIEW

Flight Day 1

Launch
OMS–2 burn
Payload bay doors open
Unstow cabin
SPACEHAB activation
RMS checkout

Flight Day 2

SPACEHAB operations
Rendezvous tool checkout
SPARTAN deploy
IAE inflation and jettison
Separation maneuvers

Flight Day 3

SPARTAN rendezvous and retrieval
SPACEHAB operations

Flight Day 4

SPACEHAB operations
PAMS–STU ejection, initial separation and observations

Flight Day 5

SPACEHAB operations
TEAMS operations
PAMS–STU rendezvous maneuvers

Flight Day 6

TEAMS operations
SPACEHAB operations
Off-duty time

Flight Day 7

PAMS–STU rendezvous and stationkeeping
Separation maneuver
SPACEHAB operations

Flight Day 8

PAMS–STU rendezvous, stationkeeping and final separation
(performed if mission is extended to ten days)
SPACEHAB operations

Flight Day 9

TEAMS operations
SPACEHAB operations
Educational activities
Crew press conference

Flight Day 10

TEAMS operations
SPACEHAB operations
FCS checkout
RCS hot fire
Cabin stow

Flight Day 11

SPACEHAB deactivation
Deorbit preparations
Deorbit burn
Entry
KSC landing

Notes:

- Each flight day includes a number of scheduled housekeeping activities. These include IMU alignment, supply water dumps (as required), waste water dumps (as required), fuel cell purge, Ku-band antenna cable repositioning, and a daily private medical conference.

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

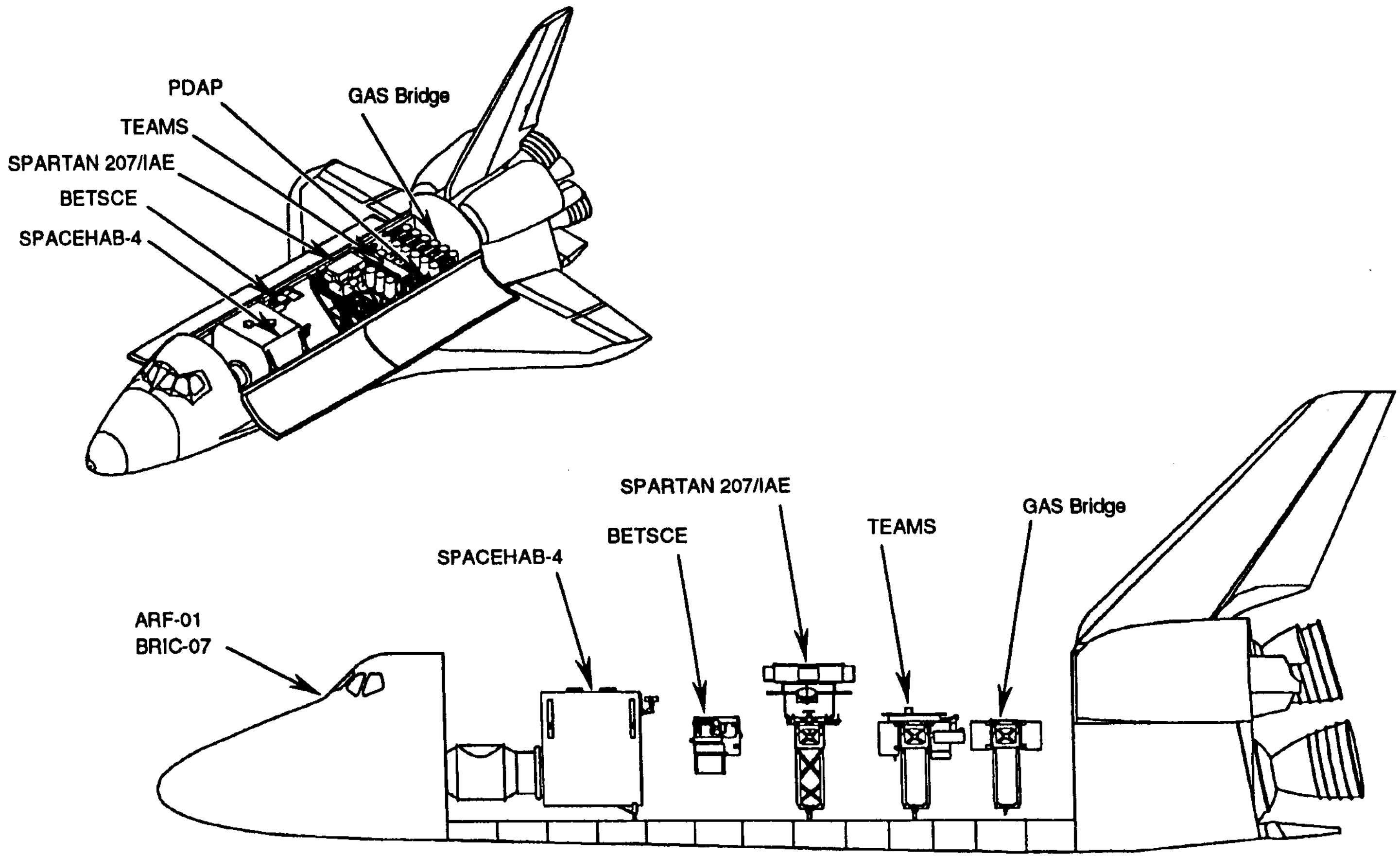
DTOs

- Ascent structural capability evaluation (DTO 301D)
- Ascent compartment venting evaluation (DTO 305D)
- Entry compartment venting evaluation (DTO 306D)
- Entry structural capability evaluation (DTO 307D)
- ET TPS performance, methods 1 and 3, no maneuvers performed (DTO 312)
- Water spray boiler electrical heater capability (DTO 415)
- Water spray boiler quick restart capability (DTO 416)
- Global Positioning System development flight test (DTO 700-8)
- Crosswind landing performance (DTO of opportunity) (DTO 805)

DSOs

- Interaction of the space shuttle launch and entry suit and sustained weightlessness on egress locomotion (DSO 331)
- Immunological assessment of crew members (DSO 487)
- Characterization of microbial transfer among crew members during spaceflight (DSO 491)
- Monitoring latent virus reaction and shedding in astronauts (DSO 493)
- Educational activities (DSO 802)
- Documentary television (DSO 901)
- Documentary motion picture photography (DSO 902)
- Documentary still photography (DSO 903)

STS-77 PAYLOAD CONFIGURATION



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SPACEHAB-4

Early in the shuttle program, it became evident that the orbiter middeck is the best place to conduct crew-tended experiments in space. Each shuttle orbiter has 42 middeck lockers but most are used to stow crew gear for a typical seven-day mission, leaving only seven or eight for scientific studies. But SPACEHAB, the first crew-tended commercial payload carrier, has initiated a new era of space experimentation.

The SPACEHAB module, which takes up a quarter of the orbiter's payload bay, is like a second middeck. The 10-foot-long pressurized module adds 1,100 cubic feet of pressurized work space that can hold 61 lockers or experiment racks or a combination of the two. The lockers are sized and equipped like those in the shuttle middeck so that experiments can be moved from one location to the other. The lockers accommodate up to 60 pounds of experiment hardware in about 2 cubic feet. A rack, which can be single or double, takes the space of ten lockers. Double racks are similar in size and design to those planned for the space station so that they can serve as test beds for future projects. A single rack can carry 625 pounds of hardware in 22.5 cubic feet.

The astronauts enter the module through a modified Spacelab tunnel adapter. SPACEHAB can accommodate two crew members on a continuous basis, but additional crew members can work in the module for brief periods. Power, command and data services, cooling, vacuum, and other utilities are supplied by orbiter crew cabin and payload bay resources.

SPACEHAB was privately developed and is privately operated by SPACEHAB, Inc., of Arlington, Va. NASA has agreed to lease two thirds of the module's space for the first six flights, which are expected to occur twice a year. Eight SPACEHAB missions have been listed on the shuttle manifest so far. Both SPACEHAB, Inc. and NASA hope that commercial interests will also begin to lease experiment space.

STS-77 is the fourth flight of SPACEHAB under this lease arrangement. It will carry ten commercial space product development payloads in the areas of biotechnology, electronic materials, polymers and agriculture in addition to experiments for other NASA organizations. The SPACEHAB single module will carry nearly 3,000 pounds of experiments and support equipment.

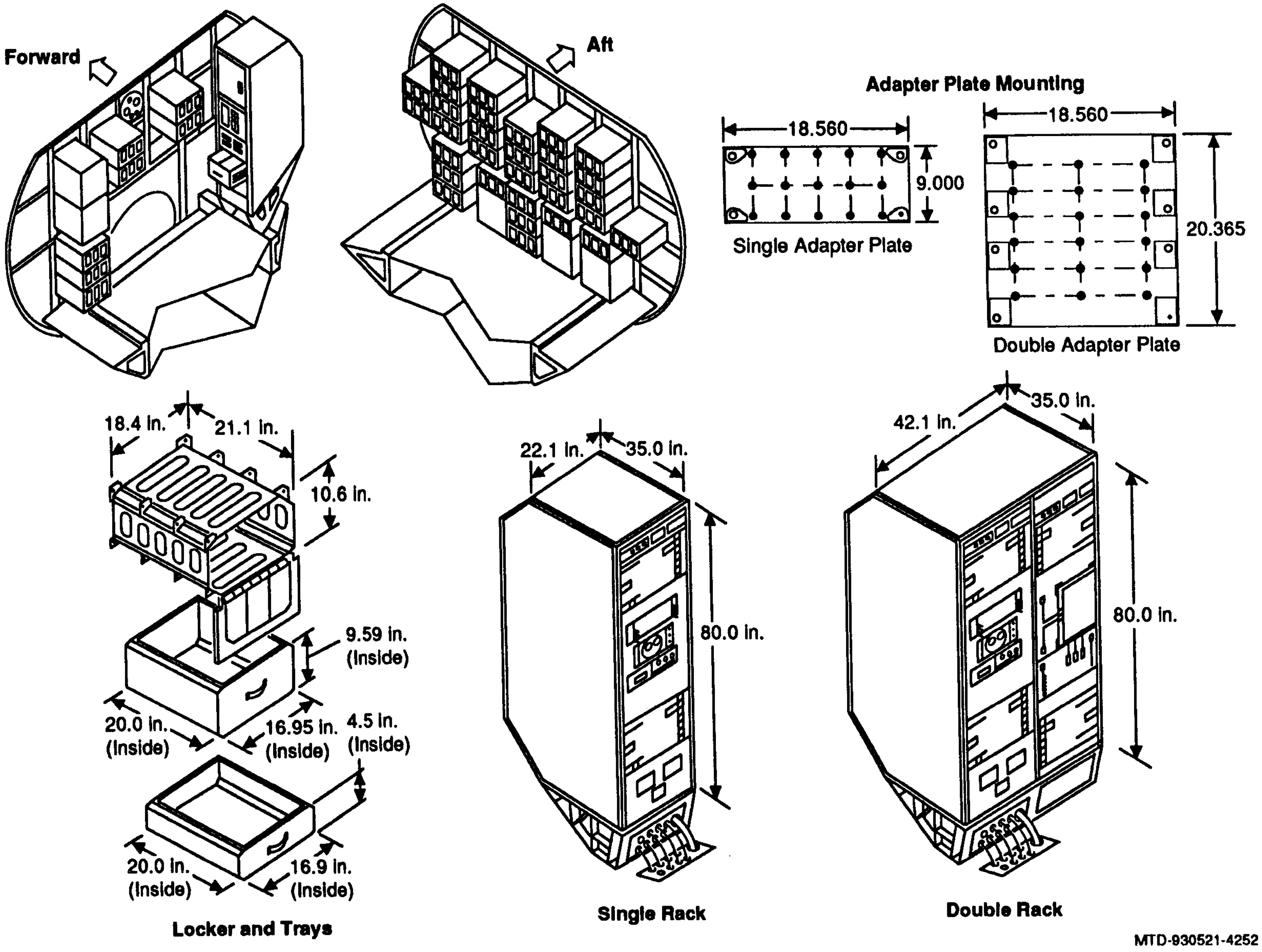
The first flight of the SPACEHAB research laboratory was on STS-57 in June 1993. All systems operated as expected, and the 21 NASA-sponsored experiments met more than 90% of the criteria for mission success. SPACEHAB-2 was flown on STS-60 in February 1994 and carried 13 experiments. More than 20 experiments were performed as part of SPACEHAB-3 on STS-63 in February 1995.

In March 1996, SPACEHAB was part of the STS-76 mission to the Russian space station Mir. The laboratory carried 37 materials processing, microgravity, Earth sciences, biology, life sciences, and International Space Station risk mitigation experiments. STS-76 was the first of a series of shuttle-Mir missions on which the orbiter will carry a SPACEHAB module. The modules will be used to transport supplies and scientific equipment to and from Mir as well as for conducting experiments.

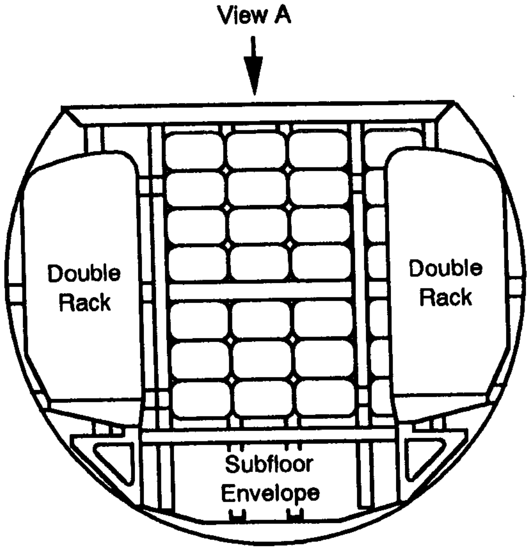
SPACEHAB-4 EXPERIMENTS

Advanced Separation Process for Organic Materials

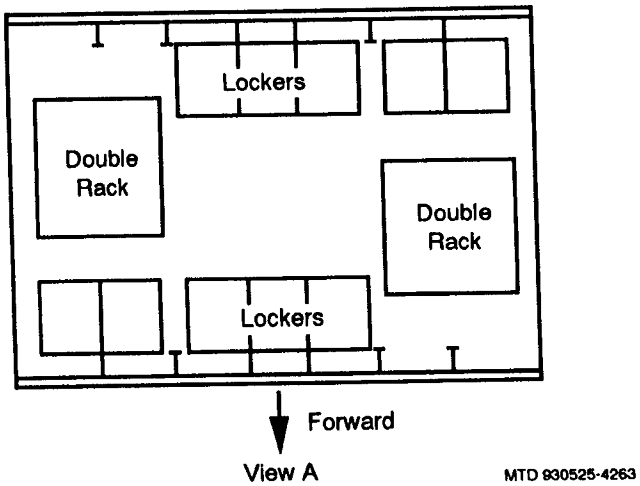
The separation, purification, and classification of cells limit biomedical research and the development of pharmaceutical drugs. ADSEP, sponsored by the Consortium for Materials Development in



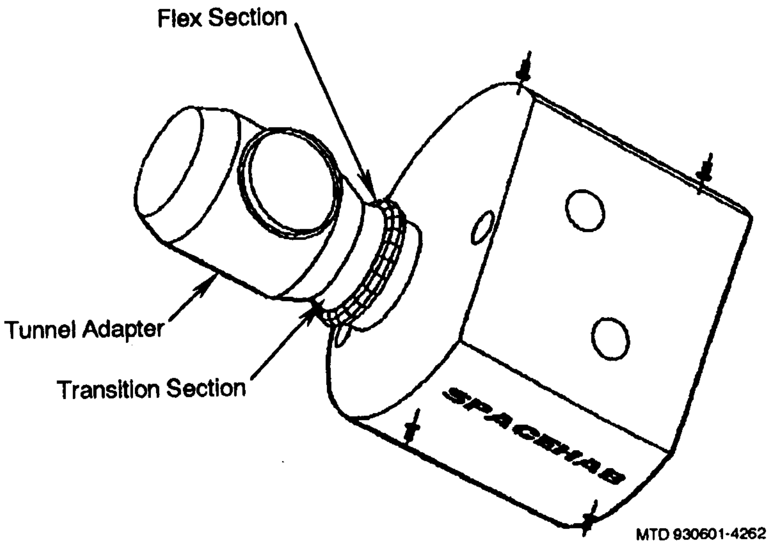
Typical SPACEHAB Interior Configuration



View Looking Aft



SPACEHAB Rack-Plus-Locker Configuration (Reference)

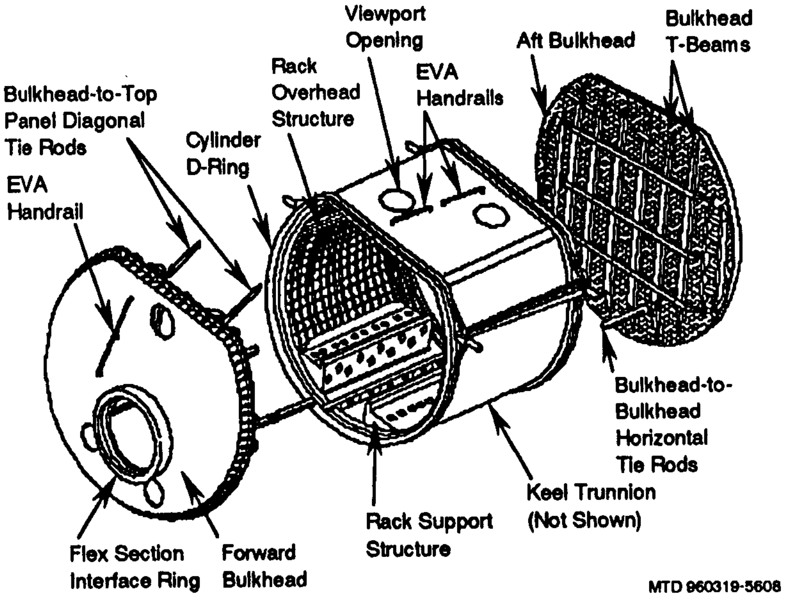


SPACEHAB External View

Space at the University of Alabama in Huntsville and developed by Space Hardware Optimization Technology Inc., is designed to improve separation capabilities for terrestrial commercial application to medical products and microgravity research. This mission will focus on understanding the effects of gravity on the manufacture of recombinant hemoglobin products. This investigation may have a significant effect on blood transfusion products by permitting the transfusion of hemoglobin rather than whole blood to reduce complications such as blood rejection, the transmission of infectious diseases, and blood contamination in areas without suitable storage.

Commercial Generic Bioprocessing Apparatus

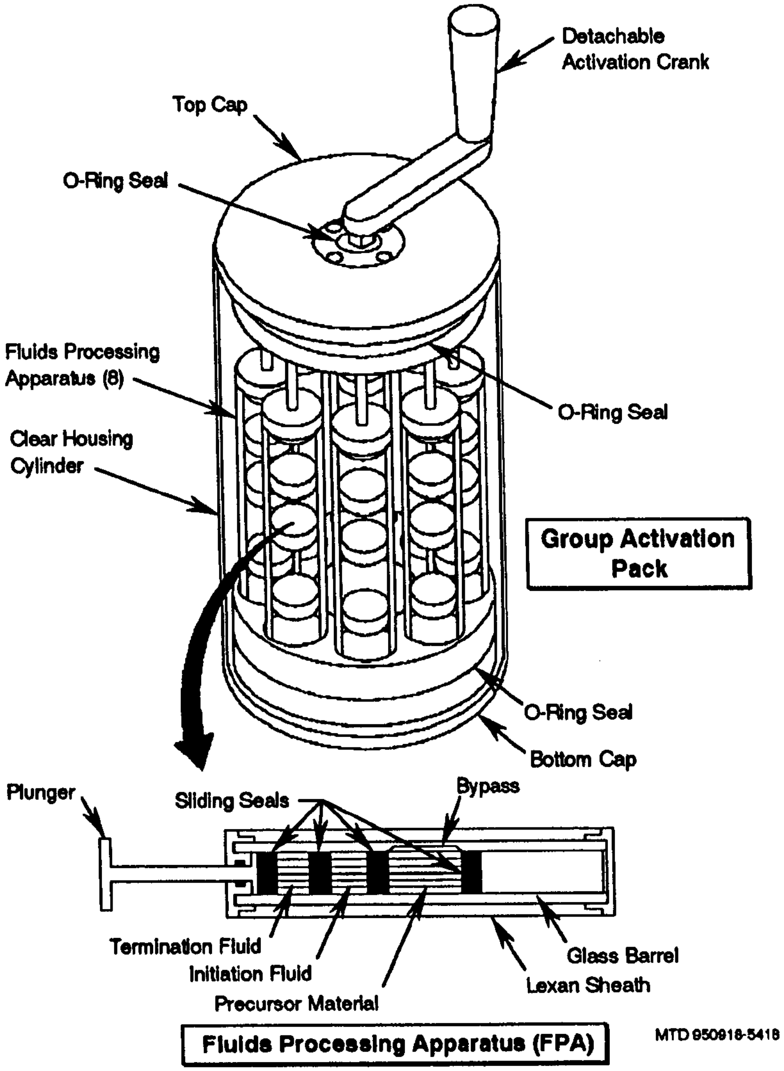
The Commercial Generic Bioprocessing Apparatus (CGBA) is a generic research tool that supports life sciences research in biophysics, cellular biology, developmental biology, and physiology. It is sponsored by NASA's Office of Advanced Concepts and Technology and developed by BioServe Space Technolo-



SPACEHAB Single-Module Structure

gies, a NASA Center for the Commercial Development of Space (CCDS) at the University of Colorado.

The CGBA is a secondary payload that serves as the housing, incubator, and data collection point for BioServe's fluids processing apparatuses (FPAs), multichambered devices that permit fluids to be mixed in space. The CGBA payload can meet a wide variety of experimenters' needs: it allows investigations of a variety of molecular, cellular, tissue, and small animal and plant systems. It has also been exceptionally reliable: quality sample and data return rates on previous flights have exceeded 99%.



FPA and Group Activation Pack (GAP)

For this flight, the CGBA will contain four temperature-controlled lockers holding 272 experiments. A number of specific commercial objectives will be pursued in partnership with several of Bioserve's industrial affiliates. These include an evaluation of the pharmaceutical production of bacterial and fungal systems, crystallization of oligonucleotides-RNA to gain 3-D structural information for drug design for use in AIDS research, administration of a proprietary chemical to enhance bone marrow macrophage differentiation, and tests of a proprietary cell growth inhibitor for use in cancer research.

Flight Hardware. The payload hardware has three major elements: GBA II, a commercial refrigerator/incubator module (CRIM), and a stowage locker. GBA II is stowed in a single middeck locker space and requires 28 volts direct current (Vdc). Stowage is mission specific. For temperature-controlled stowage, the CRIM and a middeck locker supplying 28 Vdc are used. For ambient stowage, a middeck locker is used.

The CGBA can have three different hardware combinations. Configuration A consists of the GBA II module plus the CRIM and the middeck stowage locker, configuration B consists of the GBA II module and the CRIM, and configuration C consists of the GBA II module and the middeck stowage locker. Biological samples are stowed in the CRIM and/or lockers both before and after processing in the GBA II.

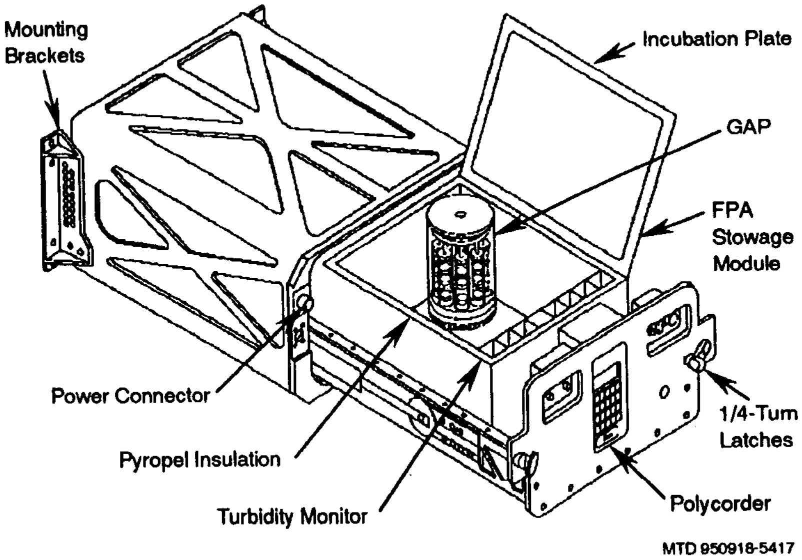
The GBA II is a self-contained mixing and heating module in which biological fluid samples are processed in microgravity. Up to 120 fluid samples contained in glass syringe with Lexan sheaths are stored in either the CRIM or a middeck locker. These fluids are manually mixed in the syringe and transferred to a sample containment vial that is then heated and incubated. At the end of the incubation period, the fluid vials are returned to the CRIM or the stowage locker.

Crew activities consist of mixing samples, incubating samples in the GBA II, transferring data to the payload and general-support computer, and photographing fluid samples.

The CGBA consists of 152 FPAs packaged in 19 group activation packs (GAPs). FPAs are multipurpose fluid mixing devices in which individual experiments are conducted. Each GAP houses a suite of eight FPAs that can be operated simultaneously. Nine of the GAPs are operated manually, and ten are automated, motor-driven types. The FPAs contain biological sample materials that are mixed in orbit to begin and end an experiment.

In the FPA, sample materials are contained inside a glass barrel that has rubber stoppers to separate three chambers. For each investigation, the chambers will contain precursor, initiation, and termination fluids. The loaded glass barrel is covered with a plastic sheath that protects the glass from breakage and serves as a second level of sample fluid containment.

The FPAs are operated by a plunger mechanism that is depressed in orbit, causing the chambers of precursor fluid and the stoppers to move forward inside the glass barrel. When a stopper reaches an indentation in the glass barrel, initiation fluid from the



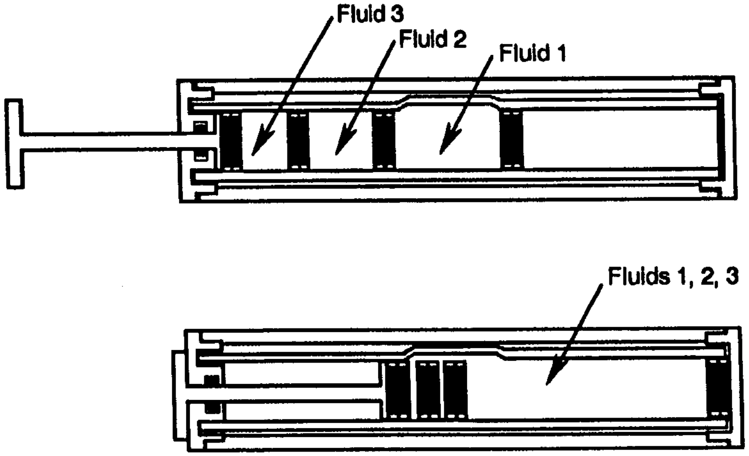
GBA-II

second chamber is injected into the first chamber, activating the biological process.

Once processing is complete, the plunger is again depressed until the termination fluid in the third chamber is injected across the bypass in the glass barrel into the first chamber. This preserves the sample materials for return to Earth and detailed analysis.

The GAP consists of a 4-inch-diameter plastic cylinder and two aluminum endcaps. Eight FPAs are located around the inside circumference of the GAP cylinder. A crank extends into one end of the GAP and attaches to a metal pressure plate. Rotating the crank advances the plate and depresses the eight FPA plungers simultaneously.

On-Orbit Operations. Upon reaching orbit, the crew initiates the various investigations by attaching a crank handle to each GAP. Turning the crank causes an internal plate to advance and push the plungers on the contained FPAs. This action causes the fluids in the forward chambers of each FPA to mix.



MTD 950918-5386

Activation of Fluid Processing

The crew terminates the investigations in a similar manner. Attaching and turning the GAP crank further depresses the FPA plungers, causing the fluid in the rear chamber to mix with the processed biological materials. This fluid typically stops the process or "fixes" the samples for return to Earth in a preserved state. Each GAP is terminated at a different time during the mission. In this manner, sample materials can be processed for as little as one hour to nearly the entire duration of the mission.

Automated versions of the GAPs can be used if no crew monitoring is required.

For most of the investigations, simultaneous ground controls are run. Using identical hardware and sample fluids and materials, ground personnel can activate and terminate FPAs in parallel with the flight crew. Synchronization is based on indications from the crew that specific GAPs are being operated.

Plant Generic Bioprocessing Apparatus

The Plant Generic Bioprocessing Apparatus (PGBA) will be flown for the first time on STS-77. The commercial goal is to investigate the change in the production of secondary metabolites in microgravity.

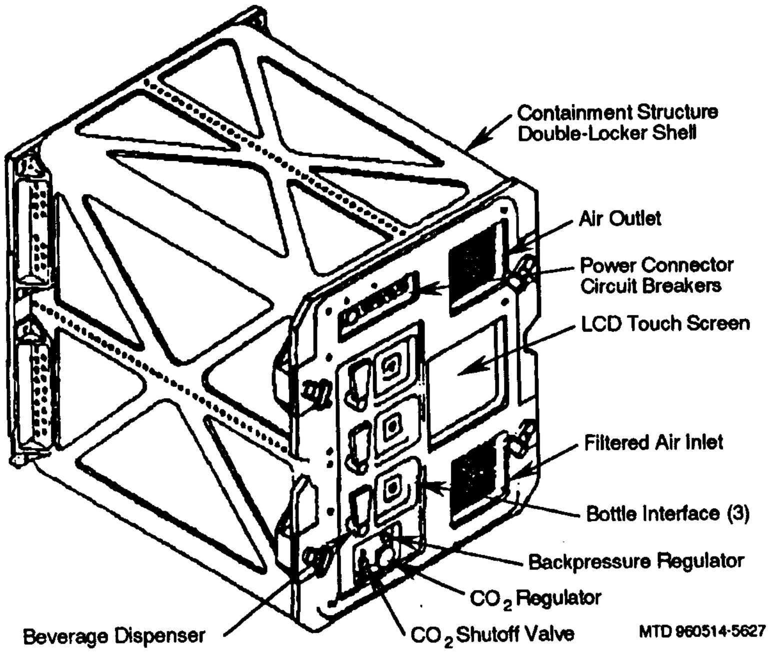
This two-locker plant growth chamber was developed by Bio-Serve Space Technologies in collaboration with the Wisconsin Center for Automation and Robotics at the Unversity of Wisconsin Madison. Commercial affiliates are Bristol-Myers Squibb, Georgia Pacific, Dean Foods, and Research Seeds, Inc.

Investigators will study *Artimisia annua*, which produces an antimalarial compound, and *Cataranthus roseus*, which produces chemotherapeutic compounds. Researchers will study the effects of space flight on the starch, sugar, and fatty acid content of special strains of spinach plants. Georgia Pacific is interested in the lignin production and reaction wood formation in loblolly pine. The nitrogen fixation mechanism of clover will also be studied.

Although the nine-day mission is not long enough to thoroughly study plant growth, the sponsoring affiliates hope to establish that new products could be developed from plants on longer missions.

Fluids Generic Bioprocessing Apparatus 2

This commercial payload will evaluate the storing, manipulating, and dispensing of two-phase fluids in microgravity. This information is expected to have applications in ecological life support, the delivery of plant nutrients, fluid dispensing, bioreactors, and advanced propellant and fuel cell systems. Physiological data obtained from astronauts participating in this experiment will be used to determine the effects of microgravity on taste perception and evaluate the potential for establishing laboratories in space to develop new beverages. The physiological data may also give researchers insights about cardiovascular deconditioning.



Fluids Generic Bioprocessing Apparatus

The Coca-Cola Co., the primary corporate sponsor, will use FGBA-2 as a test bed for determining if carbonated beverages can be produced from separately stored carbon dioxide, water, and flavored syrups and if the resulting fluids can be made available for consumption without bubble nucleation and the formation of foam. Coca-Cola also will verify and obtain additional data on the effects of space flight on changes in taste perception. Such data might help researchers understand altered tastes in specific target populations on Earth, such as the elderly, and eventually lead to beverage formulations that could increase hydration for such individuals and for astronauts.

The sponsor will apply the technology and lessons learned from this mission to other commercial space life sciences activities, such as the development of plant growth and cell culture biotechnology facilities, closed-environment research facilities, and other projects that require management of two-phase fluids. Payload health and engineering data and video images documenting the behavior of the carbonated beverages during transfer operations will be collected.

This experiment is sponsored by Bioserve Space Technologies. Commercial affiliates are the Coca-Cola Co., Lockheed Martin Astronautics, and Ohmeda Corp.

Hand-Held Diffusion Test Cell

This investigation will evaluate transparent experiment chambers that will permit the use of sophisticated optical techniques to analyze the growth of crystals in space. The test cells, which are designed for use in the new Observable Protein Crystal Growth Apparatus, will also be used on this mission to produce crystals by diffusing one liquid into another.

Researchers, who have been growing crystals in space for nearly ten years, know that about 20% of the crystals are superior to crystals grown on Earth, but they don't know exactly why. The OPCGA and the transparent test cells are intended to provide the answer, which could lead to the production of better crystals on Earth as well as in space.

Because the OPCGA device will not work with the vapor diffusion process of growing crystals, liquid diffusion will be used. In this process, liquids placed in contact but not mixed diffuse into each other. As the concentration of a precipitant in the solution increases, proteins crystallize.

Four diffusion units are being flown on this mission. Each unit contains eight test cells. The test cells have chambers for a protein solution, buffer solution, and precipitant solution. A crew member will initiate the crystallization process by opening a valve that will allow the three solutions to come in contact and begin the diffusion process. Crew members will photograph the growth of crystals in the clear plastic test cells.

Several of the proteins that will be grown by liquid diffusion have been grown on previous shuttle missions using different crystallization processes. Researchers will compare the results from the different growing processes. Among the proteins to be grown by liquid diffusion are lysozyme, myoglobin, satellite tobacco mosaic virus, concanavalin B, canavalin, catalase, thaumatin, ferritin, apoferritin, and turnip yellow mosaic virus.

IMMUNE-03

IMMUNE-03 will test the ability of insulin-like growth factor to prevent or reduce the detrimental effects of space flight on the immune and skeletal systems of rats. Space flight is known to alter the immune responses of rats and reduce their skeletal development. This may model immune disorders and impaired skeletal development on Earth. The ability to counter the reduced bone formation and immune system impairment that occur during space flight may provide new product markets on Earth and a therapeutic for future long-term space missions.

Knowledge acquired from this experiment and extensive ground-based research could be used to develop protocols to protect the immune systems of patients undergoing chemotherapy or radiotherapy and to treat patients with AIDS, primary immune-deficiency and a broad range of infectious diseases. The findings may also benefit patients suffering from a variety of bone disorders.

The first two IMMUNE experiments measured the immune response of tissue and body fluids of normal rats to microgravity, which suppresses the immune system. White rats were treated with the nontoxic compound polyethylene glycol interleukin-2 (PEG-IL-2) to determine the drug's ability to prevent or reduce the suppression of immunity during space flight. Investigators used the data collected from the flight animals and ground control animals to develop a computer model of human immune system disorders.

The results of the IMMUNE-01 experiment indicated that PEG-IL-2 induced a trend toward reducing the changes in immune responses brought on by space flight. Researchers hope that these experiments will lead to the development of therapeutic ways of dealing with the effects of space flight on the human immune system and a greater understanding of immunodeficiencies.

During the flight, the rats will remain in two self-contained modules that provide ventilation, lighting, food, water, and waste management. No handling of the animals is required.

The experiment is sponsored by Bioserve Space Technologies and Kansas State University, Manhattan. Chiron Corp. is the corporate affiliate leading the investigation.

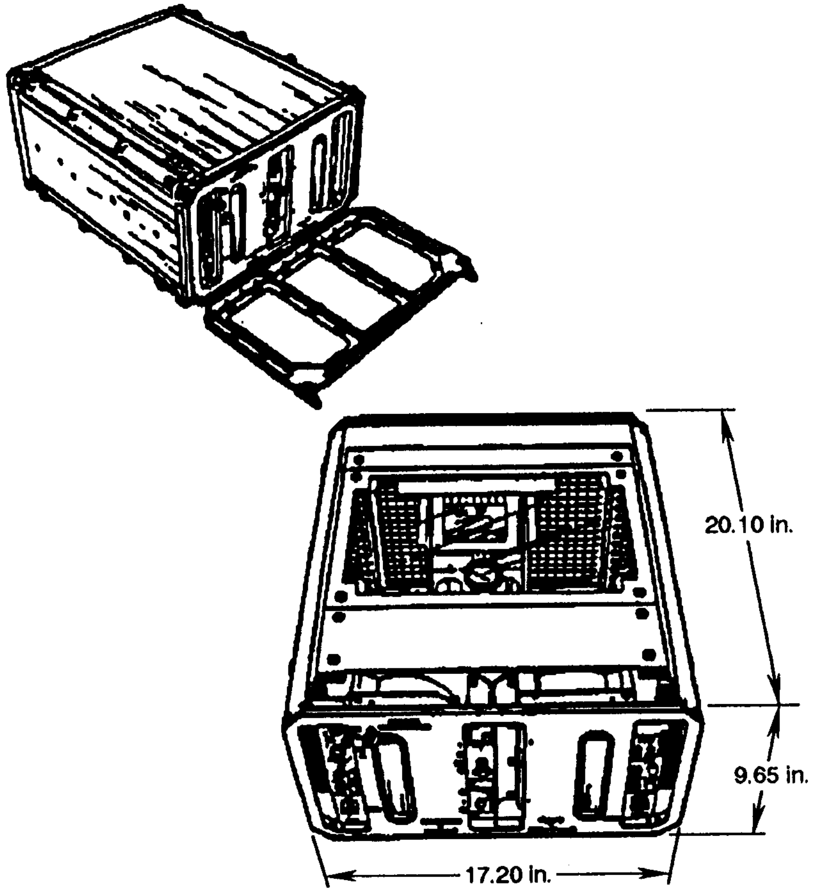
Commercial Protein Crystal Growth

The CPCG payload is designed to conduct experiments that will supply information on the scientific methods and commercial potential for growing large high-quality protein crystals in microgravity.

Because crystals produced in space tend to be larger and purer and have more highly ordered structures than crystals produced on Earth, they are ideal for crystallographic analysis of the molecular structure of proteins. Scientists want to learn about a protein's three-dimensional structure to understand how it works, how to reproduce it, or how to change it. X-ray crystallography is widely used to determine a protein's three-dimensional structure.

Proteins are important, complex biochemicals that serve a variety of purposes in living organisms. Metabolic processes involving proteins play an essential role in our lives, from providing nourishment to fighting disease. In the past decade, rapid growth in protein pharmaceutical use has resulted in the successful application of proteins to insulin, interferons, human growth hormone, and tissue plasminogen activator.

The pharmaceutical industry seeks pure protein crystals because their purity will simplify Federal Drug Administration approval of new protein-based drugs. Pure, well-ordered protein crystals of uniform size are in demand as special formulations for use in drug delivery. Other potential applications include agricultural products and bioprocesses for use in manufacturing and waste management.



Animal Enclosure Module

Such research has attracted firms in the pharmaceutical, biotechnological, and chemical industries. In response, the Center for Macromolecular Crystallography at the University of Alabama in Birmingham, one of 11 NASA Centers for the Commercial Development of Space that forms a bridge between NASA and private industry by developing methods for the crystallization of macromolecules in microgravity, has formed affiliations with companies that are investing substantial amounts of time, research, and money to develop protein samples for use in evaluating the benefits of microgravity. Protein structural information leads to the discovery and synthesis of complementary compounds that can become potent drugs specifically directed against the disease target. Structure-based drug design is a productive and cost-effective targeted drug development strategy.

The commercial applications developed using protein crystal growth have phenomenal potential, and the number of proteins that need to be studied is in the tens of thousands. Current research, with the aid of pharmaceutical companies, may lead to a whole new generation of drugs which could help treat diseases such as cancer, diabetes, rheumatoid arthritis, periodontic disease, influenza, septic shock, emphysema, aging, and AIDS.

Among the pharmaceutical companies currently in partnership with the CMC are BioCryst Pharmaceuticals, Inc., Eli Lilly and Co., and Bristol-Myers Squibb.

Two different techniques will be used for the three investigations on this flight. One is a process driven by temperature change that will produce crystals of a new form of recombinant human insulin provided by Eli Lilly; the other is a vapor diffusion process that crystallizes different proteins.

The insulin crystals will be used to study the proetin's structure to help Eli Lilly understand the mode of action of this new form of insulin.

The vapor diffusion process is an improved adaptation of the most common laboratory method of growing protein crystals. The hardware allows 128 experiments to be conducted. The temperature-driven process hardware uses sample holders of different volumes with different temperature gradients to test systems that will give industry more operational flexibility and allow researchers to use smaller amounts of expensive sample materials.

During the past several years, several hardware configurations have been used to conduct protein crystal growth middeck experiments on space shuttle flights. The CMC has developed more than ten pieces of flight hardware specifically to support microgravity investigations in protein crystal growth. These systems use vapor diffusion, temperature induction, and batch mixing techniques. Some pieces of hardware have been augmented with instrumentation for localized temperature, light scattering, and video monitoring.

The CPCG payload may be flown in one of four possible configurations, designated Blocks I, II, III and IV. In the Block I configuration, the commercial refrigerator/incubator module (CRIM) contents consist of a carrier that holds up to three vapor diffusion apparatus (VDA) trays operating in either a seeded or nonseeded mode, depending on the specific material manifest. Each VDA tray carries 20 double-barreled syringes that empty into individually sealed sample chambers. Each syringe contains a protein solution in one barrel and a precipitant solution in the other. The 20 syringes are ganged together on each of the VDA trays so that all the syringes on one VDA tray are deployed by one crew operation. The samples focus on proteins in various formulations to enhance the probability of success. In the Block II configuration, the CRIM contents consist of four containers with fluid product in a protein crystallization facility. In both configurations, the internal temperature of the CRIM is checked daily; and in the Block I configuration, photographic coverage is required. In the Block III configuration, the CRIM carries a protein crystallization facility-light scattering/temperature experiment, which is essentially a modified version of the Block II PCF.

The CPCG Block IV experiment configuration will be flown on STS-77. This configuration includes the use of the CRIM to maintain a 22-degree Celsius temperature for three commercial VDA trays. The commercial VDA assembly, which is an enhanced derivative of the CPCG Block I configuration, consists of 128 experiment chambers.

CRIM temperatures can be programmed before launch. The temperatures are monitored during flight by a feedback loop. Developed by Space Industries, Inc., of Webster, Texas, for CMC, the CRIM also has an improved thermal capability and a microprocessor that uses "fuzzy logic" (a branch of artificial intelligence) to control and monitor the CRIM's thermal environment. A thermoelectric device is used to electrically "pump" heat in or out of the CRIM.

The CPCG payload is installed in the space of one middeck locker and requires nearly continuous 28-Vdc power. Certain experiment samples may need power interruptions of no greater than three to five minutes.

In general, purified proteins have a very short lifetime in solution; therefore, the CPCG payload will be loaded on the shuttle no earlier than 24 hours before the launch. Due to the instability of the protein crystals grown, the payload will be retrieved from the shuttle within three hours of landing. The payload will be battery-powered continuously from the time the samples are placed in the enclosures and loaded on the shuttle until it is recovered and delivered to the investigating team. For launch delays of more than 24 hours, the samples will need to be replaced with fresh samples.

Activation of the experiment consists of hardware setup, an initial data take, and initialization of preloaded temperature profile software. The internal operating temperature of the CRIM will vary with the experiment science and will be controlled within the range of 4 to 40 degrees Celsius.

Once activated, the payload will not require any further crew interaction (except for periodic monitoring) or any modifications for landing.

Hardware should be stowed as late as possible in the mission. No crew deactivation is required. The crew is only required to back up data from the Macintosh Powerbook and then stow all hardware.

Immediately after the landing, the CRIM and its contents will be removed from the orbiter, and the CRIM will be connected to a 28-Vdc battery and returned to the experimenter for evaluation. The stowed Macintosh computer diskettes and the CRIM are the only items that must be turned over to the payload customer at the landing site.

When the samples are returned to Earth, they will be analyzed by morphometry to determine size distribution and absolute/relative crystal size. They also will be analyzed with X-ray crystallography to determine their internal molecular order and biochemical assays of purity to determine the homogeneity of the proteins.

Gas-Permeable Polymeric Membrane

STS-77 is the third flight of the GPPM, which uses microgravity to develop enhanced polymers for manufacturing improved, rigid gas-permeable contact lenses. Development of polymer lens material in microgravity has shown that polymers can be formed that will have greater uniformity of structure; more gas permeability, allowing greater oxygen flow to improve wearers' comfort; greater durability; and better machinability in the manufacturing process.

Monomers and activators will be mixed in two commercial refrigerator/incubator modules to form membranes that can be permeated by gas. The space-made polymers will be compared with others made on the ground to determine any differences (and improvements) in characteristics.

Plastic materials are made of very large molecules called polymers. Some polymers prevent gases, such as oxygen, from passing through. Others allow one or more gases to pass through. These gas-permeable polymeric materials have many uses. Possible applications, besides improved contact lenses, include highly sensitive sensors, medical monitors, industrial process controllers, and commercial production of pure gases.

This experiment is sponsored by NASA's Langley Research Center and its commercial affiliate, Paragon Vision Sciences of Phoenix, Ariz. The experiment was first flown on the STS-57 mission in 1993.

Commercial Float Zone Furnace

The goal of these experiments is to produce large, ultrapure compound semiconductor and mixed oxide crystals for electronic devices and infrared detectors. Three agencies cooperating on the project are the NASA Marshall Space Flight Center, the Canadian Space Agency (CSA), and the German Space Agency (DARA).

Samples of gallium arsenide (GaAs) and gallium antinomide (GaSb) prepared by the University of Florida in cooperation with industrial participant Atramet, Inc. will be melted in the CFZF. A liquid encapsulate will be used around the float zone to promote the growth of a larger crystal in the microgravity environment. This technique was investigated on the first SPACEHAB mission in 1993. The furnace, provided by the CSA and DARA, flew on the D-2 Spacelab mission in 1993.

Telescience will be used during the mission to enable researchers on the ground to view and control the melts and work with the astronauts to control the melts.

Space Experiment Facility

The Space Experiment Facility (SEF), developed and managed by the University of Alabama in Huntsville's Consortium for Materials Development in Space, houses a crystal growth experiment and a metals experiment.

The crystal growth experiment, which will be conducted in the SEF's transparent furnace, will grow crystals of mercurous chloride, a valuable electro-optic material of commercial interest. Larger and higher-quality mercurous chloride crystals could improve devices used in spectral imaging.

The metals experiment, conducted in SEF's opaque furnace, will use liquid phase sintering to bond powdered metals. The LPS process may enable researchers to gain a better understanding of alloy behavior and the porosity of these metal composites. Improved metal composites could be of benefit to the machine tool industry.

Space Tissue Loss/National Institutes of Health—Cells 7

When gravity is reduced or eliminated, as it is in space travel, life systems degrade at a remarkable rate. The Space Tissue Loss (STL) life sciences payload, a computerized tissue culture incubator, studies cell growth during space flight, specifically the response of muscle, bone, and endothelial and white blood cells to microgravity, by evaluating various parameters, including shape, cytoskeleton, membrane integrity and metabolism, activity of enzymes that inactivate proteins, and the effects or change of response to various stimulants, hormones, and drugs on these parameters. On STS-77, STL will be used to conduct two collaborative biomedical experiments sponsored by NASA and the National Institutes of Health.

STL will help scientists understand more about how white cells respond to antigens from infectious agents and tumors. It will also show how space flight can cause a tremendous loss of calcium and minerals from bones and find ways to prevent or minimize bone failure in space and on Earth. Findings from tests of muscle disintegration could yield more information about similar muscle failure that occurs in forms of muscular dystrophy and the loss of muscle mass after severe injury, prolonged bed rest, and aging.

Findings from this and other studies will be used to develop measures to maintain the strength of astronauts' muscles and bones during long space flights and to limit the extent of muscle tissue loss after fractures/cast immobilization and surgery. Anticipated benefits include savings from reducing the need for physical therapy and more rapid return to activity following injury.

On this mission, researchers will attempt to repeat and augment previous experiments investigating the effects of microgravity on musculoskeletal development at the cellular level.

The STL/NIH-C-7 experiments will study the effects of space flight on muscle and bone cells from chicken embryos. The experiments on STS-77 will augment data from the flight of the module in November 1994. The effects of space flight on calcification and development activity in maturing cartilage cells will be examined. The effects of space flight on muscles will also be studied to determine if microgravity induces damage or loss of muscle fibers. Researchers will use special markers of cell damage, growth assays, measurements of muscle size, and multiple biochemical assessments.

STL functions continuously from before launch until after landing and requires late installation into the orbiter middeck before launch. Before operations begin, the crew will enter a reference time tag using a push-button input on the front panels of the payloads. The samples will be analyzed immediately after the landing.

The STL experiment is sponsored by the Department of Space Biosciences at the Walter Reed Army Institute of Research, Washington, D.C., in conjunction with NASA's Office of Life and Microgravity Sciences and Applications Small Payloads program and the National Institute of Arthritis and Musculoskeletal Diseases. It is being integrated with and flown on the shuttle under the direction of the Defense Department's Space Test Program.

SHUTTLE POINTED AUTONOMOUS RESEARCH TOOL FOR ASTRONOMY 207/IAE

SPARTAN 207 (SP207/IAE), one of the primary STS-77 payloads, is the most ambitious SPARTAN mission to date. The STS-77 crew will deploy and test the spacecraft's sole payload, the Inflatable Antenna Experiment (IAE).

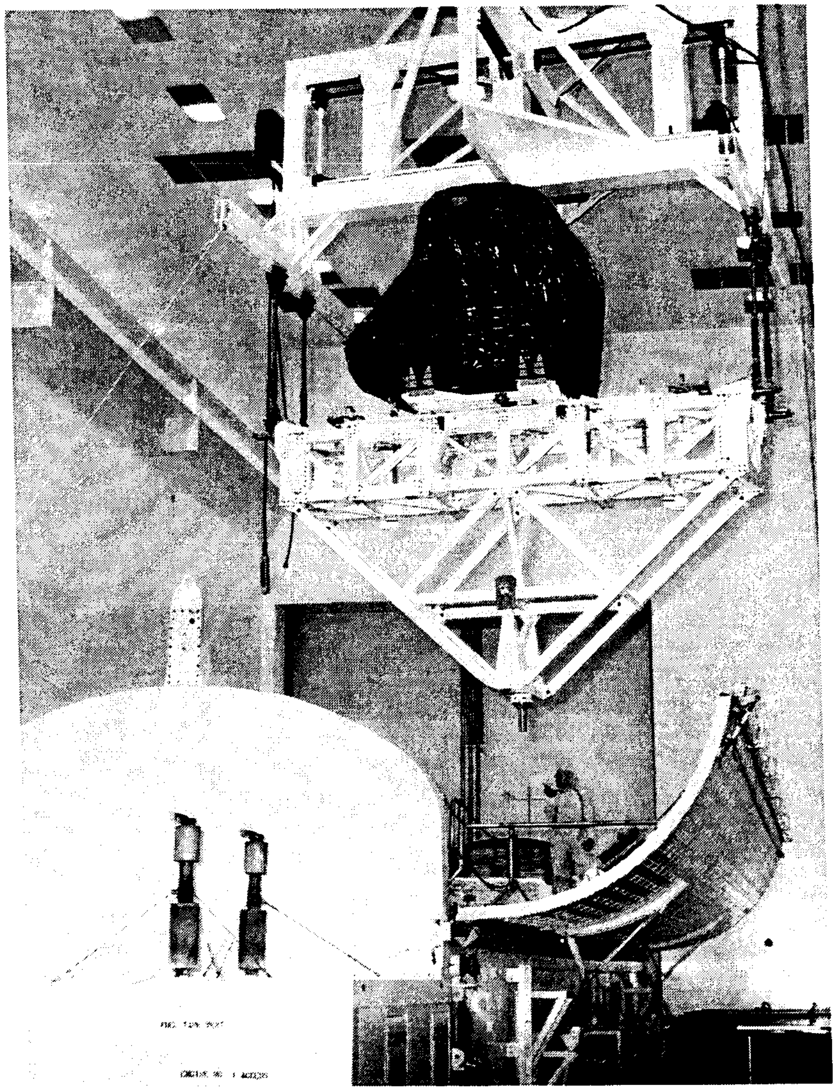
The SPARTAN astrophysics experiments evolved from NASA's sounding-rocket science program. The SPARTAN project was conceived in the late 1970s to take advantage of the opportunity offered by the space shuttle to provide more observation time for the increasingly more sophisticated experiments than the five to ten minutes allowed by sounding rocket flights.

The SPARTAN carrier is a simple, reusable vehicle that can carry a variety of scientific instruments at a relatively low cost. After it is deployed from the orbiter in space, it provides its own power, pointing, and data recording as it performs a preprogrammed mission. In addition to solar experiments, the SPARTAN spacecraft can be programmed to conduct stellar astronomy, Earth fine-pointing, spacecraft technology experiments and demonstrations, and microgravity science and technology experiments.

The SPARTAN project offers the scientific community an intermediate capability for conducting investigations in space between that afforded by small payloads that remain in the orbiter and larger satellites that orbit the Earth for long periods of time.

A typical SPARTAN configuration consists of two main pieces of hardware, a SPARTAN flight support structure (SFSS) and a free flyer with the experiment. The SFSS has a release/engage mechanism (REM) that allows the free flyer to be removed and returned to its berthing position in the orbiter cargo bay. The free flyer is deployed and retrieved by the orbiter's remote manipulator system, which is operated by an astronaut.

A service module (forming the lower portion of the spacecraft) contains the payload function control system (PFCS), attitude con-



NASA photo

Workers install SPARTAN 207/IAE in payload transporter at KSC.

trol system (ACS), structural mechanical system, thermal control system, and the power distribution system. The SPARTAN upper structure and the IAE canister, located on top of the service module, house the solar optical bench (SOB), IAE inflatable structure, inflation subsystem, light table and cameras, the IAE videocassette recorder (VCR) and television subsystem, and the gyro box. The REM adapter forms the base of the service module.

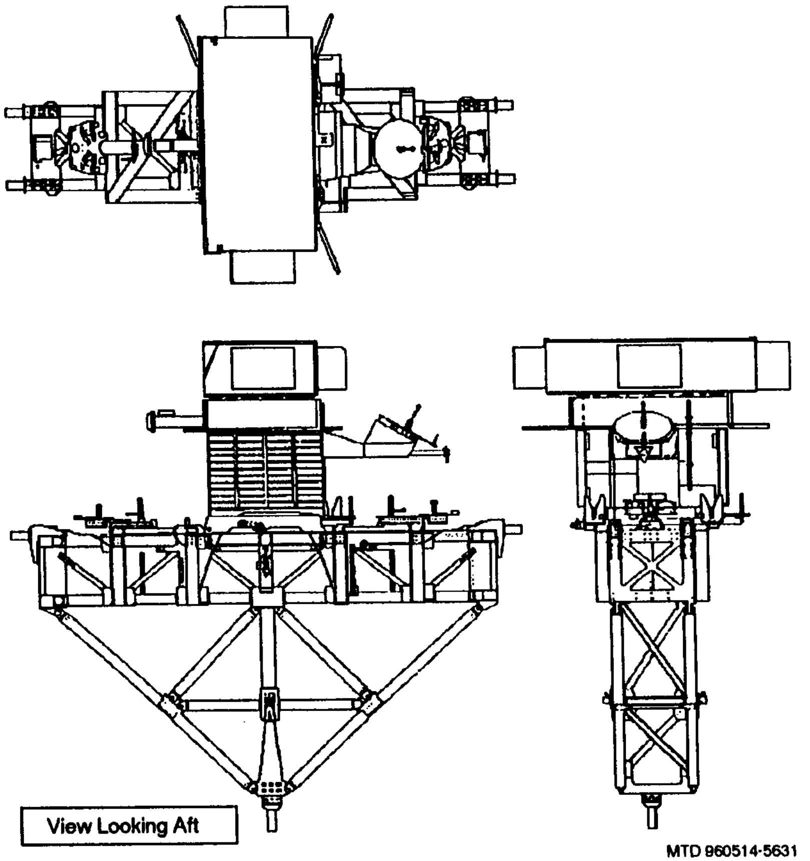
Four ACS cold-propellant gas tanks with thruster control valves are housed in the upper structure of the spacecraft. Each valve delivers argon propellant to two exhaust lines linked to a pair of opposing nozzles, forming a thruster couple.

This mission's SPARTAN configuration is unique in that the IAE is in an additional separate unit that will be ejected once the experiment is completed. Only the SPARTAN carrier with the experiment recorders will be returned to the cargo bay.

This is the second flight for this SPARTAN carrier, which flew successfully on STS-63 in February 1995. It is the fifth flight for the cross-bay SPARTAN support structure and the third for the REM. STS-77 will be the eighth SPARTAN mission to fly on the space shuttle.

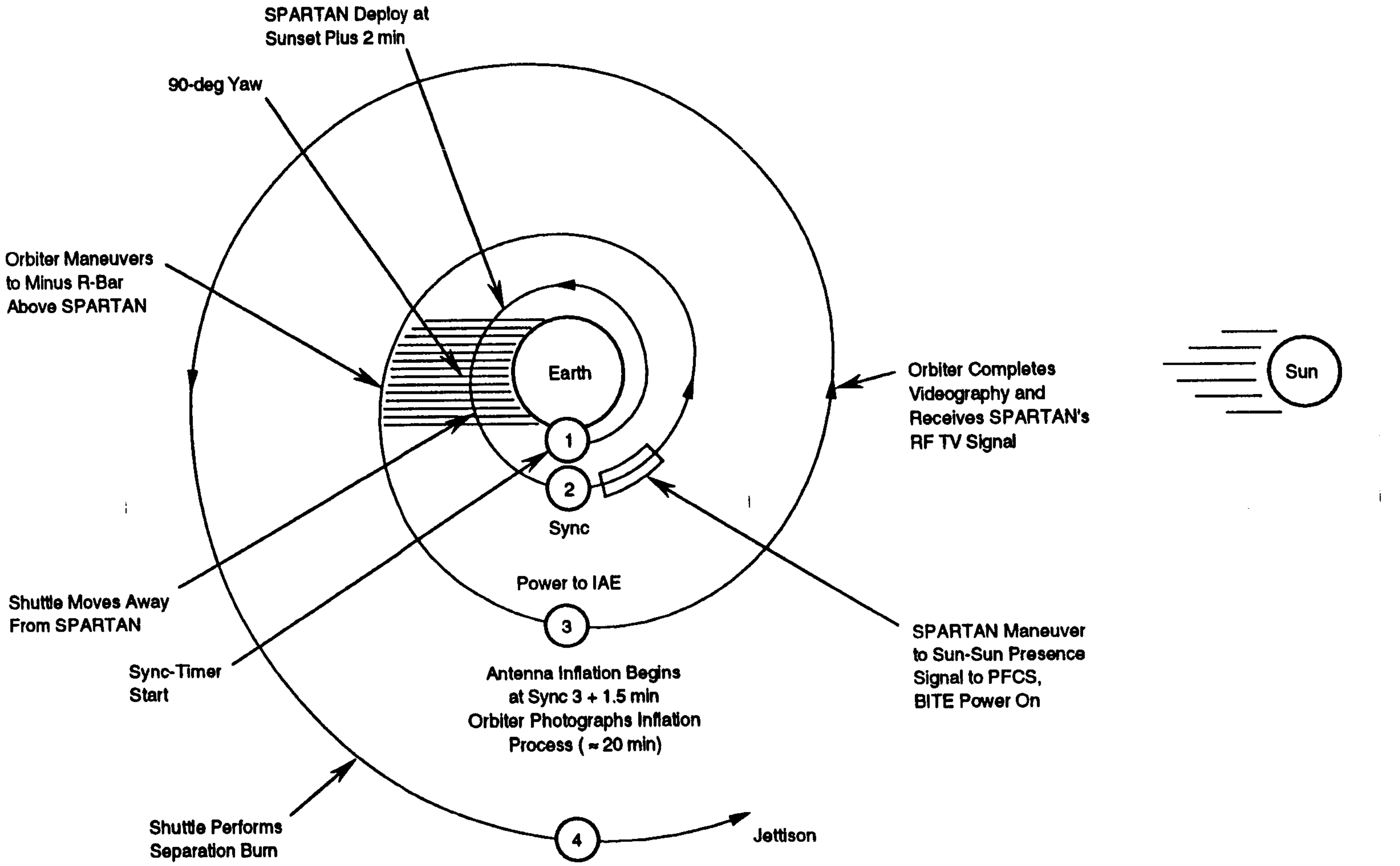
INFLATABLE ANTENNA EXPERIMENT

The IAE, which lays the groundwork for future technology development in inflatable space structures, will be launched and then inflated like a balloon on orbit. It will validate the development and performance of a large inflatable antenna during a 90-minute sequence before the antenna structure is jettisoned and the SPARTAN spacecraft is recovered at sequence end. The inflation process will be recorded by the crew with a variety of still cameras, a motion picture camera, and video cameras. The on-orbit performance of the antenna (surface accuracy) will be determined by illuminating the antenna surface with lights mounted on the SPARTAN and capturing the resulting patterns with SPARTAN's video recorders. These results will be analyzed after the SPARTAN is returned to Earth by the shuttle.



SPARTAN 207 Spacecraft on SPARTAN Support System

The IAE is a large inflatable antenna 50 feet in diameter, mounted on three 92-foot struts. Once in low Earth orbit, the SPARTAN becomes a platform for the antenna, which is almost as large as the shuttle when inflated. After SPARTAN 207 release from the RMS, power is applied to begin the IAE programmed sequence of mission events. Upon command from the IAE controller, pin pullers

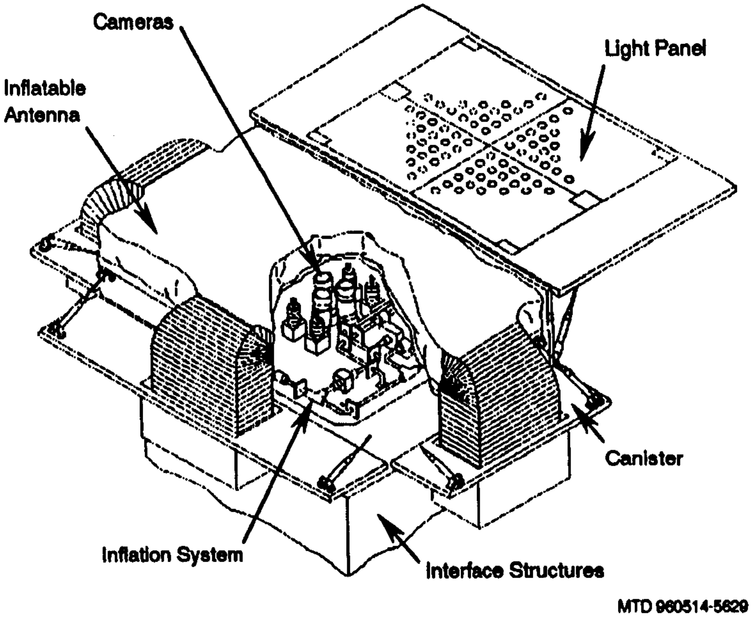


MTD 960514-5655

SPARTAN 207 Mission Operations

securing the cover of the instrument canister will fire, freeing the cover. Another pyro then fires, releasing the front and side doors. The folded antenna is released from the instrument canister when it is pushed upward and out by the light panel on which it rests. The light panel is secured by a pinned latch until antenna deployment. Once the light panel is freed by the pin puller, four springs push the light panel upward. The inadvertent deployment of the antenna or jettison of the canister/antenna assembly is considered a catastrophic hazard; therefore, all pyro devices are inhibited by two-fault tolerance.

The inflation system then pressurizes the struts and torus with inert nitrogen gas. Once the struts and torus are fully inflated, the antenna reflector is inflated. Nitrogen is stored at 3,000 psi in two 1,630-cubic-inch, fiber-wrapped aluminum tanks that are isolated from the remainder of the system by an enable/disable valve. Approximately 1,000 psi of residual gas will remain in each tank after the experiment is completed. The tanks and most of the system plumbing will be retrieved with SPARTAN 207.



Inflation System

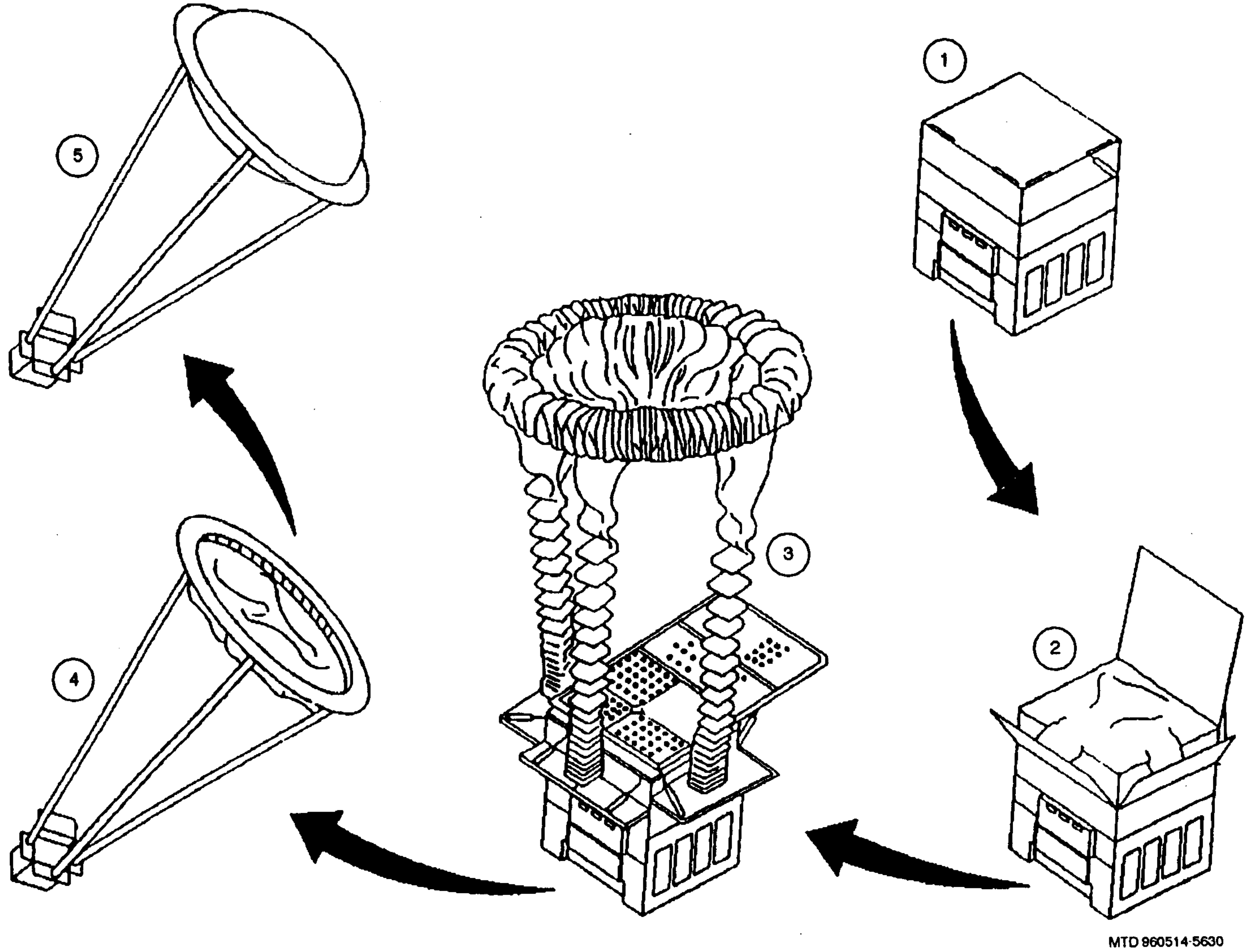
The 3-psig operating pressure in the struts and torus is controlled by a solenoid-actuated control valve and monitored by three transducers, one in each strut. The microprocessor in the electronic controller compares this actual pressure with the programmed desired pressure and actuates the control valve as required. The antenna pressure (3.1 x 10^{-4} psig) is controlled in the same manner, the struts and torus inflatant serving as the gas reservoir.

The antenna reflector is dynamically inflated. It has three holes along its periphery that are sized to vent any residual air that may be in the reflector at launch. The vent holes are small enough to maintain the very low nominal operating pressure needed for sufficient rigidity.

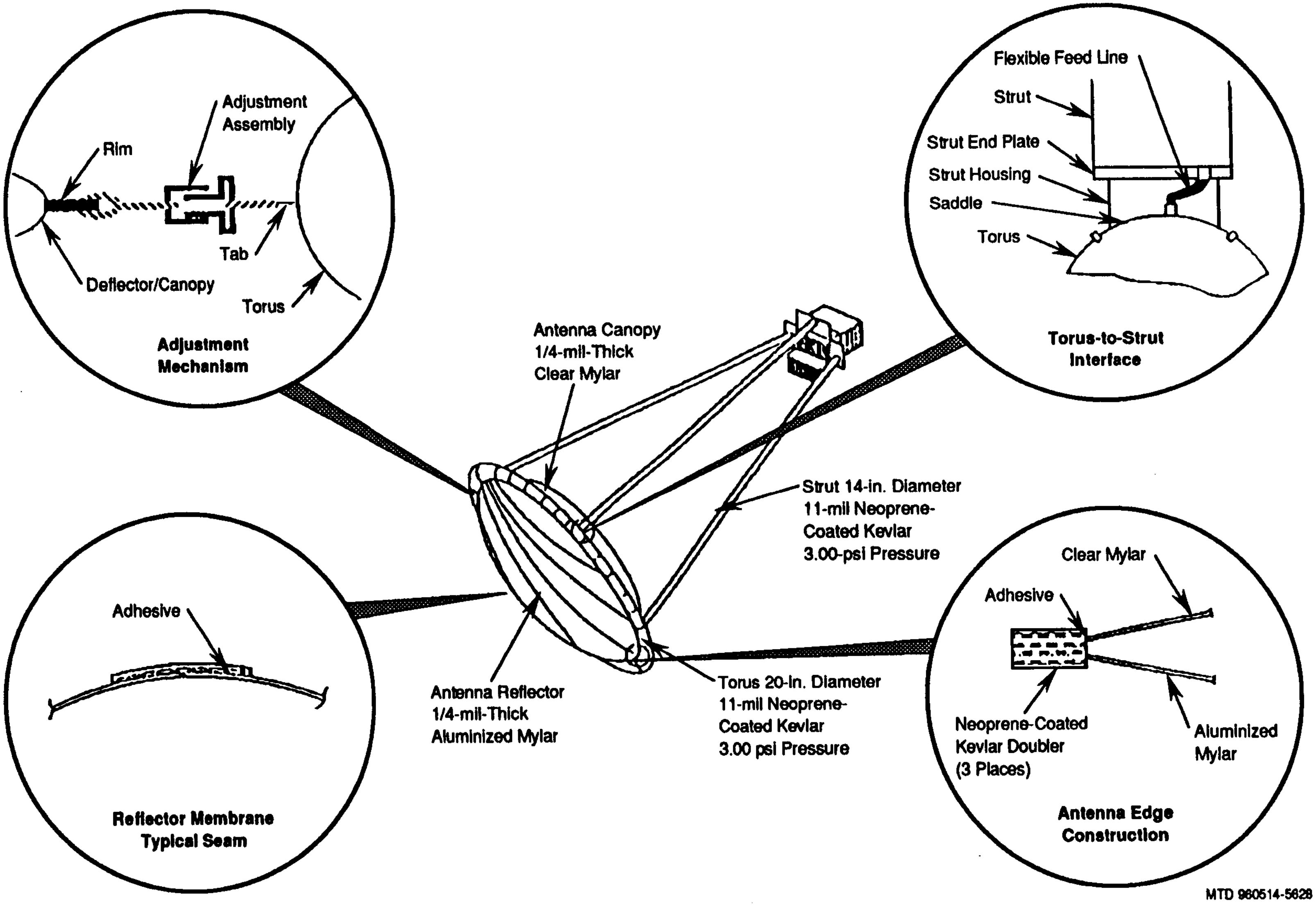
The inflation of the torus and struts requires 172 scf of nitrogen, while the antenna requires 0.35 scf (plus an additional 1.7 scf to make up the nitrogen vented during the experiment).

The deployed IAE is a lenticular-shaped antenna supported by the torus and three struts. The struts and torus are made of a Kevlar/neoprene laminate approximately 11 mils thick. The reflector is 0.25-mil aluminized Mylar. The canopy is a mirror image of the reflector but is not aluminized. The struts locate the surface accuracy measurement system (SAMS) at the center of curvature of the antenna's parabolic surface. The struts are rigidly attached to the canister doors on one end and to the torus at the other end. The total dimensions of the inflated antenna structure are as follows:

Inflated antenna reflector diameter:	45.93 feet
Inflated structure outer diameter (includes inflated torus):	50.03 feet
Inflated torus diameter:	20 inches



IAE Inflation Sequence



Inflatable Structure

Depth of reflector canopy:	5.31 feet
Distance from extreme point of antenna reflector to SPARTAN 207:	99.51 feet
Strut length:	91.86 feet
Strut diameter:	20 inches

The antenna was developed by L'Garde, Inc., of Tustin, Calif., and JPL under NASA's In-Space Technology Experiments Program.

Inflatable components show promise for space applications because they can be stowed in a much smaller space than an equivalent solid structure, which could reduce the cost of future missions by 10 to 100 times. A single small launch vehicle can carry them to orbit. This inflatable antenna weighs only about 132 pounds, and the operational version may be developed for less than $10 million—substantially less than current mechanically deployable hard structures that may cost as much as $200 million to develop and deliver to space. Inflatable structures also have the potential for much more reliable deployment than conventional mechanical systems that deploy rigid structures.

Large space antennas many times the size of today's mechanical orbiting antennas could be used for a variety of space applications, including space and mobile communications, Earth observation, astronomical observation, and space-based radar.

The IAE is a prime example of a low-cost technology validation experiment. It is designed to test the fundamental performance of a technology in the weightless vacuum of space when it is impossible to do so on the ground. Inflatable systems cannot be evaluated on Earth due to the effects of gravity and atmospheric pressure on the balloon structure. Results from space must be compared with analytical predictions before they can be used in operational systems.

In addition, the SPARTAN carrier itself will be testing new technologies. A solid-state recorder uses flash-EEPROM memory, and some of the electronic boxes use commercial plastic integrated circuits coated with Parylene.

EXPERIMENT AND MISSION MANAGEMENT

The SPARTAN project is managed by NASA's Goddard Space Flight Center in Greenbelt, Md., for the Office of Space Science in Washington, D.C. IAE is sponsored by NASA's Office of Space Access and Technology in Washington, D.C.

SPARTAN 207 RELEASE AND DEPLOYMENT

The SPARTAN 207 satellite will be deployed on day 2 of the mission. (Orbit 17 is the prime deployment opportunity, with orbit 18 as a backup.) Mission specialist Mario Runco will use the shuttle's mechanical arm to release SPARTAN and commander John Casper will back Endeavour away from the satellite.

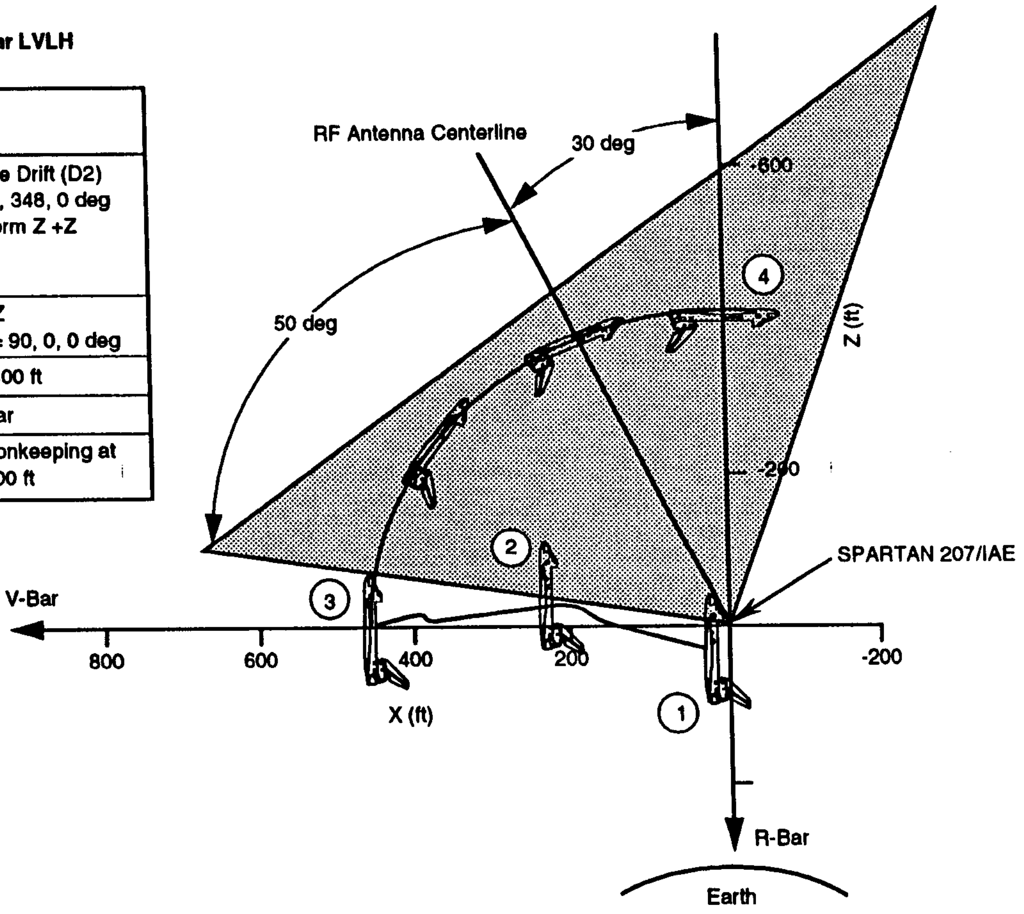
When Endeavour is 400 feet directly in front of the SPARATAN, Casper will hold position while SPARTAN experiment operations begin. Slightly less than an hour later, Casper will begin to fly around the satellite, maintaining a distance of about 400 feet, until he reaches a point directly above SPARTAN. This partial flyaround will align Endeavour with the direction of transmissions from the Inflatable Antenna Experiment.

The IAE will be inflated when Endeavour is directly above SPARTAN at a distance of 400 feet. Endeavour will station-keep 400 feet above SPARTAN for about an hour and 20 minutes while the IAE is inflated and experiments are conducted.

After the experiments are completed, Casper will fire Endeavour's jets and begin moving away from the SPARTAN. The shuttle will be about 900 feet above the satellite when the IAE is jettisoned from SPARTAN. The jettisoned IAE will move in front of and then below SPARTAN, while the separation burn moves the shuttle above

SPARTAN 207-Centered Curvilinear LVLH Coordinate Frame

	PET (h:mm)	Event
1	0:00	Release SPARTAN in Free Drift (D2) Orbiter in LVLH PYR = 90, 348, 0 deg Sep 1: Perform 0.5-fps Norm Z +Z Burn Switch to Low Z
2	0:10	At 200 ft, return to Norm Z Maneuver to LVLH PYR = 90, 0, 0 deg
3	0:24	V-Bar Stationkeeping at 400 ft
3	1:25	Initiate Flyaround to -R-Bar
4	1:51	Begin Low Z -R-Bar Stationkeeping at -Z Pitch = 275 deg and 400 ft



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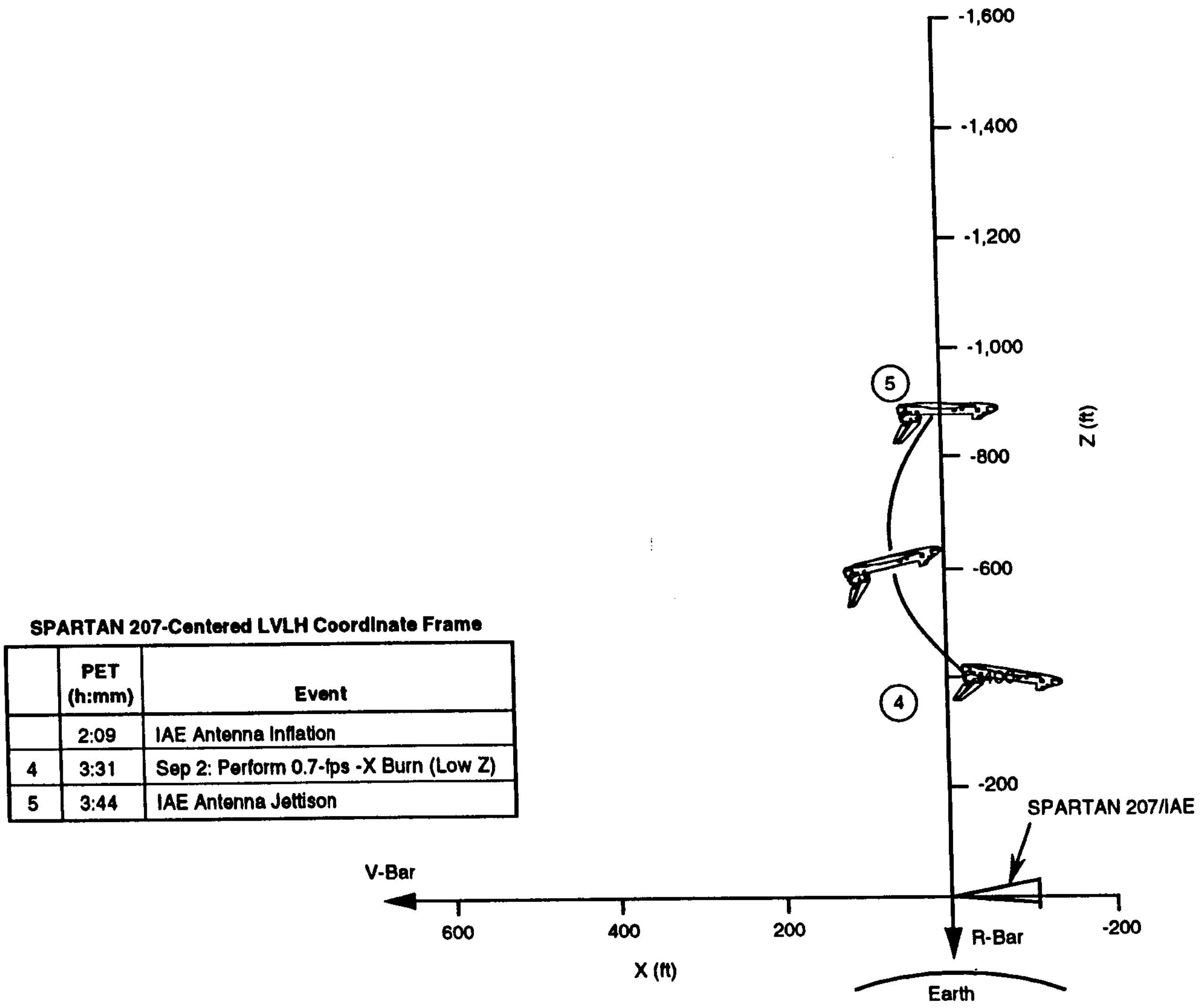
SPARTAN 207/IAE Deployment and Stationkeeping

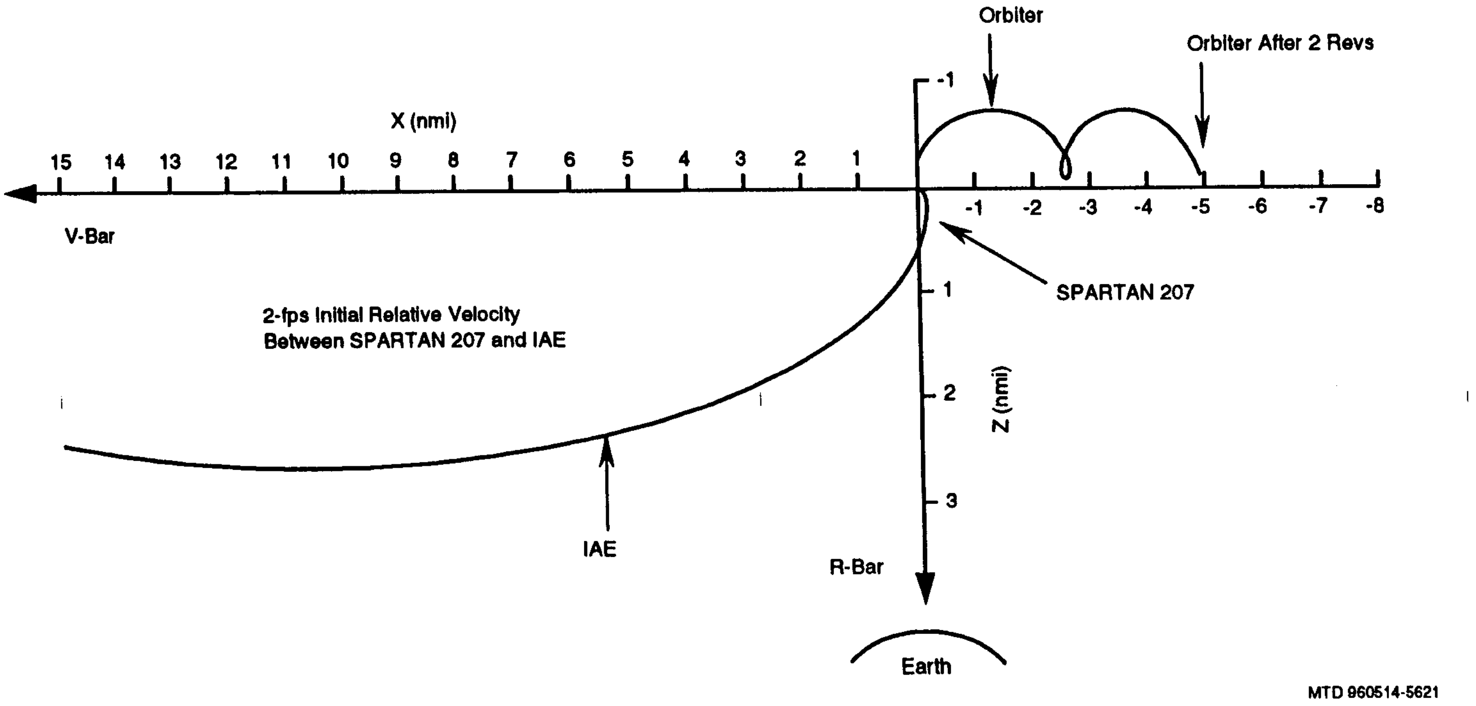


SPARTAN 207-Centered LVLH Coordinate Frame

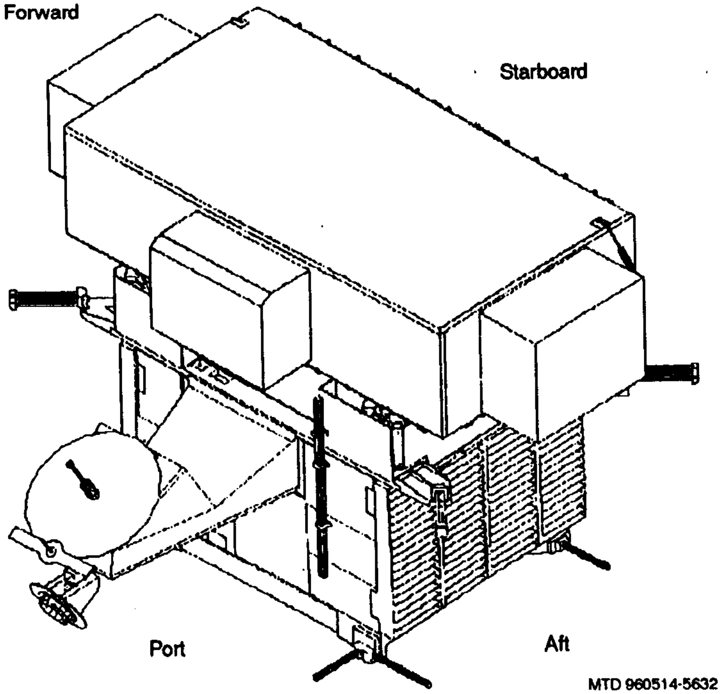
	PET (h:mm)	Event
	2:09	IAE Antenna Inflation
4	3:31	Sep 2: Perform 0.7-fps -X Burn (Low Z)
5	3:44	IAE Antenna Jettison

MTD 960514-5615

SPARTAN 207/IAE Separation



SPARTAN 207/IAE/Orbiter Relative Motion After Jettison



SPARTAN 207 Deployed Configuration, Port View

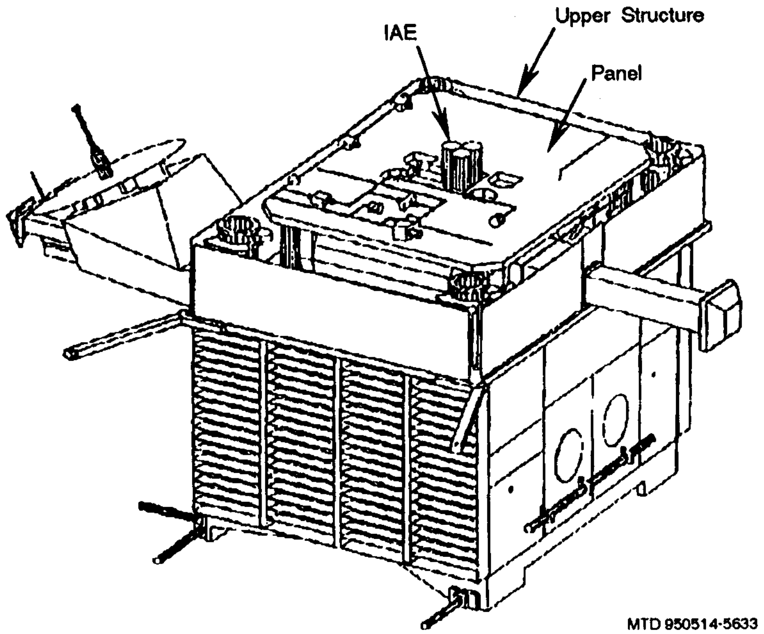
and behind the satellite at a rate of almost 2.5 nautical miles per orbit. During the next day, Endeavour will range as far as 40 to 60 nautical miles behind the satellite before again closing in.

RENDEZVOUS AND RETRIEVAL

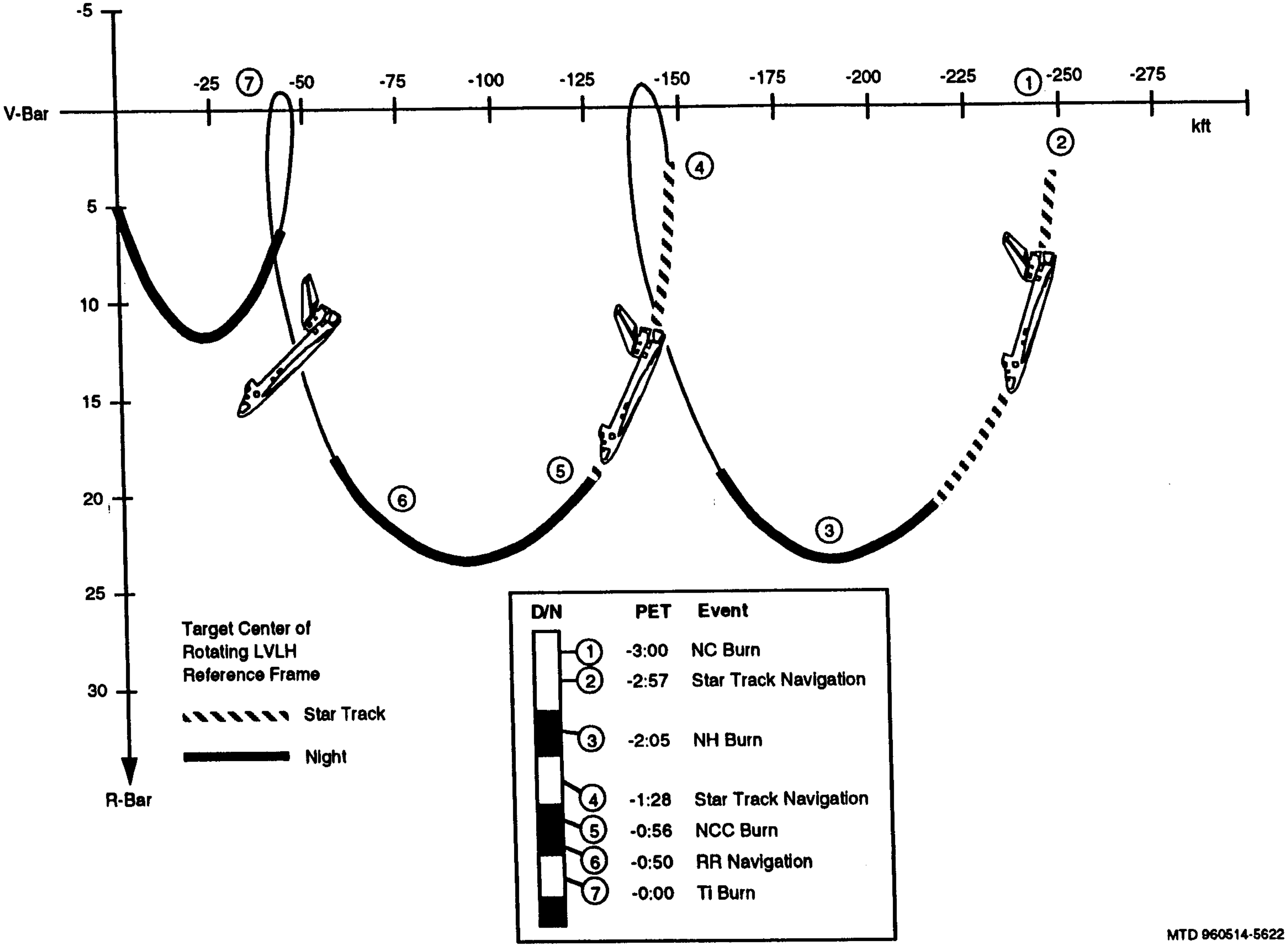
Endeavour will return to the SPARTAN's vicinity on day 3 of the mission. Satellite retrieval is planned on orbit 35. The final phase of the rendezvous will begin when Endeavour is 8 nautical miles behind the satellite; a terminal-phase initiation burn will put Endeavour on a course to intercept the SPARTAN.

As Endeavour closes in, it can make four small midcourse correction firings to fine-tune its course toward SPARTAN. Meanwhile, mission specialist Marc Garneau will extend the shuttle's mechanical arm into position for satellite retrieval.

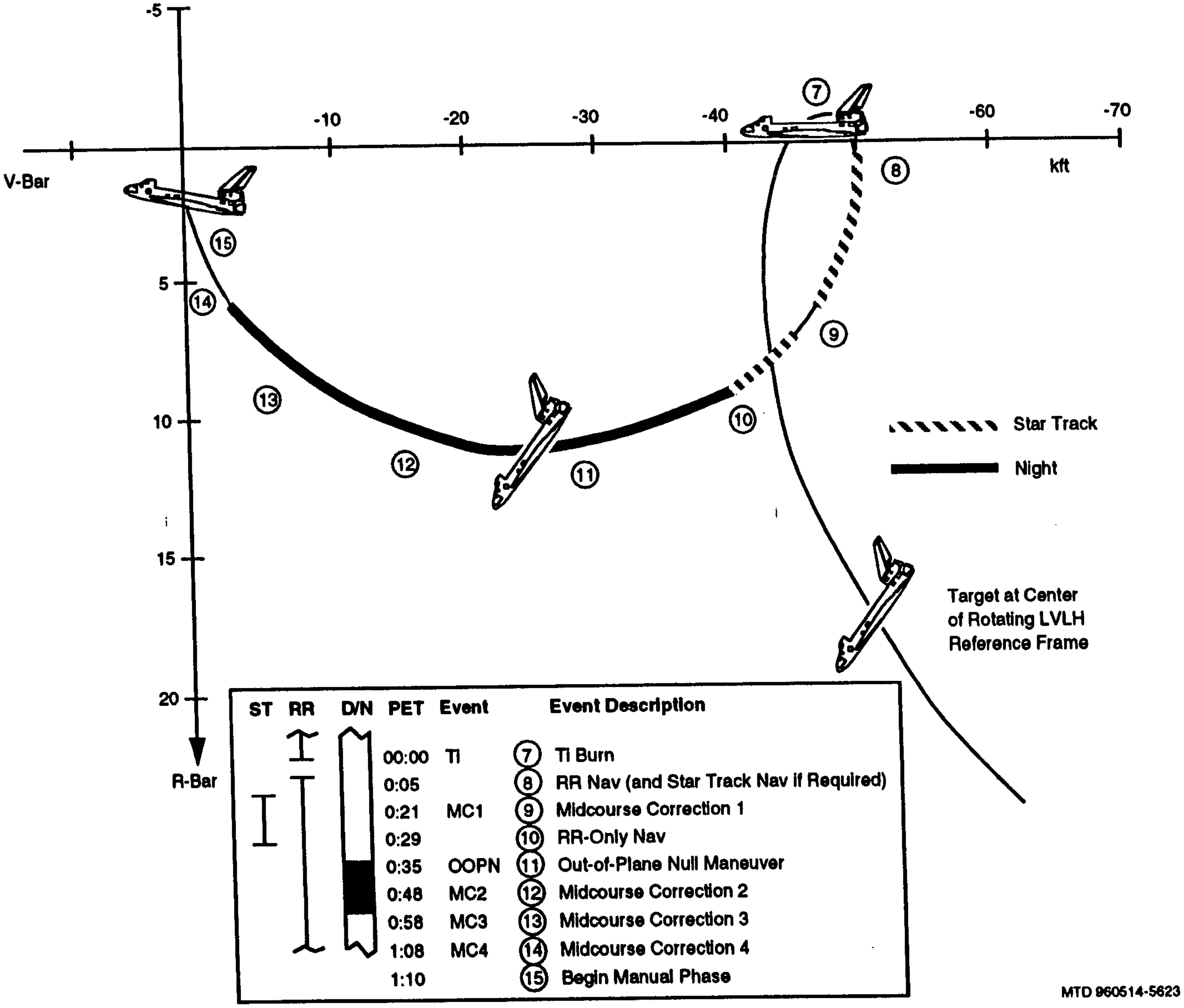
Shortly after the fourth and final midcourse correction, Casper will take manual control of Endeavour's flight. The shuttle will be about 2,500 feet directly below the satellite. Casper will fly the shuttle to a point about 400 feet directly in front of SPARTAN and then close to within 35 feet. As Casper aligns Endeavour with Spartan, Garneau will move the mechanical arm into place to lock onto the SPARTAN grapple fixture. Once captured, SPARTAN will be lowered back into the cargo bay and latched in place for return to Earth.



SPARTAN 207 Retrieved Configuration

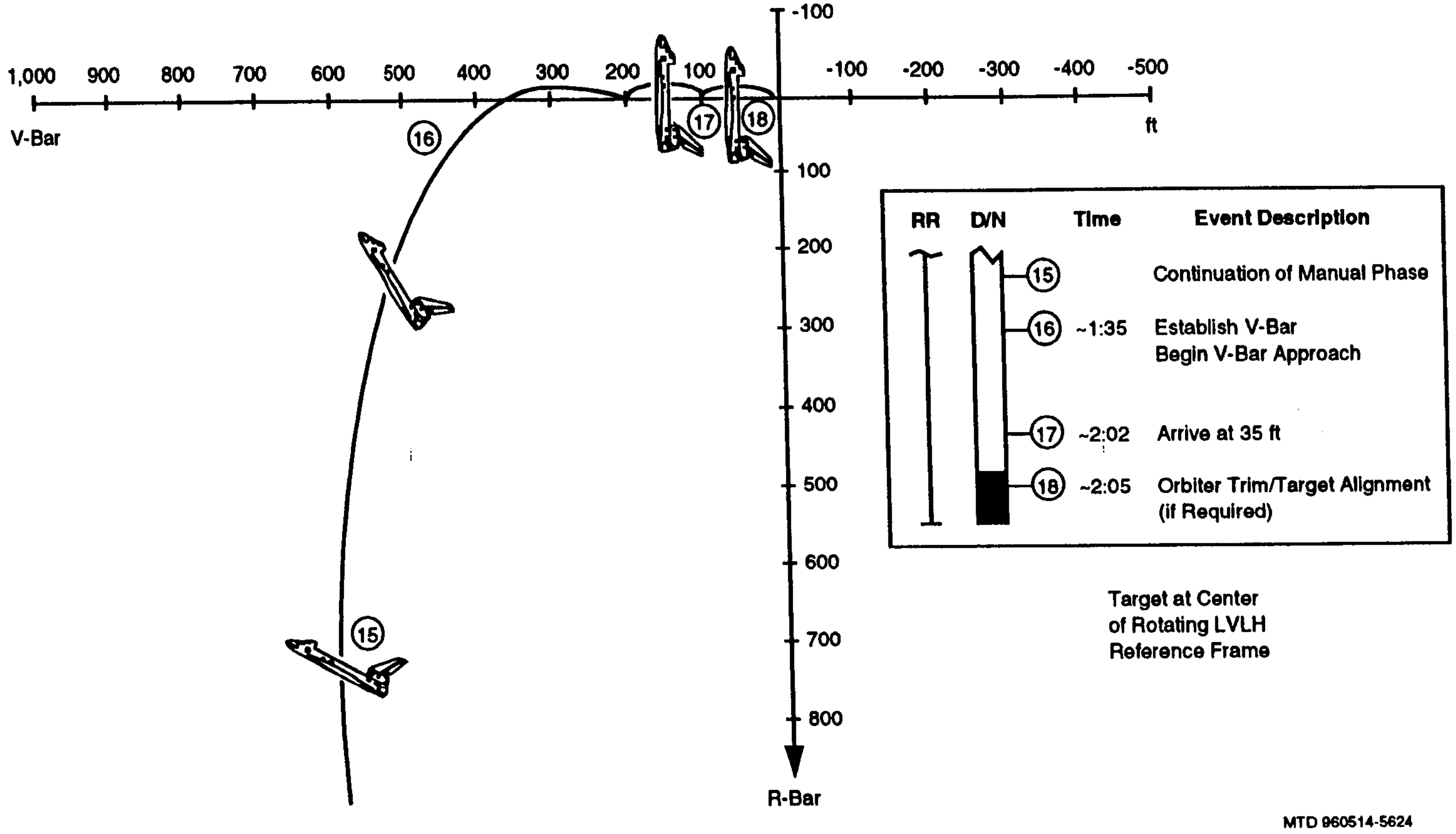


Rendezvous Profile



ST	RR	D/N	PET	Event	Event Description
			00:00	TI	⑦ TI Burn
			0:05		⑧ RR Nav (and Star Track Nav if Required)
			0:21	MC1	⑨ Midcourse Correction 1
			0:29		⑩ RR-Only Nav
		■	0:35	OOPN	⑪ Out-of-Plane Null Maneuver
		■	0:48	MC2	⑫ Midcourse Correction 2
			0:58	MC3	⑬ Midcourse Correction 3
			1:08	MC4	⑭ Midcourse Correction 4
			1:10		⑮ Begin Manual Phase

Rendezvous Profile



RR	D/N	Time	Event Description
	⑮		Continuation of Manual Phase
	⑯	~1:35	Establish V-Bar Begin V-Bar Approach
	⑰	~2:02	Arrive at 35 ft
	⑱	~2:05	Orbiter Trim/Target Alignment (if Required)

Rendezvous Profile

TECHNOLOGY EXPERIMENTS ADVANCING MISSIONS IN SPACE

NASA and the Goddard Space Flight Center (GSFC) intend to launch and operate in orbit a Hitchhiker (HH) payload, designated Technology Experiments Advancing Missions in Space (TEAMS), using the space shuttle. The TEAMS payload will fly on a shared flight as a primary payload. The payload weight will be 5,340 pounds at launch and 5,225 pounds at landing.

The HH carrier is designed for cross-bay mounting in the payload bay using the HH multipurpose equipment support structure (MPESS) bridge provided by GSFC. The payload/carrier will be initially prepared at GSFC. All experiments will be integrated to the HH-MPESS, and mechanical and electrical checkouts will be performed. The integrated payload will then be transported to a payload processing facility (PPF) at KSC where additional testing and final electrical and mechanical integration activities will be performed by GSFC. The payload will then be moved to the launch pad payload change-out room (PCR), where the payload is installed into the orbiter and interfaces are verified. Late launch pad operations are currently planned for TEAMS including final arming of the Hitchhiker Ejection System (HES) pyrotechnic initiators and removal of all remove-before-flight protective covers.

The TEAMS experiments will undergo functional testing at KSC. All safety precautions, as well as approved Technical Operating Procedures (TOPS), will be in place prior to and during these operations.

The TEAMS payload consists of the HH carrier and the following four experiments:

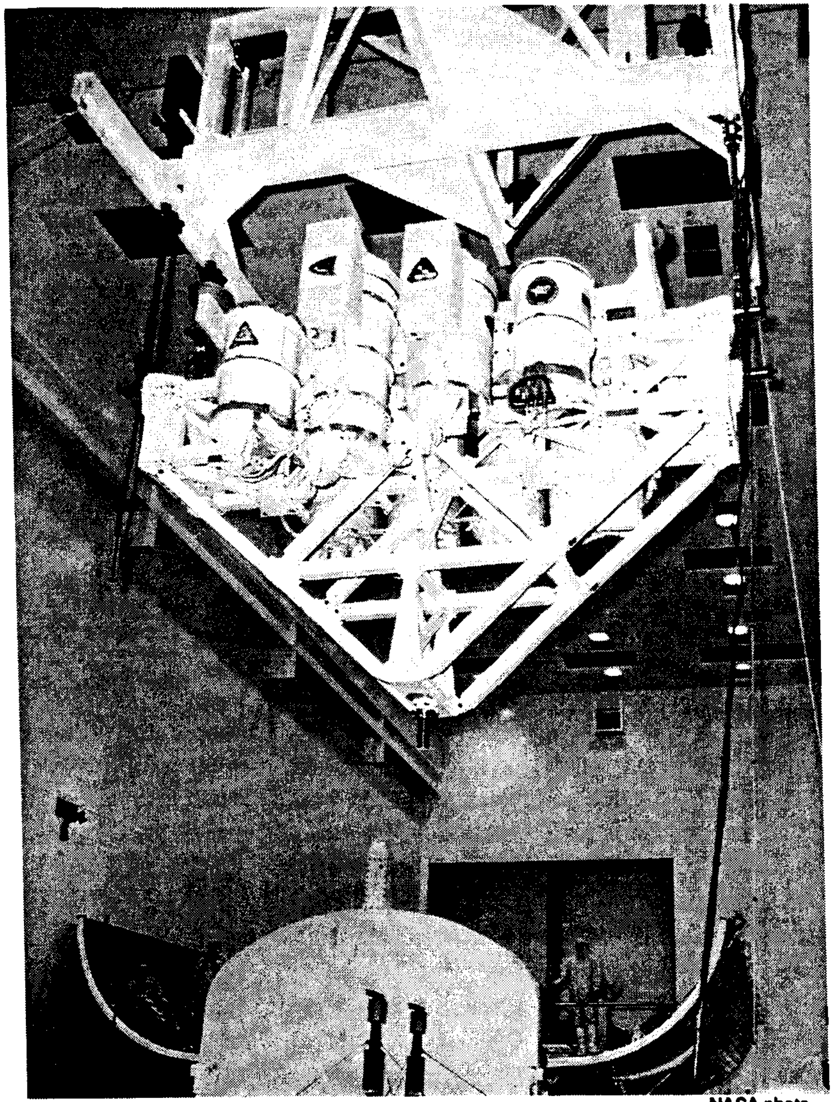
- Global Positioning System (GPS) Attitude and Navigation Experiment (GANE), managed by the Johnson Space Center (JSC) for the International Space Station Alpha (ISSA)
- Liquid Metal Thermal Experiment (LMTE), managed by Phillips Laboratory, U.S. Air Force, Kirtland Air Base, New Mexico
- Passive Aerodynamically Stabilized Magnetically Damped Satellite (PAMS), managed by GSFC for the Office of Space Access and Technology
- Vented Tank Resupply Experiment (VTRE), managed by Lewis Research Center (LeRC) for the Office of Space Access and Technology

The experiments are flown together at reduced cost, with the HH carrier providing the needed resources (power, data, etc.) to each experiment. The carrier can carry equipment mounted in canisters and has mounting plates of various sizes for user equipment. The carrier provides electrical power, command signals, and a downlink data interface. HH customers operate their payloads from a GSFC control center using their own ground support equipment (usually a personal computer) to send commands and display data.

GLOBAL POSITIONING SYSTEM (GPS) ATTITUDE AND NAVIGATION EXPERIMENT (GANE)

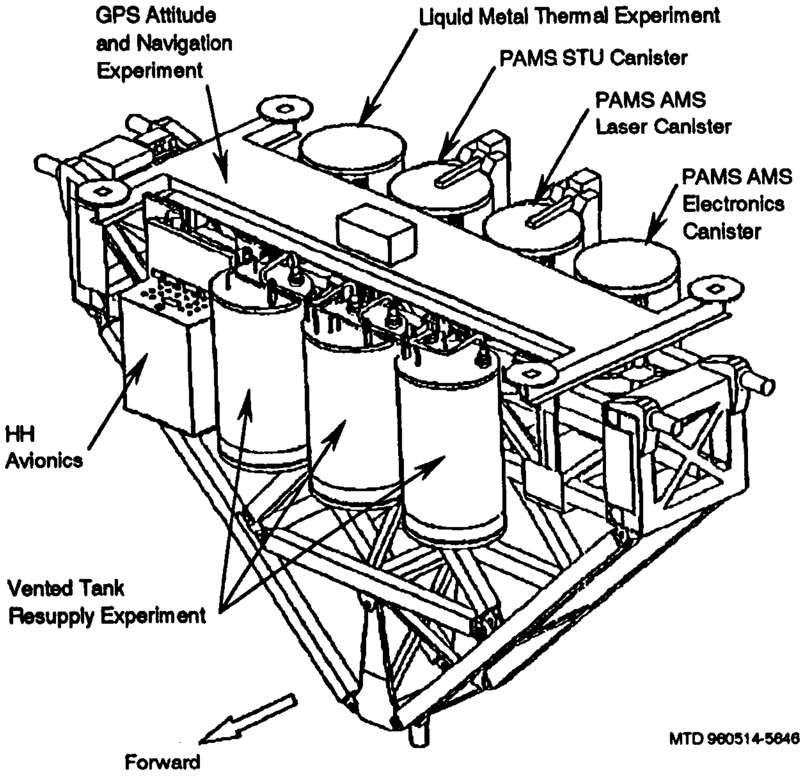
The GPS is a Department of Defense navigation system that allows worldwide navigation capabilities. GPS is becoming the world standard navigation system that allows anyone anywhere to know his position within 100 meters or less.

One unique aspect of GPS is its capability to determine the attitude of a vehicle using three or four antennas, and measuring the GPS carrier phase through each antenna. This technique has been successfully tested on surface vehicles and aircraft, but it has not been tested in space before.



NASA photo

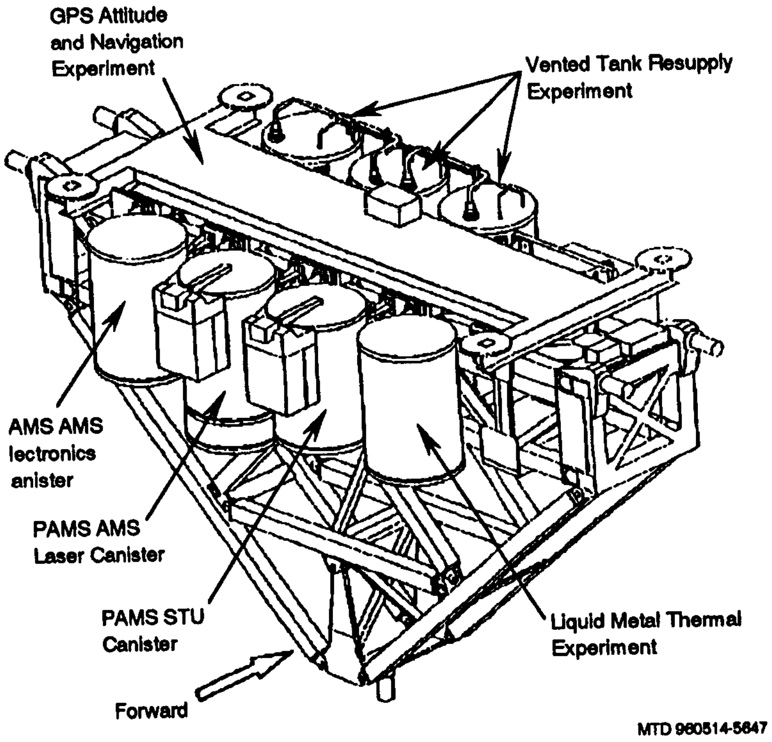
Workers at KSC prepare to place TEAMS in payload transporter.



TEAMS Payload (Forward View)

GANE will measure GPS subsystem attitude determination, navigation, and overall on-orbit performance in support of ISSA. In particular, the capability of potential candidate GPS hardware and software for ISSA will be evaluated.

GANE consists of two independent systems: a GPS receiver/processor assembly (RPA) and antenna assembly (AA), and an inertial reference unit (IRU). Both systems are mounted on top of the GANE antenna mounting structure (GAMS). All this hardware, referred to as the GANE integrated assembly platform (IAP), is attached to the top of the HH-MPESS. The GPS RPA and the IRU independently use a crew cabin-located payload and general support computer (PGSC) to store data and command operations.



TEAMS Payload (Aft View)

GANE will accomplish its experiment objectives by operating the GPS system through four on-orbit operational test sequences totaling 22 hours. Prior to and after the data collection sessions, the orbiter will perform the star line maneuvers (SLMs) to align the IRU to the orbiter inertial measurement unit (IMU). The SLM uses the orbiter star trackers (OSTs) to align the IRU. Data from the IRU and the GPS RPA is collected on the PGSCs, and a subset of this data is included in the TEAMS downlink data stream. Crew interaction is required for PGSC initiation and for verification that data is being received and stored properly.

LIQUID METAL THERMAL EXPERIMENT (LMTE)

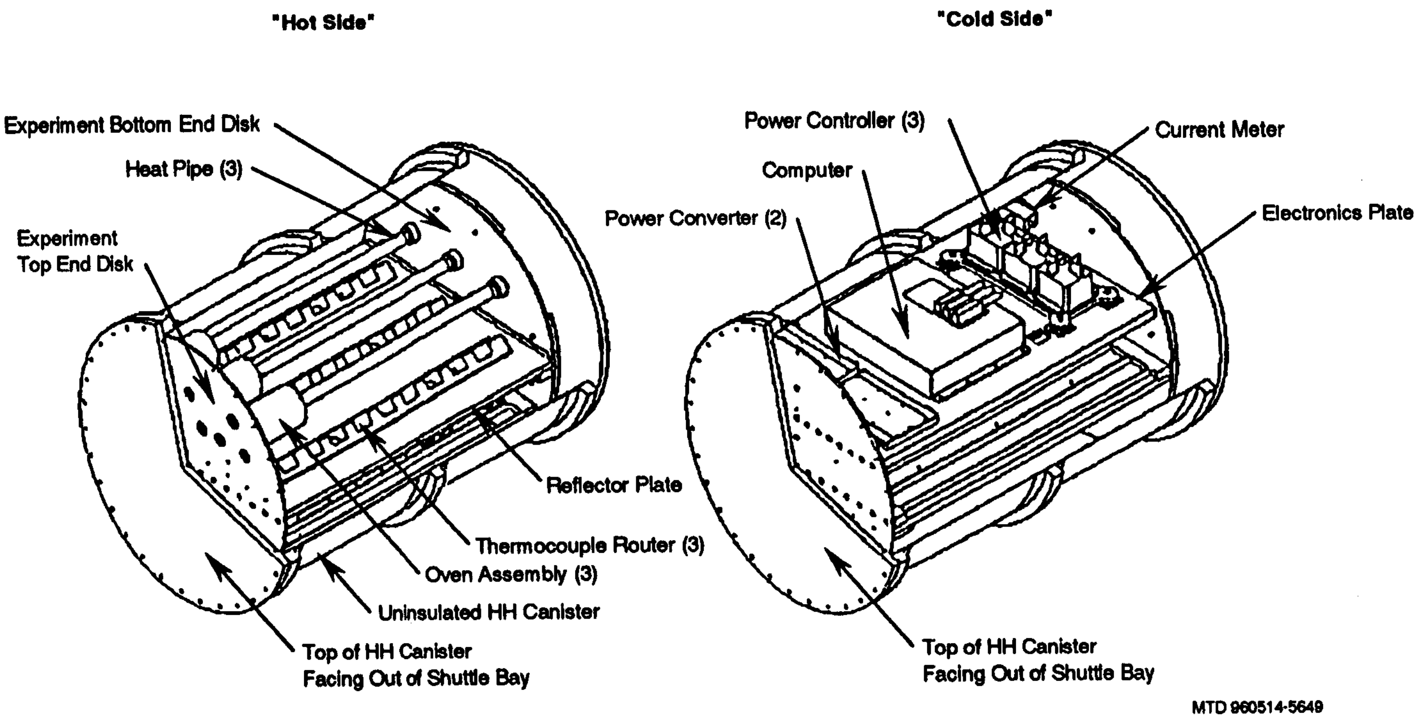
LMTE will test three metal heat pipe designs, providing a flight history to base further design and testing of liquid metal heat pipes for the Air Force Space Thermionic Reactor Program.

LMTE is mounted in a single, sealed 5-cubic-foot HH cylindrical canister. The lower end plate (LEP) is equipped with a ground-commanded vent valve to allow on-orbit evacuation of the canister. The experiment is separated into two sides: a "hot" heat pipe side and a "cold" electronics side. Major components of the hot side are the heat pipes, heaters, oven structures, and thermocouples. The cold side primarily houses all electrical components.

The LMTE mission consists of three tests for each of the three heat pipes. Data including heat pipe temperature, canister wall temperature, experiment voltage, and experiment current will be recorded by the experiment control unit (ECU) and included in the TEAMS downlink data stream during powerup, pretest verifications, steady state operation, and the cooldown phase.

Heat pipes are thermal management devices used on many existing and planned space systems for the purpose of waste heat removal. In their simplest form, they consist of a tube containing a porous wicking material saturated with a working fluid. During operation, the fluid alternately vaporizes and condenses at different ends of the pipe as it absorbs and releases the waste heat.

Many different kinds of fluids are used, including ammonia, oxygen and potassium, depending on the desired operation temperatures. The three LMTE heat pipes contain potassium and are designed to operate at 300 to 1,000 degrees Celsius. Heat pipes in this high temperature range have never been operated in microgravity conditions. The operational characteristics of liquid metals in space are, therefore, not well understood. The data obtained from LMTE will be invaluable to space system designers requiring high temperature heat rejection. The LMTE requires



LMTE

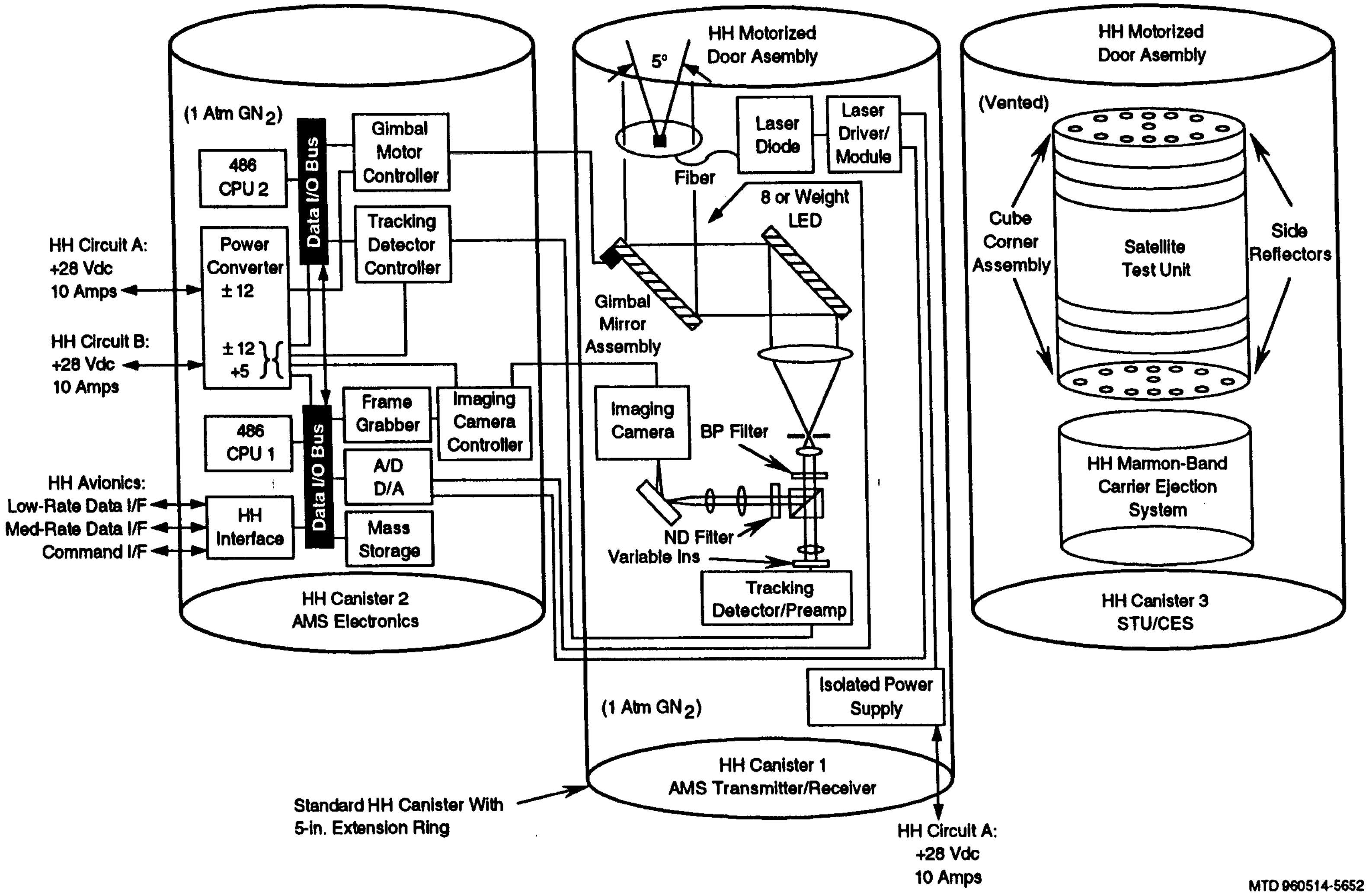
54 hours' total operating time. Flight operations consist of three tests per heat pipe for a total of nine, six-hour test cycles.

PASSIVE AERODYNAMICALLY STABILIZED MAGNETICALLY DAMPED SATELLITE (PAMS)

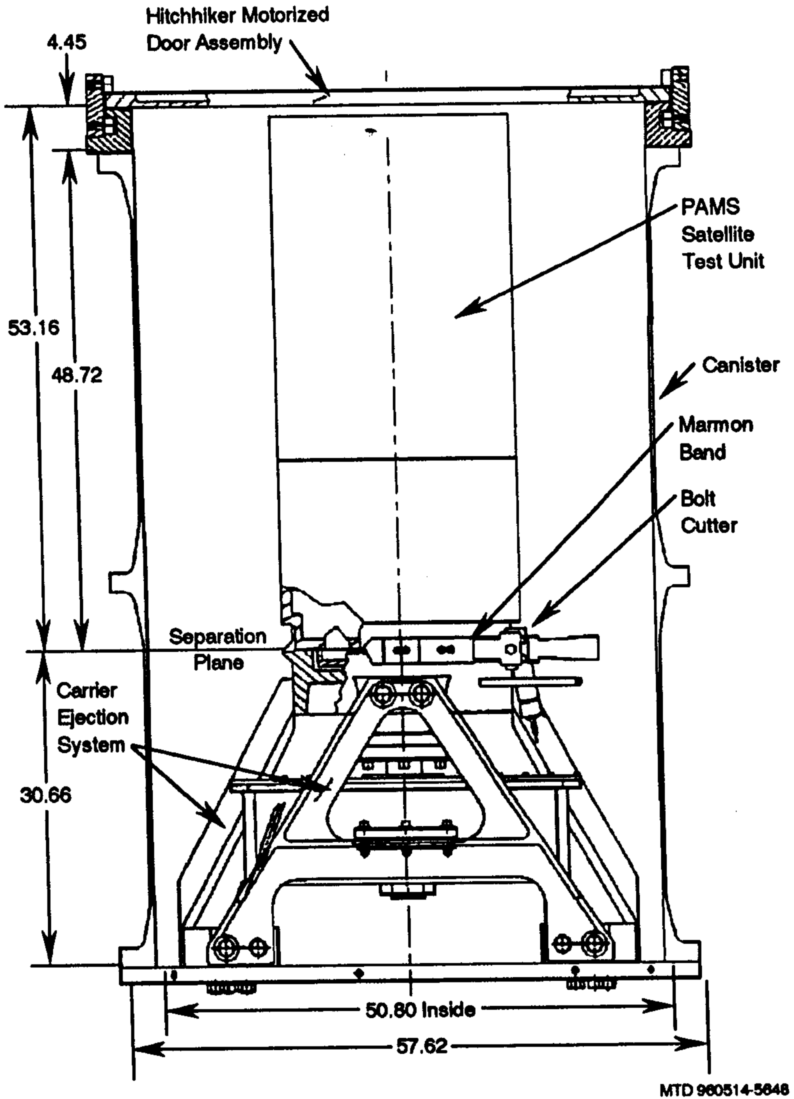
The PAMS experiment consists of three main subassemblies: the satellite test unit (STU), the attitude measurement system (AMS) transmitter/receiver (AMS canister No. 1), and the AMS electronics (AMS canister No. 2). The PAMS STU is a small, passive subsatellite deployed from a 5-cubic-foot HH cylindrical canister equipped with an HH motorized door assembly (HMDA) and the HES.

The AMS is a simple, gimbaled imaging system designed to perform measurements of the STU attitude. The AMS is housed in two separate HH canisters connected by a harness. The AMS transmitter/receiver canister has a 10-inch extension ring mounted on the bottom of the canister to accommodate the volume required by the hardware and an HMDA. The canister upper end plate (UEP) is modified to include a 5-inch-diameter fused silica window for on-orbit laser operation. The AMS electronics are housed in a standard HH canister located next to the AMS transmitter/receiver.

The purpose of PAMS is to demonstrate passive stabilization of small satellites using aerodynamics stabilization and magnetic damping. The PAMS experiment requires 20 hours' total operating time, with operations consisting of a flight checkout cycle, an initial



PAMS Functional Block Diagram



TEAMS Standard Switch Panel

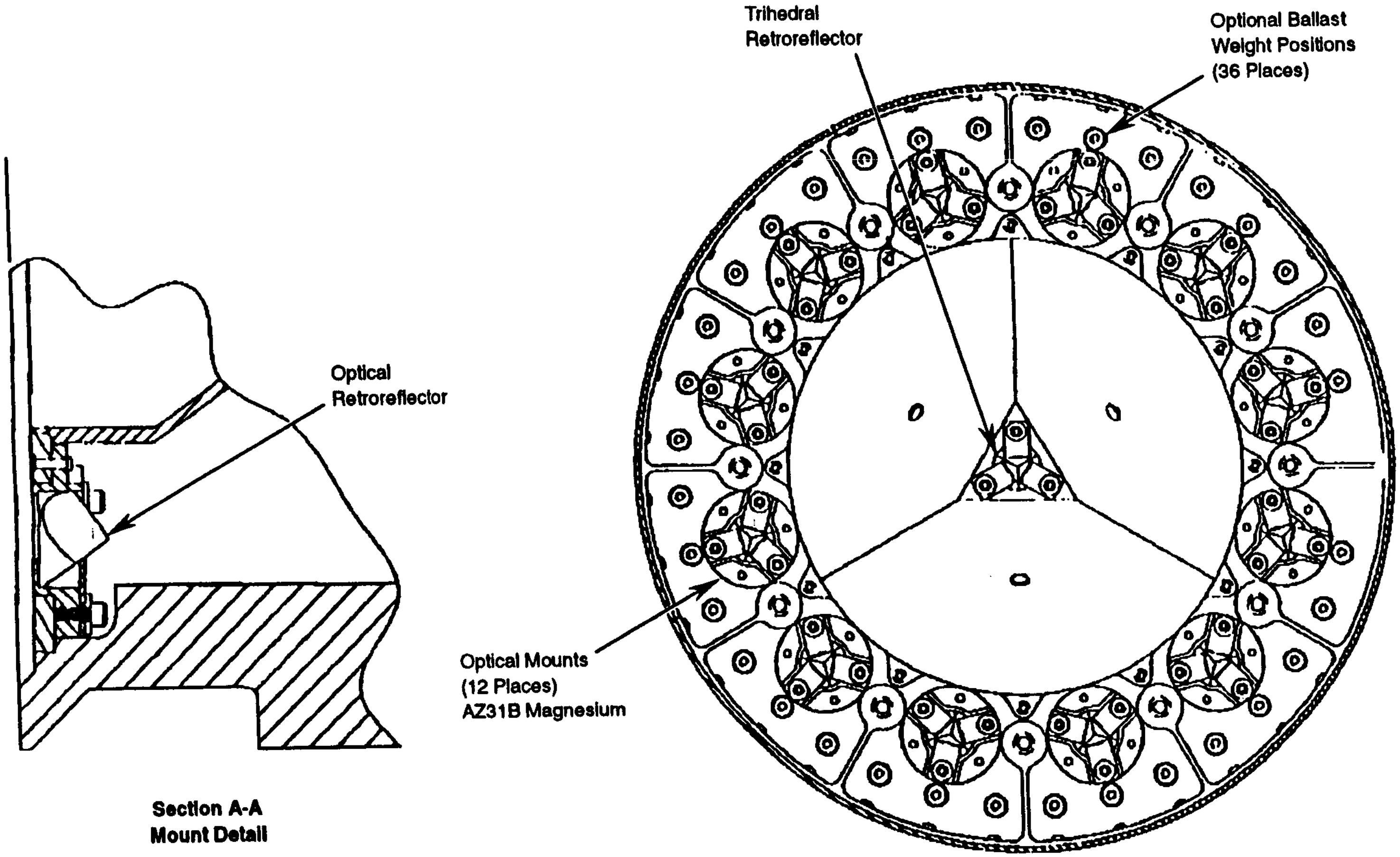
deploy and observation cycle, and two rendezvous and observation cycles. The STU is deployed in an initially unstable attitude. Subsequent stabilization and steady-state performance will be observed and measured using the AMS. The AMS accomplishes this by using a laser to illuminate the STU, which is painted white with black stripes to enhance viewing and is equipped with an array of reflectors. The AMS then records and processes the return signal to determine the attitude and attitude rates of the STU. Data from the AMS will be routed to the aft flight deck (AFD) for display on a PGSC. The data will be used to collaborate orbit pointing at the free-flying STU.

VENTED TANK RESUPPLY EXPERIMENT (VTRE)

The purpose of VTRE is to test improved methods for in-space refueling. The results of the experiment will be used in future designs of spacecraft liquid storage tanks.

When a spacecraft stay in space for long periods, such as the ISSA, it needs to be resupplied. This includes resupplying everything from rocket propellant to drinking water. The VTRE will primarily test technologies for using a vented fill method in space. In a vented fill, vapor is allowed to vent from the tank to make room for the incoming liquid. In space, the near total absence of gravity coupled with the natural tendency of liquids to wet solid surfaces makes it difficult to vent or resupply tanks with gas and liquid cannot be reliably predicted. Capillary vane devices will be tested to enable direct tank venting and resupply of partially filled tanks by locating and concentrating a liquid. VTRE will test efficient and reliable management of fluids, with respect to gas venting and vented liquid resupply using approximately 78 pounds of dyed Freon-113 as the working fluid.

VTRE is mounted in three sealed 5-cubic-foot HH cylindrical canisters. Each canister has a 5-inch extension ring mounted on the bottom and experiment-unique hardware on the top. The experi-

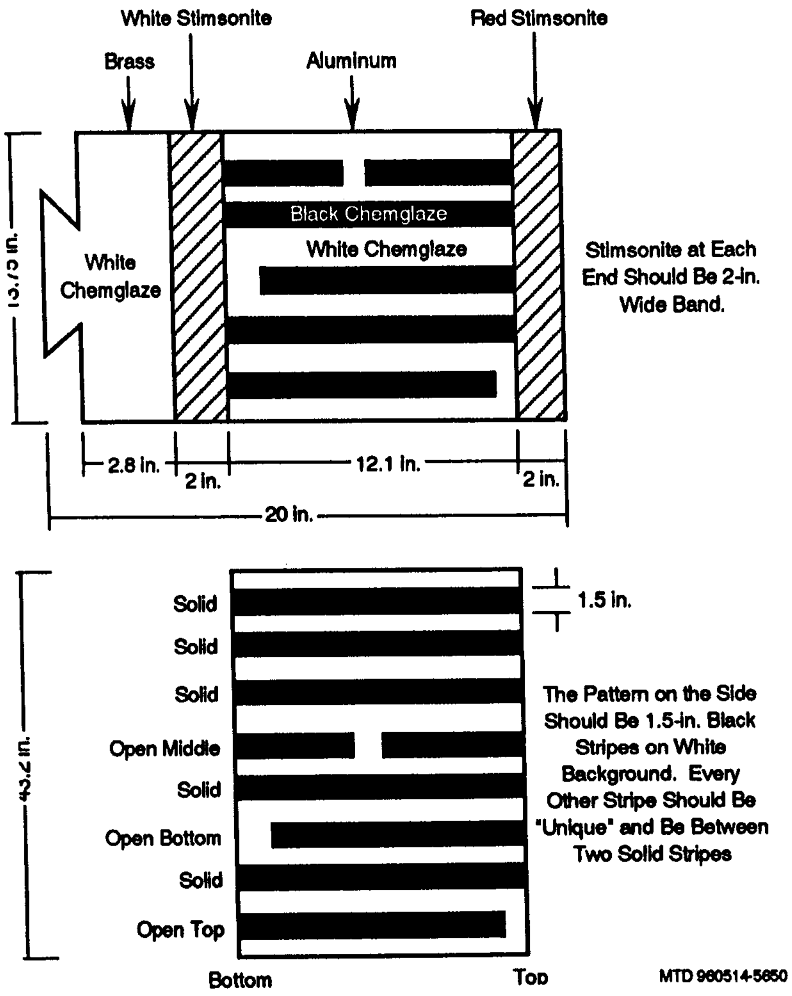


Section A-A
Mount Detail

End Assembly
With Retroreflectors

MTD 960514-5651

STU End Assembly Retroreflector Array



Outer Satellite Paint Pattern of STU

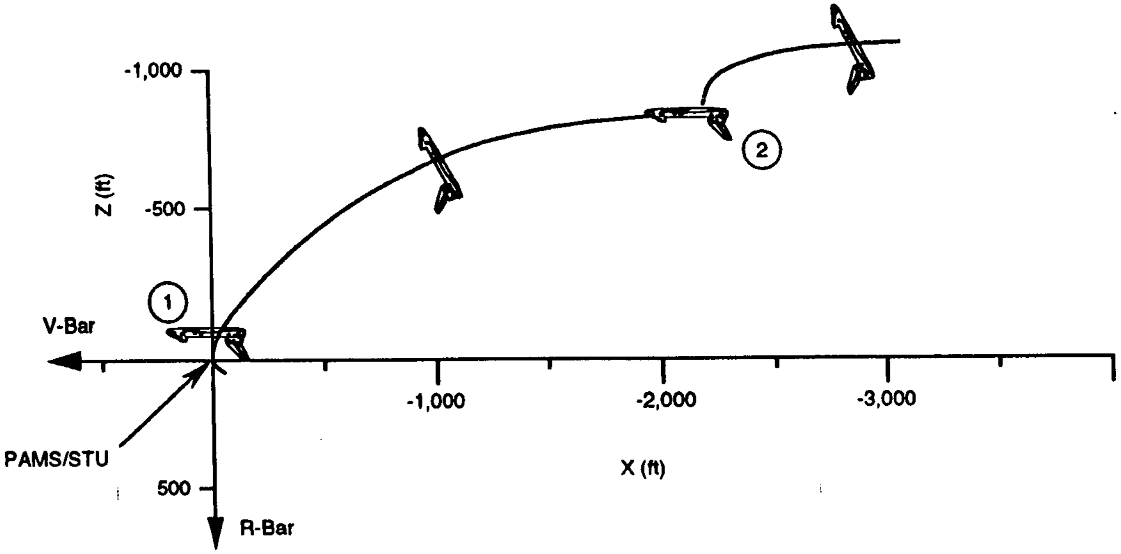
ment-unique hardware consists of hard plumbing and flexible hoses used to transfer the working fluid between the tanks, attachment hardware, heaters, and power and data lines between canisters

The VTRE flight operations require a minimum 24-hour total operating time and consist of eight groups of tests. The operations consist of transferring Freon from one test tank to another, venting gaseous Freon from each tank into the payload bay, and conducting disturbance tests that require orbiter maneuvers. The tests that do not require orbit maneuvers need a low-g operational environment (1 x 10). Data return is primarily in the form of video.

VTRE will operate during crew sleep periods except during crew member interactive science operations. During operating periods, near-continuous payload data interleaver (PDI) data and 10 minutes' commanding every house is required. During nonoperating periods, PDI data and payload signal processor (PSP) commanding are required for at least 15 minutes about every three hours for thermostatic control of the experiment.

A two-hour period of bay-to-wake attitude is required after completion of the first two test groups. Two primary reaction control system (PRCS) thruster firings that produce pure translational or rotational accelerations are highly desired. Alternatively, the objectives of this experiment can be met by providing a series of short pulse reaction control system (RCS) firings. VTRE does not wish to operate during PRCS or orbital maneuvering system (OMS) firings other than those scheduled for science operations.

Video from the VTRE experiment via the HH video interface unit will be routed to the orbiter closed circuit television system for real-time or near real-time downlink.

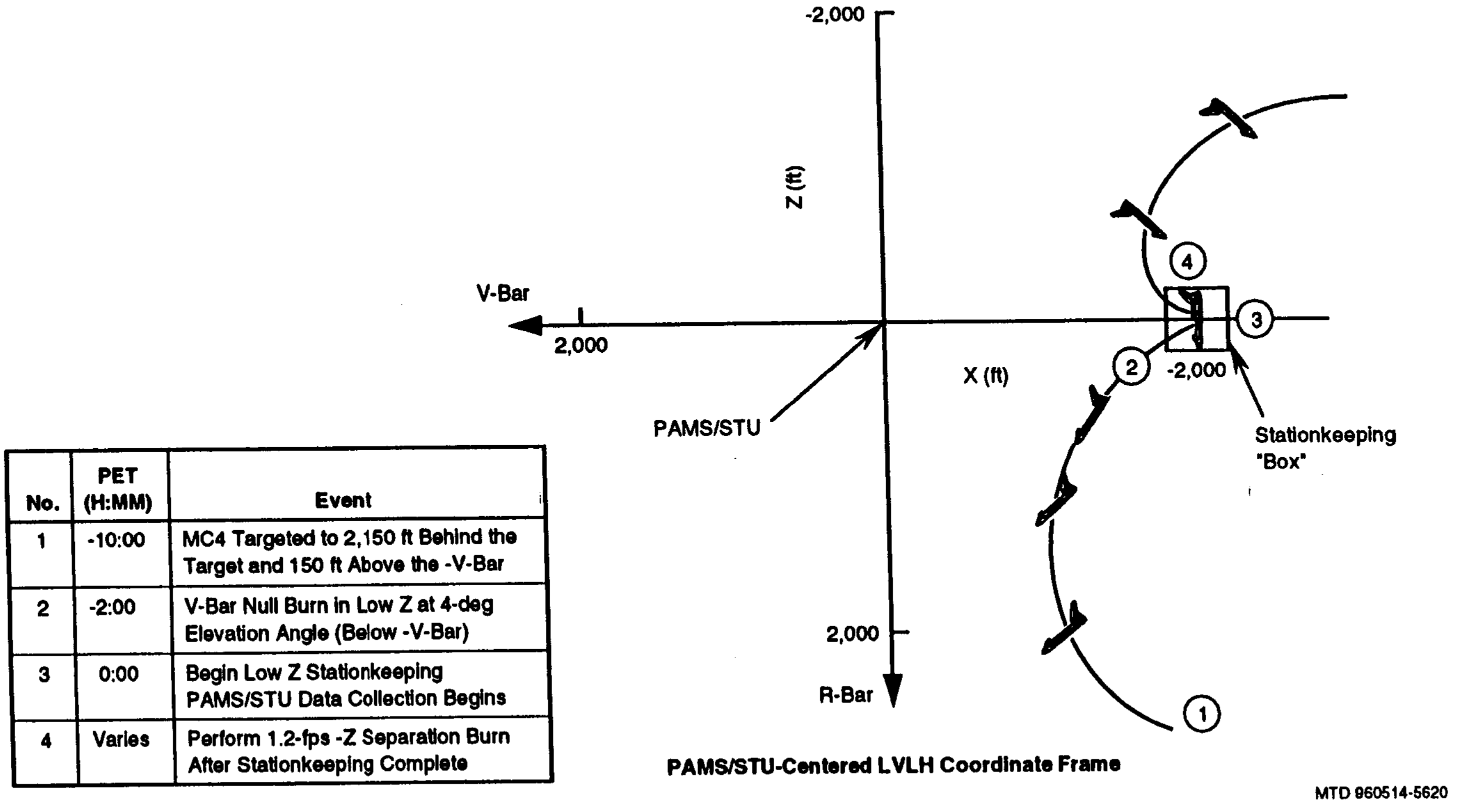


PAMS/STU-Centered
LVLH Coordinate Frame

No.	PET (H:MM)	Event
1	+0:00	Eject PAMS/STU (~1.25 fps Radial Down) in Free Drift, Low Z; Orbiter LVLH PYR = 0, 0, 180; Switch to Inertial
	~0:12	Maneuver to Sep Burn Attitude
2	~0:23	1.5-fps Posigrade Burn to Hit 8 nmi in 2 Revs. Maneuver to Target Track Attitude

MTD 960514-5618

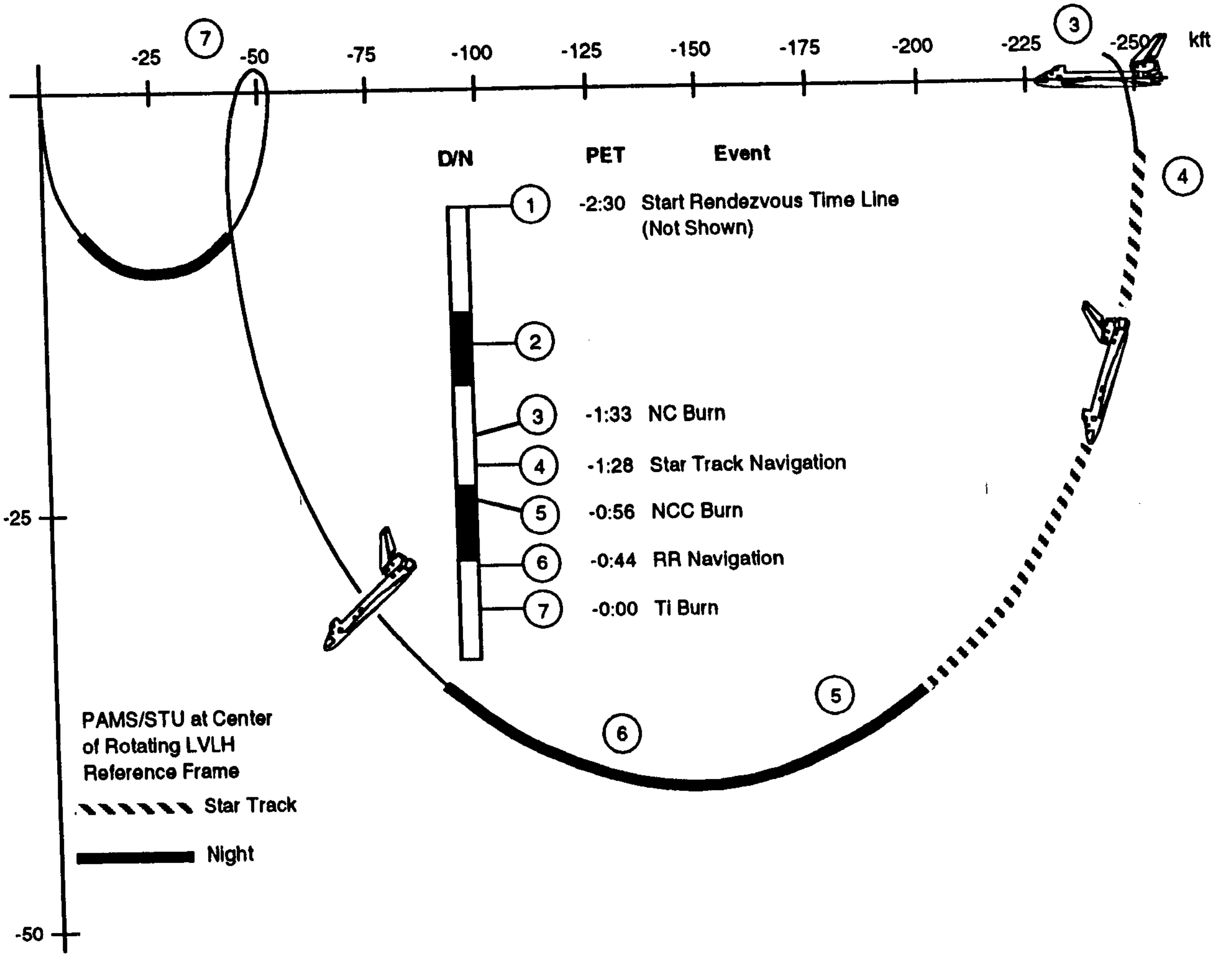
PAMS/STU Deployment/Separation



No.	PET (H:MM)	Event
1	-10:00	MC4 Targeted to 2,150 ft Behind the Target and 150 ft Above the -V-Bar
2	-2:00	V-Bar Null Burn in Low Z at 4-deg Elevation Angle (Below -V-Bar)
3	0:00	Begin Low Z Stationkeeping PAMS/STU Data Collection Begins
4	Varies	Perform 1.2-fps -Z Separation Burn After Stationkeeping Complete

PAMS/STU-Centered LVLH Coordinate Frame

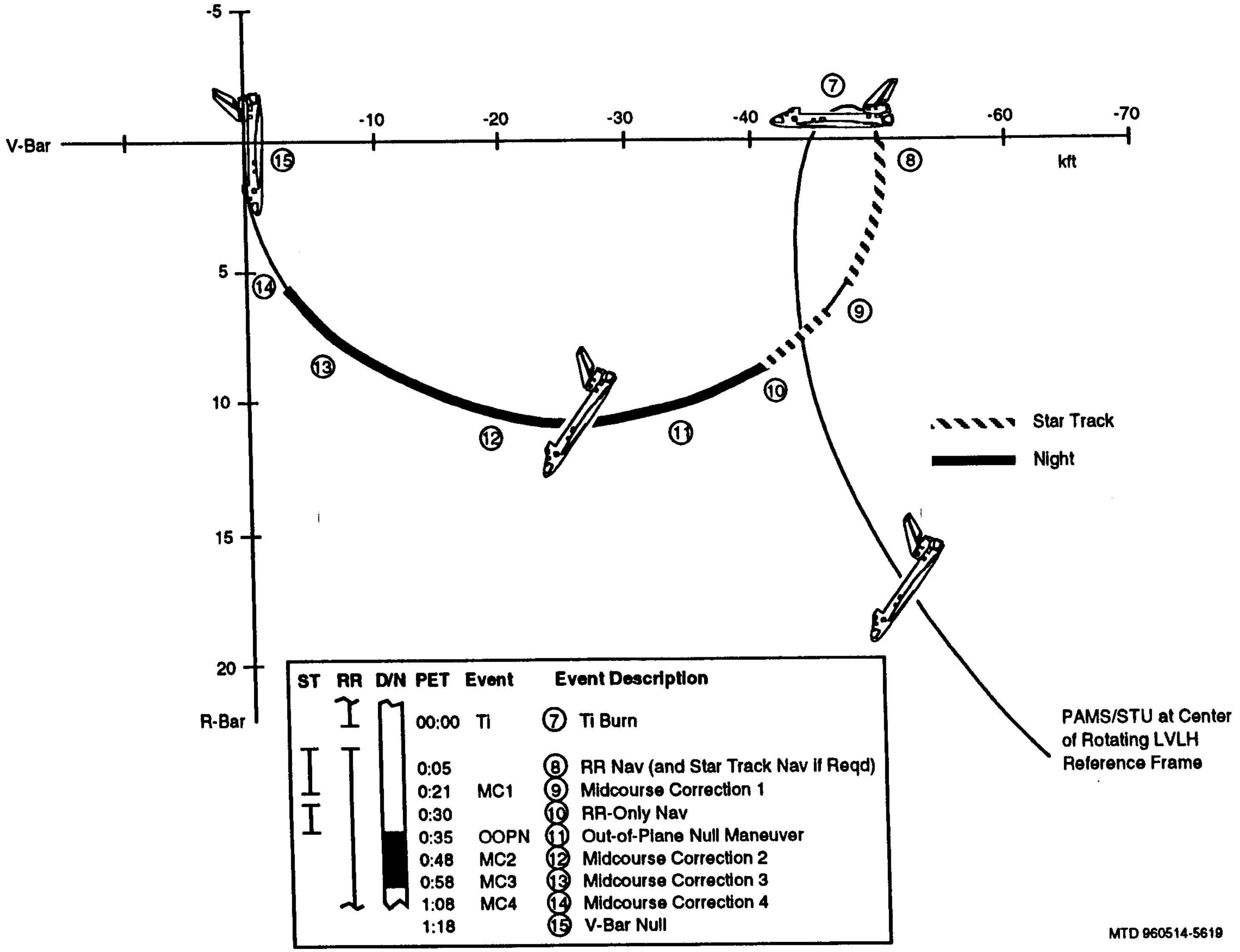
V-Bar Arrival, Stationkeeping, and Separation



D/N	PET	Event
①	-2:30	Start Rendezvous Time Line (Not Shown)
②		
③	-1:33	NC Burn
④	-1:28	Star Track Navigation
⑤	-0:56	NCC Burn
⑥	-0:44	RR Navigation
⑦	-0:00	Ti Burn

MTD 960514-5617

PAMS/STU Rendezvous Profile



ST	RR	D/N	PET	Event	Event Description
			00:00	Ti	⑦ Ti Burn
			0:05		⑧ RR Nav (and Star Track Nav if Reqd)
			0:21	MC1	⑨ Midcourse Correction 1
			0:30		⑩ RR-Only Nav
			0:35	OOPN	⑪ Out-of-Plane Null Maneuver
			0:48	MC2	⑫ Midcourse Correction 2
			0:58	MC3	⑬ Midcourse Correction 3
			1:08	MC4	⑭ Midcourse Correction 4
			1:18		⑮ V-Bar Null

Post-Ti Profile

AQUATIC RESEARCH FACILITY

This is the first flight of the Aquatic Research Facility (ARF), a joint project of the Canadian Space Agency and NASA that will be used to study small aquatic organisms. Researchers will examine the process of fertilization, embryo formation and differentiation, development of calcified tissue, and feeding behaviors.

CSA is providing the flight hardware and NASA is providing flight opportunities. Both agencies share in scientific investigations.

ARF contains three experiments that will provide an integrated investigation of early development and ocean ecology: Dr. Bruce Crawford of the University of British Columbia will study developing starfish embryos until they are able to orient and feed themselves. Dr. Ron O Dor of Dalhousie University will study advanced stages of bivalves (mussels), focusing on the development of adult tissue structure, calcium deposition/loss and feeding behavior. Dr. Heidi Schatten of the University of Wisconsin Madison will investigate the effects of gravity on sea urchin fertilization and early embryo differentiation and development. This research may improve the way scientists model human development as well as the factors which may disrupt it.

ARF is a modular facility that can support a broad range of aquatic life species for biological experiments in space. The facility fits inside two standard middeck lockers. One locker holds the main subsystem and the other locker the sample storage unit.

The main subsystem consists of a large tray replacement unit. The five basic units of the main subsystem are the controller and data unit, experiment environmental unit, optical visualization unit, power supply unit, and the housing and support structure unit.

The housing and support structure unit provides mechanical support for the various units and modules of the payload as well as vibration isolation from the orbiter. It allows the payload to be stowed or deployed outside the middeck locker in orbit. Deployed, the main subsystem is secured to other middeck lockers by Velcro straps.

The controller and data unit consists of a microcomputer-based set of digital and analog electronics. It controls and monitors payload activities, stores scientific data, and provides an interface for crew operation of the payload.

The experiment environmental unit is the core of the ARF system. The EEU accommodates 13 standard containers in a temperature-, humidity-, and illumination-controlled environment. The EEU is designed for automatic manipulation and observation of specimens. The unit is equipped with centrifuges that allow researchers to conduct microgravity and gravity experiments simultaneously. The EEU is configured with six standard containers in the 1-g centrifuge and seven in the microgravity centrifuge. After the first series of activities has been completed, the specimen containers will be exchanged with containers from the sample storage unit.

The optical visualization unit contains a videotape recorder for taping biological specimens. The dual system allows researchers to observe specimens in both the microgravity quasi-static and 1-g environments.

The sample storage unit is a thermally controlled storage area for up to 18 standard containers. The SSU uses a passive phase-change material to maintain the enclosed standard containers at 10 degrees Celsius for at least 48 hours. The SSU also can be used to stow EEU ancillary hardware, such as spare videotapes, the general control module, and the video control module.

The GCM is a hand-held unit that can be used to control EEU functions manually. The GCM will be used if the automated control system fails.

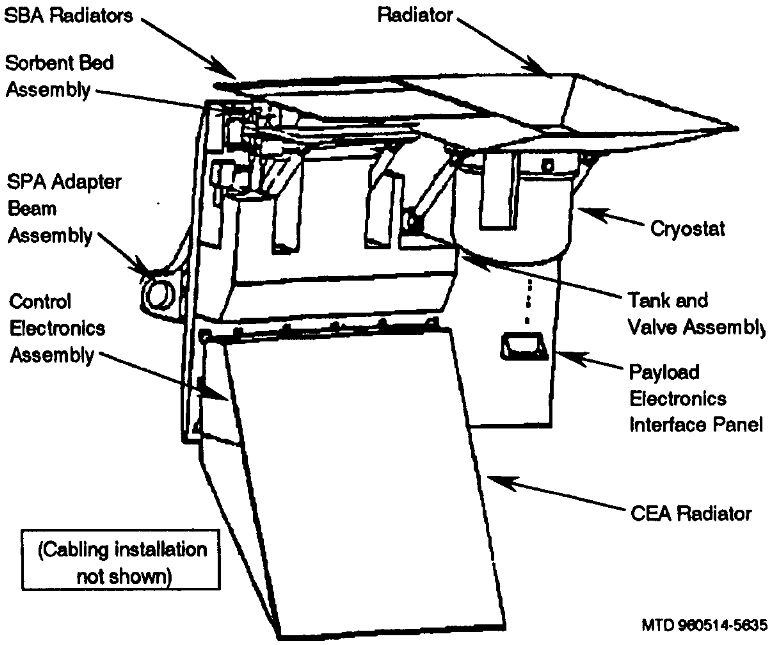
The VCM also is a hand-held unit that can be used to control OVU functions manually. It would be used to permit the crew to view the specimens or if the automated video control system fails.

Flight crew operations include loading and unloading standard containers in the main subsystem, initiating payload startup and shutdown sequences, status monitoring, and operating the payload's video system. The main subsystem and SSU will be stowed by the flight crew at the end of operations.

BRILLIANT EYES TEN-KELVIN SORPTION CRYOCOOLER EXPERIMENT

The Brilliant Eyes Ten-Kelvin Sorption Cryocooler Experiment (BETSCE) is a device that quickly cools infrared and other sensors to near-absolute zero. It will be used to cool infrared sensors aboard spacecraft to 10 Kelvins, or minus 441.6 degrees Fahrenheit. (Absolute zero is minus 459.6 degrees Fahrenheit.)

Developed at NASA's Jet Propulsion Laboratory in Pasadena, Calif., BETSCE is a space shuttle technology demonstration to see if sorption coolers can operate in the absence of gravity. Sorption coolers generate essentially no vibration, are very efficient at these cold temperatures, and can operate reliably for over ten years.



BETSCE Configuration

The cooler's specialized metal alloy powders, called metal hydrides, absorb hydrogen refrigerant through a reversible chemical reaction. In the sorption compressor, the metal powder is first heated to release and pressurize the hydrogen and then cooled to room temperature to absorb hydrogen and reduce its pressure. The sequential heating and cooling of the powder cause the hydrogen to circulate through the refrigeration cycle. The expansion of the pressurized hydrogen at the cold tip of the refrigerator lowers the temperature to 10 Kelvins. This expansion freezes the hydrogen and produces a solid ice cube. The heat load of the device being cooled then sublimates the ice. This closed-cycle operation is repeated over and over.

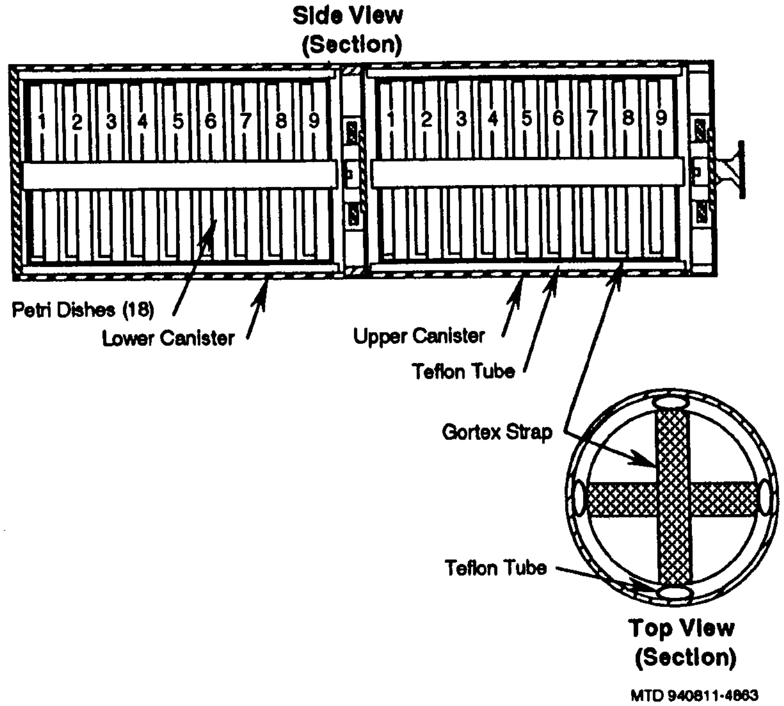
Since nothing moves in the compressor, it does not vibrate and tend to wear out like conventional refrigerator compressors whose moving pistons cause friction. The absence of vibration is an important quality for spacecraft and instruments such as infrared telescopes that require precise pointing or a mechanically quiet platform on which to operate.

Before this new technology, the only way to achieve temperatures in space as low as 10 Kelvins was to launch extremely large, heavy, and expensive Dewars containing liquid helium or solid hydrogen. Unfortunately, these Dewars have very limited lifetimes because the cryogens eventually boil off and become depleted. Lifetimes of ten or more years, with no vibration, open the door to a wide variety of future missions that could benefit from this technology. Sorption coolers are currently planned to fly on several missions, including the recently proposed Primordial Structure Investigation (PSI), and are proposed for a variety of future infrared astrophysics missions, such as the Next-Generation Space Telescope and spaceborne interferometers.

The BETSCE will be installed on a shuttle pallet applications system (SPAS) adapter beam carrier attached to the orbiter payload bay sidewall. The payload does not require any orbiter services during ascent. Shortly after the payload bay doors are opened, a crew member will activate the payload from a switch on the aft flight deck. BETSCE will operate without crew intervention for as many orbits as possible. Shortly before the doors are closed, a crew member will deactivate the payload with a switch on the aft flight deck. Data recorded by the BETSCE will be sent to ground personnel via the orbiter payload data interleaver.

BETSCE development was funded by the Air Force Space and Missiles System Center and the Department of Defense's Ballistic Missile Defense Organization. NASA's Office of Space Access and Technology is sponsoring the BETSCE shuttle flight.

BIOLOGICAL RESEARCH IN CANISTERS 07



BRIC Contents

NASA's Office of Life and Microgravity Sciences and Applications is sponsoring Biological Research in Canisters (BRIC) 07, the sixth flight of a series of life sciences experiments designed to examine the effects of microgravity on a wide range of physiological processes in higher order plants and arthropod animals (e.g., insects, spiders, centipedes, crustaceans). BRIC previously flew on STS-64, -68, -63, and -69.

One of four BRIC payload hardware configurations is chosen for each flight to meet scientific requirements:

- Block I: five 82-mm-diameter dual-chamber canisters in a single middeck locker
- Block II: two 82-mm-diameter dual-chamber canisters and one gaseous-nitrogen freezer in a single middeck locker
- Block III: three 114-mm-diameter single-chamber canisters in a single middeck locker
- Block IV: nine 114-mm-diameter single-chamber canisters in a single middeck locker

The canisters are self-contained, two-chambered aluminum holders for the specimen support hardware and require no orbiter power. The canisters and freezer are housed in a standard middeck locker. The BRIC Block I and Block III experiment configurations require no crew interaction. The Block II configuration requires a crew member to put on a pair of insulating gloves, remove a canister from the locker, and replace it in the freezer.

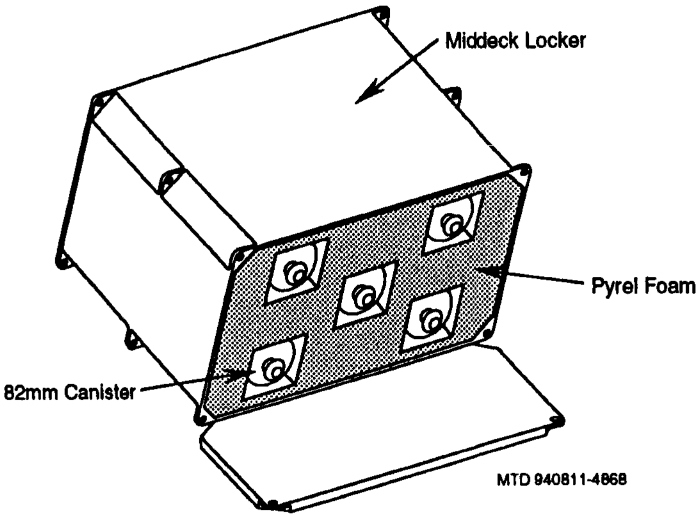
BRIC-1 examined how microgravity affects the developing gypsy moth's diapause cycle—the period of time when the moth is in a dormant state undergoing development—with the aim of creating sterile moths. BRIC-2 focused on how plant tissue culture develops in microgravity. BRIC-3 studied the development and differentiation of soybeans as well as the effects of microgravity on the plants' carbohydrate metabolism, which provides plants the energy they need to grow. BRIC-4 examined how the hormone system and muscle formation processes of the tobacco hornworm (*Manduca sexta*) are affected by an altered gravitational field, and BRIC-5 tested whether the cell division changes observed in the daylily (*Hemerocallis cultivar*, Autumn Blaze) are caused by the direct effects of microgravity or indirect effects like water availability.

BRIC-6 studied how gravity is sensed within mammalian cells. The processing of outside signals by mammalian cells is complex. Gravity is one signal that is received by these cells, but the gravity-sensing mechanism in mammalian cells has not been identified. To study this intracellular signal transmission, BRIC-6 flew a unicellular eucaryote cell culture of slime mold (*Physarum polycephalum*) as a model system. The investigator examined the cultures for specific chemical concentrations that are signs of the signal transduction process.

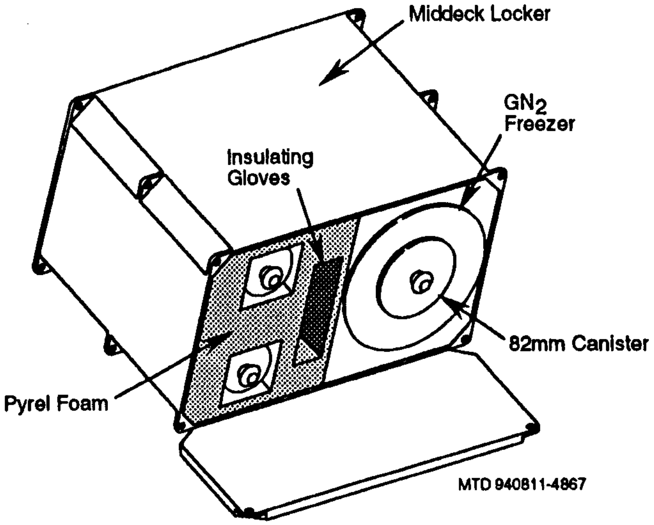
BRIC-7 will help investigators discover the mechanisms behind one endocrine system in insects, which may aid in research on endocrine systems in general, including human systems. This research is important to the space program because space flight is known to affect astronauts' endocrine systems.

The experiment begins 5 to 65 hours after the pupae, placed in the BRIC canisters before launch, start to develop. After the flight, the pupae will be examined morphologically. Half to two thirds of the insects will be sacrificed so investigators can collect and study their hemolymph, the circulatory fluid of invertebrates that is similar to the blood and lymph of vertebrates, and ecdysone, a hormone produced by insects that triggers molting and metamorphosis. The rest of the insects will be allowed to develop to adulthood. During the 24 hours before the adult insects emerge, investigators will remove their dorsolongitudinal flight muscles and analyze their protein content and concentration.

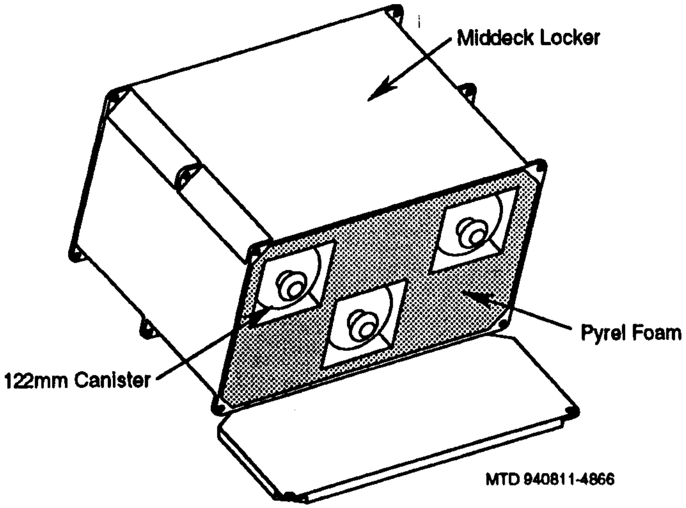
BRIC-7 is a project of the University of Arizona at Tucson. Undergraduates, high school students and an elementary school teacher are involved in the project in addition to the principal investigator and NASA staff.



The BRIC Block I Configuration



The BRIC Block II Configuration



The BRIC Block III Configuration

MTD 940811-4877

GETAWAY SPECIAL PROGRAM

STS-77 is the 26th shuttle mission to participate in NASA's Getaway Special (GAS) program, officially known as the Small, Self-Contained Payloads program. The GAS program, which began in 1982, offers interested individuals or groups the opportunity to fly small experiments in space. It enhances education by making opportunities for hands-on space research available and generates new activities unique to space. Customers also are able to inexpensively test ideas that could later grow into major space experiments.

To ensure that diverse groups have access to space, NASA rotates payload assignments among three major categories of users: educational, foreign and commercial, and U.S. government. Since the program was first announced in the fall of 1976, 121 GAS payloads have been reserved and flown by foreign governments and individuals; U.S. industrialists, foundations, high schools, colleges and universities; professional societies; service clubs; and many others. Twelve more are manifested on STS-77. Although persons and groups involved in space research have obtained many of the reservations, a large number of spaces have been reserved by persons and organizations outside the space community.

There are no stringent requirements to qualify for space flight. However, each payload must meet specific safety criteria and be screened for its propriety as well as its educational, scientific, or technological objectives. These guidelines preclude commemorative items, such as medallions, that are intended for sale as objects that have flown in space.

GAS requests must first be approved at NASA Headquarters in Washington, D.C., by the director of the Transportation Services Office. At that point NASA screens the propriety objectives of each request. To complete the reservation process for GAS payloads, each request must be accompanied or preceded by the payment of $500 earnest money.

Approved requests are assigned an identification number and referred to the GAS team at the Goddard Space Flight Center, the designated lead center for the project. The GAS team screens the proposals for safety and provides advice and consultation on payload design. It certifies that proposed payloads are safe and will not harm or interfere with the operations of the space shuttle, its crew, or other experiments on the flight. The costs of any physical testing required to answer safety questions before launch are borne by the GAS customer.

NASA's space shuttle program has specific standards and conditions relating to GAS payloads. Payloads must fit NASA standard containers and weigh no more than 200 pounds. However, two or more experiments may be included in a single container if they fit in it and do not exceed weight limitations. The payload must be self-powered and not draw on the shuttle orbiter's electricity. In addition, payload designs should consider that the crew's involvement with GAS payloads will be limited to six simple activities (such as turning on and off up to three payload switches) because crew activity schedules do not provide opportunities to either monitor or service GAS payloads in flight.

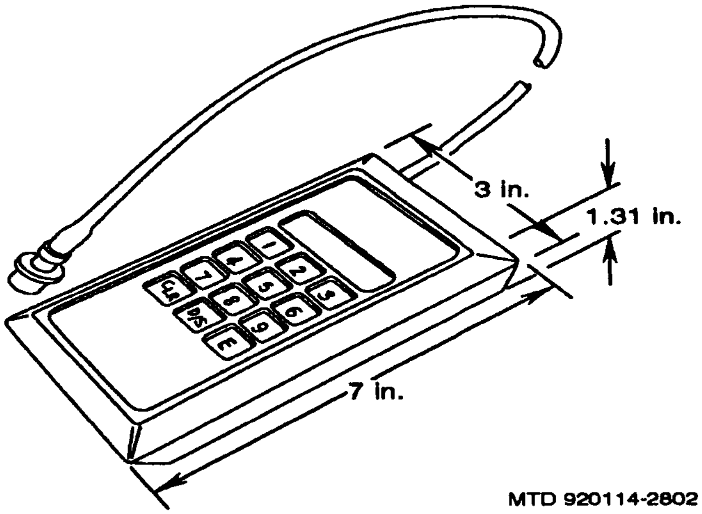
The cost of this unique service depends on the size and weight of the experiment. Getaway specials of 200 pounds and 5 cubic feet cost $10,000; 100 pounds and 2.5 cubic feet, $5,000; and 60 pounds and 2.5 cubic feet, $3,000. The weight of the GAS container, experiment mounting plate and its attachment screws, and all hardware regularly supplied by NASA is not charged to the experimenter's weight allowance.

The GAS container provides internal pressure, which can be varied from near vacuum to about one atmosphere. The bottom and sides of the container are always thermally insulated, and the top may be insulated or not, depending on the specific experiment. A lid that can be opened or one with a window may be required. These may also be offered as options at additional cost.

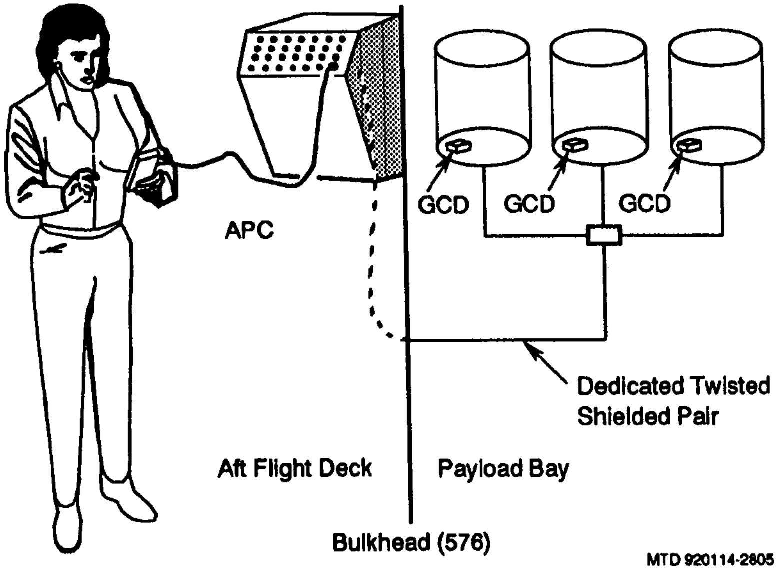
The GAS container is made of aluminum, and the circular end plates are 0.625-inch-thick aluminum. The bottom 3 inches of the container are reserved for NASA interface equipment, such as command decoders and pressure regulating systems. The container is a pressure vessel that can be evacuated before or during launch or on orbit and can be repressurized during reentry or on orbit, as required by the experimenter.

The getaway bridge, which is capable of holding 12 canisters, made its maiden flight on STS 61-C. The aluminum bridge fits across the payload bay of the orbiter and offers a convenient and economical way of flying several GAS canisters.

For additional information about NASA's Getaway Special program, contact the program manager, Code MC, NASA Headquarters, Washington, D.C. 20546. The primary contact for payload users is the technical liaison, Code 740, NASA Goddard Space Flight Center, Greenbelt, Md. 20771.



GAS Autonomous Payload Controller



Getaway Special Control Concept

STS-77 GETAWAY SPECIAL PAYLOADS

The GAS project is managed by NASA's Goddard Space Flight Center, Greenbelt, Md. NASA began flying these small self-contained payloads in 1982. The project gives individuals or organizations an opportunity to perform experiments in space on the space shuttle.

G-036

The GAS payload G-036 is sponsored by El Paso Community College. The experiment has several objectives. The effects of microgravity on the formation of concrete and on a sample of asphalt will be examined. The samples will then be compared to similar samples on Earth. Two static memory integrity experiments will be flown to investigate the effects of orbit on computer and compact disc memory. Another experiment will test the configuration stability of fluid systems in near-weightlessness.

The experiment is operated by the payload and general support computer/bus interface adapter (PGSC/BIA). Early in the mission, the crew will unstow and set up the PGSC/BIA in the aft flight deck (AFD). The G-036 payload is activated by a crew member commanding the power on as soon as a low acceleration period lasting one hour is attained. A crew member commands the payload off a minimum of one hour after experiment activation.

G-056

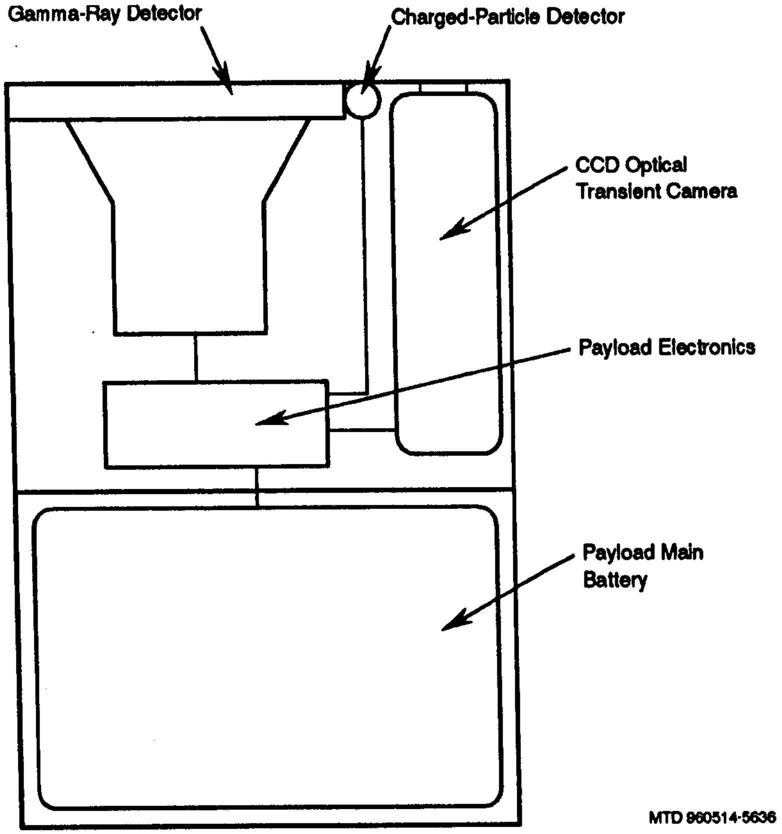
The GAS payload G-056 is by the California Institute of Technology. Caltech's Gamma-ray Astrophysics Mission (GAMCIT) payload is the first space payload built by Caltech's chapter of Students for the Exploration and Development of Space (SEDS). GAMCIT, originally designed by astronaut John Grunsfeld, will study an enigmatic source of cosmic radiation known as gamma-ray bursts. Although these intense bursts of high-energy radiation were first discovered in the late 1960s by satellites watching for clandestine nuclear tests, their precise nature and origin still remain an intriguing astrophysical mystery. The G-056 payload is designed to detect gamma-ray bursts from celestial sources and to detect the possible occurrence of optical transients coincident with the gamma-ray bursts.

When a gamma-ray burst occurs, the gamma-ray detector will signal the charge-coupled device (CCD) camera to begin imaging out of the shuttle bay (+Z). The CCD camera will take frames at the rate of one per second for the duration of the burst event and one per 10 seconds for 100 seconds following the burst. The function of the charged-particle detector is to detect charged particles related to solar events and is of no interest in this investigation. Detection of a charged particle will inhibit activation of the CCD camera. The Global Positioning System (GPS) unit is used to obtain accurate burst arrival time and shuttle location as bursts are detected.

Experiment temperature will be monitored by thermistors, with an overtemperature condition being conveyed to the GAS payload power contactor (PPC) as a malfunction input. A detected overtemperature condition will result in temporary removal of experiment power by the PPC, allowing the experiment electronics to cool. Once temperature is within acceptable limits, the PPC will restore power and the experiment will resume operation.

All attitudes except for Earth viewing (+ZLV, payload bay to Earth) will yield data. It is desired that the payload operate as long as possible throughout the mission. The minimum required non-Earth viewing operating time for the payload is one hour.

The payload carrier consists of a standard 5-cubic-foot GAS canister equipped with a standard door assembly (SDA) or



G-056 Payload Configuration

motorized door assembly (MDA). The experiment consists of a gamma-ray detector, CCD optical camera with 100-deg field of view (FOV), a charged particle detector and a GPS unit. Intrusion into the camera FOV by the SDA/MDA is expected and acceptable.

G-142

The German Space Agency (DARA) is flying two payloads: G-142 and G-144. The experiments are called MAUS, a German acronym for Autonomous Material Science Experiments Under Microgravity. It is one of the programs for flight opportunities the Federal Republic of Germany offers scientists from disciplines of material research and processing to perform material science investigations under microgravity conditions. These experiments were developed by scientists from the Technical University of Munich and the Technical University of Clausthal.

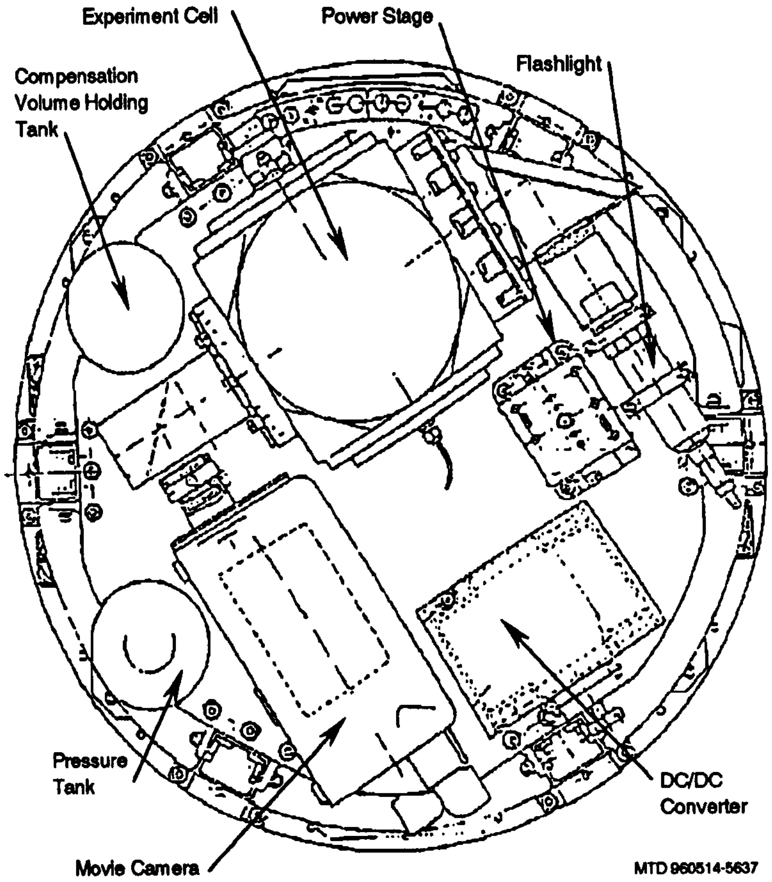
The GAS payload G-142 is entitled Subcooled and Saturated Pool Boiling in a Microgravity Environment Experiment. Its scientific objective is to yield a classification of the portions of gravity-independent heat transport mechanisms being concatenated in a very complex boiling physical separation of gravity-driven forces. In this experiment, heat transfer from platinum wires into a pool of liquid Freon R134A (Tetraf luorethane) is examined.

The Freon is contained in an experiment cell. This cell is connected to a bellows which can regulate pressure values within the cell and to a circulation system for circulating the Freon into and out of a compensation volume holding vessel. Heaters are installed inside the experiment cell for thermal control, and windows in the cell allow for illumination and observation. The Freon will be heated by supplying various voltages to the platinum filament heaters.

Early in the mission a crew member commands power on. The remainder of the G-142 payload operations is controlled by an internal controller. The lowest g levels are highly desirable for the following seven hours.

The first experiment sequence begins with the temperature of the Freon being kept constant while the pressure is increased in increments. At each pressure level, varying voltages are applied to each of the platinum wires in turn.

During the second experiment sequence, the same pressure and voltages used in the first experiment sequence will again be used, but at each pressure level the temperature will be adjusted to a corresponding saturation temperature. To account for the thermal



G-142 Payload Configuration

expansion of the liquid, Freon has to be transferred into the compensation volume holding vessel at each pressure/temperature level. When the experiment sequences are complete, the Freon is allowed to cool and is transferred back into the experiment cell.

The process of heat transfer, i.e., generation of a vapor phase (mainly bubbles), will be observed and recorded by movie cameras. Voltages, pressures, and temperatures will also be recorded. After a minimum of 24 hours, a crew member will command power off.

G-144

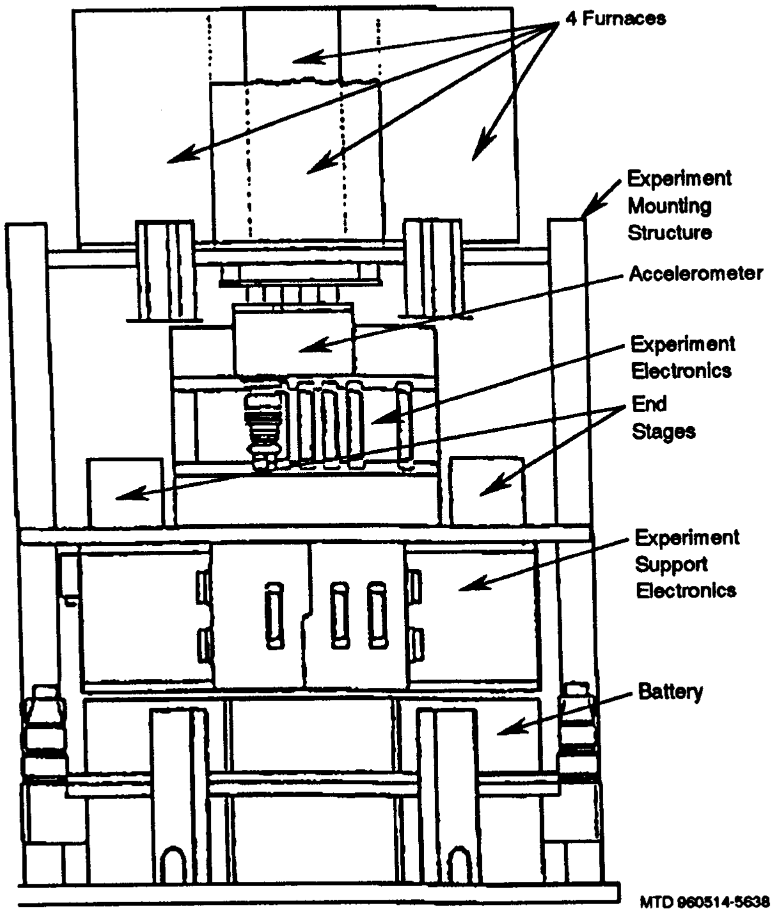
The GAS payload G-144 is sponsored by the German Federal Ministry for Research and Development. The experiment is titled Reaction Kinetics in Glass Melts.

The primary goal of the G-144 experiment is to study the processes involved in the formation of a glass melt, specifically the process of mass transport by diffusion. The intended experimental setup will use a unit of four independently controlled heating chambers, or furnaces, each containing a cylindrical platinum cartridge. Each cartridge surrounds four individual platinum crucibles in which two glass specimens of different composition are pressed together and heated for approximately 30 minutes. After the flight, the concentration profiles of each sample will be investigated by an electron microprobe. Early in the mission a crew member commands the power relays on. The lowest possible gravity levels are highly desirable for the following seven hours. The remainder of the G-144 payload's operations are controlled by an internal controller. A crew member commands the power relays off a minimum of 10 hours after power activation.

G-200

The GAS payload G-200 is by Utah State University. There are four experiments in the canister. The Polarization of Water Experiment will photograph the electrohydrodynamics of a single water droplet in an electric field. The Sound in Sand Experiment is designed to measure sound propagation in a granular material and the speed with which it propagates. The Segregation of Sand Experiment is designed to determine exactly what role gravity and friction play in vibration-induced size separation. The Growth of Slime Mold Experiment is designed to ascertain the growth pattern of slime mold in microgravity.

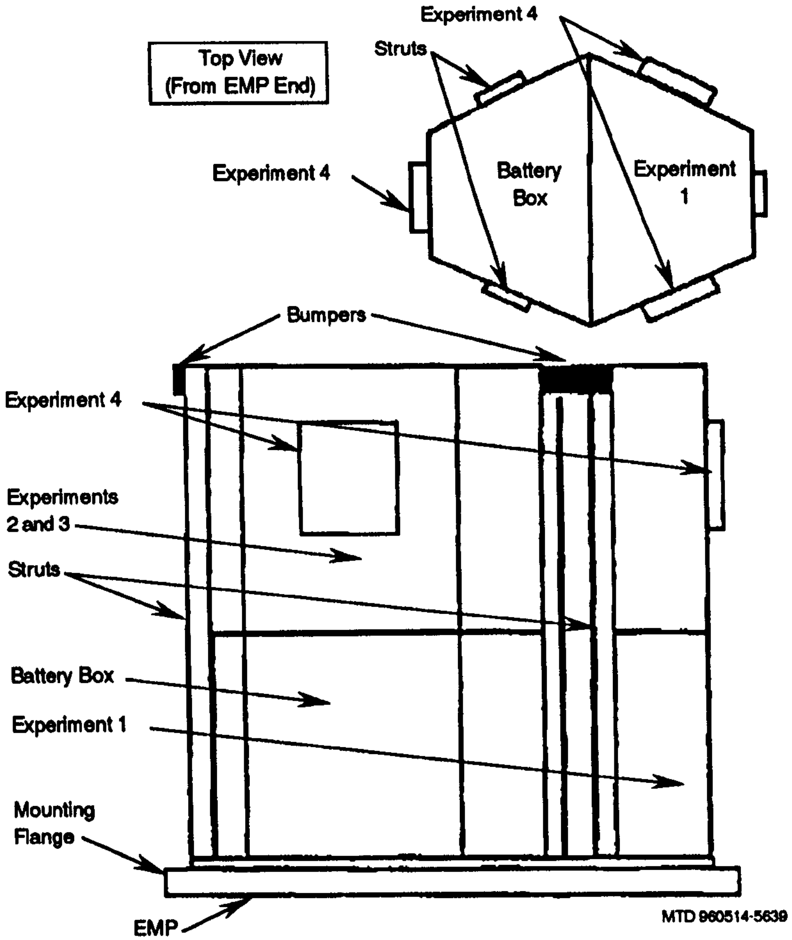
The experiments will be activated when a crew member commands three relays which will turn on the power supplies. The experiment must be activated at the beginning of a low-gravity



G-144 Payload Configuration

period lasting at least eight hours. The experiments are operated by an internal controller. The crew member commands three power supply relays off after approximately eight hours.

In addition, the payload will contain popcorn kernels in Ziplock bags as an experiment by an elementary school. After the kernels are returned to Earth, students will pop the popcorn and compare it with a similar sample maintained in one gravity.



G-200 Payload Configuration

G-432

The GAS payload G-432 is by the Chinese Academy of Science and was built by General Establishment of Space Science and Applications. The payload is divided into three experiments. The first experiment will measure the degree of undercooling of a palladium-nickel-phosphorus alloy under microgravity. The second experiment will process a single crystal of high-technetium bismuth-system oxide superconductor in microgravity. The third experiment will obtain a rod gallium-antimony single crystal through remelting and recrystallization to study the behavior of molten gallium-antimony in microgravity and its wetability with quartz as well as the influence of gravity on the chemical homogeneity of the gallium-antimony crystal.

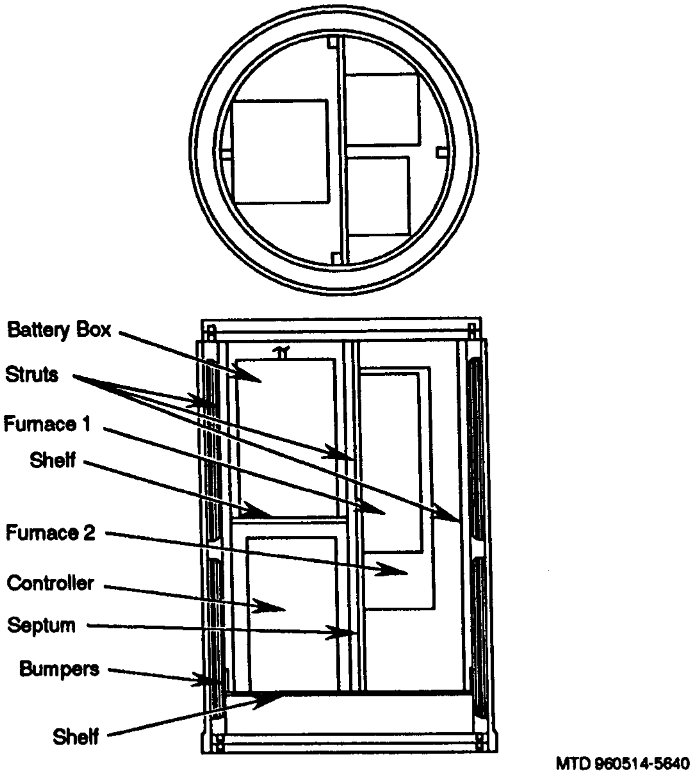
Early in the mission a crew member commands the controllers on. The lowest possible gravity levels are highly desirable for the following eight hours. The G-432 payloads operations are commanded by the internal controllers. A crew member commands the furnace controllers off a minimum of eight hours after activation.

G-564

The GAS payload G-564 is sponsored by the Canadian Space Agency. The objective of this experiment is to process 38 liquid samples at 150 degrees Celsius. The samples are prepared from various 5-milliliter water-based slurries, each containing the necessary precursors for growing unique materials called nanoporous semiconductors. The experiment is composed of four main subsystems: a structural subsystem, a sample processing subsystem, an electronics subsystem, and a power subsystem.

Early in the mission, the crew will unstow and set up the PGSC/BIA in the AFD. The experiment is initiated by a crew member commanding payload power on as early in the mission as possible. It is desired that this occur no later than a mission elapsed time (MET) of six hours.

Twenty-four hours after payload power is commanded on, the controller will start processing the samples at 150 degrees Celsius. At the end of a five-day processing period (120 hours), the controller will switch to a low-energy operating state where the samples are maintained at temperatures above 4 degrees Celsius by the sample heaters. A crew member commands payload power off as late in the mission as possible.



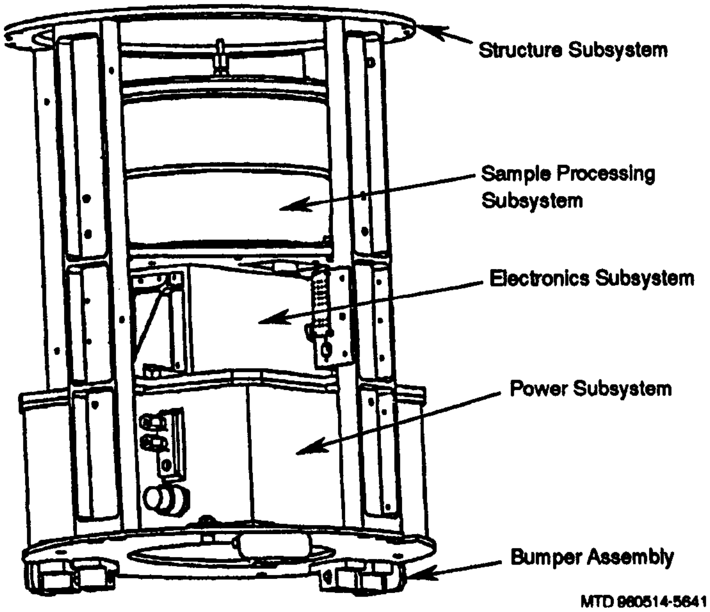
G-432 Payload Configuration

G-565

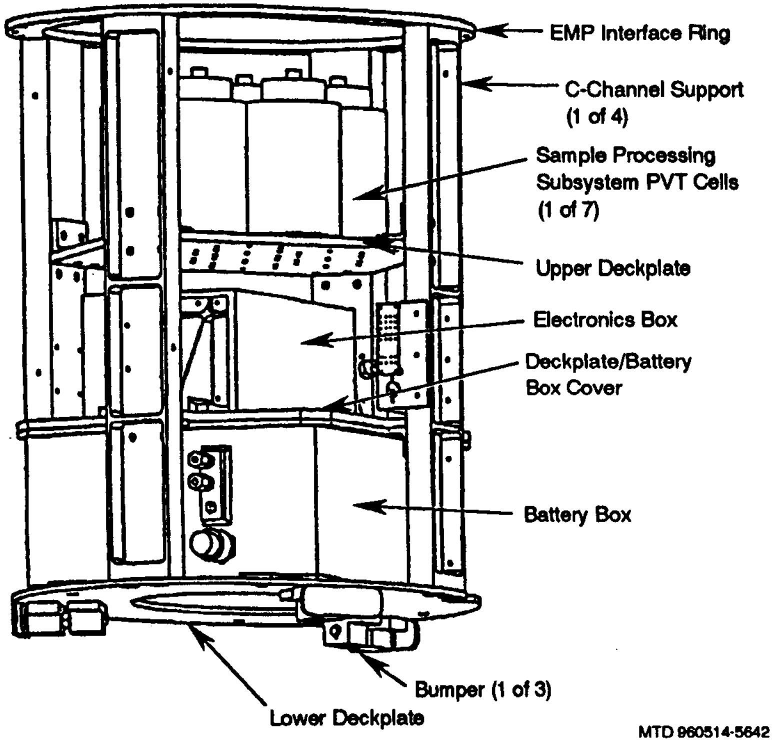
The GAS payload G-565 is sponsored by the Canadian Space Agency. The objective of this experiment is to manufacture organic thin films by the physical vapor transport (PVT) method. Seven PVT cells containing 3, 4, 9, 10-perylen-tetracarboxylic dianhydride (PTCDA) will be processed. The thin films produced in microgravity will be compared to control samples manufactured on Earth. The experiment is composed of four main subsystems: a structural subsystem, a sample processing subsystem, an electronics subsystem, and a power subsystem.

The experiment is initiated by a crew member commanding payload power on, as early in the mission as possible. It is desired that this occur no later than an MET of six hours.

Twenty-four hours after payload power is commanded on, the controller will start the heating of the first PVT cell. The cell will be brought up to 400 degrees Celsius and will be maintained at that temperature for three hours. The cell will then be powered down, and the next PVT cell will be ramped up in temperature. The seven cells will be processed sequentially in this manner. After the seventh cell is processed, the controller will continue to monitor the cell temperatures for approximately 12 hours before switching to a passive state. A crew member commands payload power off as late in the mission as possible.



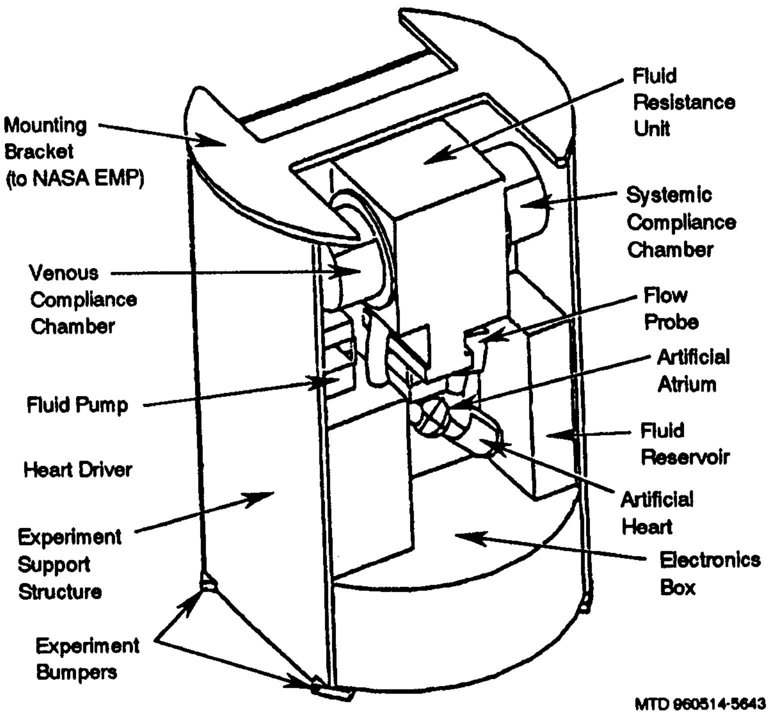
G-564 Payload Configuration



G-565 Payload Configuration

G-572

The GAS payload G-572 is sponsored by Utah State University. The experiment is titled Characterization of Fluid Physics Effects on Cardiovascular Response to Microgravity. The experiment is an investigation of fluid physics phenomena that contribute to cardiovascular changes during space flight. The experiment consists of an artificial heart, instrumented with pressure and flow sensors, that pumps a whole-blood viscosity analog solution around a fluid circuit with components that mimic the resistance—and compliance—of the blood vessels, creating physiologic pressure and flow conditions.



MTD 960514-5643

G-572 Payload Configuration

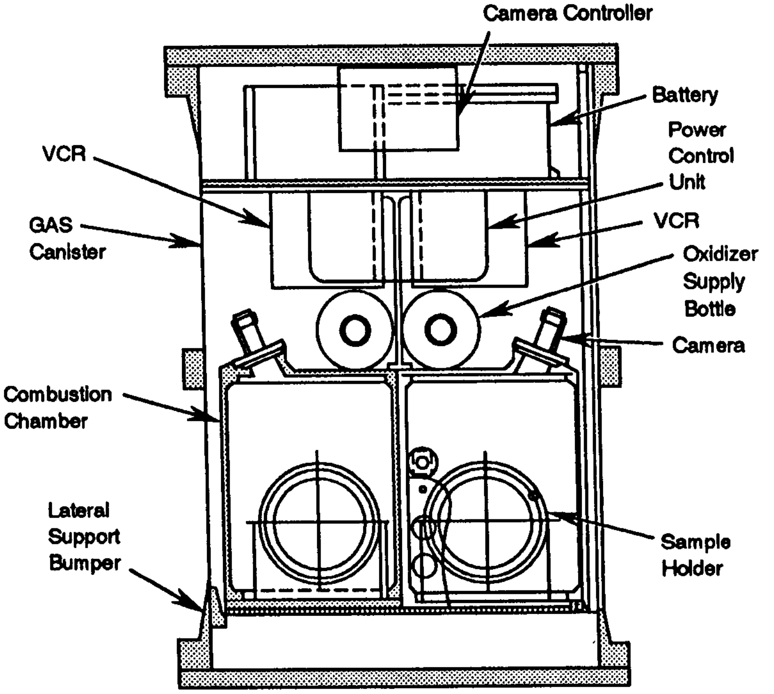
The experiment will be powered on by a barometric switch. A crew member will command the start of the experiment using the PGSC/BIA. An acceleration level of less than 10^{-3} g is highly desirable for one hour following payload activation. The G-572 payload operations are commanded by internal controllers. A crew member commands the experiment off as late in the mission as possible.

G-703

The GAS payload G-703 is sponsored by the National Aeronautics and Space Administration's Lewis Research Center. The objective of the Microgravity Smoldering Combustion Experiment is to increase the understanding of smoldering combustion in a long-term microgravity environment. This experiment will focus on one-dimensional smoldering of polyurethane foam. The variables for the two samples to be smoldered are the flow velocity and the oxygen/nitrogen volume ratio.

The payload controller will be activated by barometric switch on orbiter ascent at approximately 50,000 feet. The controller will maintain and take data on the temperature of the combustion chamber. Nominally, the experiment will be initiated when commanded to do so by a crew member; however, if the command is not received within 14 hours of payload activation, the controller will initiate the experiment.

Once the experiment is initiated, the first sample will be ignited, followed in 30 minutes by the ignition of the second sample. Each sample will be allowed to smolder for 90 minutes. Once smoldering is complete, the experiment chambers will be allowed to cool and



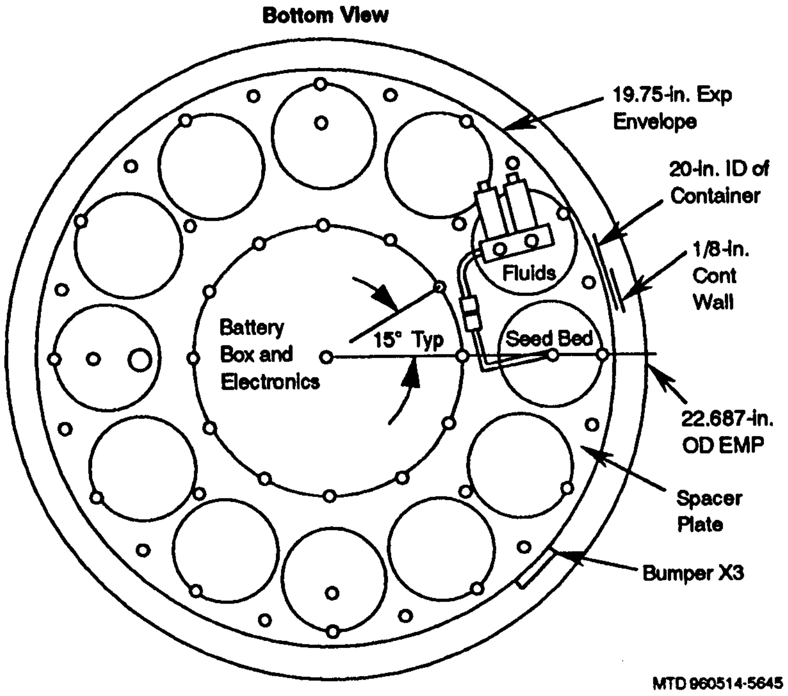
G-703 Payload Configuration

MTD 960514-5644

sensors will collect thermal data. Between 10 and 24 hours after experiment initiation, power will be removed by crew member command.

G-745

The GAS payload G-745 is sponsored by Mayo High School, Rochester, Minn. The experiment consists of six growing chambers that each contain a variety of seed types embedded in vermiculite. After launch, the seeds will be watered and allowed to germinate in a temperature-controlled environment. A portion of the seeds will be treated with growth hormone. Before reentry, the seeds will be treated with a fixative that will stop their growth.



G-745 Payload Configuration

REDUCED-FILL TANK PRESSURE CONTROL EXPERIMENT

NASA plans to launch and operate in orbit the Reduced-Fill Tank Pressure Control Experiment (RFTPCE) payload, using the space shuttle. RFTPCE is a reflight of the Tank Pressure Control Experiment (TPCE). RFTPCE is a secondary payload that will use the getaway special (GAS) carrier.

An important issue in microgravity fluid management is controlling pressure in on-orbit storage tanks for cryogenic propellants and life support fluids, particularly liquid hydrogen, oxygen, and nitrogen. The purpose of the RFTPCE is to provide some of the data required to develop the technology for pressure control of cryogenic tankage.

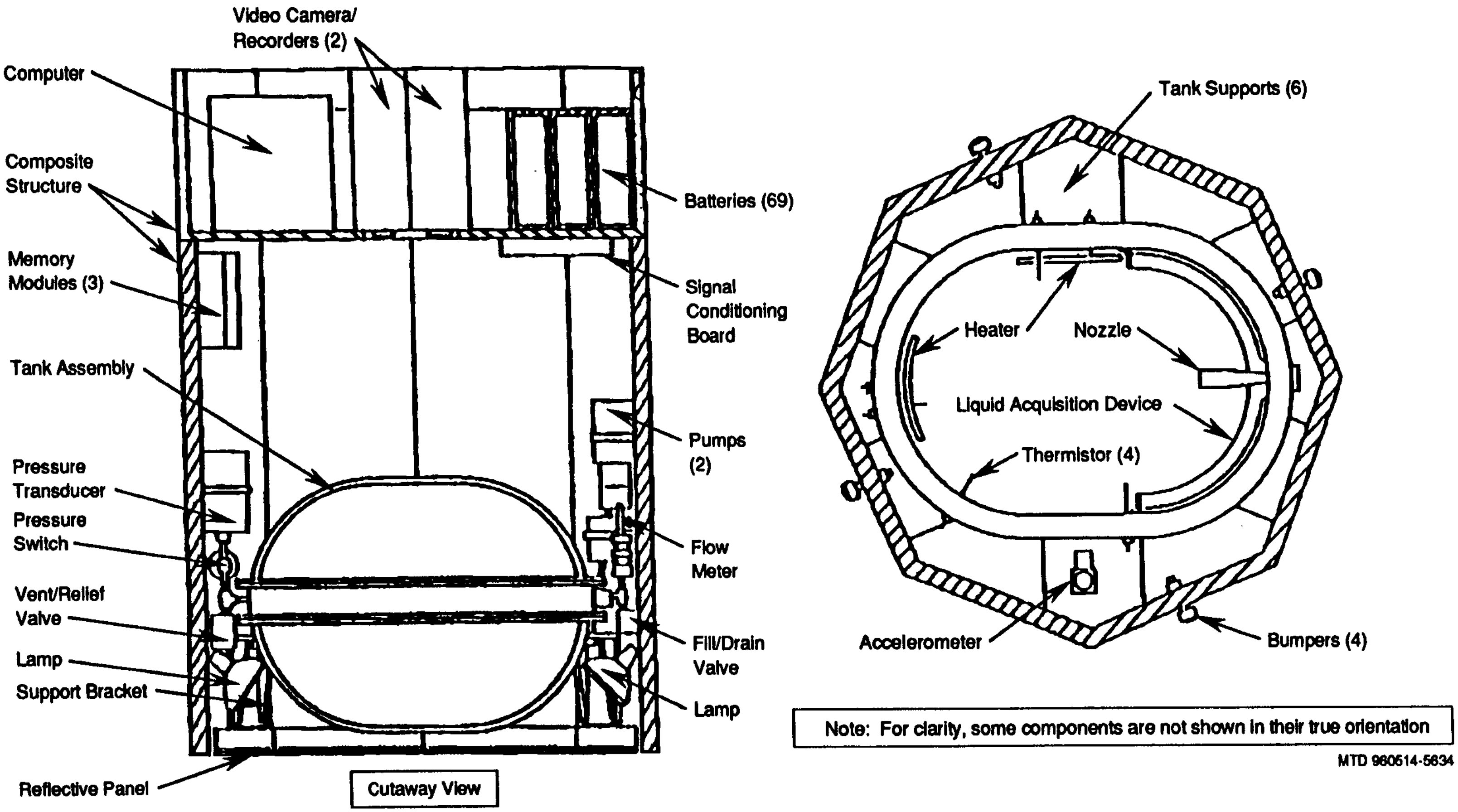
This experiment will investigate pressure rise rates and pressure control (using a mixer) for tanks that are approximately 40% full of oxygen (Freon 113). These conditions simulate those encountered by multiple-burn cryogenic stages used for lunar or planetary exploration. Although the pressure rise rates are expected to be lower for the reduced fill level tanks, the ability of the jet mixer to effectively cool all regions of the tank is of great interest.

RFTPCE uses flight hardware previously developed by the Boeing Defense and Space Group under NASA's In-Space Technology Experiments activity. The flight hardware is on loan from the NASA Lewis Research Center.

The payload is contained in a standard 5-cubic-foot sealed GAS cylindrical canister which is mounted on a GAS bridge assembly (GBA). The payload control weighs 370 pounds, allocating 200 pounds for the experiment and 170 pounds for the canister.

The payload is controlled by the payload and general support computer/bus interface adapter (PGSC/BIA). The PGSC/BIA allows control of the payload by a crew member from the aft flight deck (AFD). Already-established orbiter wiring from the AFD connects the PGSC/BIA to the GAS control decoder located in the payload canister.

The objective of this experiment is to obtain data on the effectiveness of jet mixing as a method of pressure control, but this time at a lower liquid fill level (40% for RFTPCE compared to 83% for the two previous flights of TPCE). RFTPCE will record visual information about flow patterns found with time-varying jet flow rates and provide visual information about the damping behavior of mixing-induced flows and the time required to reestablish a capillary-force-dominated fluid.



Payload Configuration

DEVELOPMENT TEST OBJECTIVES

Ascent wing structural capability evaluation (DTO 301D). The purpose of this DTO is to verify that the orbiter wing structure is at or near its design condition during lift-off and ascent with near-maximum-weight payloads. In the event that a design condition is reached, the structural instrumentation data will be used to verify that the vehicle is acceptable for reflight. It will determine flight loads and structural capability, identify any unacceptable dynamic effects, and verify that operational changes such as DOLILU II and/or modifications of the shuttle system do not invalidate orbiter structural certification. This is a data-collection-only test and requires no specific activity other than recording and returning specified data. DTO 301D is required for each flight of each vehicle; for Columbia only, body flap strain measurements are required on a minimum of six flights, including ferry flights. DTO 301D has previously been manifested on 65 flights.

Ascent compartment venting evaluation (DTO 305D). This DTO will collect data under operational conditions to validate/upgrade the ascent venting math model and verify the capability of the vent system to maintain compartment pressures within design limits. This DTO is required on each flight of Discovery and Endeavour. It has previously been manifested on 27 flights.

Descent compartment venting evaluation (DTO 306D). This DTO will collect data under operational conditions to validate/upgrade the descent venting math model and verify the capability of the vent system to maintain compartment pressures within design limits. This DTO is required on each flight of Discovery and Endeavour. It has previously been manifested on 27 flights.

Entry structural capability evaluation (DTO 307D). This DTO will collect structural load data for different payload weights and configurations to expand the data base of flight loads during entry, approach, and landing; verify the adequacy of the structure at or near design conditions; demonstrate structural system operational capability; determine flight loads; and verify the stress/temperature response of critical structural components. In the event that a design condition is reached, the structural instrumentation/data will be used to verify that the vehicle is acceptable for reflight. This data-collection-only test requires no specific activity other than recording and returning specified data. This DTO is required on each flight of each vehicle. For Columbia only, body flap strain measurements are required on a minimum of six flights, including ferry flights. DTO 307D has previously been manifested on 55 flights.

ET TPS performance, methods 1 and 3 (DTO 312). Photographs will be taken of the external tank and solid rocket boosters after separation to determine TPS charring patterns, identify regions of TPS material spallation, evaluate overall TPS performance, and identify TPS or other problems that may pose a debris hazard to the orbiter. For method 1, the 16mm and 35mm cameras are located in the orbiter umbilical well; for method 3, the camera is located on the flight deck (hand-held Nikon camera). This DTO is required on each flight of each vehicle. This DTO has previously been manifested on 52 flights.

Water spray boiler electrical heater capability (DTO 415). This DTO will monitor the performance of the water spray boiler auxiliary power unit water inlet feed line heater modification. The electric heater modification is designed to prevent water freeze-ups and to ensure that the system operates within prescribed temperature limits. Data collected will be used to verify and enhance models of the water spray boiler system capability. No crew activity is required. This DTO requires three flights on Endeavour. This is the third flight of DTO 415.

Water spray boiler quick restart capability (DTO 416). This DTO will determine the minimum time after APU shutdown that the WSB controllers can be powered on without exhibiting cooling. It will also determine the lag time between WSB vent nozzle temperatures exceeding 122 degrees Fahrenheit and controller activation with a shortened delay time between APU shutdown and WSB controller power activation. Seven flights are required. This is the first flight of DTO 416.

Global Positioning System development flight test (DTO 700-8). This DTO will demonstrate the performance and operation of the Global Positioning System (GPS) by using a modified GPS receiver processor and the existing orbiter GPS antennas. The GPS will estimate the orbiter's position, velocity, measurement discretes, and attitude during ascent, on-orbit, entry, and landing phases. The GPS receiver output data will be recorded on a 486 payload and general support computer hard drive. GPS data will be downlinked via PADM. At least one flight is required. This DTO has previously been manifested on six flights.

Crosswind landing performance (DTO 805). This DTO will continue to gather data for manually controlling landing with a 90-degree, 10- to 15-knot steady-state crosswind. This DTO can be performed regardless of landing site or vehicle mass properties. Following a crosswind landing, the drag chute will be deployed after nose gear touchdown when the vehicle is stable and tracking the centerline. This DTO has previously been manifested on 43 flights.

DETAILED SUPPLEMENTARY OBJECTIVES

Interaction of the space shuttle launch and entry suit and sustained weightlessness on egress locomotion (DSO 331). Previous flight experience has shown that astronauts' energy expenditure increases when they move around while wearing the LES. The purpose of this DSO is to investigate the effect of the launch entry suit/advanced crew escape suit (LES/ACES) on egress locomotion and to directly assess the emergency egress capacity of crew members at wheel stop. Before beginning deorbit preparations, the crew members will instrument themselves with the egress monitor assembly, which measures oxygen consumption, body temperatures, heart rate, and ventilatory equivalent.

Immunological assessment of crew members (DSO 487).* This DSO will examine the mechanisms of space-flight-induced alterations in the human immune function. As shuttle mission duration increases, the potential for the development of infectious illness in crew members during flight also increases. This investigation will use immune cells from the standard flight medicine blood draw. No on-orbit crew activities are associated with this DSO.

Characterization of microbial transfer among crew members during space flight (DSO 491). In order to minimize the spreading of infectious agents during space flight, a better understanding of microbial dissemination within the shuttle environment is needed. This DSO will serve three purposes: to adapt a method for epidemiological evaluation of microorganisms isolated from crew members and environmental sources; to assess the degree to which microbia are transferred among crew members, either directly or through the environment; and to assess the dissemination of crew microbia throughout the orbiter. The dissemination of normal crew microbia will be studied by tracking a specific target organism in samples collected from each crew member's nose and throat before and after flight. No in-flight crew activities are required.

Monitoring latent virus reactivation and shedding in astronauts (DSO 493). The objective of DSO 493 is to determine the frequency of induced reactivation of herpes viruses, herpes virus shedding, and clinical disease after exposure to physical, physiological, and psychological stresses associated with space flight. Saliva will be collected once per flight day, immediately after sleep cycle.

Educational activities (DSO 802). The purpose of this DSO is to use the attraction of space flight to capture the interest of students and motivate them toward careers in science, engineering, and mathematics. One objective is to produce interesting and motivational educational products, such as video lessons approximately 20 minutes long with scenes recorded both on orbit and on the ground. The on-orbit video will be approximately one third of the finished video product. This DSO will include videotaping of on-orbit educational activities performed by the flight crew as well as other educational activities that are deemed appropriate by the Educational Working Group and the flight crew. The other objective is to support the live TV downlink of educational activities performed by the flight crew. Typically, these activities will be limited to one or two 30-minute live downlinks.

Documentary television (DSO 901). The purpose of DSO 901 is to provide live television transmission or VTR dumps of the following crew activities and spacecraft functions: payload bay views, crew activities, in-flight crew press conference, orbiter operations, payload deployment/retrieval and operations, Earth views, rendezvous and proximity operations, and unscheduled TV activities. Telecasts are planned for communication periods with seven or more minutes of uninterrupted viewing time. The broadcast uses operational air-to-ground and/or operational intercom audio. VTR recording may be used when live television is not possible.

Documentary motion picture photography (DSO 902). This DSO requires documentary and public affairs motion picture photography of significant activities that best depict the basic capabili-

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*EDO buildup—medical evaluation DSO

ties of the space shuttle and key flight objectives. This DSO includes photography of payload bay activities, flight deck activities, mid-deck activities, and any unscheduled motion picture photography. This photography provides a historical record of the flight as well as material for release to the news media, independent publishers, and film producers.

Documentary still photography (DSO 903). This DSO requires still photography of crew activities in the orbiter and payload bay and mission-related scenes of general public and historical interest. 70mm format is used for exterior photography and a 35mm format is used for interior photography.

PRELAUNCH COUNTDOWN TIME LINE

T - (MINUS) HR:MIN:SEC	EVENT
06:00:00	Verification of the launch commit criteria is complete at this time. The liquid oxygen and liquid hydrogen systems chill-down commences in order to condition the ground line and valves as well as the external tank (ET) for cryo loading. Orbiter fuel cell power plant activation is performed.
05:50:00	The space shuttle main engine (SSME) liquid hydrogen chill-down sequence is initiated by the launch processing system (LPS). The liquid hydrogen recirculation valves are opened and start the liquid hydrogen recirculation pumps. As part of the chill-down sequence, the liquid hydrogen prevalves are closed and remain closed until T minus 9.5 seconds.
05:30:00	Liquid oxygen chill-down is complete. The liquid oxygen loading begins. The liquid oxygen loading starts with a "slow fill" in order to acclimate the ET. Slow fill continues until the tank is 2-percent full.
05:15:00	The liquid oxygen and liquid hydrogen slow fill is complete and the fast fill begins. The liquid oxygen and liquid hydrogen fast fill will continue until that tank is 98-percent full.
05:00:00	The calibration of the inertial measurement units (IMUs) starts. The three IMUs are used by the orbiter navigation systems to determine the position of the orbiter in flight.
04:30:00	The orbiter fuel cell power plant activation is complete.
04:00:00	The Merritt Island (MILA) antenna, which transmits and receives communications, telemetry and ranging information, alignment verification begins.
03:45:00	The liquid hydrogen fast fill to 98 percent is complete, and a slow topping-off process is begun and stabilized to 100 percent.
03:30:00	The liquid oxygen fast fill is complete to 98 percent.
03:20:00	The main propulsion system (MPS) helium tanks begin filling from 2,000 psi to their full pressure of 4,500 psi.
03:15:00	Liquid hydrogen stable replenishment begins and continues until just minutes prior to T minus zero.
03:10:00	Liquid oxygen stable replenishment begins and continues until just minutes prior to T minus zero.
03:00:00	The MILA antenna alignment is completed.

T - (MINUS) HR:MIN:SEC	EVENT
03:00:00	The orbiter closeout crew goes to the launch pad and prepares the orbiter crew compartment for flight crew ingress.
03:00:00 Holding	Begin 2-hour planned hold. An inspection team examines the ET for ice or frost formation on the launch pad during this hold.
03:00:00 Counting	Two-hour planned hold ends.
02:55:00	Flight crew departs Operations and Checkout (O&C) Building for launch pad.
02:25:00	Flight crew orbiter and seat ingress occurs.
02:10:00	Postingress software reconfiguration occurs.
02:00:00	Checking of the launch commit criteria starts at this time.
02:00:00	The ground launch sequencer (GLS) software is initialized.
01:50:00	The solid rocket boosters' (SRBs') hydraulic pumping units' gas generator heaters are turned on and the SRBs' aft skirt gaseous nitrogen purge starts.
01:50:00	The SRB rate gyro assemblies (RGAs) are turned on. The RGAs are used by the orbiter's navigation system to determine rates of motion of the SRBs during first-stage flight.
01:35:00	The orbiter accelerometer assemblies (AAs) are powered up.
01:35:00	The orbiter reaction control system (RCS) control drivers are powered up.
01:35:00	The flight crew starts the communications checks.
01:25:00	The SRB RGA torque test begins.
01:20:00	Orbiter side hatch is closed.
01:10:00	Orbiter side hatch seal and cabin leak checks are performed.
01:01:00	IMU preflight align begins. Flight crew functions from this point on will be initiated by a call from the orbiter test conductor (OTC) to proceed. The flight crew will report back to the OTC after completion.
01:00:00	The orbiter RGAs and AAs are tested.
00:50:00	The flight crew starts the orbiter hydraulic auxiliary power units' (APUs') water boilers preactivation.
00:45:00	Cabin vent redundancy check is performed.
00:45:00	The GLS mainline activation is performed.
00:40:00	The eastern test range (ETR) shuttle range safety system (SRSS) terminal count closed-loop test is accomplished.

T - (MINUS) HR:MIN:SEC	EVENT
00:40:00	Cabin leak check is completed.
00:32:00	The backup flight control system (BFS) computer is configured.
00:30:00	The gaseous nitrogen system for the orbital maneuvering system (OMS) engines is pressurized for launch. Crew compartment vent valves are opened.
00:26:00	The ground pyro initiator controllers (PICs) are powered up. They are used to fire the SRB hold-down posts, liquid oxygen and liquid hydrogen tail service mast (TSM), and ET vent arm system pyros at lift-off and the SSME hydrogen gas burn system prior to SSME ignition.
00:25:00	Simultaneous air-to-ground voice communications are checked. Weather aircraft are launched.
00:22:00	The primary avionics software system (PASS) is transferred to the BFS computer in order for both systems to have the same data. In case of a PASS computer system failure, the BFS computer will take over control of the shuttle vehicle during flight.
00:21:00	The crew compartment cabin vent valves are closed.
00:20:00	A 10-minute planned hold starts.
<u>Hold 10 Minutes</u>	All computer programs in the firing room are verified to ensure that the proper programs are available for the final countdown. The test team is briefed on the recycle options in case of an unplanned hold.

T - (MINUS) HR:MIN:SEC	EVENT
	The landing convoy status is again verified and the landing sites are verified ready for launch.
	The IMU preflight alignment is verified complete.
	Preparations are made to transition the orbiter on-board computers to Major Mode (MM)-101 upon coming out of the hold. This configures the computer memory to a terminal countdown configuration.
00:20:00	The 10-minute hold ends.
<u>Counting</u>	Transition to MM-101. The PASS on-board computers are dumped and compared to verify the proper on-board computer configuration for launch.
00:19:00	The flight crew configures the backup computer to MM-101 and the test team verifies the BFS computer is tracking the PASS computer systems. The flight crew members configure their instruments for launch.
00:18:00	The Mission Control Center-Houston (MCC-H) now loads the on-board computers with the proper guidance parameters based on the prestated lift-off time.
00:16:00	The MPS helium system is reconfigured by the flight crew for launch.
00:15:00	The OMS/RCS crossfeed valves are configured for launch.

T - (MINUS) HR:MIN:SEC	EVENT
	All test support team members verify they are "go for launch."
00:12:00	Emergency aircraft and personnel are verified on station.
00:10:00	All orbiter aerosurfaces and actuators are verified to be in the proper configuration for hydraulic pressure application. The NASA test director gets a "go for launch" verification from the launch team.
00:09:00	A planned 10-minute hold starts.
Hold 10 Minutes	NASA and contractor project managers will be formally polled by the deputy director of NASA, Space Shuttle Operations, on the Space Shuttle Program Office communications loop during the T-minus-9-minute hold. A positive "go for launch" statement will be required from each NASA and contractor project element prior to resuming the launch countdown. The loop will be recorded and maintained in the launch decision records.
	All test support team members verify that they are "go for launch."
	Final GLS configuration is complete.
00:09:00 Counting	The GLS auto sequence starts and the terminal countdown begins.

T - (MINUS) HR:MIN:SEC	EVENT
	From this point, the GLSs in the integration and backup consoles are the primary control until T-0 in conjunction with the on-board orbiter PASS redundant-set computers.
00:09:00	Operations recorders are on. MCC-H, Johnson Space Center, sends a command to turn these recorders on. They record shuttle system performance during ascent and are dumped to the ground once orbit is achieved.
00:08:00	Payload and stored prelaunch commands proceed.
00:07:30	The orbiter access arm (OAA) connecting the access tower and the orbiter side hatch is retracted. If an emergency arises requiring flight crew activation, the arm can be extended either manually or by GLS computer control in approximately 30 seconds or less.
00:06:00	APU prestart occurs.
00:05:00	Orbiter APUs start. The orbiter APUs provide pressure to the three orbiter hydraulic systems. These systems are used to move the SSME engine nozzles and aerosurfaces.
00:05:00	ET/SRB range safety system (RSS) is armed. At this point, the firing circuit for SRB ignition and destruct devices is mechanically enabled by a

T - (MINUS) HR:MIN:SEC	EVENT
	motor-driven switch called a safe and arm device (S&A).
00:04:30	As a preparation for engine start, the SSME main fuel valve heaters are turned off.
00:04:00	The final helium purge sequence, purge sequence 4, on the SSMEs is started in preparation for engine start.
00:03:55	At this point, all of the elevons, body flap, speed brake, and rudder are moved through a preprogrammed pattern. This is to ensure that they will be ready for use in flight.
00:03:30	Transfer to internal power is done. Up to this point, power to the space vehicle has been shared between ground power supplies and the on-board fuel cells. The ground power is disconnected and the vehicle goes on internal power at this time. It will remain on internal power through the rest of the mission.
00:03:25	The SSMEs' nozzles are moved (gimbaled) through a preprogrammed pattern to ensure that they will be ready for ascent flight control. At completion of the gimbal profile, the SSMEs' nozzles are in the start position.
00:02:55	ET liquid oxygen prepressurization is started. At this point, the liquid oxygen tank vent valve is closed and the ET liquid oxygen tank is pressurized to its flight pressure of 21 psi.
00:02:50	The gaseous oxygen arm is retracted. The cap that fits over the ET nose cone to prevent ice buildup on the oxygen vents is raised off the nose cone and retracted.
00:02:35	Up until this time, the fuel cell oxygen and hydrogen supplies have been adding to the on-board tanks so that a full load at lift-off is assured. This filling operation is terminated at this time.
00:02:30	The caution/warning memory is cleared.
00:01:57	Since the ET liquid hydrogen tank was filled, some of the liquid hydrogen has turned into gas. In order to keep pressure in the ET liquid hydrogen tank low, this gas was vented off and piped out to a flare stack and burned. In order to maintain flight level, liquid hydrogen was continuously added to the tank to replace the vented hydrogen. This operation terminates, the liquid hydrogen tank vent valve is closed, and the tank is brought up to a flight pressure of 44 psia at this time.
00:01:15	The sound suppression system will dump water onto the mobile launcher platform (MLP) at ignition in order to dampen vibration and noise in the space shuttle. The firing system for this dump, the sound suppression water power bus, is armed at this time.
00:01:00	The SRB joint heaters are deactivated.
00:00:55	The SRB MDM critical commands are verified.

T - (MINUS) HR:MIN:SEC	EVENT
00:00:47	The liquid oxygen and liquid hydrogen outboard fill and drain valves are closed.
00:00:40	The external tank bipod heaters are turned off.
00:00:38	The on-board computers position the orbiter vent doors to allow payload bay venting upon lift-off and ascent in the payload bay at SSME ignition.
	The SRB forward MDM is locked out.
00:00:37	The gaseous oxygen ET arm retract is confirmed.
00:00:31	The GLS sends "go for redundant set launch sequence start." At this point, the four PASS computers take over main control of the terminal count. Only one further command is needed from the ground, "go for main engine start," at approximately T minus 9.7 seconds. The GLS in the integration console in the launch control center still continues to monitor several hundred launch commit criteria and can issue a cutoff if a discrepancy is observed. The GLS also sequences ground equipment and sends selected vehicle commands in the last 31 seconds.
00:00:28	Two hydraulic power units in each SRB are started by the GLS. These provide hydraulic power for SRB nozzle gimbaling for ascent first-stage flight control.
	The orbiter vent door sequence starts.
00:00:21	The SRB gimbal profile is complete. As soon as SRB hydraulic power is applied, the SRB engine nozzles are commanded through a preprogrammed pattern to assure that they will be ready for ascent flight control during first stage.
00:00:21	The liquid hydrogen high-point bleed valve is closed.
	The SRB gimbal test begins.
00:00:18	The on-board computers arm the explosive devices, the pyrotechnic initiator controllers, that will separate the T-0 umbilicals, the SRB hold-down posts, and SRB ignition, which is the final electrical connection between the ground and the shuttle vehicle.
00:00:16	The sound suppression system water is activated.
00:00:15	If the SRB pyro initiator controller (PIC) voltage in the redundant-set launch sequencer (RSLS) is not within limits in 3 seconds, SSME start commands are not issued and the on-board computers proceed to a countdown hold.
00:00:13	The aft SRB MDM units are locked out. This is to protect against electrical interference during flight. The electronic lock requires an unlock command before it will accept any other command.
	SRB SRSS inhibits are removed. The SRB destruct system is now live.

T - (MINUS) HR:MIN:SEC	EVENT
00:00:12	The MPS helium fill is terminated. The MPS helium system flows to the pneumatic control system at each SSME inlet to control various essential functions.
00:00:10	LPS issues a "go" for SSME start. This is the last required ground command. The ground computers inform the orbiter on-board computers that they have a "go" for SSME start. The GLS retains hold capability until just prior to SRB ignition.
00:00:09.7	Liquid hydrogen recirculation pumps are turned off. The recirculation pumps provide for flow of fuel through the SSMEs during the terminal count. These are supplied by ground power and are powered in preparation for SSME start.
00:00:09.7	In preparation for SSME ignition, flares are ignited under the SSMEs. This burns away any free gaseous hydrogen that may have collected under the SSMEs during prestart operations. The orbiter goes on internal cooling at this time; the ground coolant units remain powered on until lift-off as a contingency for an aborted launch. The orbiter will redistribute heat within the orbiter until approximately 125 seconds after lift-off, when the orbiter flash evaporators will be turned on.
00:00:09.5	The SSME engine chill-down sequence is complete and the on-board computers command the three MPS liquid hydrogen prevalves to open. (The MPS's three liquid oxygen prevalves were opened during ET tank loading to permit engine chill-down.) These valves allow liquid hydrogen and oxygen flow to the SSME turbopumps.
00:00:09.5	Command decoders are powered off. The command decoders are units that allow ground control of some on-board components. These units are not needed during flight.
00:00:06.6	The main fuel and oxidizer valves in each engine are commanded open by the on-board computers, permitting fuel and oxidizer flow into each SSME for SSME start. All three SSMEs are started at 120-millisecond intervals (SSME 3, 2, then 1) and throttle up to 100-percent thrust levels in 3 seconds under control of the SSME controller on each SSME.
00:00:04.6	All three SSMEs are verified to be at 100-percent thrust and the SSMEs are gimbaled to the lift-off position. If one or more of the three SSMEs does not reach 100-percent thrust at this time, all SSMEs are shut down, the SRBs are not ignited, and an RSLS pad abort occurs. The GLS RSLS will perform shuttle and ground systems safing. Vehicle bending loads caused by SSME thrust buildup are allowed to initialize before SRB ignition. The vehicle moves towards ET including ET approximately 25.5 inches.

T - (MINUS) HR:MIN:SEC	EVENT
00:00:00	The two SRBs are ignited under command of the four on-board PASS computers, the four hold-down explosive bolts on each SRB are initiated (each bolt is 28 inches long and 3.5 inches in diameter), and the two T-0 umbilicals on each side of the spacecraft are retracted. The on-board timers are started and the ground launch sequence is terminated. All three SSMEs are at 104-percent thrust. Boost guidance in attitude hold.
00:00	Lift-off.

STS-77 MISSION HIGHLIGHTS TIME LINE

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
	MET DAY ZERO
0/00:00:07	Tower is cleared (SRBs above lightning-rod tower).
0/00:00:10	180-degree positive roll maneuver (right-clockwise) is started. Pitch profile is heads down, wings level.
0/00:00:19	Roll maneuver ends.
0/00:00:34	All three SSMEs throttle down from 104 to 67 percent for maximum aerodynamic load (max q).
0/00:00:51	Max q occurs.
0/00:00:57	All three SSMEs throttle to 104 percent.
0/00:02:06	SRBs separate.
	When chamber pressure (Pc) of the SRBs is less than 50 psi, automatic separation occurs with manual flight crew backup switch to the automatic function (does not bypass automatic circuitry). SRBs descend to approximately 15,400 feet, when the nose cap is jettisoned and drogue chute is deployed for initial deceleration.
	At approximately 6,600 feet, drogue chute is released and three main parachutes on each SRB provide final deceleration prior to splashdown in Atlantic Ocean, where the SRBs are recovered for reuse on another mission. Flight control system switches from SRB to orbiter RGAs.
0/00:03:59	Negative return. The vehicle is no longer capable of return-to-launch site abort at Kennedy Space Center runway.

Editor's Notes: This time line lists selected highlights only. For full detail, please refer to the NASA Mission Operations Directorate STS-77 Flight Plan, Ascent Checklist, Post Insertion Checklist, Deorbit Prep Checklist, and Entry Checklist. The STS-77 Rendezvous MOD documents contain detailed time lines for the SPARTAN 207/IAE and and PAMS/STU payloads.

The STS-77 Flight Plan assumes on-orbit acquisition of the energy dependent extension day. The nominal time line reflects a 10-day mission.

On every shuttle mission, some day-to-day replanning takes place to adjust crew and event time lines according to unforeseen developments or simply to optimize the use of time in orbit. Each day's replanning effort will produce an execute plan defining the approach for the next day's activities in space and on the ground.

All orbiter maneuvers are recalculated in real time and the burn values are frequently updated during the mission. Also, some burns may not be needed and could be deleted in real time.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/00:07:07	Single engine press to main engine cutoff (MECO).
0/00:08:21	All three SSMEs throttle down to 67 percent for MECO.
0/00:08:27	MECO occurs at approximate velocity 25,861 feet per second, 42 by 147 nautical miles (48 by 169 statute miles).
0/00:08:34	Zero thrust.
0/00:08:46	ET separation is automatic with flight crew manual backup switch to the automatic function (does not bypass automatic circuitry).
	The orbiter forward and aft RCSs, which provide attitude hold and negative Z translation of 11 fps to the orbiter for ET separation, are first used.
	Orbiter/ET liquid oxygen/liquid hydrogen umbilicals are retracted.
	Negative Z translation is complete.
	In conjunction with this thrusting period, approximately 1,700 pounds of liquid hydrogen and 3,700 pounds of liquid oxygen are trapped in the MPS ducts and SSMEs, which results in an approximate 7-inch center-of-gravity shift in the orbiter. The trapped propellants would sporadically vent in orbit, affecting guidance and creating contaminants for the payloads. During entry, liquid hydrogen could combine with atmospheric oxygen to form a potentially explosive mixture. As a result, the liquid oxygen is dumped out through the SSME combustion chamber nozzles, and the liquid hydrogen is dumped out through the right-hand T-minus-zero umbilical overboard fill and drain valves.
	MPS dump terminates. APUs shut down.
	MPS vacuum inerting occurs.
	— Remaining residual propellants are vented to space vacuum, inerting the MPS.
	— Orbiter/ET umbilical doors close (one door for liquid hydrogen and one door for liquid oxygen) at bottom of aft fuselage, sealing the aft fuselage for entry heat loads.
	— MPS vacuum inerting terminates.
0/00:42	OMS-2 thrusting maneuver is performed, approximately 2 minutes, 6 seconds in duration, at 199 fps, 152 by 154 nautical miles.
0/00:51	Commander closes all current breakers, panel L4.
0/00:53	Mission specialist (MS), payload specialist seat egress.
0/00:54	Commander and pilot configure GPCs for OPS-2.
0/00:57	MS configures preliminary middeck.
0/00:59	MS configures aft flight station.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/01:01	MS unstows, sets up, and activates PGSC.
0/01:04	MS configures for payload bay door operations.
0/01:05	Pilot activates payload bus (panel R1).
0/01:08	Commander and pilot don and configure communications.
0/01:11	Pilot maneuvers vehicle to payload bay door opening attitude, biased negative Z local vertical, negative X velocity vector attitude.
0/01:18	Commander activates radiators.
0/01:28	MS opens payload bay doors.
0/01:30	MS configures payload communications.
0/01:35	Mission Control Center (MCC), Houston (H), informs crew to "go for orbit operations."
0/01:37	Commander and pilot seat egress.
0/01:38	Commander and pilot clothing configuration.
0/01:39	MS/PS clothing configuration.
0/01:52	Commander begins post-payload bay door operations and radiator configuration.
0/01:55	MS/PS remove and stow seats.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
0/01:56	Commander activates star tracker and opens door.
0/01:57	MS configures and activates WCS.
0/01:58	MS activates switch configuration/galley.
0/01:59	MS stows escape pole.
0/01:59	MS sets up tunnel configuration.
0/02:00	Commander configures freon loop.
0/02:03	Pilot activates auxiliary power unit steam vent heater, panel R2, boiler controller/heater, 3 to A, power, 3 to ON.
0/02:06	Commander configures vernier controls.
0/02:10	MS deploys Ku-band antenna.
0/02:11	Commander, MS configure controls for on-orbit.
0/02:14	MS performs on-orbit initialization.
0/02:18	Pilot enables hydraulic thermal conditioning.
0/02:20	MS activates Ku-band antenna.
0/02:24	MS resets caution/warning (C/W).
0/02:28	MS plots fuel cell performance.

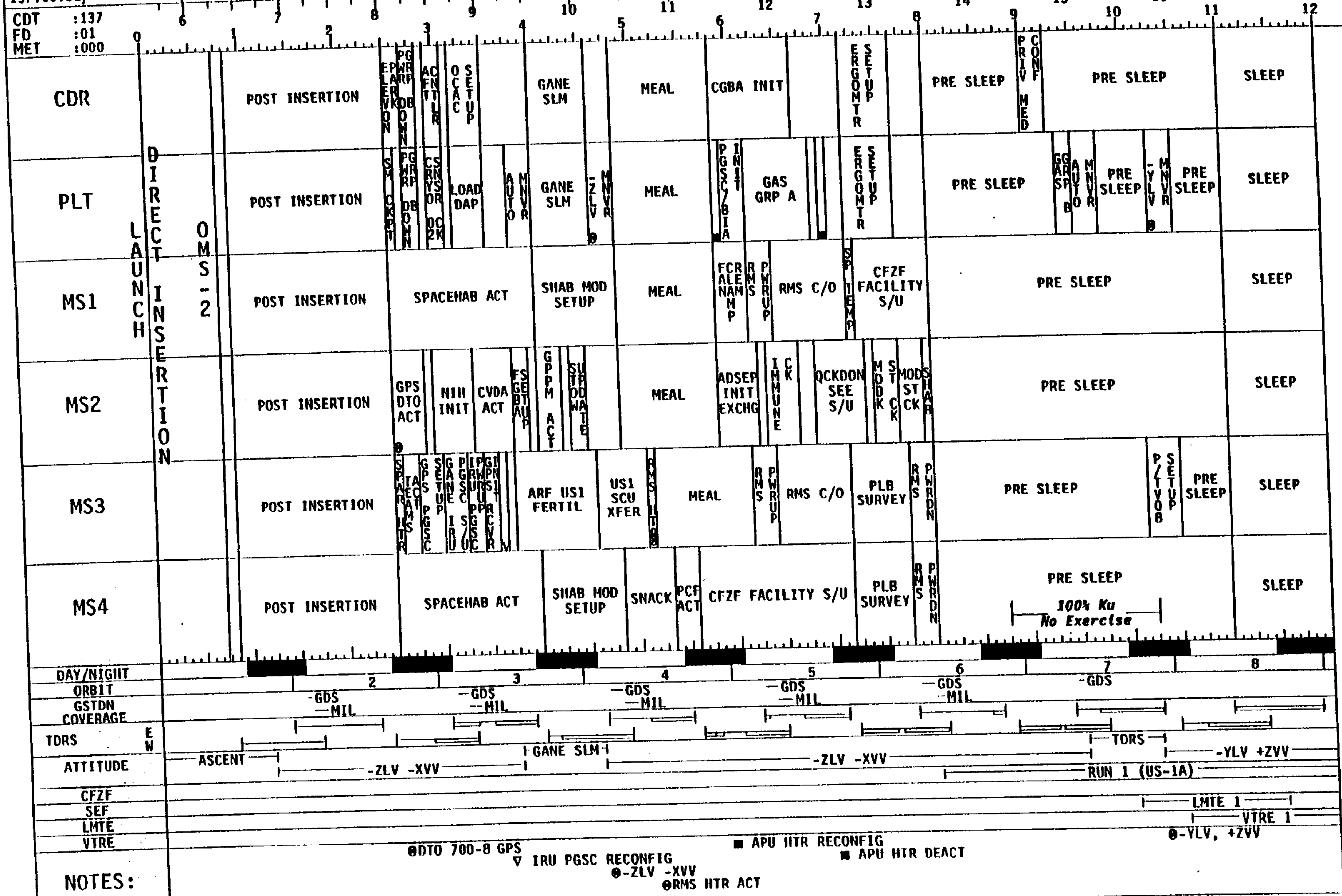
(Editor's Note: for mission details from MET 0/02:30 through the start of deorbit preparations, please refer to the enclosed Rockwell Major Mission Events and NASA MOD STS-77 Flight Plan Summary Timeline charts)

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
9/19:37	Crew begins deorbit preparation.
9/19:37	CRT timer setup.
9/19:57	Stow radiators, if required.
9/20:15	Commander configures DPS for deorbit preparation.
9/20:18	Mission Control Center updates IMU star pad, if required.
9/20:27	MS configures for payload bay door closure.
9/20:38	MCC-H gives "go/no-go" command for payload bay door closure.
9/20:46	Maneuver vehicle to IMU alignment attitude.
9/20:55	IMU alignment/payload bay door operations.
9/21:05	MCC gives the crew the go for OPS 3.
9/21:08	Pilot starts repressurization of SSME systems.
9/21:10	Commander and pilot perform DPS entry configuration.
9/21:12	MS deactivates ST and closes ST doors.
9/21:14	All crew members verify entry payload switch list.
9/21:29	All crew members perform entry review.
9/21:31	Crew begins fluid loading, 32 fluid ounces of water with salt over next 1.5 hours (2 salt tablets per 8 ounces).
9/21:52	Commander and pilot configure clothing.
9/22:07	MS/PS configure clothing.
9/22:18	Commander and pilot seat ingress.
9/22:20	Commander and pilot set up heads-up display (HUD).
9/22:22	Commander and pilot adjust seat, exercise brake pedals.
9/22:30	Final entry deorbit update/uplink.
9/22:36	OMS thrust vector control gimbal check is performed.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
9/22:45	APU prestart.
9/22:50	Close vent doors.
9/22:54	MCC-H gives "go" for deorbit burn period.
9/22:56	Maneuver vehicle to deorbit burn attitude.
9/22:59	MS/PS ingress seats.
9/23:29	First APU is activated.
9/23:37	Deorbit burn.
9/23:42	Initiate post-deorbit burn period attitude.
9/23:46	Terminate post-deorbit burn attitude.
9/23:54	Dump forward RCS, if required.
10/00:00	Activate remaining APUs.
10/00:06	Entry interface, 400,000 feet altitude.
10/00:10	Automatically deactivate RCS roll thrusters.
10/00:17	Automatically deactivate RCS pitch thrusters.

T + (PLUS) DAY/ HR:MIN:SEC	EVENT
10/00:25	Initiate first roll reversal.
10/00:27	TACAN acquisition.
10/00:28	Initiate second roll reversal.
10/00:28	Initiate air data system (ADS) probe deploy.
10/00:30	Initiate third roll reversal.
10/00:31	Begin entry/terminal area energy management (TAEM).
10/00:31	Initiate payload bay venting.
10/00:33	Automatically deactivate RCS yaw thrusters.
10/00:36	TAEM/approach and landing interface.
10/00:36	Initiate landing gear deployment.
10/00:37	Vehicle has weight on main landing gear.
10/00:37	Vehicle has weight on nose landing gear.
10/00:37	Initiate main landing gear braking.
10/00:38	Wheel stop.

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
137:10:32/ 137:22:32	000:00:00/ 000:12:00	137:05:32/ 137:17:32	01 /137 CDT	-6.0	◐	MAY 16, 1996	STS 77	FINAL, PCN-1	04/29/96

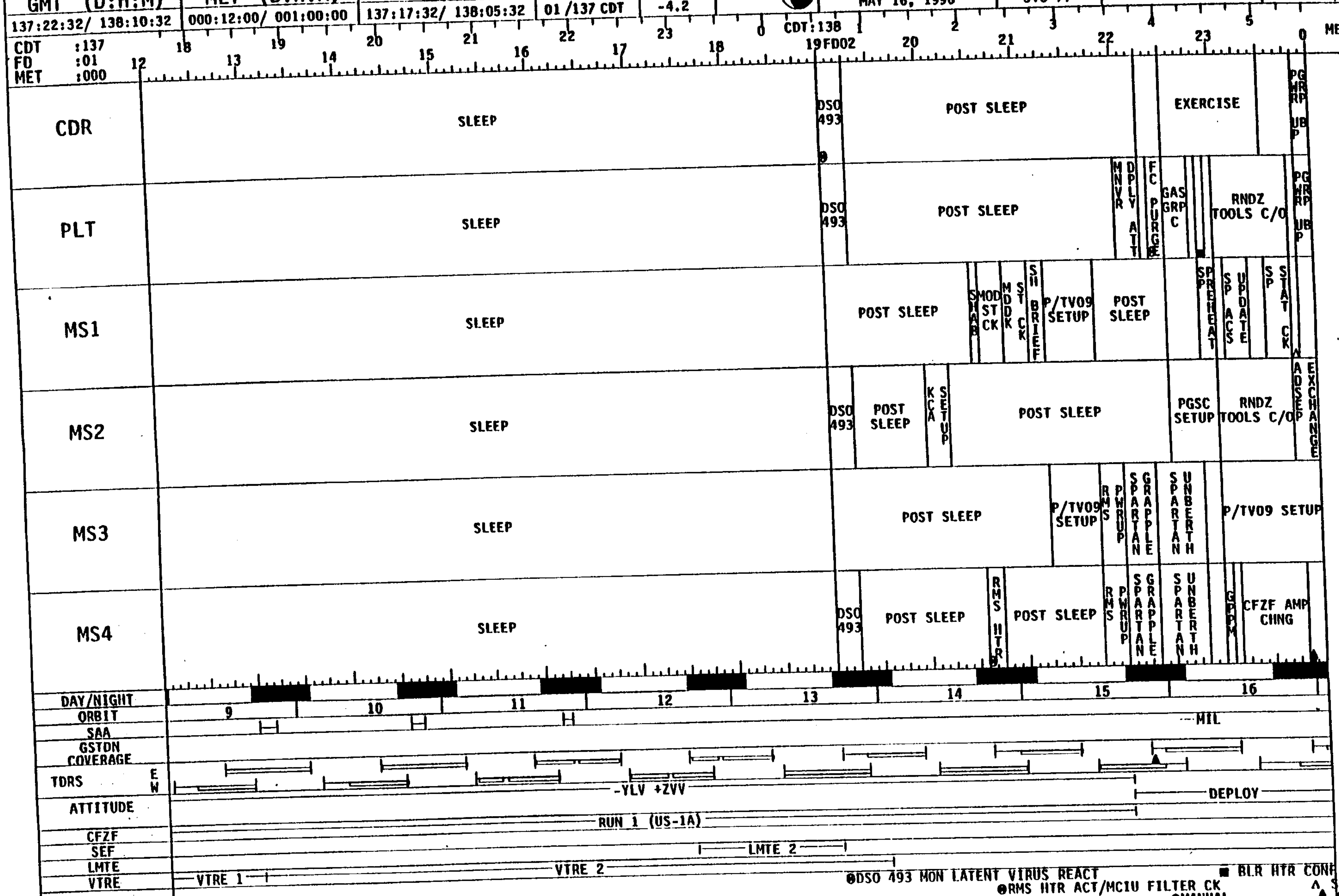


NOTES:

●DTO 700-8 GPS
▽ IRU PGSC RECONFIG
●-ZLV -XVV
●RMS HTR ACT
■ APU HTR RECONFIG
■ APU HTR DEACT
●-YLV, +ZVV

96

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
137:22:32/ 138:10:32	000:12:00/ 001:00:00	137:17:32/ 138:05:32	01 /137 CDT	-4.2	◐	MAY 16, 1996	STS 77	FINAL	04/02/96



NOTES:

● DSO 493 MON LATENT VIRUS REACT

● RMS HTR ACT/MCIU FILTER CK

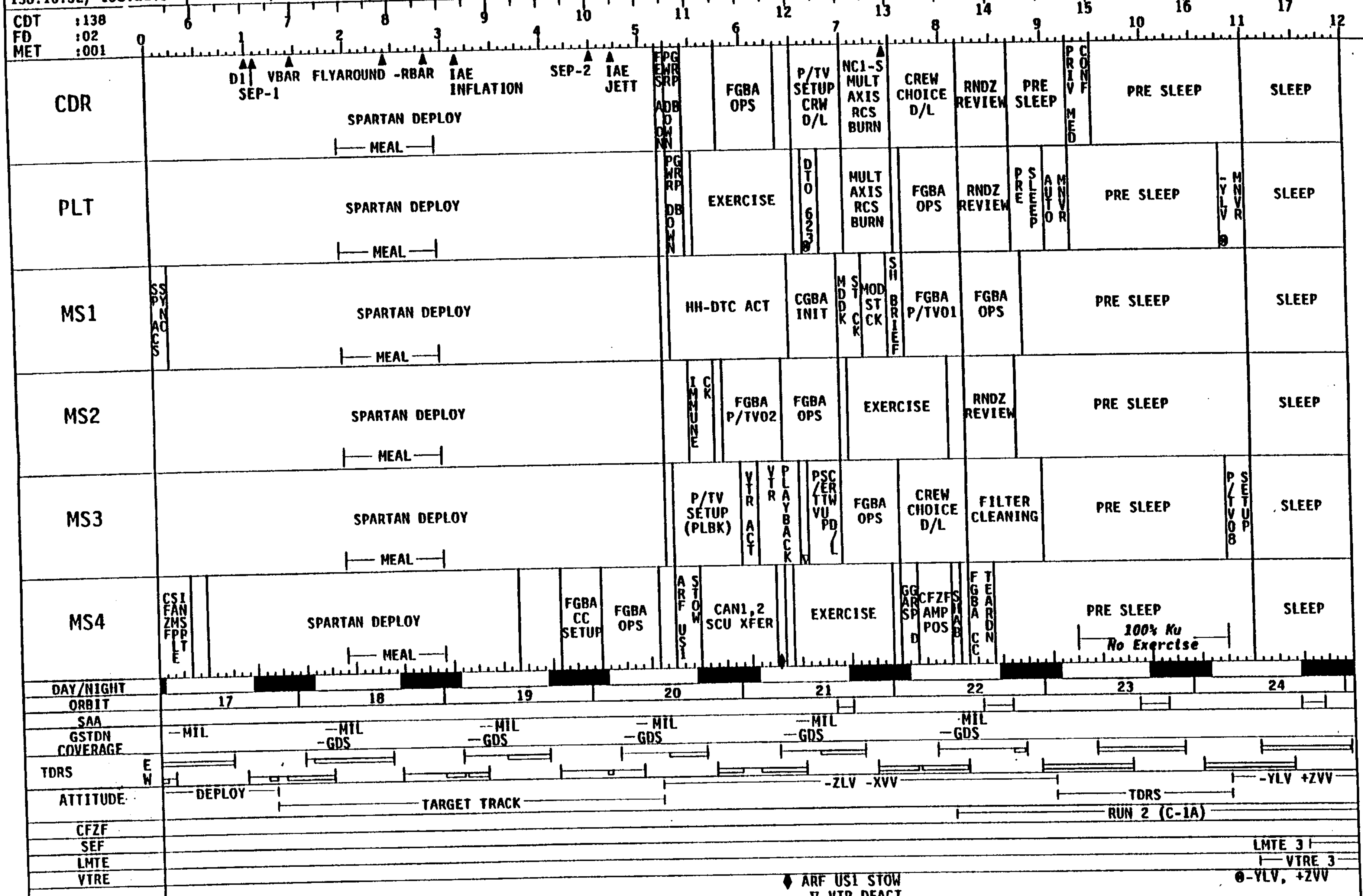
● MANUAL

■ BLR HTR CONFIG

∧ SPARTAN STNDBY

♦ CFZF SAMPLE INS

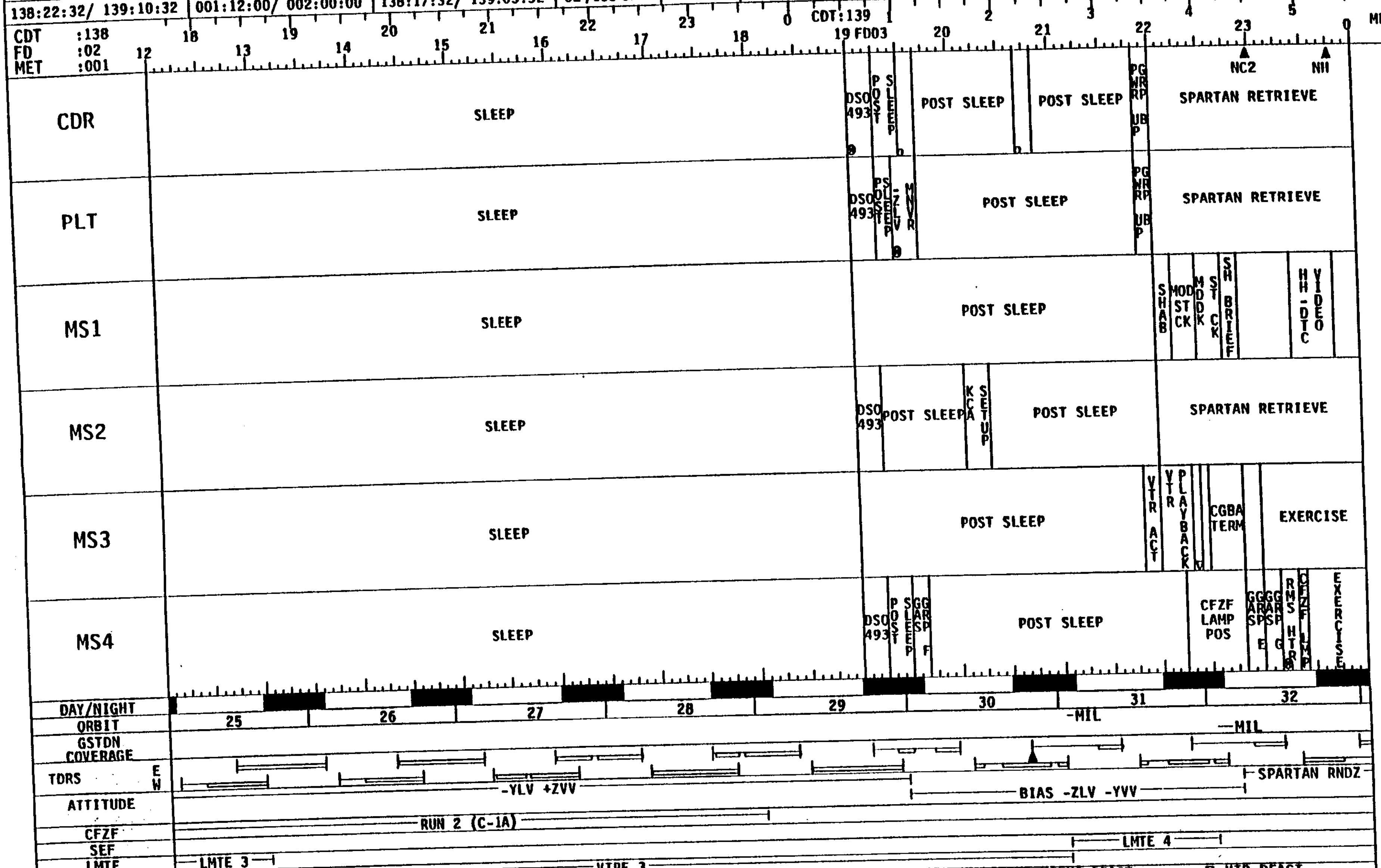
GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
138:10:32/ 138:22:32	001:00:00/ 001:12:00	138:05:32/ 138:17:32	02 /138 CDT	-2.1	●	MAY 17, 1996	STS 77	FINAL	04/02/96



NOTES:

⬥ ARF USI STOW
▽ VTR DEACT
● DTO 623 CAB AIR MON
● -YLV, +ZVV

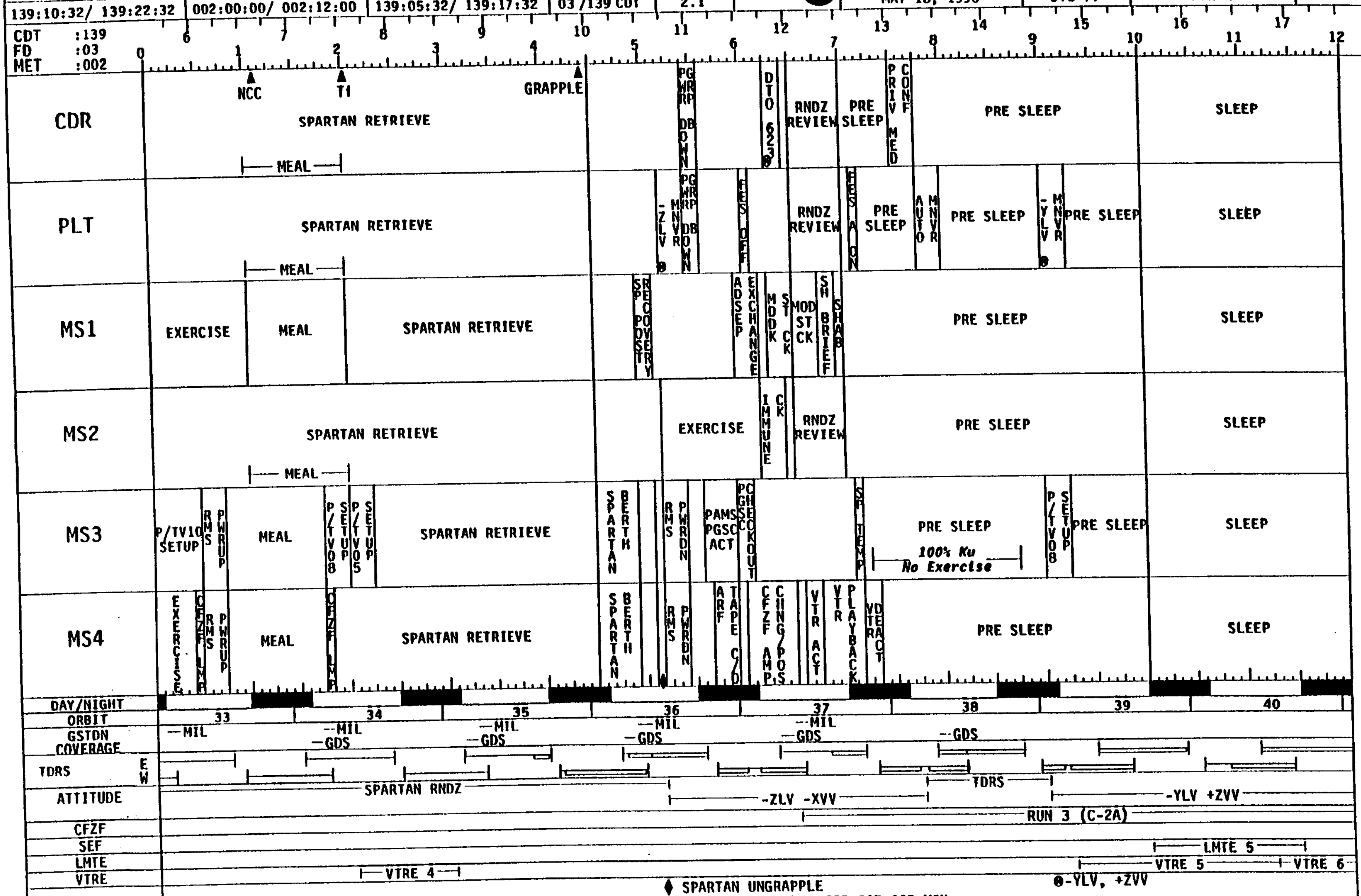
GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
138:22:32/ 139:10:32	001:12:00/ 002:00:00	138:17:32/ 139:05:32	02 /138 CDT	-0.0	●	MAY 17, 1996	STS 77	FINAL	04/02/96



NOTES:

ⓞDSO 493 MON LATENT VIRUS REACT
ⓞBIASED -ZLV, -YVV
o SIMO DUMP INIT
o SIMO DUMP TERM
▽ VTR DEACT
ⓞRMS HTR ACT/MCIU FILTER

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
139:10:32/ 139:22:32	002:00:00/ 002:12:00	139:05:32/ 139:17:32	03 /139 CDT	2.1	●	MAY 18, 1996	STS 77	FINAL	04/02/96



NOTES:

◆ SPARTAN UNGRAPPLE

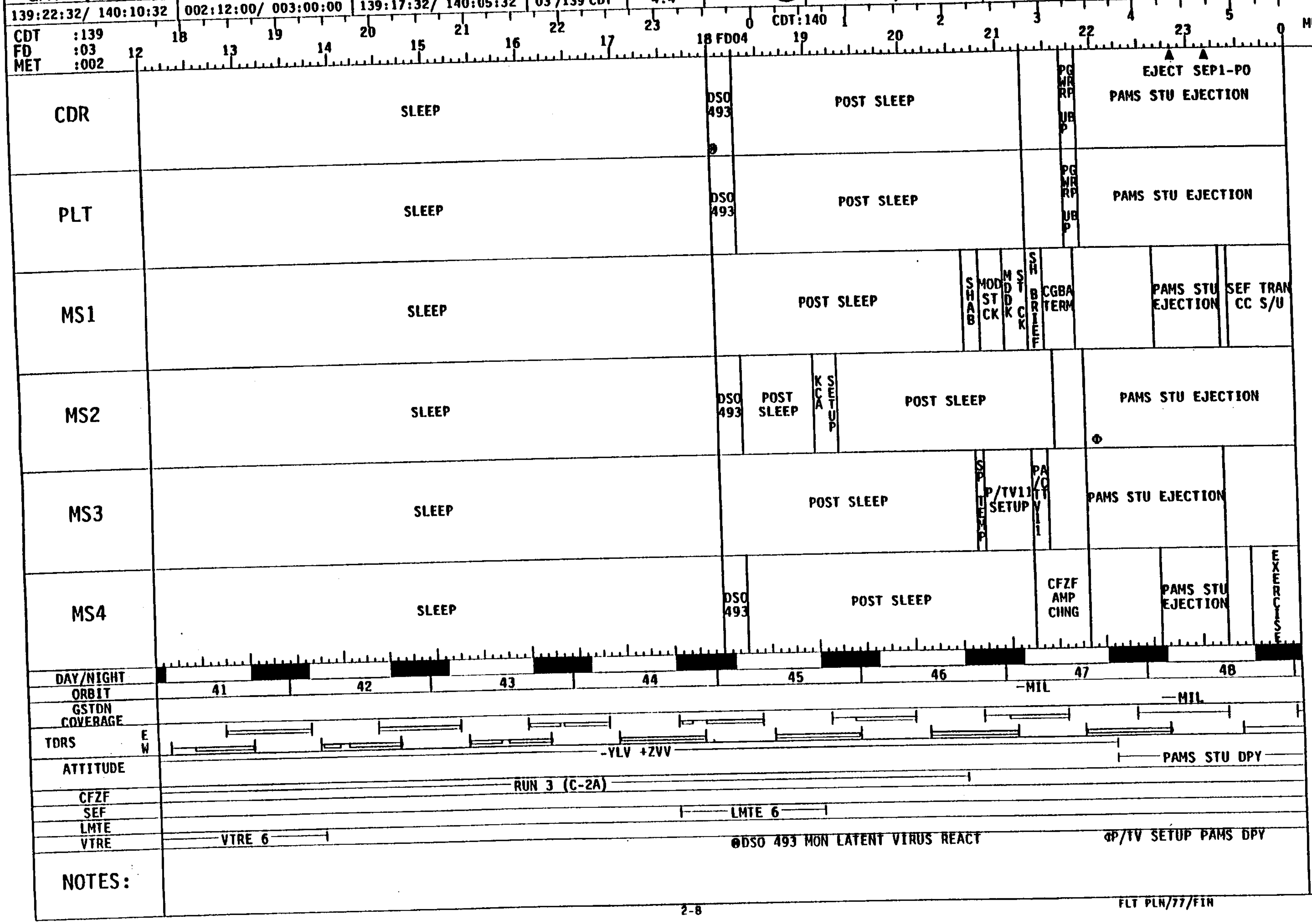
⊖-ZLV -XVV ⊕DTO 623 CAB AIR MON

⊖-YLV, +ZVV

PAMS STU C/O (GND)

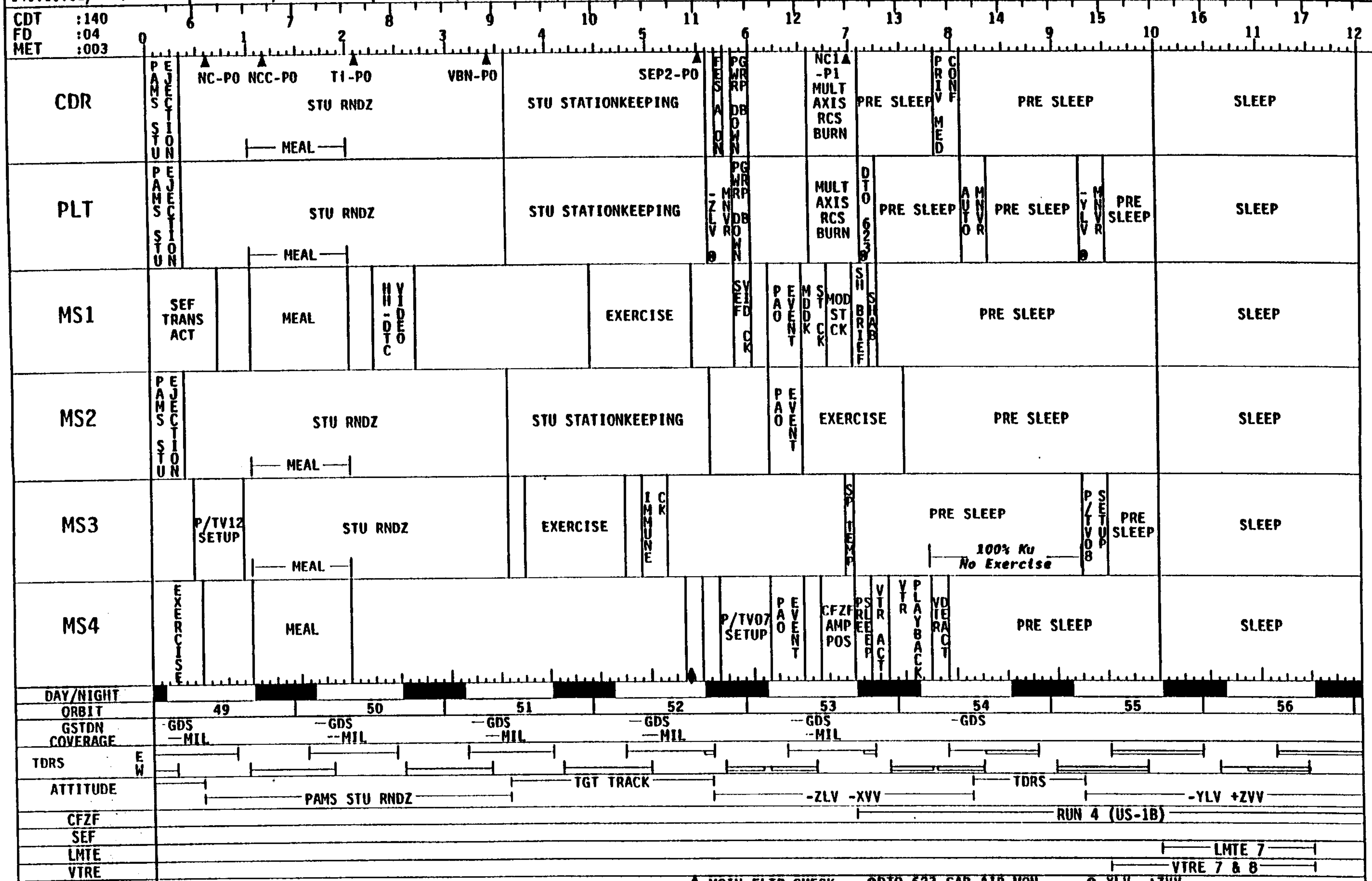
100

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
139:22:32/ 140:10:32	002:12:00/ 003:00:00	139:17:32/ 140:05:32	03 /139 CDT	4.4	●	MAY 18, 1996	STS 77	FINAL	04/02/96



101

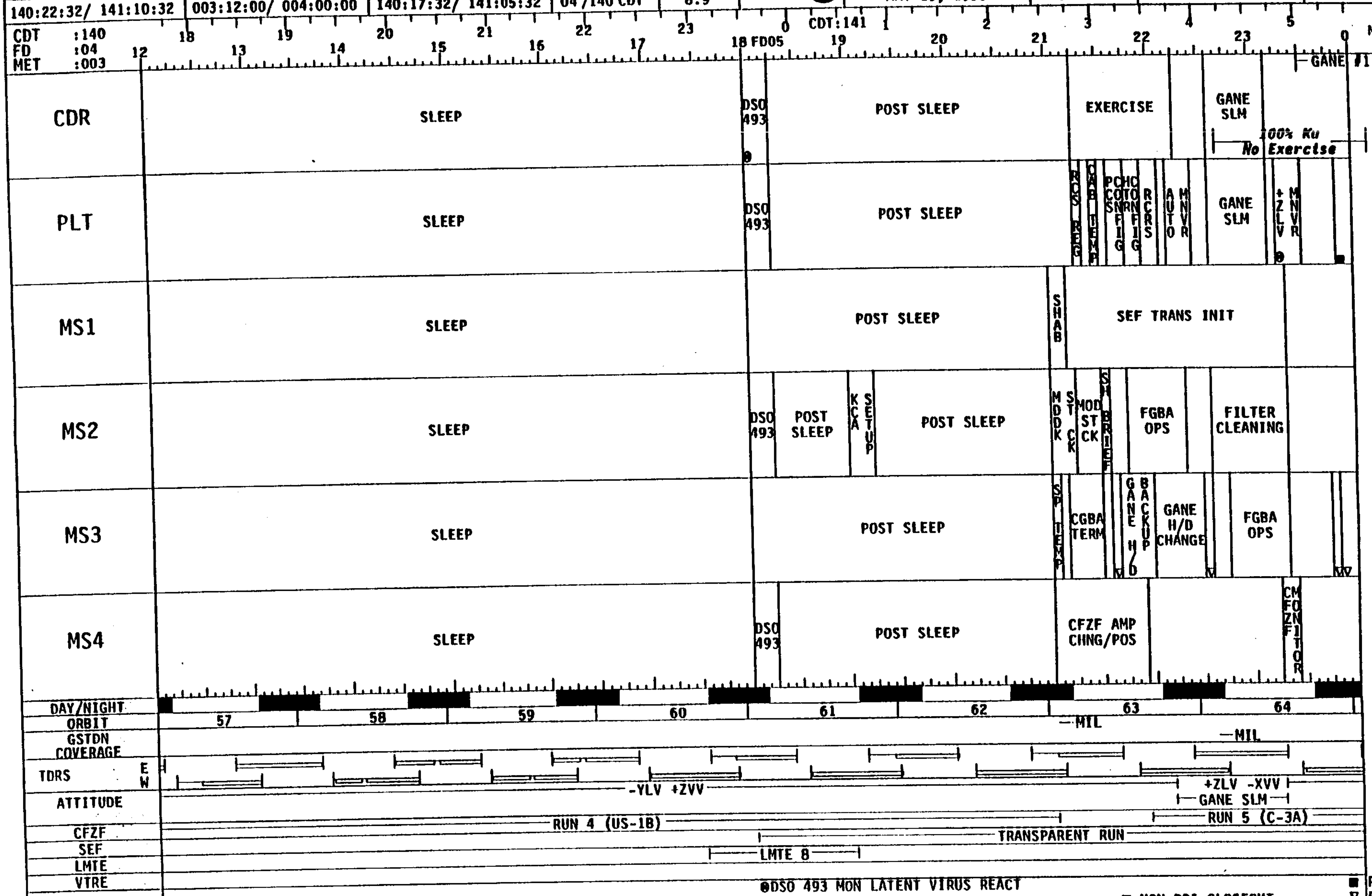
GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
140:10:32/ 140:22:32	003:00:00/ 003:12:00	140:05:32/ 140:17:32	04 /140 CDT	6.6	●	MAY 19, 1996	STS 77	FINAL	04/02/96



NOTES:

◆ MCIU FLTR CHECK
●-ZLV, -XVV
●DTO 623 CAB AIR MON
●-YLV, +ZVV

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
140:22:32/ 141:10:32	003:12:00/ 004:00:00	140:17:32/ 141:05:32	04 /140 CDT	8.9	●	MAY 19, 1996	STS 77	FINAL	04/02/96



NOTES:

⊖DSO 493 MON LATENT VIRUS REACT

▽ NON-PRI CLOSEOUT

▽ DATA COLLECT

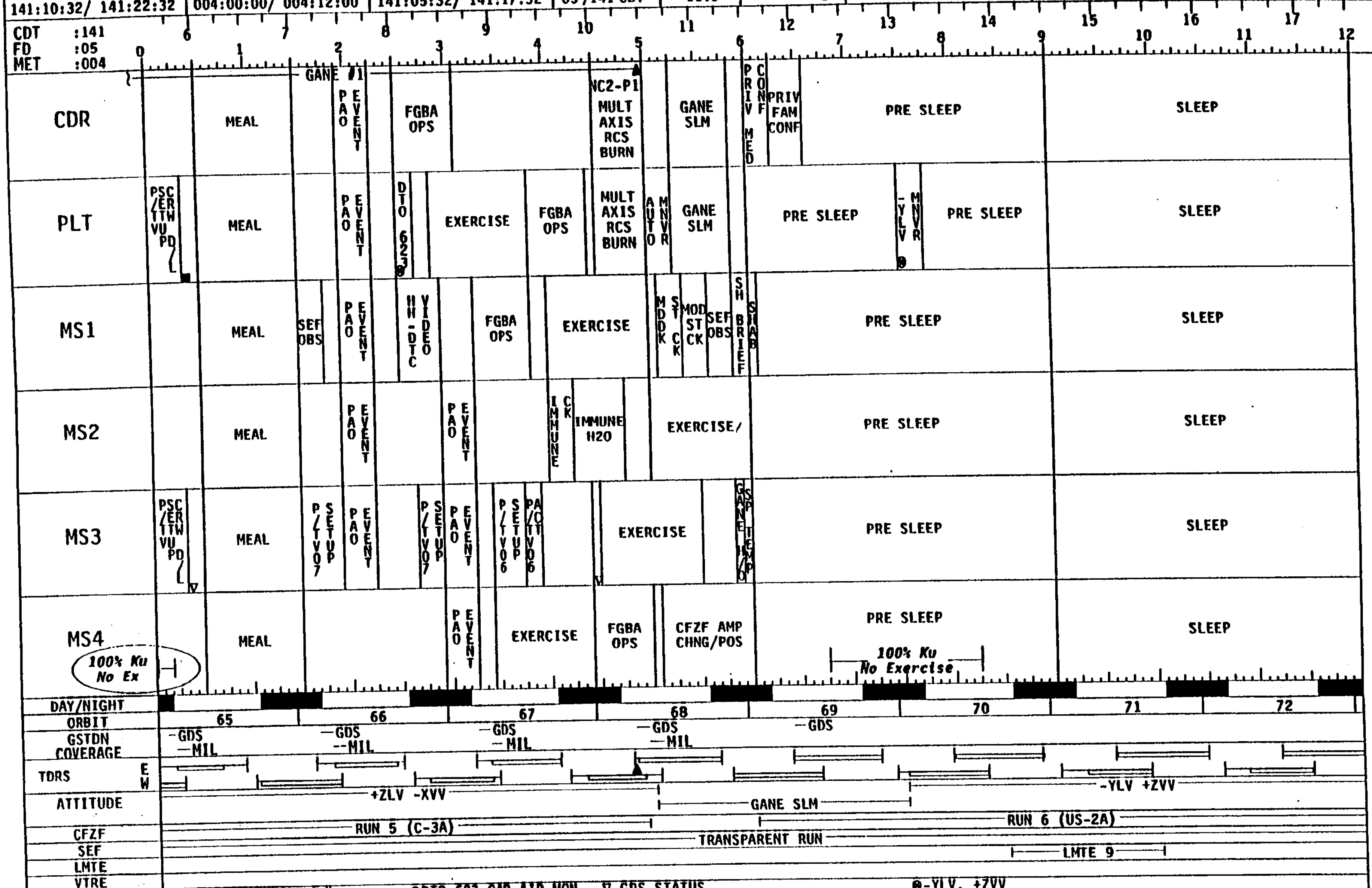
⊖BIASED +ZLV -XVV

▽ GPS STATUS

■ P/TV SETUP CRW D,

▽ P/TV SETUP CRW D,

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
141:10:32/ 141:22:32	004:00:00/ 004:12:00	141:05:32/ 141:17:32	05 /141 CDT	11.3	●	MAY 20, 1996	STS 77	FINAL	04/02/96



NOTES:

■ CREW CHOICE D/L
▽ CREW CHOICE D/L

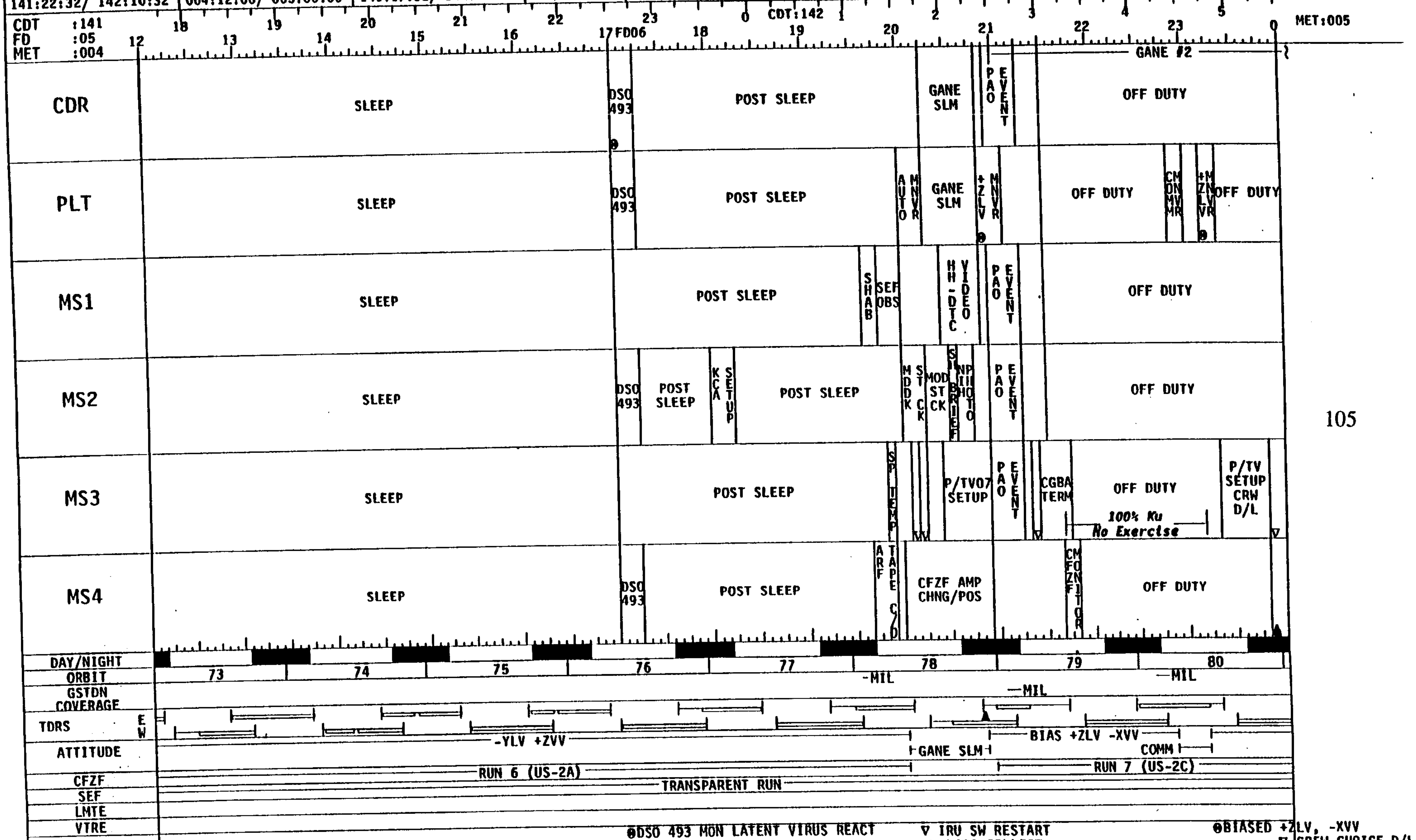
ⓓDTO 623 CAB AIR MON

▽ GPS STATUS

⊖-YLV, +ZVV

104

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
141:22:32/ 142:10:32	004:12:00/ 005:00:00	141:17:32/ 142:05:32	05 /141 CDT	13.7	●	MAY 20, 1996	STS 77	FINAL	04/02/96



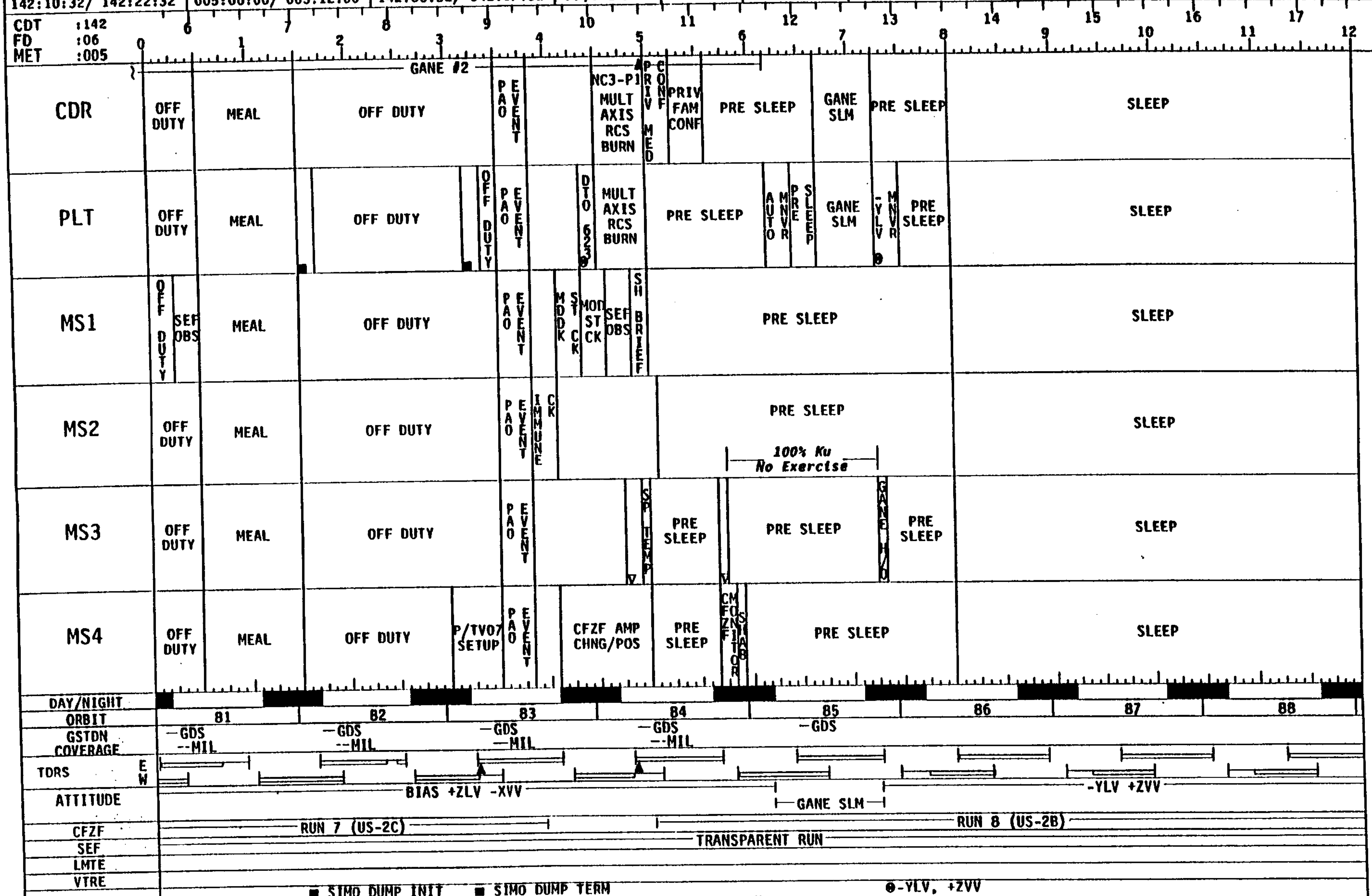
NOTES:

⊕DSO 493 MON LATENT VIRUS REACT

∇ IRU SW RESTART
∇ DATA COLLECT
⊕BIASED +ZLV -XVV
∇ GPS STATUS

⊕BIASED +ZLV, -XVV
∇ CREW CHOICE D/L
♦ CREW CHOICE D/L

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
142:10:32/ 142:22:32	005:00:00/ 005:12:00	142:05:32/ 142:17:32	06 /142 CDT	16.1	●	MAY 21, 1996	STS 77	FINAL	04/02/96



NOTES:

■ SIMO DUMP INIT ■ SIMO DUMP TERM

⊖DTO 623 CAB AIR MON

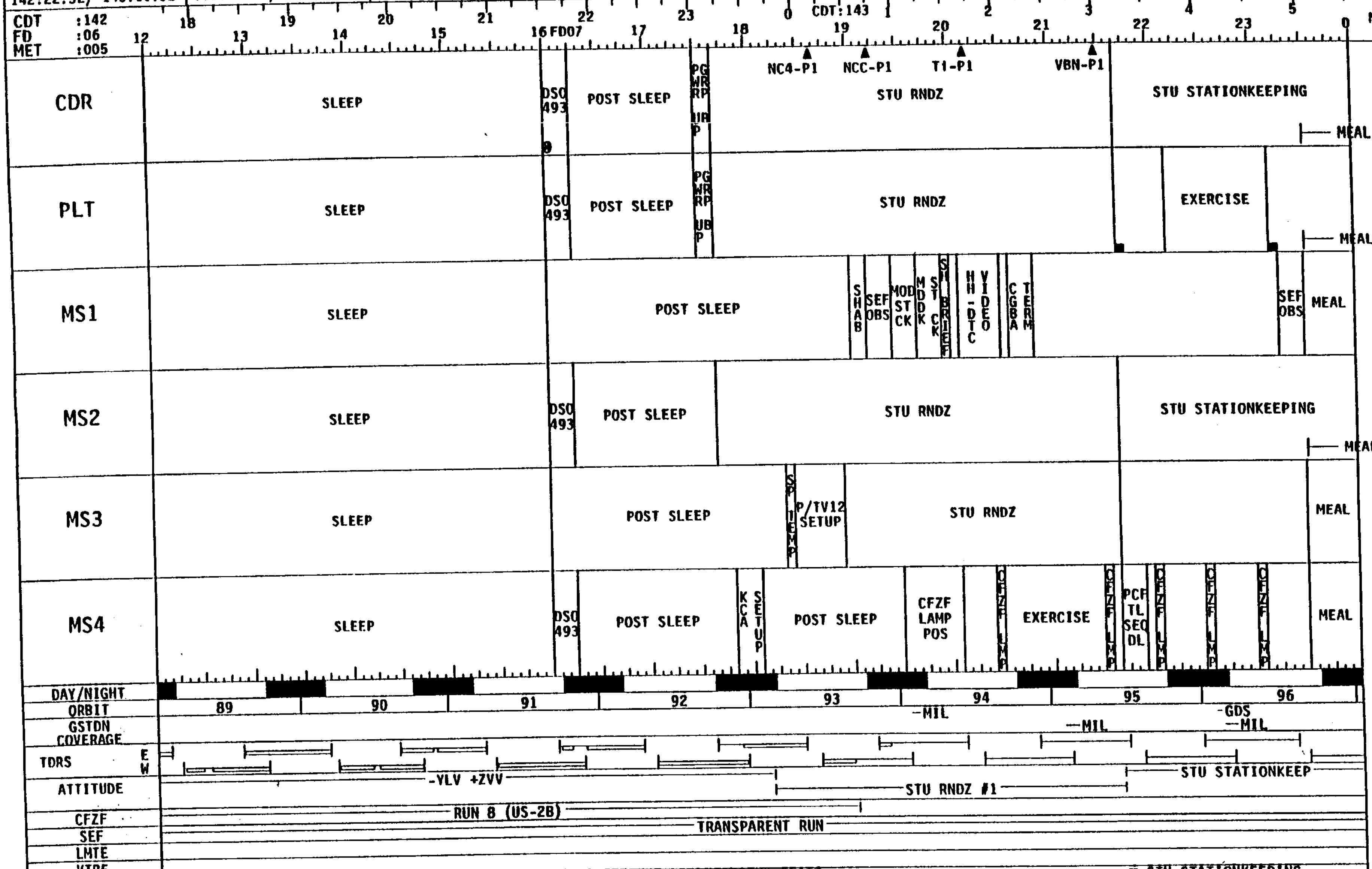
▽ MCIU FLTR CHECK

▽ GPS STATUS

⊖-YLV, +ZVV

106

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
142:22:32/ 143:10:32	005:12:00/ 006:00:00	142:17:32/ 143:05:32	06 /142 CDT	18.6	●	MAY 21, 1996	STS 77	FINAL	04/02/96



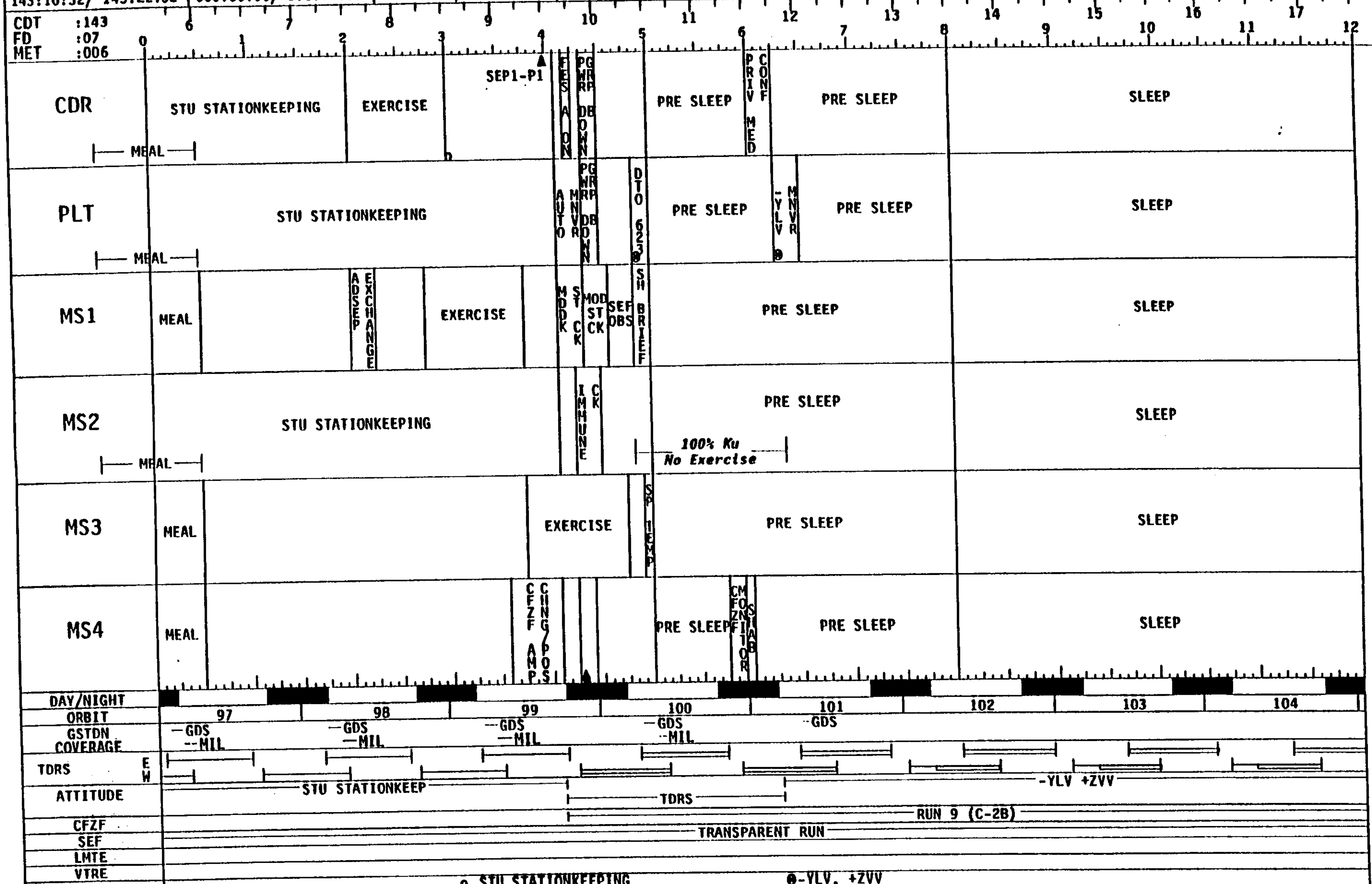
NOTES:

●DSO 493 MON LATENT VIRUS REACT

■ STU STATIONKEEPING

■ STU STATIONKEEPING

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
143:10:32/ 143:22:32	006:00:00/ 006:12:00	143:05:32/ 143:17:32	07 /143 CDT	21.0	◐	MAY 22, 1996	STS 77	FINAL	04/02/96



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NOTES:

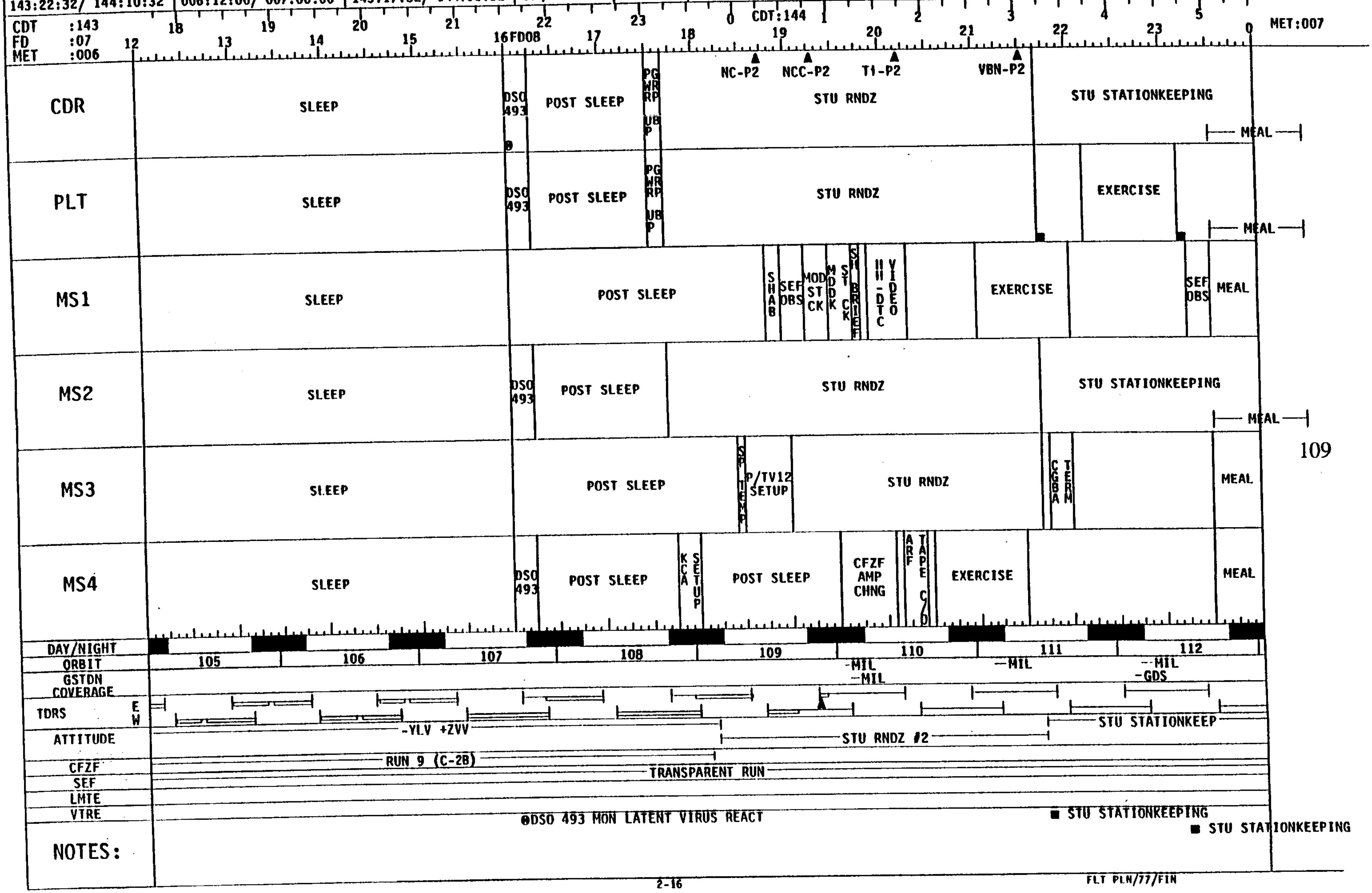
o STU STATIONKEEPING

⧫ MCIU FLTR CHECK

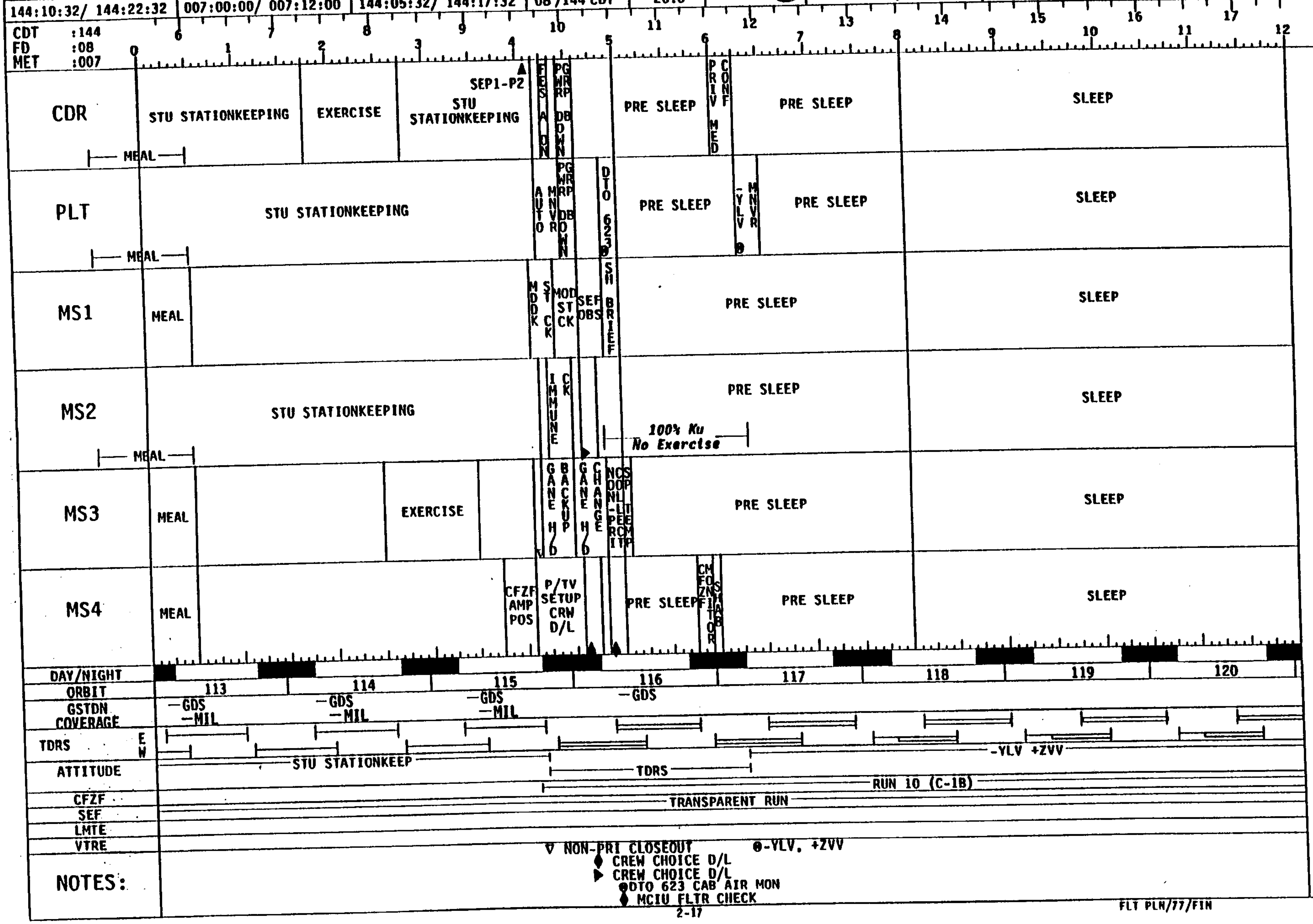
⊕-YLV, +ZVV

⊕DTO 623 CAB AIR MON

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
143:22:32/ 144:10:32	006:12:00/ 007:00:00	143:17:32/ 144:05:32	07 /143 CDT	23.5	◐	MAY 22, 1996	STS 77	FINAL	04/02/96

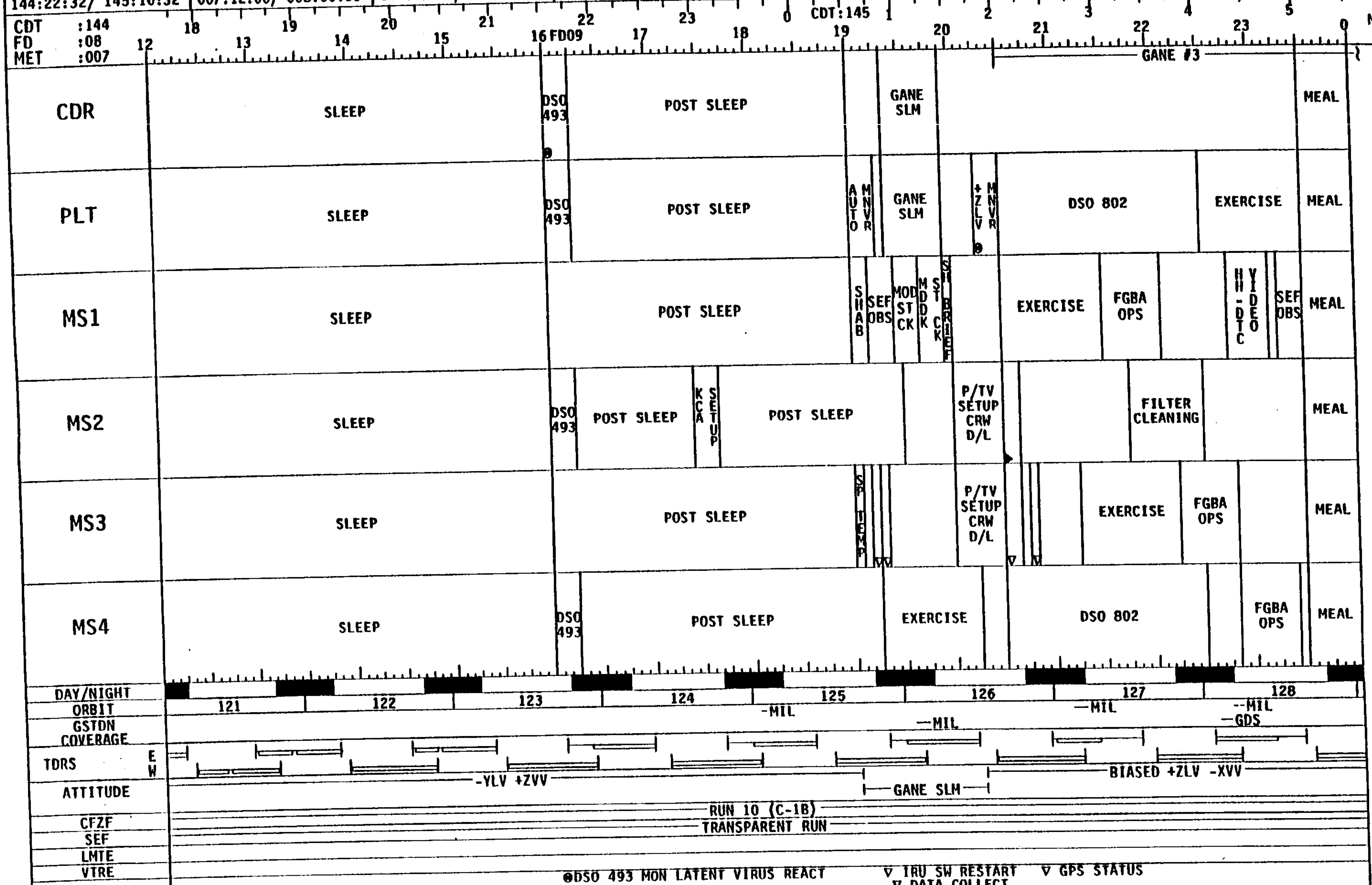


GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
144:10:32/ 144:22:32	007:00:00/ 007:12:00	144:05:32/ 144:17:32	08 /144 CDT	26.0	◐	MAY 23, 1996	STS 77	FINAL	04/02/96



▽ NON-PRI CLOSEOUT ●-YLV, +ZVV
◆ CREW CHOICE D/L
▶ CREW CHOICE D/L
● DTO 623 CAB AIR MON
◆ MCIU FLTR CHECK

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
144:22:32/ 145:10:32	007:12:00/ 008:00:00	144:17:32/ 145:05:32	08 /144 CDT	28.5	◐	MAY 23, 1996	STS 77	FINAL	04/02/96



NOTES:

●DSO 493 MON LATENT VIRUS REACT

∇ IRU SW RESTART ∇ GPS STATUS

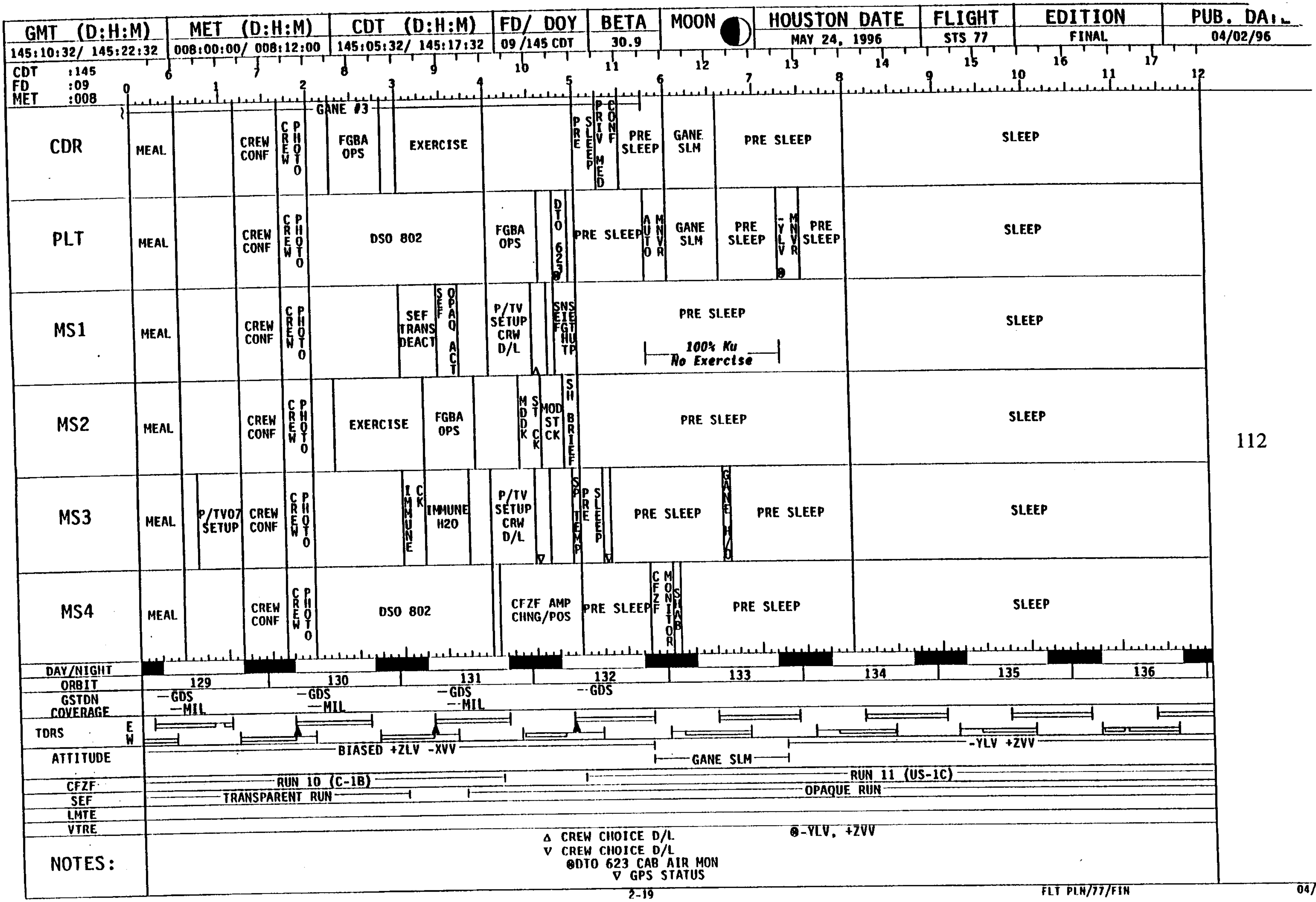
∇ DATA COLLECT

●BIASED +ZLV -XVV

▶ CREW CHOICE D/L

∇ CREW CHOICE D/L

111



GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DA
145:10:32/ 145:22:32	008:00:00/ 008:12:00	145:05:32/ 145:17:32	09 /145 CDT	30.9	◐	MAY 24, 1996	STS 77	FINAL	04/02/96

CDT :145
FD :09
MET :008

CDR: MEAL | CREW CONF | CREW PHOTO | GANE #3 | FGBA OPS | EXERCISE | PRE SLEEP | PRIV MED | CONF | PRE SLEEP | GANE SLM | PRE SLEEP | SLEEP

PLT: MEAL | CREW CONF | CREW PHOTO | DSO 802 | FGBA OPS | DTO 623 ⊗ | PRE SLEEP | AUTO | MNVR | GANE SLM | PRE SLEEP | -YLV ⊗ | MNVR | PRE SLEEP | SLEEP

MS1: MEAL | CREW CONF | CREW PHOTO | SEF TRANS DEACT | SEF | OPAQ ACT | P/TV SETUP CRW D/L | Δ | SEF NIGHT SETUP | PRE SLEEP | 100% Ku No Exercise | SLEEP

MS2: MEAL | CREW CONF | CREW PHOTO | EXERCISE | FGBA OPS | MDDK | ST CK | MOD ST CK | SH BRIEF | PRE SLEEP | SLEEP

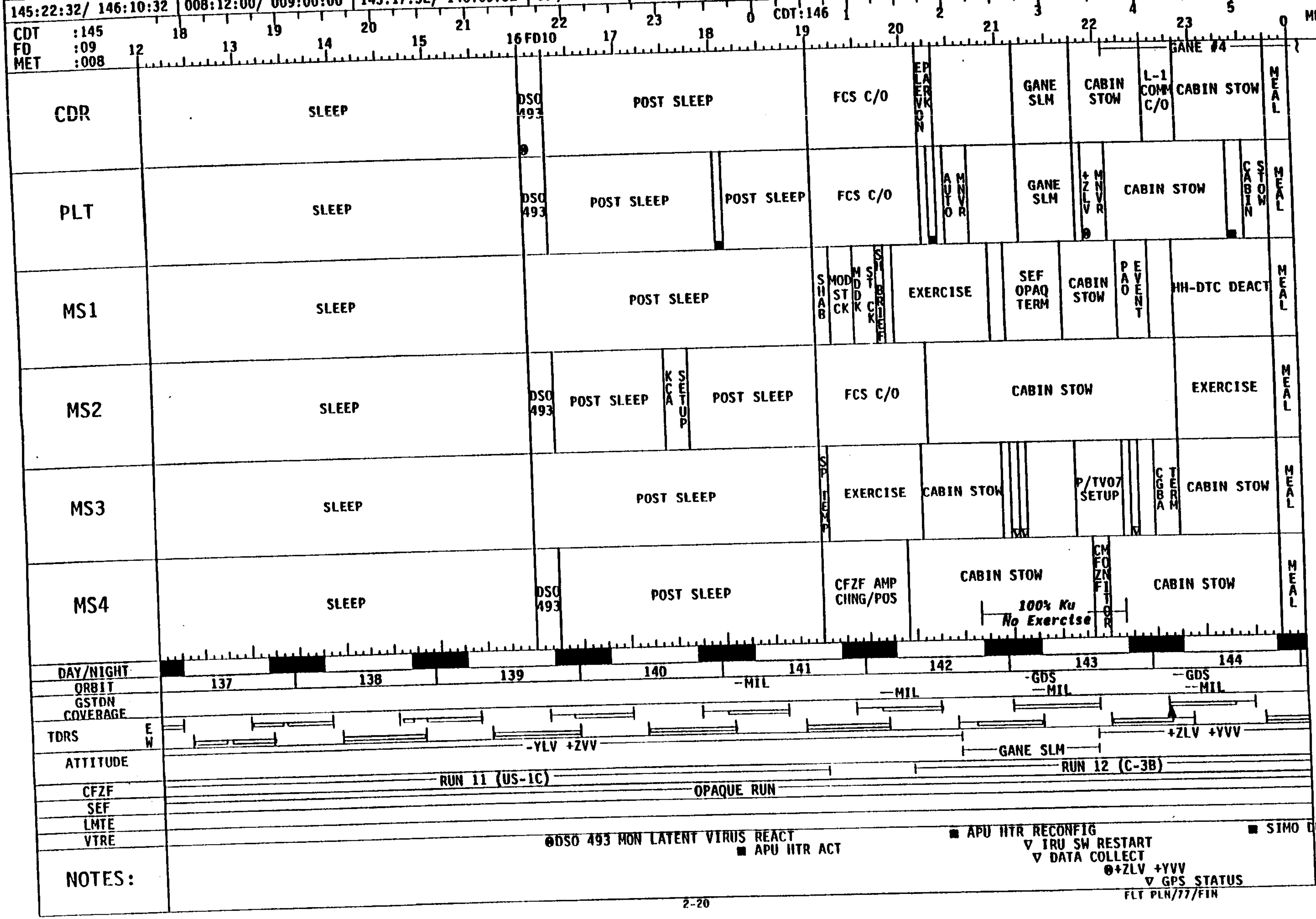
MS3: MEAL | P/TV07 SETUP | CREW CONF | CREW PHOTO | IMMUNE | CK | IMMUNE H2O | P/TV SETUP CRW D/L | ∇ | SP TEMP | PRE SLEEP | ∇ | PRE SLEEP | GANE H/O | PRE SLEEP | SLEEP

MS4: MEAL | CREW CONF | CREW PHOTO | DSO 802 | CFZF AMP CHNG/POS | PRE SLEEP | CFZF | MONITOR | STΔB | PRE SLEEP | SLEEP

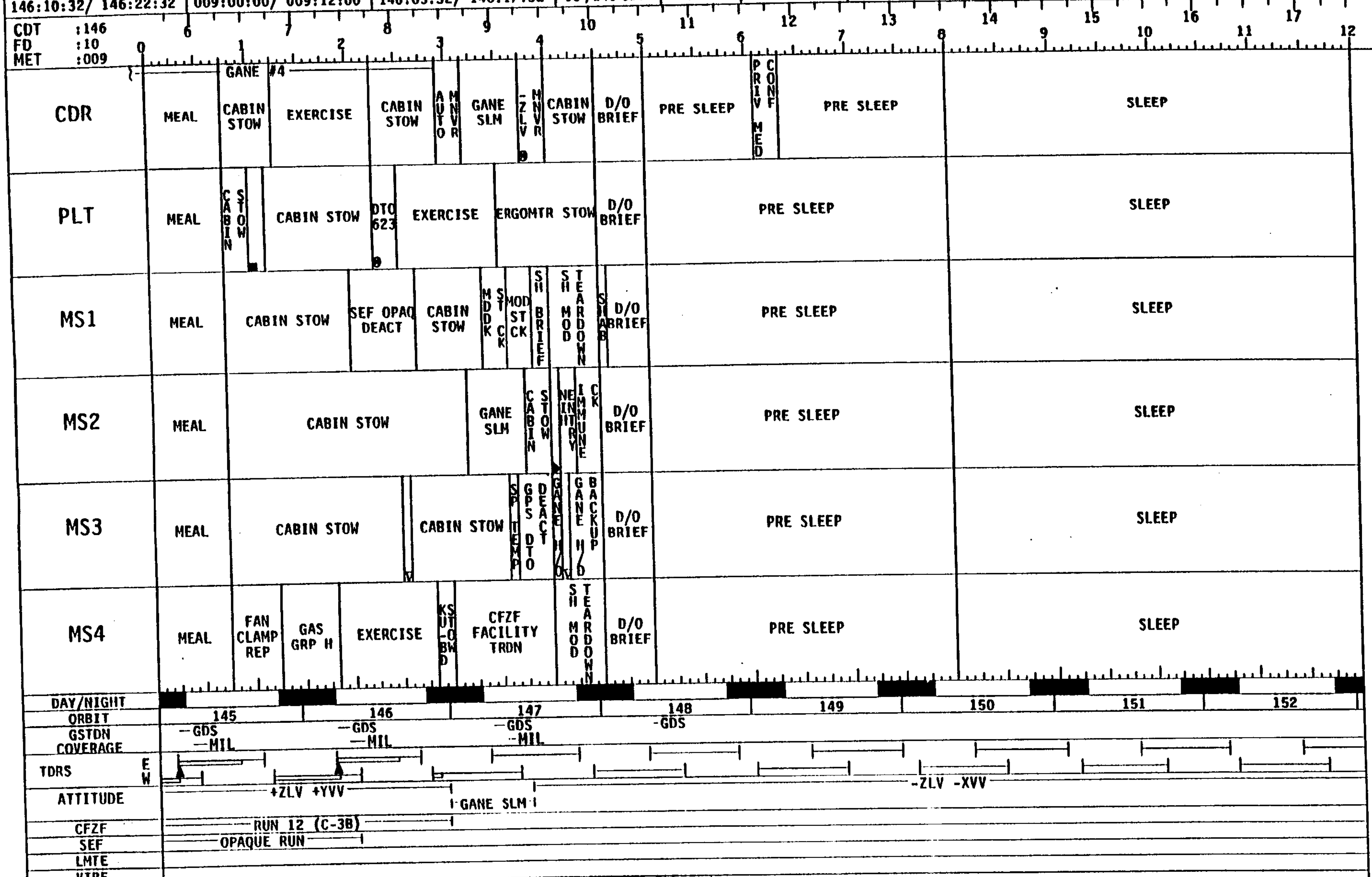
DAY/NIGHT
ORBIT: 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136
GSTDN COVERAGE: GDS MIL | GDS MIL | GDS MIL | GDS
TDRS E W
ATTITUDE: BIASED +ZLV -XVV | GANE SLM | -YLV +ZVV
CFZF: RUN 10 (C-1B) | RUN 11 (US-1C)
SEF: TRANSPARENT RUN | OPAQUE RUN
LMTE
VTRE

NOTES:
Δ CREW CHOICE D/L
∇ CREW CHOICE D/L
⊗DTO 623 CAB AIR MON
∇ GPS STATUS
⊗-YLV, +ZVV

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
145:22:32/ 146:10:32	008:12:00/ 009:00:00	145:17:32/ 146:05:32	09 /145 CDT	33.4	◐	MAY 24, 1996	STS 77	FINAL	04/02/96



GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
146:10:32/ 146:22:32	009:00:00/ 009:12:00	146:05:32/ 146:17:32	10 /146 CDT	35.9	◑	MAY 25, 1996	STS 77	FINAL	04/02/96



NOTES:

■ SIMO DUMP TERM

● DTO 623 CAB AIR MON

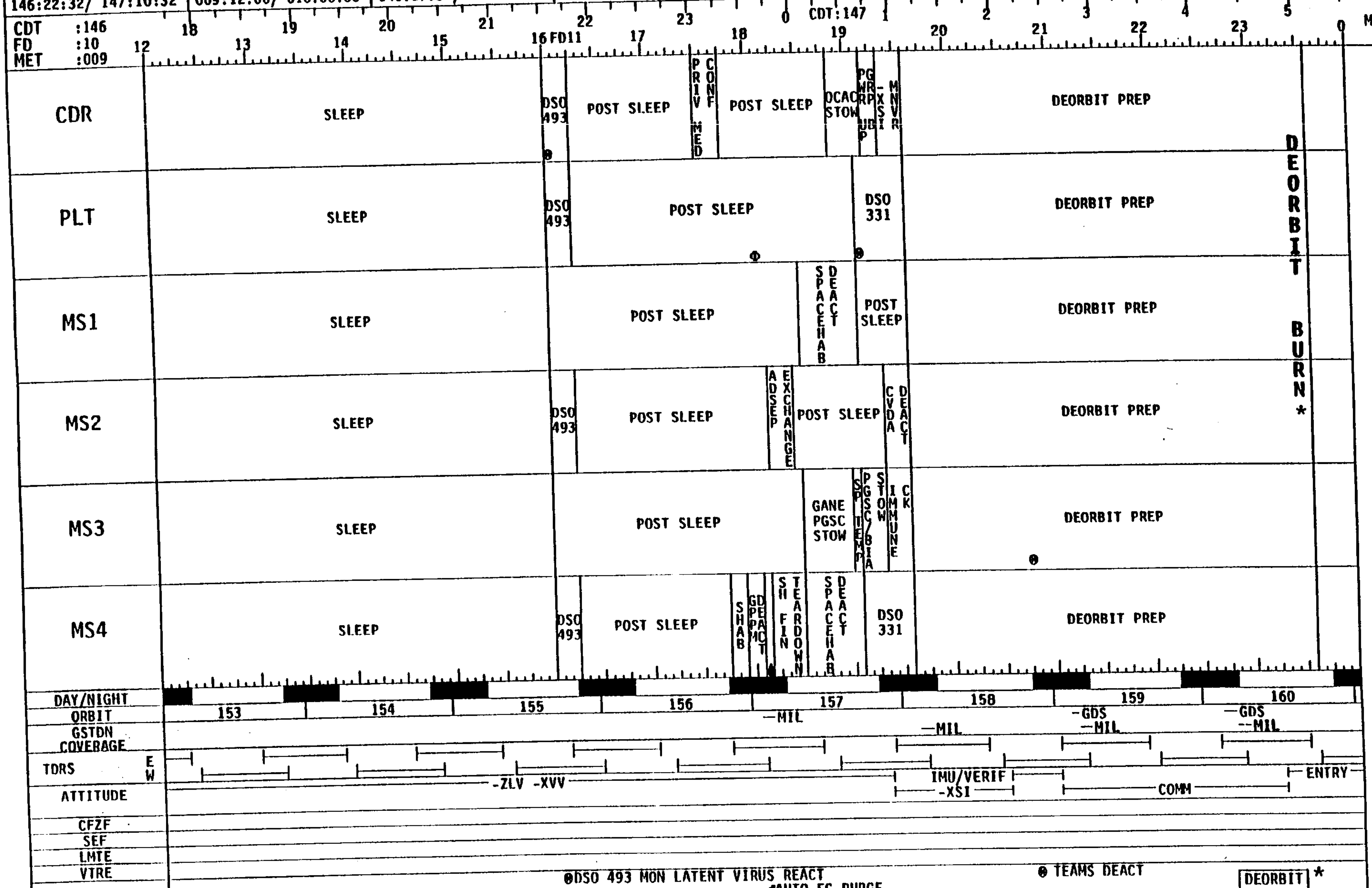
▽ GPS STATUS

▽ NON-PRI CLOSEOUT

●-ZLV, -XVV

▶ FGBA TEARDOWN

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
146:22:32/ 147:10:32	009:12:00/ 010:00:00	146:17:32/ 147:05:32	10 /146 CDT	38.3	◑	MAY 25, 1996	STS 77	FINAL	04/02/96



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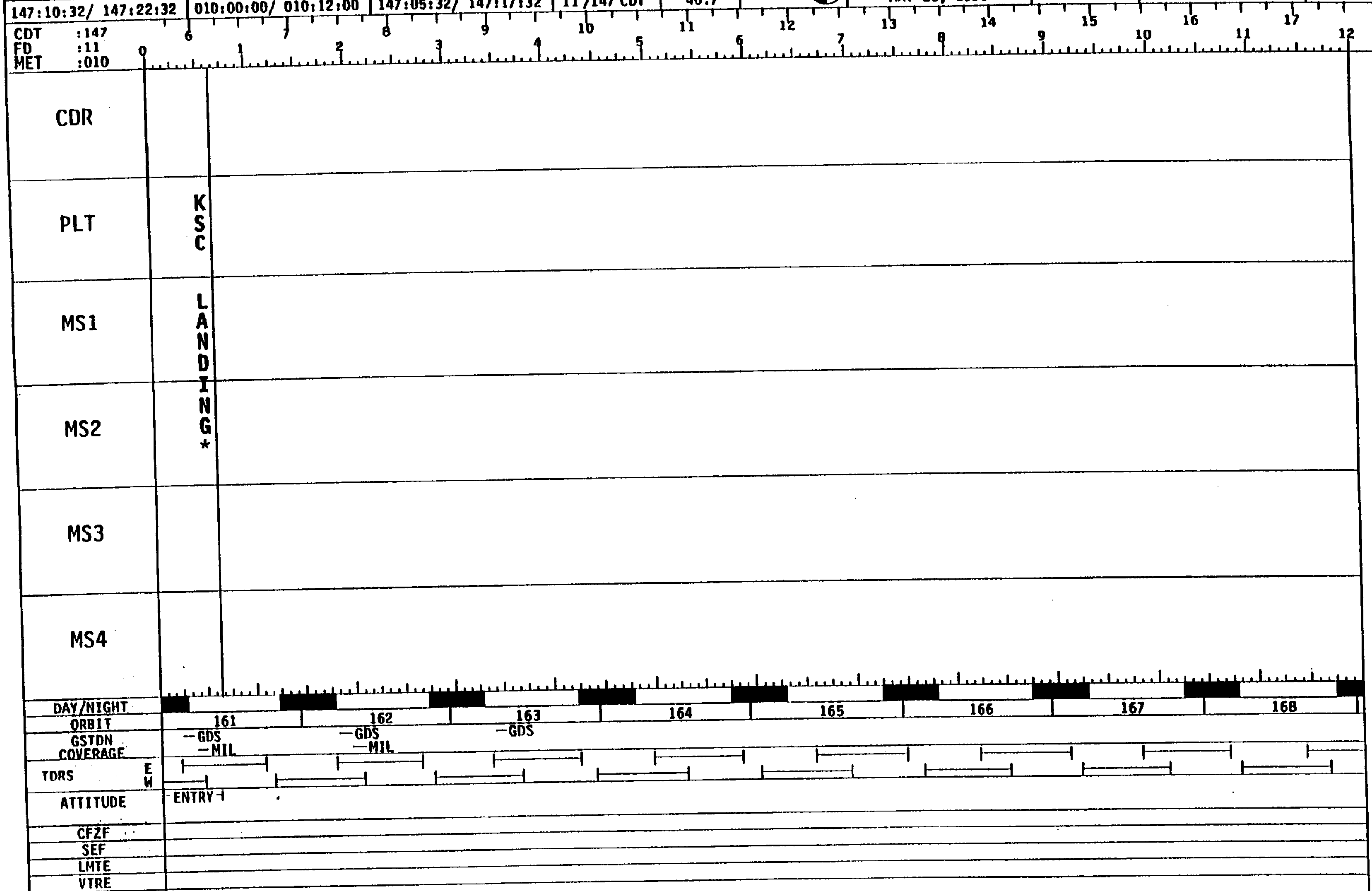
NOTES:

●DSO 493 MON LATENT VIRUS REACT
◐AUTO FC PURGE
♦ PGBA LANDING
●DSO 331 EGRESS LOCOMOTION
● TEAMS DEACT

DEORBIT BURN 9/23:37 *

GMT (D:H:M)	MET (D:H:M)	CDT (D:H:M)	FD/ DOY	BETA	MOON	HOUSTON DATE	FLIGHT	EDITION	PUB. DATE
147:10:32/ 147:22:32	010:00:00/ 010:12:00	147:05:32/ 147:17:32	11 /147 CDT	40.7	◐	MAY 26, 1996	STS 77	FINAL	04/02/96



NOTES:

*KSC LANDING 10/00:37

STS-77 Major Mission Events

Based on Sunday, May 19, 1996, 03:30 AM PDT launch and a mission duration of 10 days

DATE	EVENT	MET (D/H:M)	TIME (PDT)
19-May-96 (Sun)	Launch	00 / 00 : 00	03:30 AM
19-May-96	OMS-2	00 / 00 : 42	04:12 AM
19-May-96	GPS Activation	00 / 02 : 30	06:00 AM
19-May-96	Spacehab Activation	00 / 02 : 35	06:05 AM
19-May-96	Teams Activation	00 / 02 : 40	06:10 AM
19-May-96	Priority Powerdown, Group B	00 / 02 : 45	06:15 AM
19-May-96	RMS Checkout	00 / 06 : 25	09:55 AM
19-May-96	Crew Sleep	00 / 11 : 00	02:30 PM
19-May-96	Crew Wake	00 / 19 : 00	10:30 PM
20-May-96 (Mon)	Priority Powerup, Group B	00 / 21 : 45	01:15 AM
20-May-96	SPARTAN Grapple	00 / 22 : 00	01:30 AM
20-May-96	SPARTAN Unberth	00 / 22 : 20	01:50 AM
20-May-96	SPARTAN Release	01 / 00 : 59	04:29 AM
20-May-96	SEP-1 burn	01 / 01 : 05	04:35 AM
20-May-96	Establish 400 ft Vbar	01 / 01 : 23	04:53 AM
20-May-96	Initiate flyaround to Rbar	01 / 02 : 24	05:54 AM
20-May-96	Establish Rbar	01 / 02 : 50	06:20 AM
20-May-96	IAE Inflation	01 / 03 : 08	06:38 AM
20-May-96	SEP-2 burn	01 / 04 : 30	08:00 AM
20-May-96	IAE Jettison	01 / 04 : 43	08:13 AM
20-May-96	Spacehab Ops	01 / 05 : 00	08:30 AM
20-May-96	Priority Powerdown, Group B	01 / 05 : 20	08:50 AM
20-May-96	NC1-S burn	01 / 07 : 25	10:55 AM
20-May-96	Crew Sleep	01 / 11 : 00	02:30 PM
20-May-96	Crew Wake	01 / 19 : 00	10:30 PM

STS-77 Major Mission Events

Based on Sunday, May 19, 1996, 03:30 AM PDT launch and a mission duration of 10 days

DATE	EVENT	MET (D / H : M)	TIME (PDT)
21-May-96 (Tue)	Priority Powerup, Group B	01 / 21 : 45	01:15 AM
21-May-96	SPARTAN Retrieve	01 / 22 : 00	01:30 AM
21-May-96	NC2-S burn	01 / 22 : 58	02:28 AM
21-May-96	NH-S burn	01 / 23 : 46	03:16 AM
21-May-96	NCC-S burn	02 / 01 : 05	04:35 AM
21-May-96	Ti-S burn	02 / 02 : 01	05:31 AM
21-May-96	Vbar arrival	02 / 03 : 35	07:05 AM
21-May-96	SPARTAN Berth	02 / 04 : 30	08:00 AM
21-May-96	Spacehab Ops	02 / 05 : 00	08:30 AM
21-May-96	Priority Powerdown, Group B	02 / 05 : 30	09:00 AM
21-May-96	Crew Sleep	02 / 10 : 00	01:30 PM
21-May-96	Crew Wake	02 / 18 : 00	09:30 PM
22-May-96 (Wed)	Priority Powerup, Group B	02 / 21 : 40	01:10 AM
22-May-96	PAMS STU Deploy	02 / 22 : 48	02:18 AM
22-May-96	SEP-P0 burn	02 / 23 : 11	02:41 AM
22-May-96	NC-P0 burn	03 / 00 : 35	04:05 AM
22-May-96	NCC-P0 burn	03 / 01 : 09	04:39 AM
22-May-96	Ti-P0 burn	03 / 02 : 05	05:35 AM
22-May-96	VBN-P0 burn	03 / 03 : 24	06:54 AM
22-May-96	STU Stationkeeping	03 / 03 : 35	07:05 AM
22-May-96	SEP2-P0 burn	03 / 05 : 30	09:00 AM
22-May-96	Spacehab Ops	03 / 05 : 40	09:10 AM
22-May-96	NC1-P1 burn	03 / 06 : 58	10:28 AM
22-May-96	Crew Sleep	03 / 10 : 00	01:30 PM
22-May-96	Crew Wake	03 / 18 : 00	09:30 PM

STS-77 Major Mission Events

Based on Sunday, May 19, 1996, 03:30 AM PDT launch and a mission duration of 10 days

DATE	EVENT	MET (D / H : M)	TIME (PDT)
23-May-96 (Thu)	Spacehab Ops	03 / 21 : 00	12:30 AM
23-May-96	NC2-P1 burn	04 / 04 : 56	08:26 AM
23-May-96	Crew Sleep	04 / 09 : 00	12:30 PM
23-May-96	Crew Wake	04 / 17 : 00	08:30 PM
23-May-96	Spacehab Ops	04 / 20 : 00	11:30 PM
24-May-96 (Fri)	NC3-P1 burn	05 / 04 : 57	08:27 AM
24-May-96	Crew Sleep	05 / 08 : 00	11:30 AM
24-May-96	Crew Wake	05 / 16 : 00	07:30 PM
24-May-96	NC4-P1 burn	05 / 18 : 39	10:09 PM
24-May-96	NCC-P1 burn	05 / 19 : 14	10:44 PM
24-May-96	Ti-P1 burn	05 / 20 : 10	11:40 PM
25-May-96 (Sat)	VBN-P1 burn	05 / 21 : 29	12:59 AM
25-May-96	STU Stationkeeping	05 / 21 : 30	01:00 AM
25-May-96	Priority Powerdown, Group B	05 / 21 : 45	01:15 AM
25-May-96	SEP1-P1 burn	06 / 04 : 00	07:30 AM
25-May-96	Spacehab Ops	06 / 04 : 10	07:40 AM
25-May-96	Crew Sleep	06 / 08 : 00	11:30 AM
25-May-96	Crew Wake	06 / 16 : 00	07:30 PM
25-May-96	Priority Powerup, Group B	06 / 17 : 30	09:00 PM
25-May-96	NC-P2 burn	06 / 18 : 42	10:12 PM
25-May-96	NCC-P2 burn	06 / 19 : 15	10:45 PM
25-May-96	Ti-P2 burn	06 / 20 : 11	11:41 PM
26-May-96 (Sun)	VBN-P2 burn	06 / 21 : 30	01:00 AM
26-May-96	STU Stationkeeping	06 / 21 : 40	01:10 AM
26-May-96	SEP-P2 burn	07 / 04 : 05	07:35 AM

STS-77 Major Mission Events

Based on Sunday, May 19, 1996, 03:30 AM PDT launch and a mission duration of 10 days

DATE	EVENT	MET (D/H:M)	TIME (PDT)
26-May-96	Spacehab Ops	07 / 04 : 15	07:45 AM
26-May-96	Priority Powerdown, Group B	07 / 04 : 30	08:00 AM
26-May-96	Crew Sleep	07 / 08 : 00	11:30 AM
26-May-96	Crew Wake	07 / 16 : 00	07:30 PM
26-May-96	Spacehab Ops	07 / 19 : 00	10:30 PM
27-May-96 (Mon)	Crew Sleep	08 / 08 : 00	11:30 AM
27-May-96	Crew Wake	08 / 16 : 00	07:30 PM
27-May-96	FCS Checkout	08 / 19 : 00	10:30 PM
27-May-96	Cabin stow & Spacehab experiment deactivation	08 / 20 : 15	11:45 PM
28-May-96 (Tue)	Crew Sleep	09 / 08 : 00	11:30 AM
28-May-96	Crew Wake	09 / 16 : 00	07:30 PM
28-May-96	Spacehab Deactivation	09 / 18 : 30	10:00 PM
28-May-96	Go to Deorbit Prep	09 / 19 : 37	11:07 PM
29-May-96 (Wed)	Payload Bay Door Closure	09 / 20 : 55	12:25 AM
29-May-96	GO For OPS 3	09 / 21 : 05	12:35 AM
29-May-96	APU Prestart	09 / 22 : 45	02:15 AM
29-May-96	Maneuver to Deorbit Burn Attitude	09 / 22 : 56	02:26 AM
29-May-96	Single APU Start	09 / 23 : 32	03:02 AM
29-May-96	Deorbit Burn	09 / 23 : 37	03:07 AM
29-May-96	KSC Landing	10 / 00 : 37	04:07 AM

GLOSSARY

A/G	air-to-ground
AA	accelerometer assembly
ACS	active cooling system
ADACS	attitude determination and control system
ADS	air data system
ADSEP	advanced separations experiment (SPACEHAB)
AEM	animal enclosure module
AFB	Air Force base
AFD	aft flight deck
AG	airglow
A/L	approach and landing
AOS	acquisition of signal
APC	autonomous payload controller
APCS	autonomous payload control system
APU	auxiliary power unit
ARF	aquatic research facility 01
ASE	airborne support equipment
BETSCE	brilliant eyes ten-Kelvin sorption cryocooler experiment
BFS	backup flight control system
BHPS	boiling heater power supply
BRIC	biological research in canisters 07
CCD	charge-coupled device
CCTV	closed-circuit television
CDMS	command and data management subsystem
CFZF	commercial float zone furnace (SPACEHAB)
CGBA	commercial generic bioprocessing apparatus (SPACEHAB)
COAS	crewman optical alignment sight
CP	condenser profile
CRIM	commercial refrigerator/incubator module
CRT	cathode ray tube
CSI	control structure integration
CST	controlled structures technology
CVDA	commercial vapor diffusion apparatus (SPACEHAB)
C/W	caution/warning
DACA	data acquisition and control assembly
DA	detector assembly
DACS	data acquisition and control system
DAP	digital autopilot
DC	detector controller
DM	docking module
DOD	Department of Defense
DPS	data processing system
DSO	detailed supplementary objective
DTO	development test objective
EAFB	Edwards Air Force Base
ECLSS	environmental control and life support system
EDFT	extravehicular activity development flight test
EDO	extended duration orbiter
EDOMP	extended duration orbiter medical project
EGA	electron gun assembly
EHF	extremely high frequency
ELV	expendable launch vehicle
EMP	enhanced multiplexer/demultiplexer pallet
EMU	extravehicular mobility unit
EOM	end of mission
EOS	Earth observing system
EPS	electrical power system
EPS	electrical power subsystem
ESA	European Space Agency

ESC	electronic still camera
ESS	equipment support section
ET	external tank
ETR	Eastern Test Range
EUV	extreme ultraviolet
EV	extravehicular
EVA	extravehicular activity
FC	fuel cell
FCP	fuel cell power plant
FCS	flight control system
FDF	flight data file
FES	flash evaporator system
FF	flight forward
FGBA	fluid generic bioprocessing apparatus (SPACEHAB)
FPEG	fast-pulse electron gun
FPS	feet per second
FRCS	forward reaction control system
FSTV	fast-scan TV
FTS	force torque sensor
GANE	global positioning system attitude and navigation experiment (TEAMS) (RME 1316)
GAS	getaway special
GBA	getaway special bridge assembly
GLS	ground launch sequencer
GMT	Greenwich Mean Time
GN&C	guidance, navigation, and control
GPC	general-purpose computer
GPPM	gas permeable polymer materials (SPACEHAB)
GPS	global positioning system
GSE	ground support equipment
GSFC	Goddard Space Flight Center
HAINS	high accuracy inertial navigation system
HH-DTC	hand-held-diffusion test cells (SPACEHAB)
HRM	high-rate multiplexer
HUD	heads-up display
IAE	inflatable antenna experiment (SPARTAN 207/IAE)
IFM	in-flight maintenance
IMMUNE	immunology experiment (SPACEHAB)
IMU	inertial measurement unit
I/O	input/output
IR	infrared
IUS	inertial upper stage
IV	intravehicular
IVIS	inertial vibration isolation system
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KEAS	knots equivalent air speed
KSC	Kennedy Space Center
LCD	liquid crystal display
LES	launch escape system
LMA	liquid mixing assemblies
LMTE	liquid metal test experiment (TEAMS)
LPS	launch processing system
LRU	line replaceable unit
MCC-H	Mission Control Center--Houston
MCP	microchannel plate
MDM	multiplexer/demultiplexer
MECO	main engine cutoff
MEE	magnetic end effector
MET	mission elapsed time
MILA	Merritt Island
MLP	mobile launcher platform

MM	major mode
MOD	Mission Operations Directorate
MPESS	multi-purpose experiment support structure
MPM	manipulator positioning mechanism
MPS	main propulsion system
MS	mission specialist
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCC	corrective combination maneuver
NH	differential height adjustment that adjusts the altitude of orbiter's orbit
NLO	non-linear optical
nm	nanometer
NMI	nautical miles
NOR	Northrup Strip
NSR	coelliptic maneuver that circularizes orbiter's orbit
O&C	operations and checkout
OAA	orbiter access arm
OAST	Office of Aeronautics and Space Technology
OCP	Office of Commercial Programs
ODS	orbiter docking system
OG	orbiter glow
OMS	orbital maneuvering system
OPF	orbiter processing facility
OSVS	orbiter space vision system
OTC	orbiter test conductor
PAO	public affairs officer
PAMS-STU	passive aerodynamically-stabilized magnetically-damped satellite - satellite test unit (TEAMS)
PASS	primary avionics software system
PC	proportional counter
PCF	protein crystallization facility (SPACEHAB)
PCF-LST	protein crystal facility-light scattering and temperature controlled (SPACEHAB)
PCIS	passive cycle isolation system
PCMMU	pulse code modulation master unit
PCS	pressure control system
PCU	power control unit
PDI	payload data interleaver
PDU	playback/downlink unit
PGBA	plant growth bioprocessing apparatus (SPACEHAB)
PGSC	payload and general support computer
PI	payload interrogator
PIC	pyro initiator controller
PLBD	payload bay door
PMCU	payload measurement and control unit
POCC	Payload Operations Control Center
PRCS	primary reaction control system
PRD	payload retention device
PRLA	payload retention latch assembly
PRSD	power reactant storage and distribution
PS	payload specialist
PTI	preprogrammed test input
P/TV	photo/TV
RAAN	right ascension of the ascending node
RAM	random access memory
RCRS	regenerable carbon dioxide removal system
RCS	reaction control system
REM	release engage mechanism
RF	radio frequency
RFTPCE	reduced-fill tank pressure control experiment
RGA	rate gyro assembly
RME	risk mitigation experiment
RMS	remote manipulator system
ROEU	remotely operated electrical umbilical
RPM	revolutions per minute

RSS	range safety system
RTLS	return to launch site
S&A	safe and arm
SA	solar array
SAF	Secretary of the Air Force
SDA	sealed door assembly
SEF	space experiment facility (SPACEHAB)
SHF	superhigh frequency
SM	statute miles
SM	single module
SPARTAN	shuttle pointed autonomous research tool for astronomy 207
SPASP	small payload accommodations switch panel
SRB	solid rocket booster
SRM	solid rocket motor
SRSS	shuttle range safety system
SSME	space shuttle main engine
SSP	standard switch panel
SSPP	Shuttle Small Payload Project
SSPP	solar/stellar pointing platform
SSTV	slow scan TV
ST	star tracker
STA	structural test article
STS	Space Transportation System
SURS	standard umbilical retraction/retention system

TAEM	terminal area energy management
TAGS	text and graphics system
TAL	transatlantic landing
TDRS	tracking and data relay satellite
TDRSS	tracking and data relay satellite system
TEAMS	technology experiments advancing missions in space 01
TFL	telemetry format load
TI	thermal phase initiation burn
TIG	time of ignition
TIPS	thermal impulse printer system
TPS	thermal protection system
TRAC	targeting and reflective alignment concept
TSM	tail service mast
TT&C	telemetry, tracking, and communications
TV	television
TVC	thrust vector control
UHF	ultrahigh frequency
VBAR	along the velocity vector
VRCS	vernier reaction control system
VTR	videotape recorder
VTRE	vented tank resupply experiment (TEAMS)
WCCS	wireless crew communication system
WCS	waste collection system