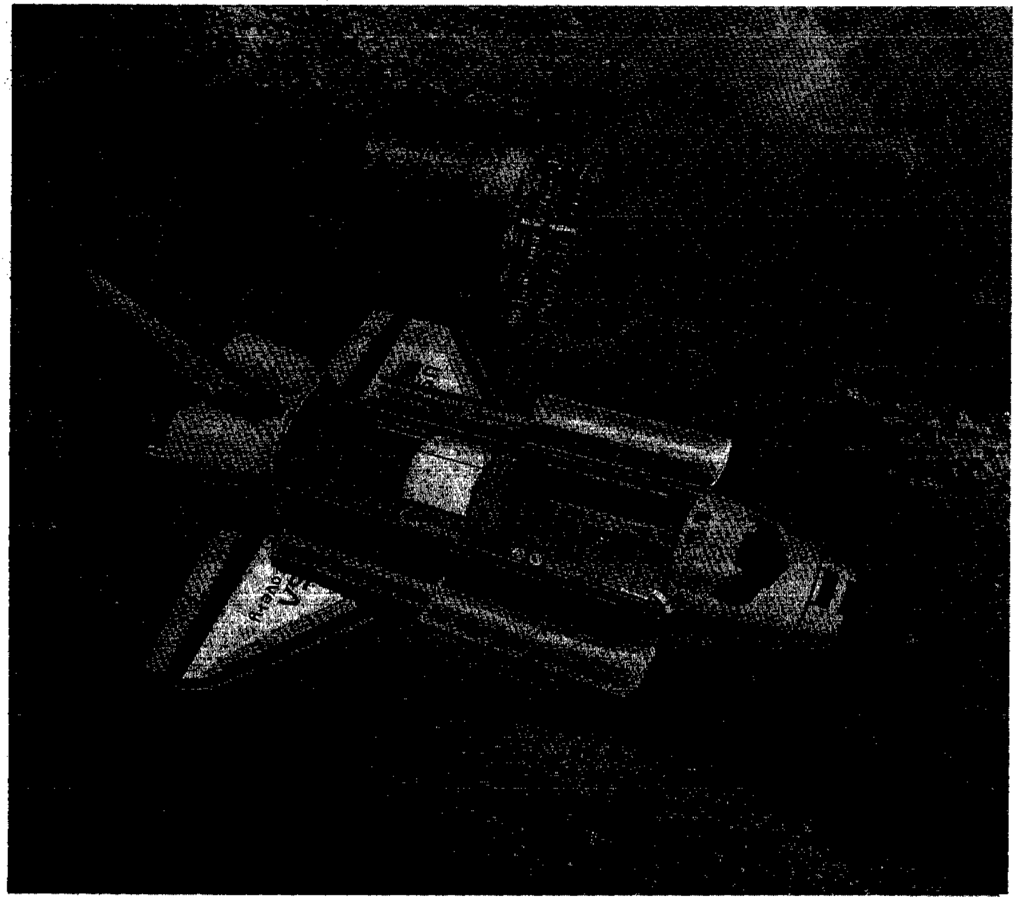

51-D

PRESS INFORMATION

April 1985

Rockwell International

Space Transportation Systems Division

Office of Public Relations

NEWS About Space Flight

...it comes from Rockwell International

A few days prior to the March 5th scheduled liftoff (on March 1, 1985), the NASA cancelled STS Mission 51-E because of a generic problem in a timing device aboard a system on the Tracking and Data Relay System (TDRS) satellite, one of two payloads slated for deployment from *Challenger's* cargo bay and subsequent launch to geostationary orbit.

The spacecraft and its booster components were rolled back from Launch Complex 39A to the Vehicle Assembly Building (VAB) for destacking. Both satellites had been removed from the cargo bay to the Payload Changeout Room and later were returned to the Vehicle Processing Facility (VPF).

NASA program officials remanifested the launch schedule, with assignment of the spacecraft *Discovery* to the next flight (the 16th STS mission) with a revised cargo and number—51-D. The revised mission would have as payloads the Telesat-I (Anik) Canadian communications satellite, originally aboard *Challenger* on 51-E, and the Syncom IV-3 (Leasat) which had previously been manifested for the 51-D mission. The original 51-D was scheduled to retrieve the Long Duration Exposure Facility (LDEF) which had been deployed into orbit last April. The retrieval will be rescheduled for a later flight.

Challenger's cargo bay has been reconfigured to carry the Spacelab 3 with tunnel adapter in STS Mission 51-B which is expected to be launched late in April.

The flight crew for the new 51-D mission consists of Commander Karol Bobko, Pilot Donald Williams, Mission Specialists, Margaret Seddon, Jeffrey Hoffman and David Griggs and Payload Specialists Charles Walker and Senator Jake Garn of Utah.

Garn is chairman of the Senate subcommittee on appropriations which reviews and recommends final approval of the NASA budget. Senator Garn is considered an official government representative on the flight and has been assigned and trained for medical experiments and demonstrations. He will also conduct a phase partitioning experiment in the mid-deck during the mission.

Payload Specialist Patrick Baudry of France, originally scheduled on the canceled 51-E mission with the above flight crew is reassigned to the 51-G mission.

Discovery's mid-deck was already configured with the McDonnell Douglas Astronautics Continuous Flow Electrophoresis System for the original 51-D mission and is retained for the new 51-D mission.

The flight crew for the original 51-D mission consisting of Commander Daniel Brandenstein, Pilot John Creighton, Mission Specialists Shannon Lucid, John Fabian and Steven Nagel are reassigned to the 51-G mission.

The Hughes Fluids Dynamics Experiment scheduled for the original 51-D mission is reassigned to the 51-I mission and Hughes will inform NASA whether Payload Specialist Gregory Jarvis (assigned on original 51-D mission) or John Konrad will accompany the experiment on the 51-I mission.

The new 51-D mission is scheduled as a five day eleven minute mission. The major operational objectives of the new 51-D mission is the on-orbit launch of the two satellites and operation of the Continuous Flow Electrophoresis System (CFES).

The ascent profile in this mission is a direct insertion, which has only one Orbital Maneuvering System (OMS) thrusting maneuver. OMS-2 is used to achieve orbit insertion into an elliptical orbit. The OMS-1 thrusting maneuver at Main Engine Cutoff (MECO) plus approximately two minutes is eliminated in this direct insertion ascent profile and is replaced by a 1.5 meter per second (5 feet per second) Reaction Control System (RCS) maneuver to facilitate the Main Propulsion System (MPS) propellant dump. This ascent profile allows the MPS to provide more energy to the orbit and easier to use existing software.

It is also noted, that due to this ascent profile, the External Tank (ET) impact area is in the Pacific Ocean, south of Hawaii.

The ascent phase and OMS-2 plus a series of on orbit thrusting maneuvers are accomplished to place *Discovery* at the proper position in earth orbit for the deployment of SYNCOM-IV-3 and TELESAT-I.

The deployment of the third in the series of TELESAT (Canadian Communication Satellite)-I/ANIK (Eskimo — for big brother) C's with its Payload Assist Module (PAM)-D is nominally scheduled for deployment at an Mission Elapsed Time (MET) on day zero, nine hours and 39 minutes on orbit 7. The PAM-D perigee kick solid rocket motor ignition is to occur approximately 45 minutes later during orbit 8. Backup deployment opportunity is provided on orbit 32, with PAM-D solid rocket motor ignition occurring during orbit 33.

The deployment of the third SYNCOM (IV-3) with its unique stage is nominally scheduled for deployment at an MET on day one, zero hours and 58 minutes on orbit 17. SYNCOM IV-3 perigee kick solid rocket motor ignition occurs approximately 45 minutes later during orbit 18. Backup deployment opportunity is provided on orbit 32, with perigee kick motor ignition occurring on orbit 33.

The McDonnell Douglas Astronautics Continuous Flow Electrophoresis System (CFES) will make its sixth spaceflight in this mission. Payload Specialist Charles Walker of McDonnell Douglas Astronautics will operate the unit in space for the second time. This will be the second flight of the CFES Block III which was flown previously on the 41-D mission. CFES is located in *Discovery's* mid-deck.

An American Flight Echocardiograph experiment (AFE) instrument will utilize ultrasonic scanning techniques of the heart body to investigate heart changes in space flight and upon return to earth. This experiment will be accomplished primarily by Margaret Seddon and on a time available basis on Charles Walker, Jeffrey Hoffman, David Griggs and Senator Garn.

An image intensifier with a standard Nikon camera will utilize a special window hood arrangement to photograph objects at various distances from the Sun, below the horizon which could possibly lead to use of the equipment for viewing of Halley's comet in future Space Shuttle flights.

The National Science Foundation funded the Informal Science Study at the University of Houston to develop science curricula on positive student experiments. The flight crew will demonstrate the behaviors of ten simple toys in zero gravity during the flight in *Discovery's* crew compartment. Through the filming and video taping of simple generic motion toys in zero "g", students of all ages will share a learning experience and discover how the different toy mechanical systems work without the constant tug of gravity and make science more interesting.

Two Shuttle Student Involvement Program (SSIP) experiments are flown on this mission. One is a Corn Statolith experiment and the other is a Brain Cell experiment consisting of 300 houseflies in an Fly Enclosure Module. Both experiments are located in the mid-deck of *Discovery*.

Two Getaway Special (GAS) canisters are located in *Discovery's* payload bay. Each canister is 0.14 cubic meter (5 cubic feet). One canister contains a Goddard Space Flight Center experiment and the other contains a reflight of experiments from Japan.

Two Statute of Liberty statutes are also carried for the U.S. Postal Service.

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THE SPACECRAFT THAT LANDS ON EARTH...

NEWS About Space Flight

...it comes from Rockwell International

51-D MISSION STATISTICS

Launch: Friday April 12, 1985 8:04 A.M. E.S.T.
7:04 A.M. C.S.T.
5:04 A.M. P.S.T.

(First launch window 8:04 to 8:18 a.m. E.S.T. and second launch window 8:45 to 9:00 a.m. E.S.T.)

Mission Duration: 120 hours (5 days), eleven minutes.

Landing: Wednesday April 17, 1985 8:15 A.M. E.S.T.
7:15 A.M. C.S.T
5:15 A.M. P.S.T

Inclination: 28.45 degrees

Altitude: The ascent profile in this mission is a direct insertion which has only one Orbital Maneuvering System (OMS) thrusting maneuver, OMS-2, is used to achieve orbit insertion into an elliptical orbit.

The OMS-1 thrusting maneuver at Main Engine Cutoff (MECO) plus approximately two minutes is eliminated in this direct insertion ascent profile and is replaced by a 1.5 meters per second (5 feet per second) Reaction Control System (RCS) maneuver to facilitate the Main Propulsion System (MPS) propellant dump. This ascent profile allows the MPS to provide more energy to the orbit and easier to use existing software.

It is also noted, that due to this ascent profile, the External Tank (ET) impact area is in the Pacific Ocean south of Hawaii.

The altitudes for this mission are; 160 by 245 nautical miles (nmi) (184 by 281 statute miles [sm]), 167 by 246 nmi (192 by 283 sm), 166 by 245 nmi (191 by 281 sm), and 175 by 246 nmi (201 by 283 sm).

Total Liftoff Weight: Approximately 2,043,936 kilograms (4,506,032 pounds)

Payload Weight Up: Approximately 16,249 kilograms (35,824 pounds)

Payload Weight Down: Approximately 6,009 kilograms (13,248 pounds)

Payloads: TELESAT-I/PAM-D (Weight approximately 3,421 kilograms [7,542 pounds]). SYNCOM IV-3 (Weight approximately 6,890 kilograms [15,190 pounds]).

Entry Angle of Attack: 40 degrees

Crew Members:
Commander (CDR): Karol J. Bobko
Pilot (PLT): Donald E. Williams

Mission Specialist (MS)-1: Jeffrey A. Hoffman
Mission Specialist (MS)-2: S. David Griggs
Mission Specialist (MS)-3: Margaret Rhea Seddon
Payload Specialist: Charles D. Walker (McDonnell Douglas)
Payload Specialist: Senator Jake Garn (Utah)

Ascent Seating
Front left seat—Karol Bobko
Front right seat—Donald Williams
Flight deck aft center seat—David Griggs
Flight deck aft right seat—Margaret Seddon
Mid-deck—Charles Walker, Jake Garn and Jeffrey Hoffman

Entry Seating:
Jeffrey Hoffman and Margaret Seddon trade seating from ascent seating arrangement

Extravehicular Activity Flight Crew Members, if required:
Jeffrey Hoffman Extravehicular (EV)-1 and David Griggs EV-2

Entry: Will use the automatic mode until subsonic, then to control stick steering (CSS)

Runway: Runway 15, Kennedy Space Center, Florida, on orbit 79

FLIGHT TEST AND MISSION OBJECTIVES

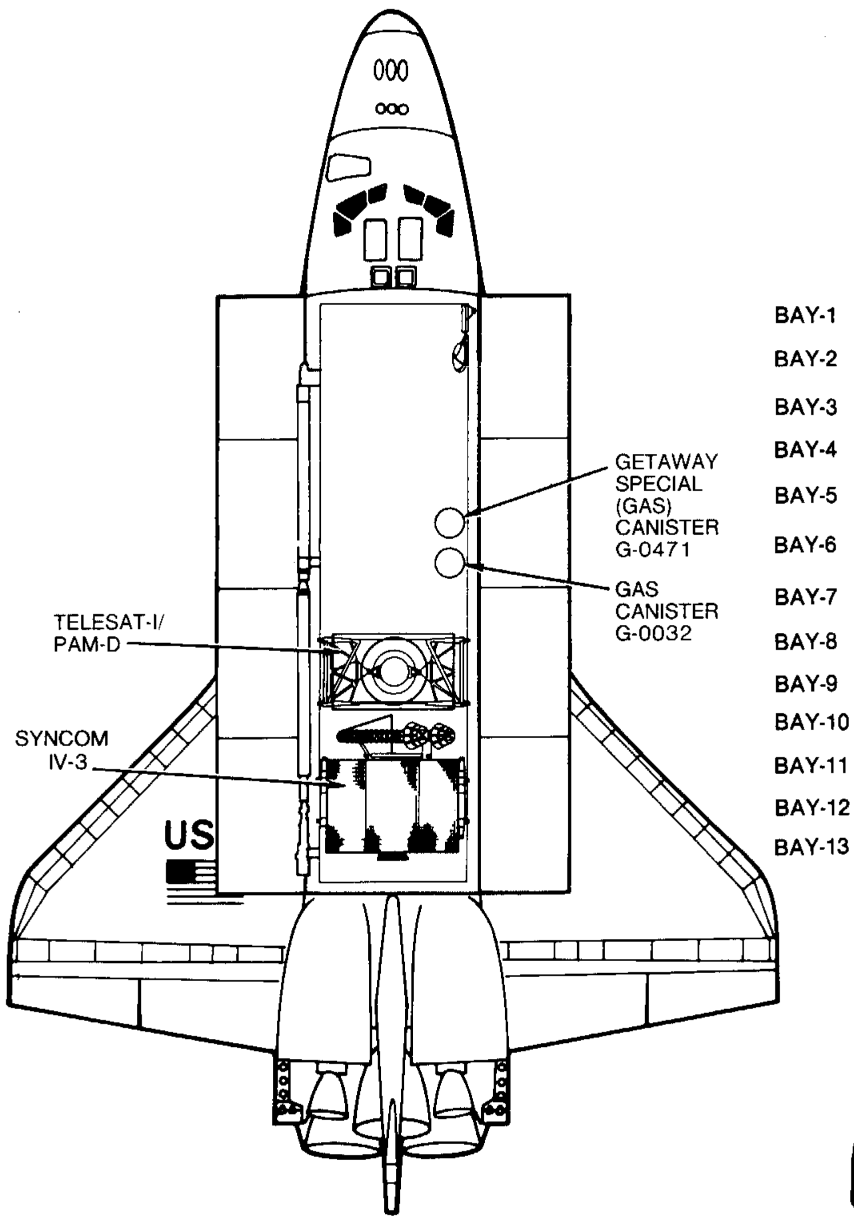
FLIGHT TEST

- External tank (ET) impact in Pacific Ocean near Hawaii
- Crew module measurements, alignment and gap
- Checkout of redundant Environmental Control Life Support System (ECLSS)
- On-orbit TACAN (Tactical Air Navigation) test
- Waste and supply water dumps (waste dump only)
- Orbital aero and gravity gradient torque measurements
- Programmed test inputs

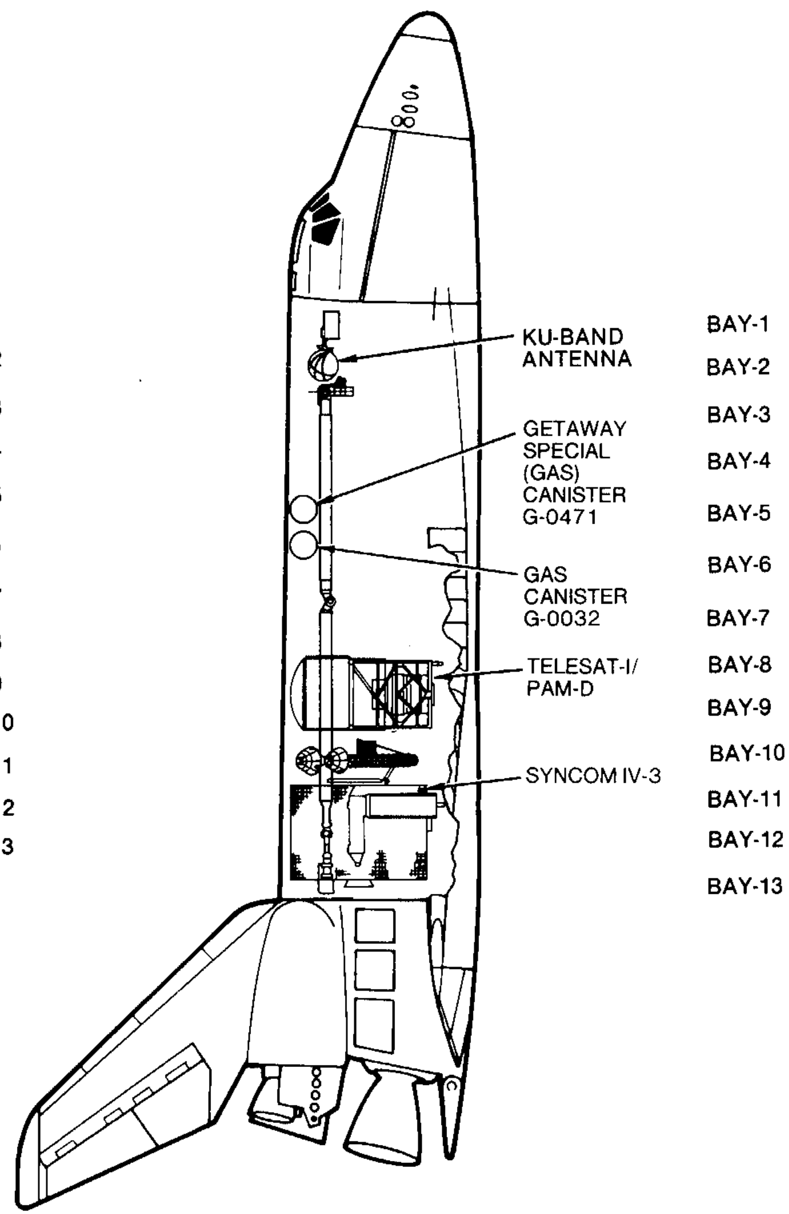
MISSION OBJECTIVES

- TELESAT-I/PAM-D deployment
- SYNCOM IV-3 deployment
- Continuous Flow Electrophoresis System (CFES)-III
- Space Adaptation Syndrome — Inflight medical experiments
- Phase Partitioning Experiment
- American Flight Echocardiograph (AFE)
- Informal science studies (Toys in space)
- Shuttle Student Involvement Program (SSIP) experiments
- Two Get-Away Specials (GAS)

51-D PAYLOAD CONFIGURATION



51-D Payload (Top View)



51-D Payload (Side View)

PAYLOAD ASSIST MODULE (PAM)

The Payload Assist Module (formerly called the Spinning Solid Upper Stage — SSUS) is designed as a higher altitude booster of satellites deployed in near Earth orbit but operationally destined for higher altitudes.

The PAM-D is used to boost various satellites to geosynchronous orbit (35,887 kilometers — 22,300 miles) after deployment from the Space Shuttle spacecraft.

There are two versions of the PAM — the "D" which is utilized to launch lighter weight satellites and the "A" which is capable of launching satellites weighing up to 1,995 kilograms (4,400 pounds) into a 27-degree geosynchronous transfer orbit after being deployed from the Shuttle spacecraft's cargo bay.

The PAM-D is capable of launching satellite weights up to 1,247 kilograms (2,750 pounds) into a 27 degree geosynchronous orbit following deployment. A requirement for a 1,361 kilogram (3,000 pound) transfer orbit capability requires about a 10-percent increase in the PAM-D motor performance, which can be accomplished by adding more length to the motor case, but reducing the nozzle length the same amount to retain the overall stage length. The motor case extension is about 137 milimeters (5.4 inches). This uprating will require other changes, namely the strengthening and addition of cradle members so that the system structural dynamic frequency will avoid the Space Shuttle forcing frequencies.

The PAM-A and PAM-D have deployable (expendable) stage consisting of a spin stabilized solid rocket fueled motor (SRM), a payload attach fitting (PAF) to mate with the unmanned spacecraft, and the necessary timing, sequencing, power and control assemblies.

The reusable airborne support equipment (ASE) consists of the cradle structure for mounting the deployable system in the Space Shuttle orbiter payload bay, a spin system to provide the stabilizing rotation, a separation system to release and deploy the stage and unmanned spacecraft, and the necessary avionics to control, monitor, and power the system.

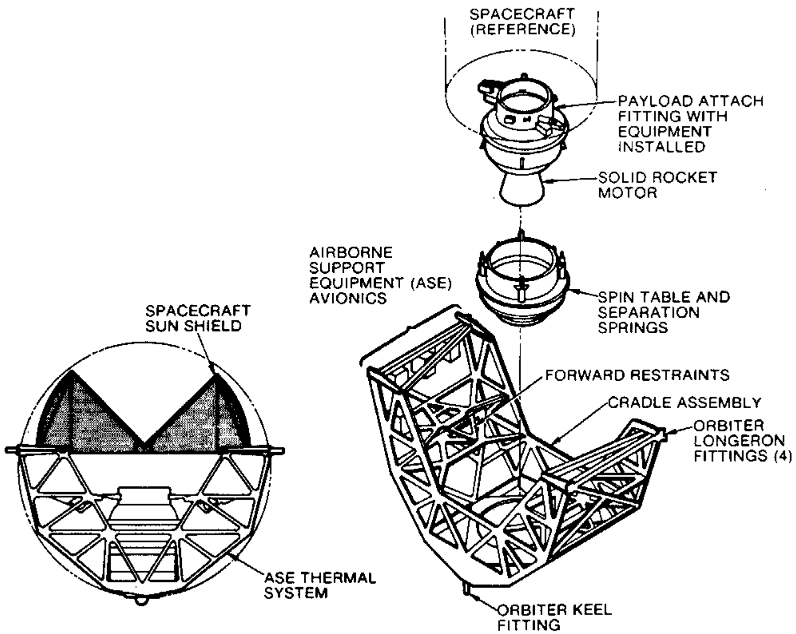
The PAM-A and PAM-D stages are supported through the spin table at the base of the motor and through restraints at the PAF. The forward restraints are retracted before deployment.

The PAM-D also provides a sunshield for thermal protection of the satellite when the Space Shuttle orbiter payload bay doors are open.

PAM-D AIRBORNE SUPPORT EQUIPMENT AND ORBITER INSTALLATION

The PAM-D Airborne Support Equipment (ASE) consists of all the reusable hardware elements that are required to mount, support, control, monitor, protect, and operate the PAM-D expendable hardware and unmanned spacecraft from liftoff to deployment from the Space Shuttle. It will also provide the same functions for the safing and return to the stage and spacecraft in case of an aborted mission. The ASE is designed to be as self-contained as possible, thereby minimizing dependence on orbiter or flight crew functions for its operation. The major ASE elements include the cradle for structural mounting and support, the spin table and drive system, the avionics system to control and monitor the ASE and the PAM-D vehicle and the thermal control system.

The cradle assembly provides a vertical structural mounting support for the PAM-D/unmanned spacecraft assembly in the orbiter payload bay. The nominal envelope for the PAM-D vertical installation provides a cylindrical volume 2,562 millimeters (100.88 inches) in height on the centerline and a diameter of 2,184 millimeters (86 inches). The diameter limitation applies to all early unmanned spacecraft that require the capability to use the Delta launch vehicle as a backup to the Space Shuttle. After full transition to the Space Shuttle is complete, the unmanned spacecraft configuration may use the extra volume available

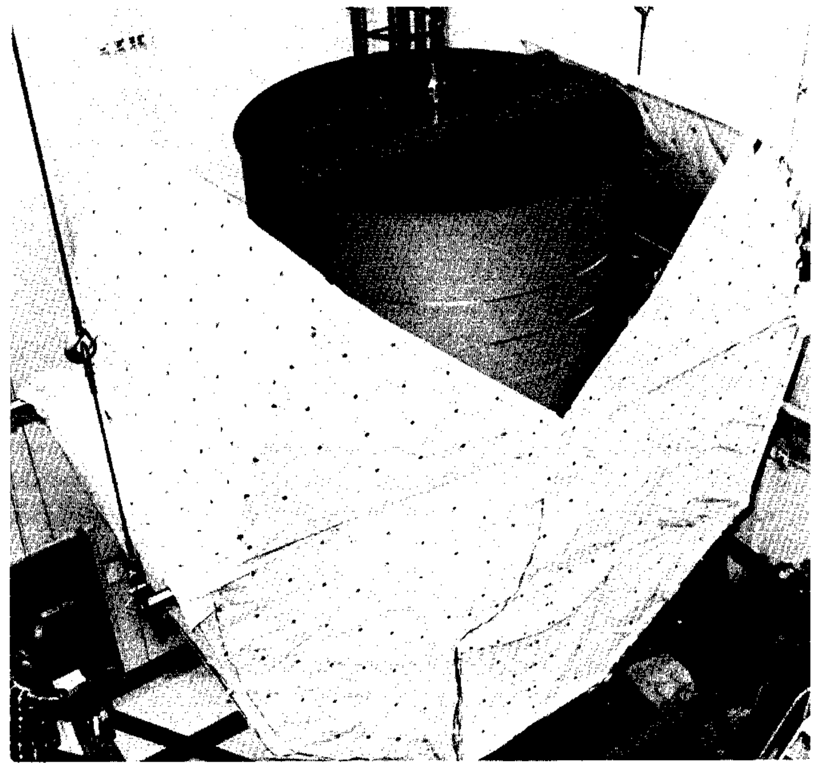


PAM-D System

within the Space Shuttle payload bay, a maximum diameter of 2,743 millimeters (108 inches) inside the cradle, 3,048 millimeters (120 inches) above the cradle. The cradle is 4.5 meters (15 feet) wide. The length of the cradle is 2,362 millimeters (93 inches) static and 2,438 millimeters (96 inches) dynamic. The open truss structure cradle is constructed of machined aluminum frame sections and chrome plated steel longeron and keel trunnions.

The spacecraft-to-cradle lateral loads are reacted by forward retractable retraction fittings between the payload attach fitting and cradle, which are driven by redundant dc electrical motors. After the reaction fittings are retracted, the spin table is free to spin the PAM unmanned spacecraft when commanded.

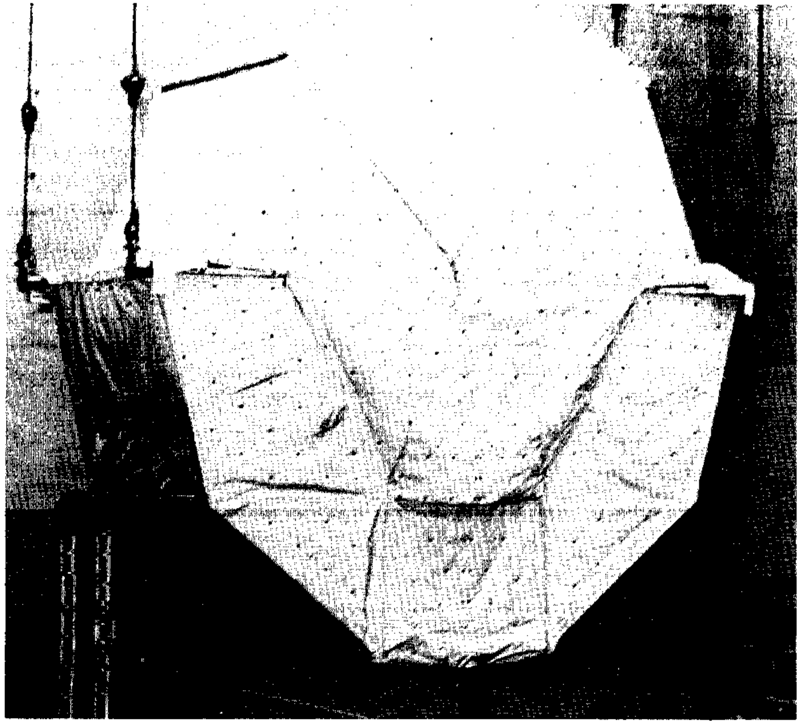
The spin table consists of three subsystems, spin, separation, and electrical interface. The spin subsystem consists of the spin table, the spin bearing, the rotating portion of the spin table, a



PAM-D Sunshield Open

gear and gear support ring, two redundant drive motors, a despin braking device, and a rotational index and locking mechanism. The separation subsystem includes four compression springs mounted on the outside of the rotating spin table, each with an installed preload of 635 kilograms (1,400 pounds) and a Marman-type clamp band assembly.

The electrical interface subsystem is composed of a slipring assembly to carry electrical circuits for PAM-D and spacecraft across the rotating spin bearing. The electrical wiring from the slipring terminates at electrical disconnects at the spintable separation point. The slipring assembly is used to carry safety-critical command and monitor functions and those commands required before separation from the spin table.



PAM-D Sunshield Closed

The system provides a capability for spin rates between 45 and 100 rpm. Upon command, the spin table will be spun up to the nominal rpm by two electric motors, either of which can produce the required torque. When the spin table rpm has been verified and the proper point is reached in the parking orbit, redundant debris-free explosive bolt cutters are fired upon command from the electrical ASE to separate the band clamp (which is mechanically retained on the spin table) and the springs provide the thrust to attain a separation velocity of approximately 0.9 meters per second (3 feet per second).

In case of an abort mode after spinup, the multiple-disc stack friction-type braking device will despin the PAM-D unmanned spacecraft assembly and the spin drive motor will slowly rotate the assembly until the solenoid-operated indexing and locking device is engaged. Upon confirmation by the ASE that the spin table is properly aligned and locked, the restraint pins will be re-engaged.

PAM-D MOUNTED THERMAL CONTROL SYSTEM

The PAM-D thermal control system is provided to alleviate severe thermal stresses on both the unmanned spacecraft and the PAM-D system.

The system consists of thermal blankets mounted on the cradle to provide thermal protection for the PAM-D system, and a passive sunshield mounted on the cradle to control the solar input to and heat loss from the payload when the orbiter payload bay doors are open.

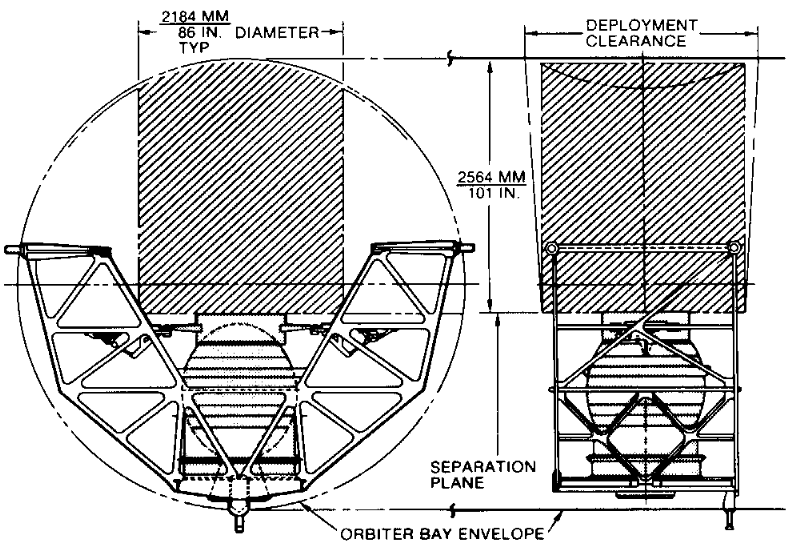
Thermal blankets consisting of multilayered insulation mounted to the forward and aft sides of the cradle protect the PAM-D from thermal extremes. On the sides and the bottom, the orbiter payload bay liner protects the PAM-D from the environmental extremes.

A sunshield, consisting of multilayered, Mylar lightweight insulation supported on a tubular frame, mounts to the cradle and protects the unmanned spacecraft from environmental extremes. The sunshield panels on the sides are fixed and stationary. The portion of the shield covering the top of the unmanned spacecraft is a clamshell structure that remains closed to protect against thermal extremes when the orbiter payload bay doors are open. The sunshield resembles a two-piece baby buggy canopy. The clamshell is opened by redundant electric rotary actuators operating a control-cable system.

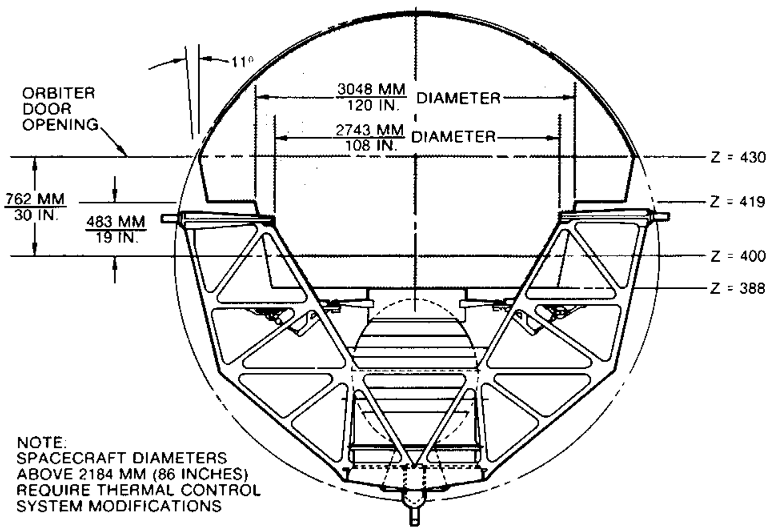
The sunshield required for the PAM-D growth will have a width adjustment capability to accommodate spacecraft up to 2,901 millimeters (115 inches) in diameter.

PAM-D VEHICLE CONFIGURATION

The PAM-D expendable vehicle hardware consists of a Thiokol Star-48 solid-fueled rocket motor, the payload attach



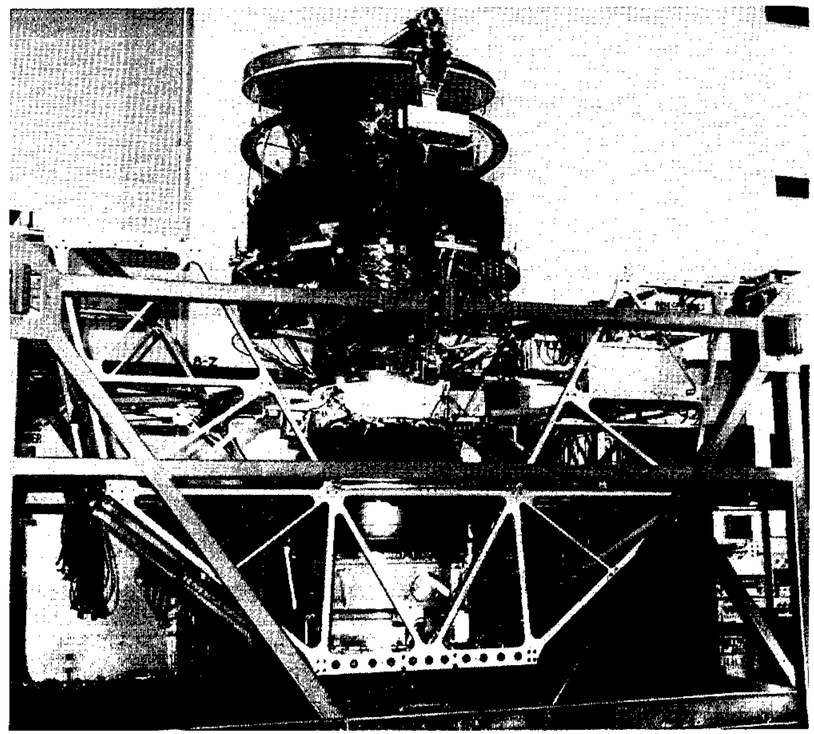
PAM-D Orbiter Vertical Installation



Maximum Spacecraft Envelope With STS PAM-D

fitting and its functional system. The Star-48 motor features a titanium case, an 89-percent solid propellant, a carbon-carbon throat insert, and a carbon-carbon exit cone. Maximum loading of propellant is 1,998 kilograms (4,405 pounds) with a nominal of 1,738 kilograms (3,833 pounds). The motor is 1,239 millimeters (48.8 inches) in diameter and is 1,828 millimeters (72 inches) long.

The payload attach fitting (PAF) structure is a machined forging and provides the subsystem mounting installations and mounts on the forward ring of the motor case. The two cradle reaction fittings provide structural support to the forward end of the PAM-D stage and unmanned spacecraft, and transmit loads to the ASE cradle structure. The forward interface of the PAF provides the spacecraft mounting and separation system. One



PAM-D/Telesat-I

steel band is preloaded to approximately 2,585 kilograms (5,700 pounds) and separation is achieved by redundant bolt cutters. Four separation springs, mounted inside the PAF provide the impetus for clear separation. The installed preload for each spring is approximately 90 kilograms (200 pounds) with a spring stroke of 133 millimeters (5.25 inches), providing a spacecraft separation velocity of about 0.9 meters per second (3 feet per second). The electrical interface connectors between the PAM-D and the spacecraft are mounted on brackets on opposite sides of the PAF. Other subsystems mounted on the PAF include the redundant safe-and-arm device for motor ignition, and telemetry components (if desired) and the S-band transmitter.

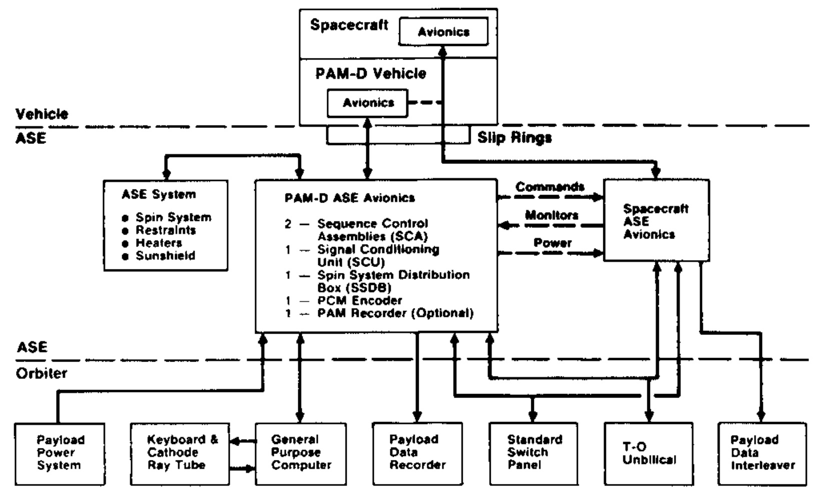
PAM-D AVIONICS

The electrical ASE minimizes the number of operations to be performed by the flight crew so that greater attention can be paid to monitoring functions that are critical to safety and reliability.

Flight crew control functions include system power on, SRM arming, deployment ordnance arming, emergency deployment and sequence control assembly (SCA) control.

The electrical ASE performs control and monitoring of restraint withdrawal, spin-table spin and deployment functions; arms (and disarms, if necessary) the SRM; controls and monitors the PAM-D vehicle electrical sequencing system (and telemetry system, when used); generates system status information for display to the flight crew (cathode ray tube) via the data lens and from the orbiter keyboard panel; and provides wiring to carry required spacecraft functions. And, as a mission option, it provides control and monitoring of spacecraft systems.

The Payload Assist Modules are designed and built by McDonnell Douglas Astronautics, Co., Huntington Beach, California.



PAM-D Interfaces

TELESAT-I (ANIK)-C1

TELESAT Canada is a commercial shareholder-owned Canadian telecommunications common carrier engaged in the transmission and distribution of all forms of telecommunications in Canada by satellite. It is regulated by the Canadian Radio-television and Telecommunications Commission (CRTC).

TELESAT is neither a Crown Corporation nor an agent of Her Majesty. Although the government of Canada is a major but not a majority shareholder, TELESAT Canada does not have access to government grants or other funding. It is dependent for its financing on the revenues it generates through its operations and from banks and other commercial sources of debt financing.

The company has the statutory mandate to establish satellite communications systems providing, on a commercial basis, telecommunications services between locations in Canada and subject to the appropriate intergovernmental arrangements, to and between other locations.

The TELESAT-I, also called Anik C (Eskimo for "brother") when on orbit, is the last in TELESAT's trio of 14 and 12 gigahertz (GHz) Anik C satellites. TELESAT-I will be the first satellite placed in final orbit using TELESAT's new global tracking antenna system at Perth, Australia and TELESAT's existing Tracking, Telemetry and Command (TT&C) antenna at Allan Park, Ontario to guide TELESAT-I into its final position. With the addition of this tracking antenna, TELESAT will offer tracking services to other satellite companies on a commercial basis.

Anik C1 will be put in a three-year storage orbit at 107.5 degrees West, longitude above the equator due south of Saskatoon, Saskatchewan. The storage orbit does not use station-keeping fuel, so after the storage period, Anik C1 will operate for approximately eight years providing satellite broadcasting, voice and data services across Canada.

The satellite is TELESAT's ninth since the Canadian Company launched the world's first domestic geostationary communications satellite in 1972.

In addition to the satellites which make up the space segment of the system, several hundred earth stations, more than 125 of which are owned and operated by TELESAT, compose the earth segment.

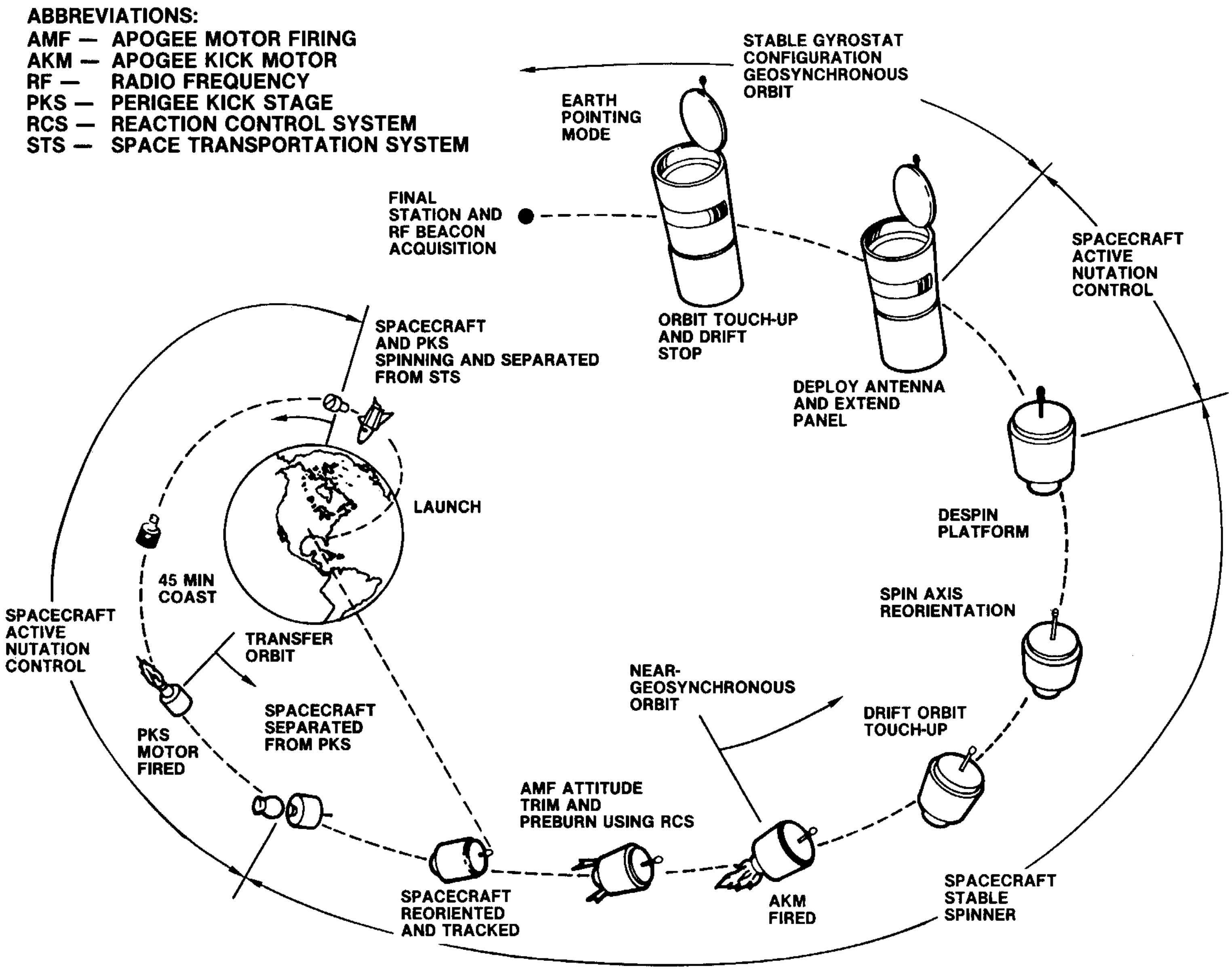
TELESAT employs 500 people, most of whom work in the company's Ottawa, Ontario headquarters. The majority of the remaining employees staff the company's main heavy route earth station at Allan Park, north of Toronto.

The satellite weighs approximately 1,140 kilograms (2,513 pounds) in transfer orbit and approximately 654 kilograms (1,441 pounds) after consuming its solid propellant for insertion into near final orbit. On station attitude control and station keeping is provided by four small thrusters fueled by an approximate 131 kilograms (288 pounds) of hydrazine propellant.

TELESAT communication satellites are cylindrical in shape and will operate exclusively in the high frequency 14 and 12 gigahertz (GHz) radio bands, with 16 radio frequency (RF) channels (transponders). Each of these 16 transponders are capable of carrying 1,344 one way voice channels or two color television signals, together with their associated audio cue and control circuits, for a total television signal capacity of 32 programs or 21,504 voice channels.

The combination of higher transmit power from 15-watt output tubes with use of the 14 and 12 gigahertz bands means that the satellite will be able to work with much smaller earth stations than those in use today.

Because of the smaller size, and the fact the higher frequencies in use won't interfere (or be interfered with by) existing terrestrial microwave communications that share the lower frequencies used by older satellites, the Anik C earth terminals can be located easily in relatively crowded spaces. They can be placed in city centers or mounted on rooftops of individual homes. Anik C satellites are able to deliver a high quality television picture to a private earth terminal equipped with a dish antenna as small as 1.2 meters



Telesat I Mission Scenario

(3.93 feet) in diameter, making it ideal for direct broadcast satellite services.

Anik C can provide rooftop to rooftop transmission of integrated voice, video and data communications for Canadian businesses. Anik C3 is now carrying newly-licensed Canadian TV and other broadcasting services and is generally helping to meet Canada's growing needs for efficient, flexible and reliable satellite communications of many kinds.

The antenna coverage of Anik C satellites will include virtually all of populated Canada, with four contiguous spot beams serving the West, Western-Central, Eastern-Central, and Eastern regions of the country. Anik C3 and Anik C2 are currently carrying Canadian pay television services, educational broadcasting and long distance telephone and data traffic. TELESAT's customers will be able to choose regional half- or whole-country coverage, depending on their needs.

Designed to last 10 years, the satellites are expected to have minimum mission lives of around eight years.

The three TELESAT-I (Anik) C satellites are built for TELESAT Canada by Hughes Aircraft Company, Los Angeles, Calif., with considerable work performed by Spar Aerospace Limited and other Canadian companies.

For launch the TELESAT-I spacecraft is compressed to a height of about 2.75 meters (9 feet) and diameter of roughly 2.18 meters (7 feet) and positioned in its cradle in the orbiter cargo bay. With the PAM, the payload is 4.2 meters (14 feet) tall.

TELESAT-I satellite measures more than 6.4 meters (21 feet) tall with concentric solar skirts and antennas fully deployed.

TELESAT-I PAM-D EJECTION

Before ejection, the deployable payload is supported by its cradle and electronics system.

To prepare for cargo ejection, the orbiter flight crew verifies the spacecraft through a series of checks and configures the payload for deployment. The orbiter is in an eliptical orbit of approximately 160 by 245 nautical miles (184 by 281 statute miles) altitude for spacecraft deployment. The satellite is spun up (to 50 rpm) on the cradle's spin table, communications and other subsystems are checked by means of an electrical and communications harness to the flight crew cabin, and the payload ordnance items are armed. All the checks are performed remotely from the flight crew cabin, and payload data are transmitted from the orbiter to the Mission Control Center in Houston (MCC-H) for analysis.

During a final pre-ejection sequence lasting approximately 30 minutes, the orbiter is maneuvered into a deployment attitude with the open cargo bay facing the direction desired for firing the PAM motor.

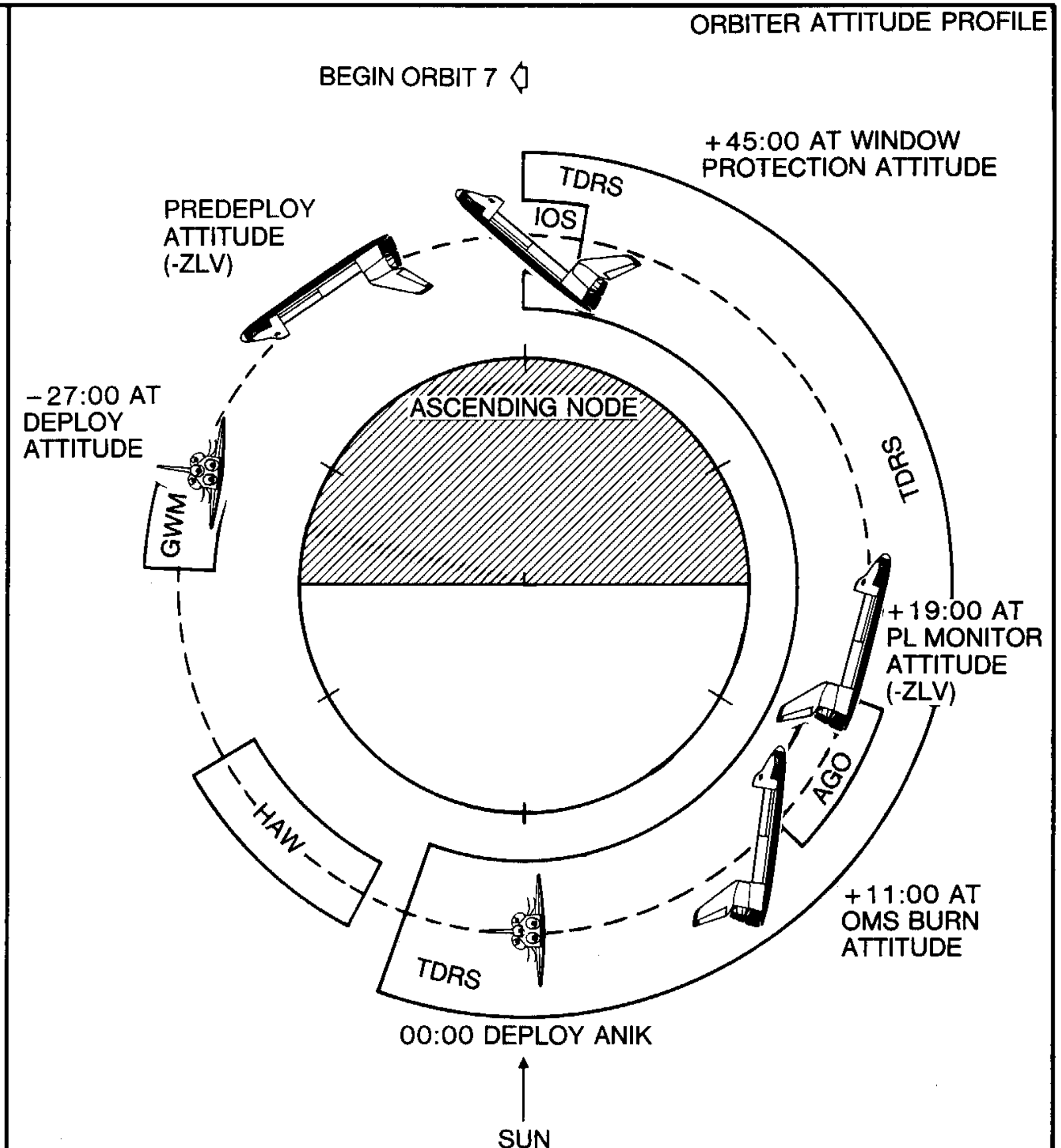
Ejection will occur, nominally on Mission Elapsed Time (MET) day zero, about nine hours and 39 minutes when the orbiter is on the seventh orbit. A Marman clamp is released by explosive bolts, and the spinning payload pops out of the cradle and cargo bay at 0.9 meters per second (3 feet per second).

At ejection from the orbiter cargo bay, the TELESAT-I spacecraft has completed only the first of several critical launch events. At this point it is in an orbit similar to the orbiter's, a velocity of about 27,835 kilometers (17,300 mph), an inclination to the equator of 28.5 degrees, and a period of 90 minutes.

Fifteen minutes after TELESAT-I deployment, an Orbital Maneuvering System (OMS) separation maneuver is performed by *Discovery*. This is a 3.3 meter per second (11 feet per second) separation maneuver resulting in a 167 by 246 nautical mile (192 by 283 statute mile) orbit of *Discovery*.

Twenty-nine minutes after TELESAT-I deploy, *Discovery* is maneuvered to its window protection attitude to protect its windows from the PAM-D perigee solid rocket kick motor.

	ORBIT 7 EVENTS
−45:00	BEGIN ORBIT 7
−40:00	INITIATE MANEUVER TO DEPLOY ATTITUDE
−30:00	SUNRISE
−26:00	TO −23:00 GUAM CONTACT
−27:00	AT DEPLOY ATTITUDE
−15:00	TO −07:00 HAWAII CONTACT
−15:00	MECHANICAL SEQUENCE START
−05:00	TO +50:00 TDRS CONTACT
−03:00	TERMINAL SEQUENCE START
00:00	DEPLOY TELESAT-I
+03:00	INITIATE MANEUVER TO OMS BURN ATTITUDE
+12:00	TO +18:00 SATIAGO CONTACT
+15:00	OMS SEPARATION BURN
+18:00	INITIATE MANEUVER TO PAYLOAD MONITORING ATTITUDE
+25:00	SUNSET
+29:00	INITIATE MANEUVER TO WINDOW PROTECTION ATTITUDE
+43:00	TO +51:00 INDIAN OCEAN SHIP CONTACT
+45:00	PAM PERIGEE MOTOR FIRING INITIATE INERTIAL ATTITUDE HOLD



Telesat-I Deploy Sequence

To perform its intended communications service, the spacecraft must be raised to an altitude of about 36,800 kilometers (22,871 statute miles), with a velocity of about 10,941 kilometers per hour (6,800 mph), at a zero-degree inclination to the equator and a period of 24 hours.

The first in a series of major in-orbit events is the firing of the solid-propellant motor aboard the payload's PAM. At ejection, this motor is armed to automatically fire in 45 minutes. Spacecraft sensors and thrusters automatically maintain the payload's correct attitude (longitudinal axis included 9 degrees to the equator) for firing.

The PAM motor firing raises the apogee (high point) of the orbit to about 36,800 kilometers (22,871 statute miles). Now the spacecraft is in a highly elliptical transfer orbit, an orbital period of 11 hours, and an inclination to the equator of 23.8 degrees. The PAM motor casing is jettisoned after firing.

Nominally, on the seventh apogee of the transfer orbit, an onboard solid-fuel motor (or apogee motor) is fired to raise the perigee of the orbit. This puts the spacecraft into a near-circular orbit at near-geosynchronous altitude. The apogee motor will be fired on command by TELESAT controllers at TELESAT Satellite Control Center in Ottawa, Ontario.

Next comes a series of spacecraft thruster firings by TELESAT controllers to refine the orbit and adjust spacecraft velocity so that a controlled drift will bring it to its final destination.

Three other critical maneuvers, in sequence, are the despin of the communications platform, the raising of the spacecraft's antenna reflector, and the lowering of its solar-panel skirt, all by means of on-board electric motors activated on command.

When the maneuvers are completed, TELESAT conducts a series of in-orbit tests and verifications of all spacecraft subsystems, before commercial service is begun. TELESAT-I assigned station is directly above the equator at 107.5 degrees west. ANIK C-3 is stationed at 117.5 degrees West Longitude and ANIK C-2 is temporarily stationed at 105.0 degrees West.

Backup deployment opportunity occurs on orbit 32 with PAM solid rocket motor ignition on orbit 33.

The TELESAT Satellite Control Center, Analysis Center and Computer Center are located at TELESAT Headquarters in Ottawa, Ontario.

NASA's responsibility for the launch mission is completed upon the satellite's ejection from the orbiter, except for tracking of the payload until the PAM is fired.

SYNCOM IV-3

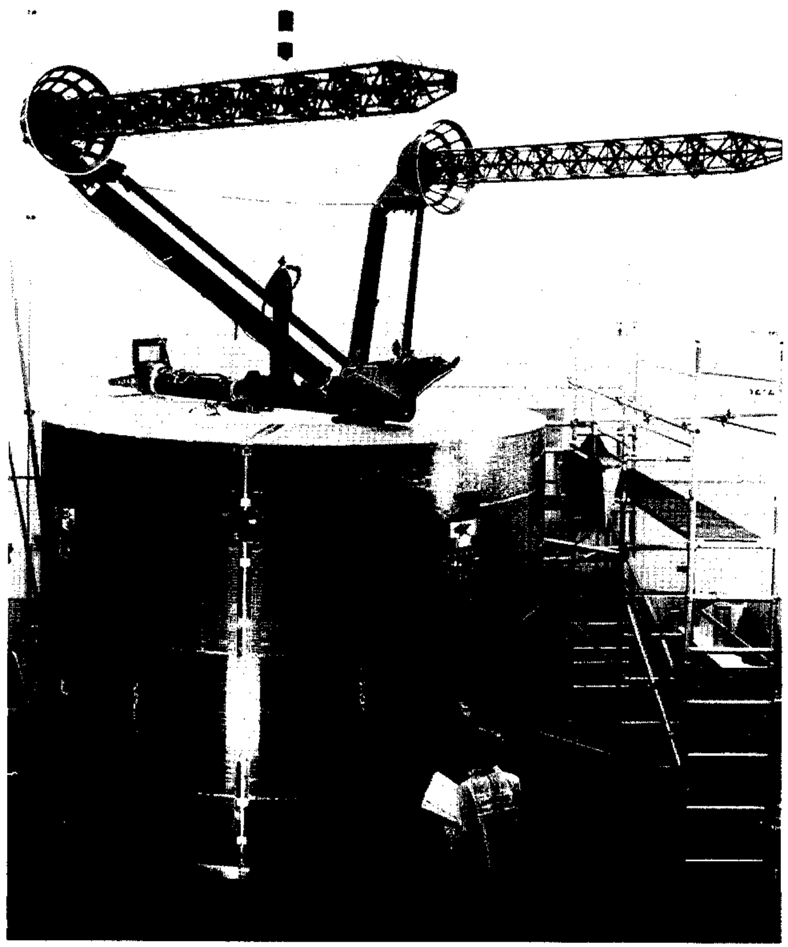
Syncom (Synchronous Communication)-IV-3 is the third of the Syncom series satellites designed and built by Hughes Communications Services, Incorporated, a subsidiary of Hughes Aircraft Company, Los Angeles, California. NASA's Space Shuttle manifest carries the name of the satellite as Syncom, however Hughes calls the satellite Leasat. Syncom is the name of the hardware, and Leasat refers that the satellite will be leased to the U.S. Navy.

The United States Navy awarded the contract to Hughes Communications Services, Incorporated in September 1978. The Leasat network is owned and operated by Hughes Communications Services, Incorporated and provides leasing services for world wide communications to the Department of Defense for at least five years at four orbital locations. The U.S. Navy acts as executive agent on behalf of the Department of Defense. Users include mobile air, surface, subsurface, and fixed earth stations of the U.S. Navy, Marine Corps, Air Force and Army. Voice and data are transmitted.

The contract calls for Hughes to design, build, launch and operate a complete communications satellite system. Included are five satellites, one of which will be a spare, as well as associated ground facilities, an operational control center, a network of four fixed ground stations and two movable stations. The satellites will occupy geostationary positions at the equator over the United States, Atlantic, Indian and Pacific Oceans.

Syncom IV-2 was positioned at geosynchronous orbit at the equator at 100 degrees for U.S. coverage. Syncom IV-1 is positioned at geosynchronous orbit at the equator over the Atlantic Ocean. Syncom IV-3 will be carried aboard *Discovery*, for deployment and eventual position at geosynchronous orbit at the equator over the Indian Ocean. The fourth Syncom will be carried aboard a Space Shuttle flight later this year, for deployment and eventual position at geosynchronous orbit at the equator over the Pacific Ocean.

The Syncom satellites are the first satellites designed to be launched exclusively by the Space Shuttle, as its 4.2 meter (14 foot) diameter makes it too large to launch on any other launch vehicle. Syncom is a cylindrical satellite and are deployed from the payload bay in a horizontal position.



Syncom IV-3

Each satellite is 4.2 meters (14 feet) in diameter and are 6.1 meters (20 feet) in length with the UHF (Ultra High Frequency) and omnidirectional antenna deployed. On orbit with its twin helical antennas extended, Syncom is 7.6 meters (25 feet) tall. Total payload weight of each satellite and its cradle in the payload bay of the space Shuttle are approximately 7,711 kilograms (17,000 pounds). Weight after deployment from the payload bay of the Space Shuttle, is approximately 6,894 kilograms (15,200 pounds), and the weight of each satellite on station at the beginning of life is approximately 1,388 kilograms (3,060 pounds).

Syncom's wide body allows its perigee kick motor to be designed into the satellite's structure as well as its apogee kick motor. Syncom's perigee kick motor is a third stage Minuteman solid rocket motor. Syncom's two perigee kick motors are a liquid bipropellant system, which wraps around the cavity filled by the perigee kick motor. This concept eliminates the extra length of a separate stage solid rocket fuel perigee kick motor used in other types of communications satellites and results in considerable savings of launching the satellite from the Space Shuttle payload bay. Space Shuttle launch costs are based on a formula which takes into account the ratio of either weight or length of satellite cargo, whichever is greater, to the Space Shuttle's total capacity.

The deployment of the third Syncom (IV-3) with its unique stage is nominally scheduled for deployment at a Mission Elapsed Time (MET) of day one, zero hours and 58 minutes on orbit No. 17. Syncom IV-3 perigee kick solid rocket motor ignition occurs approximately 45 minutes later on orbit 18. Backup deployment opportunities occur on orbit 32 with perigee kick motor ignition occurring on orbit 33.

Syncom's attached at five contact points (four longeron and one keel) to a cradle in the Space Shuttle payload bay with five contact points from the cradle to the Space Shuttle payload bay. In preparation for Syncom deployment from the Space Shuttle payload bay, the Space Shuttle is oriented so that Syncom's spin axis is pointed in the direction that its perigee kick motor must thrust. The Space Shuttle attitude is negative Z local vertical (tail forward and payload bay towards earth). Locking pins at four of the contact points, are mechanically retracted by electrical motors, taking about five minutes per pin. A pyrotechnic operated device at the fifth contact point is initiated releasing a spring that will push one side of the satellite upward while the other side pivots. This provides Syncom with a separation velocity of 0.4 meters per second (1.5 feet per second) and a stabilizing spin of approximately two revolutions per minute (rpm). This provides a simultaneous rotation and translation maneuver (Frisbee concept) to Syncom. This also provides a settling of the liquid propellants in Syncom. Thirty seconds after deployment Syncom is automatically turned on and its onboard timer started which commands Syncom perigee kick motor to fire approximately 45 minutes after Syncom deployment. One minute after deployment, Syncom's omni antennas are deployed.

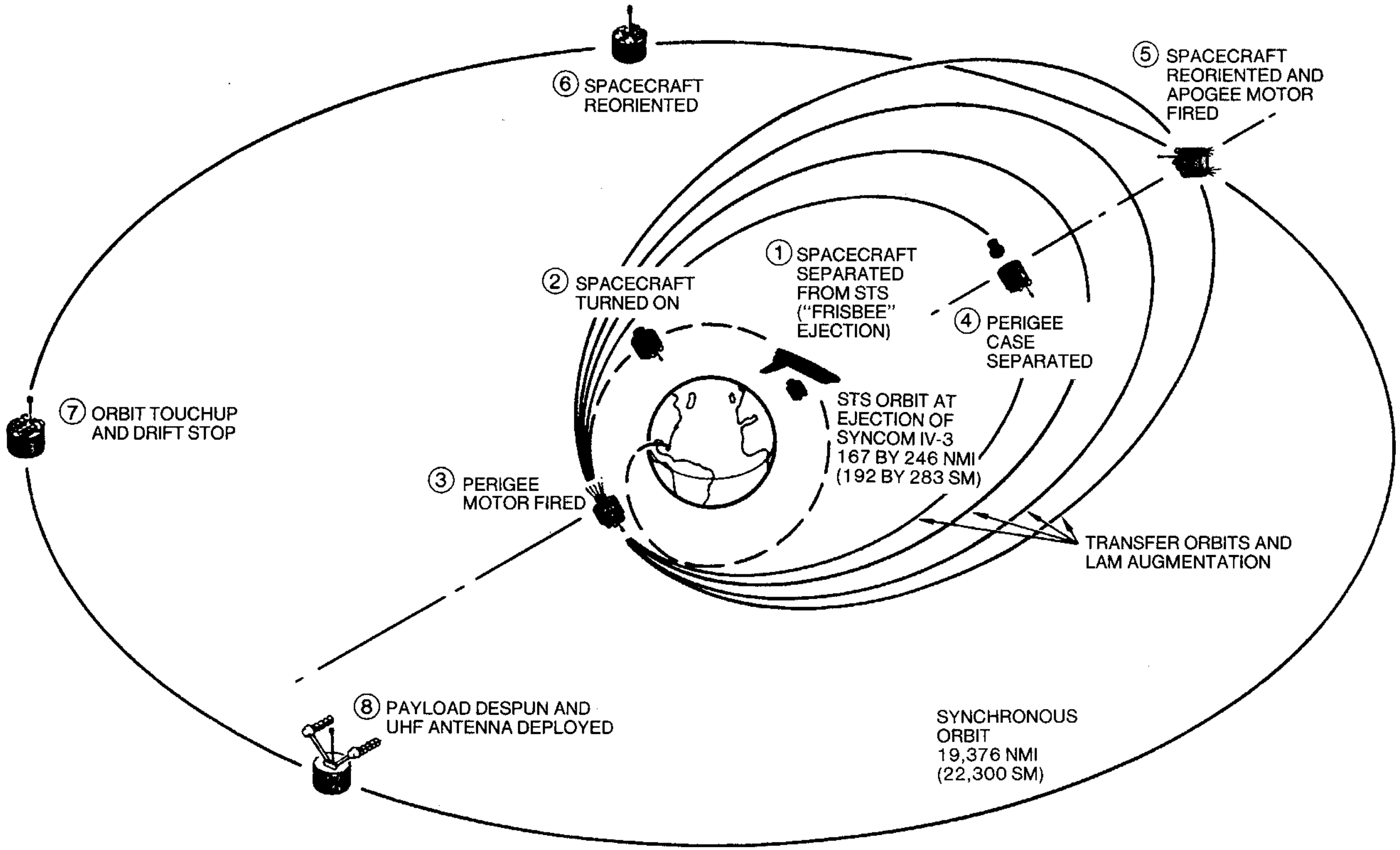
Seven minutes after deployment, when Syncom is approximately 152 meters (500 feet) from *Discovery*, Syncom's separate orbit and attitude control hydrazine reaction control system small thrusters are commanded to thrust to increase Syncom's spin rate to 33 rpm.

Fifteen minutes after Syncom deployment, an Orbital Maneuvering System (OMS) separation maneuver, is performed by *Discovery*. This is an 4.5 meter per second (15 feet per second) separation maneuver resulting in an 175 by 246 nautical mile (201 by 283 statute mile) orbit of *Discovery*.

Twenty-seven minutes after Syncom deploy, *Discovery* is maneuvered to its window protection attitude to protect its windows from Syncom's perigee solid rocket kick motor plume which occurs approximately 45 minutes after Syncom deploys.

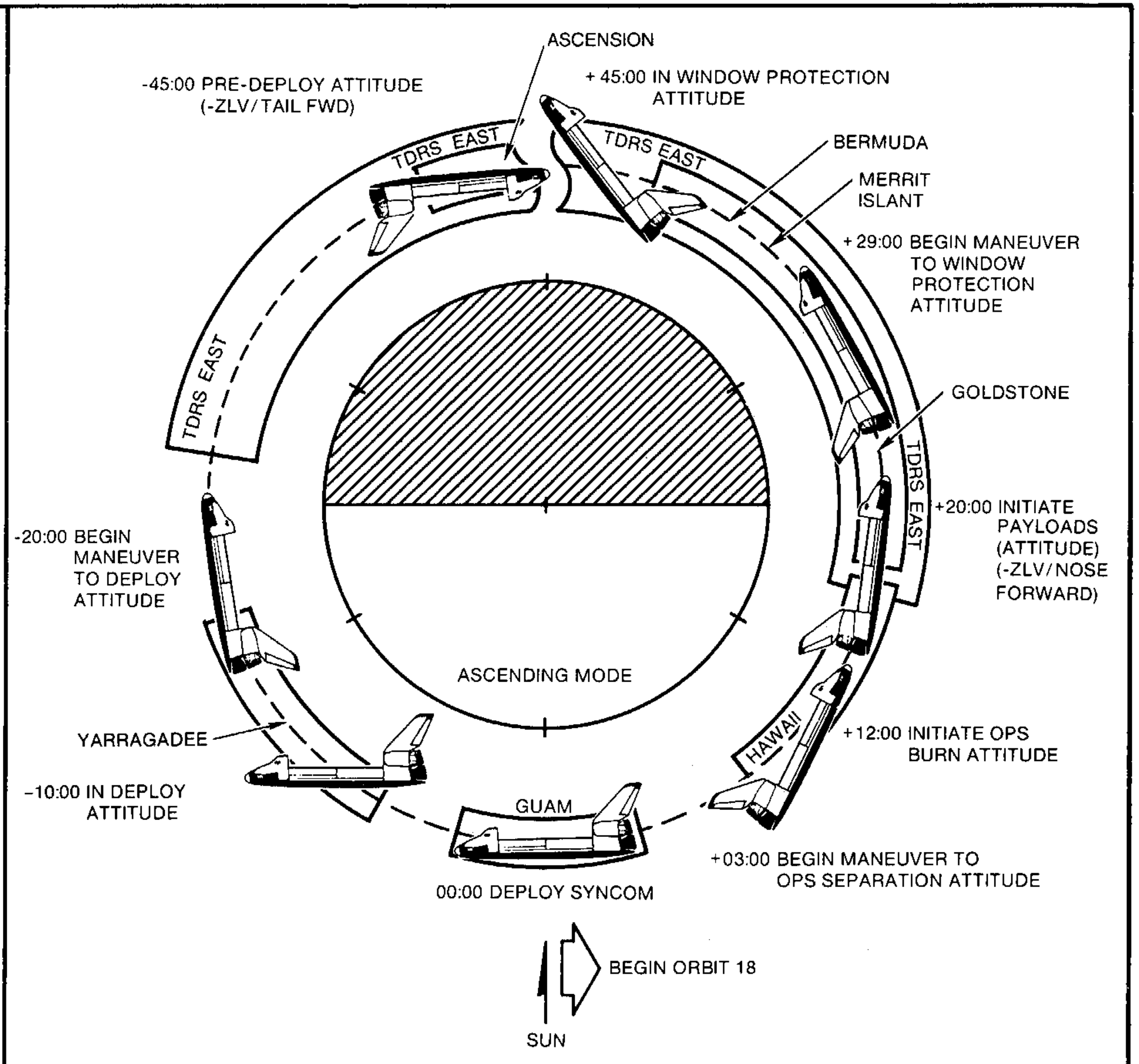
The remote manipulator system (RMS) on *Discovery* is positioned so its wrist television camera can view the thrusting of Syncom's perigee solid rocket kick motor.

Syncom's perigee solid rocket kick motor places it in an 8,300 by 178 nautical mile (9,551 by 204 statute mile) elliptical orbit. The perigee solid rocket kick motor is jettisoned from Syncom upon completion of its thrusting period.



Launch Sequence

ORBIT 17/18 EVENTS	
-50:00	TO -39:00 ASCENSION CONTACT
-35:00	SUNRISE
-24:00	END TDRS CONTACT
-20:00	INITIATE MANEUVER TO DEPLOY ATTITUDE
-17:00	TO -07:00 YARRAGADEE CONTACT
-10:00	IN DEPLOY ATTITUDE PUSH-OFF PIN RETRACT
-05:00	SYNCOM HEATER DEACTIVATION
-03:00	TO +4:00 GUAM CONTACT
00:00	DEPLOY SYNCOM BEGIN ORBIT18
+03:00	INITIATE MANEUVER TO OMS BURN ATTITUDE
+09:00	TO +20:00 HAWAII CONTACT
+15:00	OMS SEPARATION BURN
+18:00	INITIATE MANEUVER TO PAYLOAD MONITORING ATTITUDE
BEGIN TDRS CONTACT	
+20:00	TO +29:00 GOLDSTONE CONTACT
+23:00	SUNSET
+28:00	TO +39:00 MERRIT ISLAND CONTACT
+29:00	INITIATE MANEUVER TO WINDOW PROTECTION ATTITUDE
+33:00	TO +41:00 BERMUDA CONTACT
+45:00	SYNCOM PERIGEE MOTOR FIRING
	INITIATE INERTIAL ATTITUDE HOLD
	PERIGEE KICK MOTOR MONITOR



Orbiter Attitude Profile Acquisition/Loss of Signal
Syncom IV-3 Orbit 18

The transfer to geosynchronous orbit is accomplished by the thrusting of the two 444 Newton (100 pound) hydrazine apogee kick motor system as Syncom passes through three succeeding perigees, a maneuver called an orbit augmentation. This raises the transfer orbit's apogee to 10,774 nautical miles (12,400 statute miles), 14,249 nautical miles (16,400 statute miles), and 19,376 nautical miles (22,300 statute miles) respectively. At this final apogee another three thrusting periods will occur using the hydrazine apogee kick motors. The first thrusting period positions Syncom in an intermediate orbit, the second thrusting period positions Syncom in a near circular orbit, and the last thrusting period circularizes Syncom's orbit with a planned three-degree inclination to the equator at geosynchronous altitude.

The hydrazine reaction control system and its small thrusters provide orbit and attitude control.

Syncom is spin stabilized, with the spun portion containing the solar array, sun and earth sensors for attitude determination and earth pointing reference, batteries for eclipse operation, and all propulsion and attitude control hardware.

Syncom despun platform contains the earth pointing twin helical antennas, communication repeaters, and the majority of the telemetry, tracking and command equipment.

The satellite's solar drum generates about 1,200 watts at the end of seven years. Three 25 ampere hour nickel-cadmium batteries provide electrical power for eclipse operations.

Twelve UHF channels operating in the 240 to 400 MHz range provide Syncom's main communications capability.

Services provided on a long term lease basis includes an option to extend the five year lease for up to two years and to purchase the satellites after seven years.

The ground segment of the new Leasat system includes Hughes Communications' Operations Control Center (OCC), located in Los Angeles, California; two movable ground stations in Guam and Norfolk, Virginia; and four satellite control sites in Guam, Hawaii, Stockton, California, and Norfolk, Virginia. In addition, there is a leased communications line to the Naval Space Command Operations Center in Dahlgren, Virginia, for coordination of all Leasat operations.

CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES)

The Continuous Flow Electrophoresis System (CFES) Block III hardware designed for mass production operations was previously flown on mission 41D and is flown on the mission. This is the sixth space flight for CFES. It is located in the mid-deck of *Discovery's* view compartment.

CFES is operated by payload specialist Charles Walker of McDonnell Douglas Astronautics Company, St. Louis, Missouri.

CFES is an electrochemical system that segregates particles of varying electrical charges within a biological sample using a continuous separation process. The process is based on relative motion of particles within an electric field (electrophoresis).

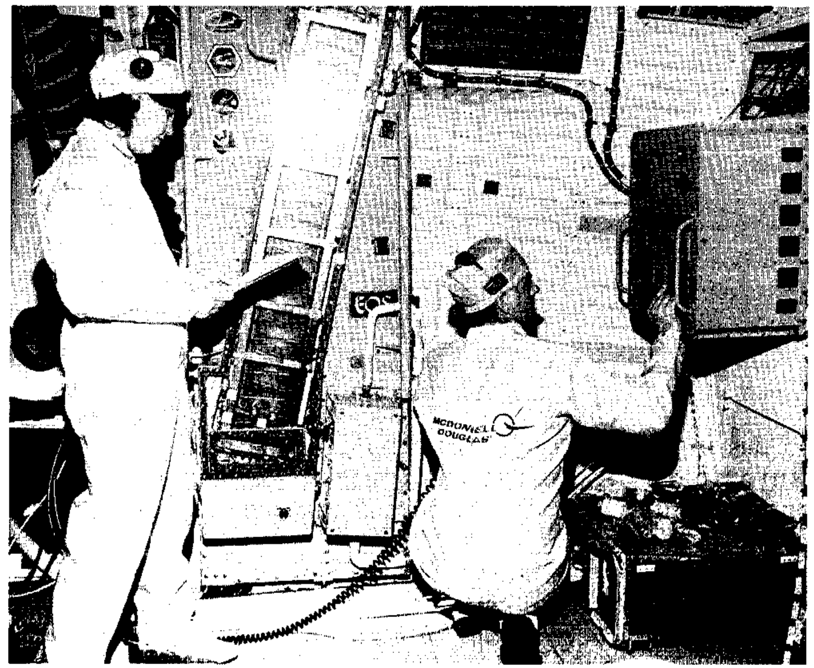
The primary objectives of this flight are to separate and collect a quantity of the first product of interest, and to evaluate contamination control and sample stream dynamics. In addition, Walker will conduct a series of protein crystallization experiments for NASA researchers.

The company expects to process 1.1 liters of concentrated protein material over the course of three flight days. On the final flight day, nine separate tests will be conducted to determine the optimum ratio between sample and buffer concentrations.

During mission 41D early last fall, the middeck CFES unit separated 83% of the concentrated protein material on board. Post flight assays, however, revealed levels of endotoxin contamination which rendered the hormone unsuitable for animal testing. In order to prevent this occurrence, stronger sterilizing chemicals will be used preflight to cleanse the middeck unit. Also, procedures have been modified to maintain cooler operating temperatures throughout the course of the mission in an effort to retard bacterial growth. These changes proved successful in maintaining acceptable levels of sterility during recent CFES flight simulations with the middeck hardware. These simulations were conducted in Florida prior to the hardware's installation onboard *Discovery*.

Additionally, the degassing units and sensors which failed during the August mission have been replaced. Software modifications have been made to the system's computer control device to lengthen the unit's response time between commands. Difficulties in the automation software were causing the system to adjust too quickly.

Once each day Walker will test for the presence of microbes and endotoxins. These tests will be made by withdrawing a small sample of fluid from five locations and incubating them in vials which have been previously loaded with freeze dried reactants. Although there are no corrective actions possible during flight, this information will be helpful in determining possible sources of contamination.



Continuous Flow Electrophoresis System (CFES) Being Installed in the Mid Deck of Orbiter Discovery

For NASA, Walker will fly several protein crystalization experiments. Because the lack of gravity promotes the growth of larger, more perfect crystals, protein crystals grown in space will be useful to crystolographers in determining the arrangement of molecules in various proteins. Walker will mix the protein materials on the first flight day and then put them in a quiet locker until the final flight day when he will make visual observations and photographs. The materials will be turned over to NASA's principal investigators Dr. Robert Kauman and Dr. Robert Snyder of Marshall Spaceflight Center and Dr. Charles Bugg from the University of Alabama-Birmingham after the flight.

When the McDonnell Douglas hormone material is removed from *Discovery* after landing, the material will be returned to St. Louis. It will be stored in a frozen state. A third middeck production flight has been scheduled for Mission 51-I, scheduled for launch in August 1985. It is hoped that sufficient material will be available from these two flights to allow Ortho Pharmaceutical Division of Johnson & Johnson to begin the testing necessary to obtain Food and Drug Administration approval.

Because of the delays in producing sufficient test material, the company now believes it will be some time in 1988 before the first product will be available for market. This represents a slip of about one year from the program's early forecasts.

SPACE ADAPTATION SYNDROME INFLIGHT MEDICAL EXPERIMENTS

The Space Adaptation Syndrome inflight medical experiments will be performed during the mission by Senator Jake Garn. Senator Garn volunteered to conduct the experiments during the mission and provides a unique opportunity to conduct various tests, observations, and measurements at points and times in the flight that cannot be done by the other flight crew members due to their activities associated with the flight, orbiter, and payloads. Senator Garn can conduct the various tests at launch, immediately after orbit insertion and during entry time periods that are not ordinarily available by the other flight crew members.

The various tests and measurements will investigate the changes that the human body undergoes in weightlessness from several points of views. These investigations began in the STS-4 mission and continued in the STS-7 and 8 missions with Mission specialists Dr. Thornton and Thagard and others.

The shopping list of inflight medical experiment activities to be performed by Senator Garn are not rigidily scheduled and does not require the participation of other flight crew members or interfere with other on-going activities in the mission.

GASTRIC MOTILITY—STOMACH ACTIVITY

Two inflight medical activities associated with the stomach in space flight will be measured on Senator Garn.

Bowel sounds. The noises that the stomach and intestine make as they pass material food and digestive juices are measured to document changes in gastric activity that occurs in space flight. It has been documented that in the case of space motion sickness, the level of stomach activity decreases greatly. The equipment used consists of an electronic stethoscope microphone on an ace bandage and the sounds are picked up on the microphone and are recorded on a voice cassette recorder.

Electrogastrogram (EGG). Electrical signals generated by stomach muscle activity correlated with the emptying of the stomach are measured to identify changes in the electrical signal that occurs in an individual if he experiences motion sickness and is it immediate or later. The normal activity of these electrical signals is three cycles per second. If the individual becomes motion sick, the electrical signal activity in the stomach increases, the stomach slows down, but the emptying of the stomach does not. This is the first time this test has been done in space flight and will identify the changes in the electrical signal that occurs in the individual, should he become motion sick. Four electrodes are placed on the skin over the stomach and will report the electrical activity of the stomach.

These two tests are made on launch and immediately after orbit insertion.

SPACE MOTION SICKNESS

Should Senator Garn experience symptoms of space motion sickness, he would participate in the following measurements. If he should not experience motion sickness, he would be one of the 50 percent of individuals that does not experience motion sickness.

An electroencephalogram (EEG) measurement would be performed to observe changes in electrical brain wave activity.

An electrocardiogram (EKG) measurement would be performed to investigate the automatic part of the nervous system. The EKG would be used to measure the changes in the intervals of the EKG signals.

The changing of the color of the face (pallor or flushing—flush to pale) using a color chart would quantify and assess the change that occurs and the degree of effect of blood flow to the face and head.

Body temperature would be measured, as body temperature would be slightly lower when experiencing motion sickness.

Pupillary size. Photographs of the change in the size of the pupil of the eye would be done by Garn, should he have symptoms of motion sickness. The size of the pupil is controlled by the amount of light and is also affected by the general status of the automatic nervous system.

A composite of all of these bits of information go a long way to help understand the relationships that are going on in the various parts of the body in adapting to weightlessness.

SHIFTS IN BODY FLUID

In zero gravity, body fluids shift towards the head. The legs lose fluids and shifts to the upper chest and to the head.

Leg Plethysmography documents the changes in leg volume that occur when going from one "g" to weightlessness, during the flight and upon return to one "g". Senator Garn will wear a leg stocking from the ankle to the thigh with a series of circumference tape that can be marked to measure the circumference of the leg at various points. From this, the volume change that occurs in the leg can be calculated. The leg stocking will be worn during launch and Senator Garn will conduct the measurements immediately upon insertion into orbit as it occurs quite rapidly. This is also accomplished during entry.This data has not been obtainable on previous flights.

The assessment of total body water involves the measurement of changes in total body water occurring as a consequence of exposure to weightlessness.

It involves the consumption of approximately five cc's of water containing oxygen 18, a heavy water (natural occurring oxygen atom-non-radioactive), that can be detected. It is measured by collecting samples of saliva at various times over several hours after the consumption of the water. The amount of oxygen 18 that is present in the saliva correlates very close with blood levels. By collecting the saliva, information can be obtained without drawing blood, fly centrifuges, freezer, etc.

BLOOD PRESSURE MONITORING

Blood pressure monitoring is part of an ongoing effort. Heart rate and blood pressure changes that occurs in flight and during the re-entry phase are used to determine the body's ability to react and respond appropriately to the re-exposure to gravity during reentry. Automatic blood pressure device records Senator Garn's heart rate and blood pressure every three and one-half minutes throughout entry and landing.

ANTHROPOMETRY—MEASUREMENT OF HEIGHT AND GIRTH

The spine extends a bit in orbit without the effect of gravity. The flight crew members grow up to approximately two inches during zero gravity space flight. These measurements of Senator Garn will provide better and more complete data on the change of body size and shape that takes place in orbit which is of importance for clothing and suit fit in flight.

PERFORMANCE IN SPACE

These tests consist of two different tests. One is a test of the eye and hand coordination and the other is a reaction test in weightlessness.

The eye and hand coordination test in weightlessness uses a tracking device. The tracking device is 16 inches long with a series of Light Emitting Diodes (LED). Light travels back and forth across the device and Senator Garn tracks the light as it moves with a pointer. This test of eye-hand coordination accuracy is to determine if there is any alteration in weightlessness for well individuals as well as those who may experience any motion sickness symptoms. The results are recorded internally and evaluated in postflight.

The reaction time test uses an onboard HP-41 pocket calculator-computer to evaluate changes in Senator Garn's motor processing that may occur in flight. Numbers are presented on the calculator screen and Senator Garn is to respond to particular numbers and his reaction time and accuracy are reported.

PHARMACODYNAMICS—METABOLISM AND ACTIVITIES OF MEDICATION

This test is to determine that the doses of medication that are appropriate on the ground are appropriate in flight. The test will be looking at changes in body fluid distribution, changes in drug distribution, changes in absorption of the stomach, intestines, and metabolism.

The test will use one Tylenol tablet and obtain samples of saliva over several hours to measure salivary levels, consequently blood levels, of Tylenol as it is metabolized. This gives information concerning the rate of metabolisms of medications, with this drug, and help in others, in determining that dosages given in one "g" are correct in zero "g."

PRE AND POSTFLIGHT TESTS

Senator Garn will undergo pre and post flight parallel swing tests prior to and after the mission at NASA's Johnson Space Center.

The otolith, the part of the inner ear that senses gravity in linear accelerations, on earth, does not have gravity to respond to in space flight, zero gravity.

The belief and evidence in previous tests with this experiment, is that the brain re-interrupts all of the signals that the otolith sends to the brain during space flight as linear translations (movements side-to-side and forward and back). This reinterruption is very much involved with the adaptation process that individuals undergo to adapt to zero gravity in flight.

The pre and postflight testing is interested in the change in perception of motion and alteration of eye movement that occurs in preflight versus that of postflight testing on the individual.

NON-MEDICAL TESTS

Senator Garn is trained in this mission to conduct earth observations, such as, geological and ocean current surveys.

PHASE PARTITIONING EXPERIMENT

Senator Garn will conduct this experiment in the mid deck of *Discovery* and is an experiment involving the first test in space of a separation process called "phase partitioning."

The experiment hardware consists of a hand-held transparent plexiglass container 127 by 91 by 28 millimeters (5 by 3-1/2 by 1-1/8 inches). Inside the container are 15 chambers, each containing a small metal mixing ball and differing quantities of the polymer and water solutions. Blue dye has been added to one of the solutions in 13 of the chambers for better viewing. The solutions in the other two chambers are both clear, but human red blood cells have been added for experimentation purposes as well as for better viewing.

The process uses two solutions of polymers called phases that cannot be mixed. They are dissolved in water and react to one another in a manner similar to oil and water.

When biological material is added to the solutions and shaken, the different biological cells, or macromolecules, attach to another of the solutions or phases and separate, or "partition" with them. Separation is determined by the surface properties of the biological cells interacting with the solutions.

The phase partitioning process is capable of achieving high resolution, or purity, in the separation of biological materials. However, on earth it does not achieve the highest resolution theoretically possible because of gravity-induced fluid flow. The reason for performing the experiment in microgravity is to better understand and control the separation of the solutions both on earth and in space. It may also be possible to obtain separations in space that are unobtainable on earth.

Senator Garn will shake the container and mount it in front of a fluorescent light. He will use a mounted Nikon camera with a close-up lens to photograph the interaction of the solutions.

The experiment will be performed at least twice during the five-day mission. Each run of the experiment will take about 30 minutes of Senator Garn's time over a period of about 90 minutes. About 20 photographs will be taken each time the experiment is performed.

After *Discovery* has landed, the film will be turned over to the investigators for computer analysis and comparison with similar experiments which have been performed on earth.

The phase partitioning experiment is supported by the NASA Office of Space Science and Applications' Microgravity Science and Applications Division. It is managed by NASA's Marshall Space Flight Center in Huntsville, Alabama. Principal investigators are Dr. Donald E. Brooks of the Oregon Health Sciences University in Portland, Oregon and Dr. J. Milton Harris of the University of Alabama in Huntsville, Alabama. Dr. Robert S. Snyder of the Marshall Center's Space Science Laboratory and Dr. James M. Van Alstine, a Universities Space Research Association visiting scientist working at the Marshall Center are co-investigators.

AMERICAN FLIGHT ECHOCARDIOGRAPH

The American Flight Echocardiograph (AFE) will investigate changes to the heart due to spaceflight and upon return to earth.

The echocardiograph utilizes an ultrasonic scanning technique which will be primarily accomplished on Margaret Seddon and on a time available basis on Charles Walker, Jeffrey Hoffman, David Griggs and Senator Garn.

A minimum of four views will be taken of the heart area of the body. The data is recorded on videotape and analyzed on the ground. The AFE is located in a mid-deck locker of *Discovery*.

IMAGE INTENSIFIER

Previous numerous missions have flown low light level photographic equipment using an image intensifier coupled with the standard Nikon camera. The image intensifier intensifies the amount of light which can be used to make photographs by a factor of 10,000. The equipment was originally used to study the skin glow on the orbiter in previous missions.

It occurred that perhaps this equipment could be used for astronomical purposes in future flights, such as viewing Halley's comet and take pictures of Halley's comet from space so that people on earth could study it.

In this mission, the equipment is not used for astronomical observations, but as a demonstration of the equipment which might be usable in the future for this sort of astronomical observations.

The image intensifier camera system will utilize a special window hood arrangement to shield the camera from the ambient light level inside the orbiter crew compartment. Mission Specialist Jeffrey Hoffman will take photographs of extended objects at various distances from the Sun, when the Sun is below the horizon. This would be basically the same situation facing future Space Shuttle flight crews that would try to take pictures of the comet and see what sort of sensitivity levels can be reached.

Other questions of concern are the deposits on the orbiter windows from the solid rocket boosters, how steady can the orbiter hold, and how long of an exposure. Hopefully, the answers to some of these questions can perhaps lead to the ability for future Shuttle flight crews to take pictures of the comet when it comes around.

INFORMAL SCIENCE STUDY
TOYS IN SPACE

The National Science Foundation funded the Informal Science Study in 1980 at the University of Houston to develop science curricula on positive student experiences. Dr. Carolyn Summers, the Museum's Director of Astronomy and Physics is the curriculum writer for this project and directs the Toys in Space program.

Studies have shown that students can learn physic concepts by watching mechanical systems in action. From roller coasters to bouncing balls, mechanics are in motion in the student's world. Through experimentation, students learn to vary one parameter (such as force) and to measure the resulting changes in other parameters (such as acceleration and momentum).

In an earth based classroom, the gravitational field has a constant value of "g." Although the gravity force varies greatly throughout the universe and in non-inertial frames, students can only experiment in a constant one "g" environment.

Through the filming (16mm camera) and video taping (3/4" video tape) of simple generic motion toys in zero "g" in this mission, students of all ages will share a learning experience and discover how the different toy mechanical systems work without the constant tug of gravity and make science more interesting. The results of the toy experiments in space will be made available to school districts around the country through the National Diffusion network.

The flight crew on this mission selected the toys to be carried aboard and demonstrated on their own time during the flight. The ten toys selected were based on the ability of the flight crew to manipulate them in a one "g" environment.

Karol Bobko selected the top and gyroscope. Donald Williams selected a spring-wound flipping mouse, a paddleball and will try juggling. Margaret Rhea Seddon selected a slinky and a ball and jacks. David Griggs selected the yoyo. Jeffrey Hoffman selected magnetic marbles, a spring-wound friction car and a wheelo.

SHUTTLE STUDENT INVOLVEMENT PROGRAM

Two Shuttle Student Involvement Program (SSIP) experiments are carried aboard *Discovery* in the 51-D mission. The two experiments are located in the mid-deck of *Discovery*. One is a Corn Statolith experiment and the other is a Brain Cell experiment.

The Corn Statolith experiment will investigate the effect of weightlessness on the formation of statoliths (a plant cell containing protoplasmic structures of starch grains) in plants. Capped and uncapped corn roots will be exposed to space flight. The corn root caps of flight and control plants will be examined post-flight by electron microscope for statolith changes. The student experimenter is Sean Amberg of Nebraska. His sponsor is Dr. Harold Papazian from Martin Marietta Aerospace.

The Brain Cell experiment consist of 300 houseflies contained in a Fly Enclosure Module located in a mid-deck locker. The experiment is to study the impact of weightlessness in brain cells. It is expected to show accelerated aging of the brain cells based on an increased accumulation of age pigment in, and deterioration of the neurons (the structural and functional unit of the nervous system - consisting of the nerve cell body and all its processes). The student experimenter is Andrew Franz of Binghamton, New York.

Getaway Special (GAS) G-0471 Capillary Pump Loop (CPL) Priming Experiment. This experiment is to study the priming of capillary pumps under zero-g conditions and demonstrate the performance of an isolation wick to prevent liquid drainage in the event of dryout.

Scientific instruments mounted to large advanced orbiting spacecraft, platforms and Space stations will require thermal systems which have high density heat acquisition and transport capability. One such system under development at the Goddard Space Flight Center, Greenbelt, Maryland, is the capillary pumped loop (CPL) which transfers heat from a series of evaporators to condensers, through a liquid pumped by capillary forces. As these pumps rely solely on the small pressure developed by the capillary, they are very sensitive to the effects of gravity.

The experiment consists of a pair of capillary pumps each containing a wick of porous material. The pumps are fed liquid by a reservoir which holds sufficient Freon-11 fluid to saturate the wicks. Liquid drawn from a reservoir is evaporated into vapor at each pump site through the use of heaters. The vapor is transported to an aluminum block located under the GAS canister cover, which acts as a condenser. The condensed liquid is then returned to the reservoir to complete the transport loop. By selectively cycling the heaters, the pumps can be deprimed and reprimed several times during the mission. Thermal dryout can also be reached and the wick isolation elements, located in the manifold connecting the pumps, can be evaluated. Thermistors will monitor temperatures.

The experiment will contain a tape recorder for data collection, a silver zinc battery for power and two electronic boxes for signal conditioning and experiment operations.

The experiment should be turned on within 24 hours after launch to allow the GAS canister top cover (heat sink) to cool down. Using an internally programmed sequencer, heaters on the evaporators will be cycled to evaluate the depriming/repriming and wick isolation functions. The experiment should be left on for at least 60 hours and up to 96 hours if possible. Following this period the experiment will be shut off.

The experiment is in a 0.14 cubic meter (5 cubic feet) GAS canister. It is located in *Discovery's* payload bay on the starboard (right hand) side in bay five.

The payload manager for this experiment is Roy McIntosh of the Goddard Space Flight Center, Greenbelt, Maryland.

Getaway Special (GAS) G-0032 Experiments on Water Ball Collision and Formation of Alloys and Glass Composites. This is a reflight of the same experiment which was flown on mission 41-G which was unsuccessful. The experiment is to study the physics of solids and liquids in zero gravity.

The Asahi National Broadcasting Company, Limited, Tokoyo, Japan, with the cooperation of the Asahi Shimbun Company, Limited Tokoyo, Japan, and Kazuo Fujimoto as the payload manager, intends to make two kinds of experiments in weightlessness. The Getaway Special (GAS) canister is located on the starboard (right) hand side in bay five of *Discovery's* payload bay and is a 0.14 cubic meter (5 cubic feet) canister.

One experiment is designed to provide clear-cut answers to the following questions: While water in weightlessness minimizes its surface area by assuming a spherical shape, what kind of behavior does the water ball take when hit by a metal ball? And how does this phenomena change with the varying speed of the metal ball? The experiments are very simple but no one has provided clear cut answers to these questions. The experiments are to recorded on videotape by means of CCTV color cameras.

The other experiment is designed to produce five kinds of new materials simultaneously in the void of space which has an ideal environmental condition for producing new alloys and in which only a few experiments have already been made and will further be made on similar subjects. This experiment contains five small electrical furnaces and is expected to form crystals of three metal alloys and two glass composites.

STS MISSION 41C (STS-13) SUMMARY

Major objectives of the STS 41-C mission were to successfully deploy the Long Duration Exposure Facility (LDEF) and retrieve, repair and redeploy the Solar Maximum Mission (SMM) spacecraft and IMAX and Cinema 360 camera photography.

The overall performance of *Challenger* during the 41-C mission was satisfactory and the 41-C flight crew completed all 25 objectives during the mission, a completion rate of 100 percent.

The STS 41-C flight was launched on April 6, 1984 at 13:57:59.999 G.M.T. (8:57:59.999 a.m. E.S.T.) at Kennedy Space Center, Florida; and landed at Edwards Air Force Base, California, on April 13, 1984, at 13:38:07 G.M.T. (5:38:07 a.m. P.S.T.). This flight was scheduled as a six day mission, but due to retrieval problems with Solar Maximum Mission (SMM) satellite during flight day three operations, the mission was extended one day for a total of seven days. Also, this flight was scheduled to land at the Kennedy Space Center Shuttle Landing Facility, Florida; however, the possibility of adverse weather (rain), resulted in the decision to land *Challenger* at Edwards Air Force Base, California.

The flight crew members were Robert L. Crippen, commander, Frances R. Scobee, pilot, and Terry J. Hart, James D. van Hoften, and George D. Nelson, mission specialists. George D. Nelson and James D. van Hoften were the two extravehicular activity (EVA) astronauts.

The ascent phase was nominal in all respects, as was Solid Rocket Booster (SRB) and External Tank (ET) separation as well as the single Orbital Maneuvering System (OMS) maneuver that placed *Challenger* in the 252 by 137 nautical mile (290 by 157 statute mile) elliptical orbit. The SRB's were recovered along with their parachutes although one main parachute did not open fully. The ET was tracked and impacted within the planned Hawaii footprint.

During prelaunch operations, a multiplexer/demultiplexer (MDM) on *Challenger* failed and was removed and replaced and operated satisfactorily throughout the mission.

Flight day one progressed satisfactorily with the exception of the gas generator valve module (GGVM) temperature on all three Auxiliary Power Units (APU's) which had a short duration drop in temperature during ascent. The first maneuver of the rendezvous sequence, Normal Corrective (NC)-1 phasing maneuver with SMM was successfully performed about five hours into the flight. The optional plane change maneuver was not required. The Remote Manipulator System (RMS) and the LDEF systems were checked out during this day.

Early on the second day of the flight, two rendezvous maneuvers, Normal Height (NH)-1 adjust maneuver and Normal Slow Rate (NSR) coelliptic maneuver, scheduled for this day were completed. The second maneuver placed the *Challenger* in a 259 by 256 nautical mile (298 by 294 statute mile) orbit. About 24 hours into the flight, activation of the LDEF for deployment was initiated. In the following four hours, two objectives with the RMS and LDEF were accomplished and the LDEF was released at 17:19:27 G.M.T. The cabin pressure was lowered to 10.2 psia in preparation for the EVA that was to be conducted on day three following SMM rendezvous. Because of a procedural error in the prebreathing protocol with the EVA suits, the cabin was repressurized to 14.7 psia and depressurized again to the 10.2 psia level to insure that the required prebreathing was accomplished prior to the EVA. All subsystems in the crew cabin area functioned satisfactorily during the extended period of low pressure.

Following rendezvous with SMM on the third day of the flight, George Nelson and James van Hoften in their Extravehicular Mobility Units (EMU's) depressurized the airlock and egressed the airlock and began preparations for SMM spacecraft retrieval. George Nelson in the Manned Maneuvering Unit (MMU) translated from *Challenger* to SMM. His attempts to dock with SMM were unsuccessful because the jaws of the Trunnion Pin Attachment Device (TPAD) would not release and permit the soft dock of the TPAD to the SMM spacecraft trunnion pin. Using the MMU, Nelson moved to the SMM spacecraft solar wing and held on to a solar wing in an attempt to slow SMM rotation so that SMM could be grappled by the RMS on *Challenger*, but this procedure was also unsuccessful. At this time, Nelson returned to *Challenger's* payload bay. Additional attempts were made by using the RMS to grapple SMM, but these were also unsuccessful. The EVA was terminated as well as attempts to retrieve SMM were terminated and *Challenger* performed a separation maneuver to allow the SMM spacecraft to stabilize.

The fourth day was a replanning day for the re-rendezvous and recovery of the SMM. Planning during this fourth day also included a one-day extension to the mission, if the second attempt to capture the SMM was successful. Because of the extensive station keeping and maneuvering performed in attempting to retrieve the SMM, the forward Reaction Control System (RCS) had only 22 percent propellant remaining after the first rendezvous activity. As a result, the re-rendezvous was delayed until the fifth day because the propellant usage would be significantly less since the SMM would be in a more advantageous orbital position with respect to *Challenger*.

Early on the fifth day, the rendezvous maneuvers were begun. A minimum amount of propellant was used to reach the station keeping position from where grappling could begin with the RMS. The first grapple attempt was successful in capturing the SMM. SMM was then placed in the SMM Flight Support Structure (FSS) in *Challenger's* payload bay and SMM was locked in place for the repairs that were to be conducted on the sixth day.

The EVA on the sixth day was successful with Nelson and van Hoften completing all repair activities in less than four hours. Due to the shorter than planned time required for SMM repair, van Hoften was given permission to conduct a performance evaluation of the second MMU. The second MMU evaluation was successfully evaluated and completed and the second EVA was completed in six hours and 16 minutes. Using the RMS, the SMM spacecraft was raised from the FSS and held above *Challenger's* payload bay so a complete checkout of SMM could be completed. Tests of SMM showed that the repairs on SMM were successful in restoring SMM to full operational capability.

Original planning for this mission included a reboost of the SMM spacecraft orbit to about 285 nautical miles (327 statute miles) circular orbit. Since *Challenger's* propellant was becoming a critical consumable, and since SMM extended mission life was not a high priority item, the reboost of SMM was cancelled, resulting in SMM operating in about a 270 nautical mile (310 statute mile) circular orbit.

Upon release of SMM in its planned attitude, *Challenger* remained nearby until the overall condition of SMM could be determined by engineers at NASA's Goddard Space Flight Center. The extensive tests showed that SMM was operating properly and SMM was released and *Challenger* separated from SMM. The flight crew then began final stowage for entry.

All preparations for entry were completed and the flight crew were making final preparations for the deorbit maneuver when ground controllers made a decision to delay entry one orbit because of unsatisfactory weather that was headed toward the Shuttle Landing Facility area at Kennedy Space Center. Further weather evaluations lead to the decision to land at Edwards Air Force Base where the weather was ideal.

The descent was flown as planned with only one PTI (programmed test input) not being performed. This was expected based on the trajectory flown for entry and landing at Edwards Air Force Base. All other aspects of entry were as planned and after a 249-degree heading alignment circle maneuver, *Challenger* touched down at 13:38:07 G.M.T. (5:38:07 a.m. PS.T.) on lakebed runway 17.

The Long Duration Exposure Facility (LDEF) contained 57 individual science and technology experiments. It is approximately 4.2 meters (14 feet) in diameter and 9.1 meters (30 feet) long, and weighs approximately 3,628 kilograms (8,000 pounds). The LDEF was successfully deployed on STS 41-C, and will be retrieved from its gravity-gradient stabilized attitude on a future Space Shuttle mission.

The LDEF unberthing and deployment operations on day two went as planned. The LDEF was deployed on time and the crew reported no observable rates at deployment. A preliminary film review shows that the LDEF rates at deployment were at least four times less than the maximum allowable rate of 0.025 degrees per second. After deployment, the separation maneuver was performed by *Challenger* and the flight crew confirmed the separation rate with radar. The flight crew also reported that the view of the LDEF trunnion pins and berthing guides using the closed circuit television (CCTV) system was not satisfactory, and they expressed some concern about the use of the CCTV system during the LDEF retrieval mission.

FIRST RENDEZVOUS. The first star tracker (ST) navigation pass began at a range of approximately 105 nautical miles (115 statute miles) and ended at approximately 88 nautical miles (101 statute miles). The target was bright enough to be seen visually early in the pass, and could be seen in the Crewman Optical Alignment Sight (COAS) at approximately 100 nautical miles (115 statute miles). The two ground computed maneuvers, Normal Corrective (NC) and Normal Height (NH), were executed with small residuals. The second star tracker (ST) pass ranged from 53 to 48 nautical miles (60 to 55 statute miles). The star tracker (ST) initially locked onto a star. The flight crew recognized this situation, broke lock and then the star tracker (ST) tracked the target successfully. During this tracking period, noisy behavior was noted within the star tracker (ST). Postflight data analysis showed that the source of the noise was not the star tracker as originally suspected. The tracking anamolies were correlated to the inertial measurement unit (IMU) redundancy management (RM) software. The radar acquired the target prior to Terminal Initiation (TI) at a range of 17 nautical miles (19 statute miles).

Due to the abnormal star tracker behavior noted during the second star tracker pass, radar angles were incorporated instead of star tracker angles for the post-TI navigation interval. All Midcourse Corrections (MC) were small as expected. The rendezvous was successfully flown manually following the MC4 maneuver to within 60 meters (200 feet) of the target and station keeping was initiated.

SECOND RENDEZVOUS. The first ground-computer maneuver, normal corrective (NC) phasing maneuver for the second rendezvous was executed at a range of 54 nautical miles (62 statute miles).

The first star tracker pass occurred after the NC maneuver at a range between 56 and 53 nautical miles (64 and 60 statute miles). The second star tracker pass began on the next revolution. The position updates were consistently less than 60 meters (200 feet) throughout the period. Star tracker behavior was normal.

The Normal Corrective Combination (NCC) maneuver solutions were computed before, during, and after the second star tracker pass. All solutions agreed within mission limits and the final NCC maneuver solution was executed.

The radar locked on at about 18 nautical miles (20 statute miles). All midcourse corrections were small as expected. Manual procedures began after the MC4 maneuver and target station keeping was successfully achieved.

EXTRAVEHICULAR ACTIVITY. Two periods of EVA were planned and completed during STS 41-C. The first EVA was planned to capture and stabilize the SMM using the MMU.

All preparations for this first EVA went as planned and the EVA was initiated by the two crew members at about 14:18 G.M.T.

The donning of the starboard-side MMU and the translation to the SMM spacecraft by Nelson all progressed as planned. The docking sequence was initiated, but the TPAD would not fire to capture the SMM trunnion pin. Nelson made numerous unsuccessful attempts and as an alternate procedure, Nelson held onto one of the solar wings in an attempt to stabilize the SMM. This action increased the instability of the SMM. As a result, the decision was made to terminate the EVA. The first EVA lasted two hours and 57 minutes, and the starboard-side MMU was flown for 42 minutes during this EVA.

After the successful retrieval and berthing of the SMM, plans for the second EVA were solidified. The crew preparations proceeded smoothly and the crew exited the airlock at 08:58 G.M.T., over an hour ahead of schedule. Nelson and van Hoften proceeded directly to the SMM, repair activity was completed, and van Hoften was given permission to conduct an MMU performance evaluation in *Challenger's* payload bay, using the port-side MMU.

Before departing the SMM, Nelson and van Hoften took measurements of the SMM trunnion pin and adjacent equipment, using a tape measure. All equipment and tools used during the repair activity operated satisfactorily.

The port-side MMU operated satisfactorily during all tests; however, some difficulty was experienced in docking the MMU with its stowage station. The port-side MMU was flown for 28 minutes during the second EVA. The overall performance of the MMU's during both EVA's was flawless. After the MMU evaluation was completed, Nelson and van Hoften removed a cover from an instrument on the SMM and entered the airlock. The second EVA lasted six hours and 16 minutes.

IMAX CAMERA. The IMAX 70mm camera was operated by the flight crew in *Challenger's* crew cabin. The system had four interchangeable lenses and nine 304 meter (1,000 feet) film magazines. The flight crew had no difficulty operating the camera or in changing film magazines or lenses. All film was exposed and IMAX personnel reported that 75 to 80 percent of the film was studio usable. The flight crew experienced some temporary difficulty with the voice recorder that was used in conjunction with the camera, but they were able to repair the recorder.

CINEMA 360 CAMERA. The Cinema 360 camera in the payload bay was an Arriflex 35mm camera which used a 304 meter (1,000 foot) magazine and was mounted in a modified GAS (getaway special) canister. The modified GAS canister had a precision-machined lid that housed a quartz dome for the fisheye lens to look through, and electronics that allowed the flight crew to remotely change f-stop, frame rate, plus operate the camera. This camera was used to capture footage of EVA's, payload deployment, and RMS operations. The camera was controlled with the APC (autonomous payload controller) and all film was exposed as planned. The Cinema 360 personnel were extremely pleased with the results.

BEE EXPERIMENT. A student-sponsored bee experiment was successfully flown. The flight crew observed some initial bee disorientation during the first orbital day; however, the bees then settled and were able to walk, fly, and float with no apparent difficulty. A similar period of disorientation was also observed after entry.

The bees built approximately 193 centimeters squared (30 square inches) of honeycomb while on orbit and the queen bee laid approximately 35 eggs. The initial inspection showed that the honeycomb was normal; i.e., the same as would be produced under one-g conditions. Only 120 bees (3-1/2 percent of the population) died during the flight and that is less than expected.

The bees apparently worked well under zero-g conditions and films show that they are able to fly faster in the weightless condition. Further analysis by the experimenter is continuing.

SOLID ROCKET BOOSTERS. The SRB aft skirt shoe shim material on the south posts remained intact; however, the north post shims were missing and eroded by the flame impingement. This condition has been observed on previous flights.

The performance of the solid rocket motors (SRM's) was near predicted levels and well within the specification limits. Quick-look evaluation shows that head pressures and propellant burn rates were slightly greater than predicted for both motors. The separation time for the SRB's was approximately 1.4 seconds earlier than predicted. Operation of both SRB thrust vector control (TVC) systems was satisfactory and no anomalies were experienced. Thrust imbalance between the SRB's was within specification throughout the ascent phase.

The left-hand SRB range safety system channel A signal strength dropped to one volt at lift-off plus one minute 15 seconds for five seconds and then returned to saturation for the remainder of the flight. An investigation is underway to determine if this condition is due to some part in the measuring system or to the range safety system hardware.

Chase plane video and photographic coverage showed that one main parachute on the right-hand SRB failed to inflate and indicated normal parachutes on the left-hand SRB. All parachutes were recovered and the postflight inspection revealed the following: right-hand main parachute serial number 4030 failed in gore 47 from horizontal ribbon 24 through the vent band; left-hand drogue parachute serial number 3006 severely damaged in gore 49 and other surrounding material, apparently from SRM hot propellant debris; and left-hand main parachute serial number 4027 failed all horizontal ribbons in gore 18 (skirt band, vent band intact). An investigation team has been established to determine the cause of these anomalies. Flashing lights and RF beacons performed normally.

EXTERNAL TANK. The ET performance was excellent. During liquid hydrogen reduced flow prior to topping, the primary 100-percent number one level sensor measurement circuit erroneously indicated wet. The measurement indicated wet for 36 minutes and then returned to a dry state. The measurement operation was normal throughout the remainder of the loading.

All prelaunch requirements were met with no launch commit criteria (LCC) violations. ET separation and entry were as predicted, tumble was confirmed, and impact was within the footprint. The entry of the ET could be seen from Hawaii.

The prelaunch thermal environment was as expected. The thermal protection system (TPS) experienced ony minor ice/frost buildup in areas that had approved waivers prior to flight.

SPACE SHUTTLE MAIN ENGINE/MAIN PROPULSION SYSTEM. All prelaunch countdown and mainstage main engine flight data looked very good. The high-pressure oxidizer and fuel turbo-pump turbine discharge temperatures compared favorably with predicted values. Space Shuttle Main Engine (SSME) start, cutoff and propellant dump appeared to be normal. No problems were encountered throughout the flight. Performance during mainstage appeared satisfactory.

Overall ascent performance was satisfactory. During maximum dynamic pressure (max q), the SSME's throttled down to about 67 percent compared to the predicted 71 percent. The lower-than-predicted throttle level indicates higher-than-predicted SRB impulse delivered during the first 20 seconds of flight.

Engine operation and pe·formance during mainstage appeared satisfactory. During steady-state performance, ET/ORB, (Orbiter) pressures and temperatures and ORB/SSME pressures and temperatures satisfied interface requirements. Quick-look mixture ratio and thrust values from the flight indicate repeatable engine performance.

The liquid hydrogen two-percent liquid-level sensor tripped at about MECO (main engine cutoff), and the liquid oxygen engine cutoff sensors tripped as expected. A velocity cutoff was achieved. MECO occurred at approximately 511 seconds compared to a predicted time of 510 seconds.

41C (STS-13) TIMELINE

DAY OF YEAR	GMT* HR:MIN:SEC	EVENT
97	13:53:07	APU-1 activation
	13:53:07	APU-2 activation
	13:53:08	APU-3 activation
	13:57:32	SRB HPU activation
	13:57:53.4	MPS - start (Engine 3)
	13:57:59.999	SRB ignition command from GPC (lift-off)
	13:58:25.8	Initiate throttle down to 67 percent thrust for max q (Engine 3)
	13:58:50.5	Max q
	13:58:57.6	Initiate throttle up to 104 percent thrust (Engine 3)
	14:00:06	SRB separation initiation
	14:05:30.4	Throttle down for 3 "g" acceleration (Engine 3)
	14:06:31.2	MECO (main engine cutoff) command
	14:06:49.3	ET separation
	14:10:11	APU deactivation (3)
	14:40:54.1	OMS-2 engine ignition
	14:42:29.3	OMS-2 engine cutoff
98	17:19:27	Long duration exposure facility (LDEF) deploy
99	14:18	Start first extravehicular activity (EVA)

DAY OF YEAR	GMT* HR:MIN:SEC	EVENT
	17:15	End first EVA
101	13:52:20	Solar Maximum Mission Spacecraft grapple
102	08:58	Start second EVA
	15:14	End second EVA
103	09:26:29	Solar Maximum Mission Spacecraft release
	13:53:29	OPS-8 Flight Control System checkout
104	12:24:33	APU-1 activation
	12:29:30.3	Deorbit OMS engine ignition
	12:33:32.8	Deorbit OMS engine cutoff
	12:54:58	APU-2 and APU-3 activation
	13:07:51.6	Entry Interface
	13:24:12	End blackout
	13:31:54.5	TAEM
	13:38:07	Main landing gear contact
	13:38:23	Nose landing gear contact
	13:38:55	Wheels stop
	13:51:16	APU deactivation complete

*GMT - Subtract 5 hours for EST
6 hours for CST
7 hours for MST
8 hours for PST

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41D (STS-14) SUMMARY

The major objectives of the STS-41D mission were to successfully deploy the SYNCOM IV-2 (LEASAT), AT&T TELSTAR 3-C and Satellite Business System (SBS)-D satellites; operate the Office of Aeronautics and Space Technology (OAST)-1 Solar Array experiment; the Continuous Flow Electrophoresis System (CFES) III experiment; the IMAX camera and the Radiation Monitoring Equipment (RME). All 15 of the planned detailed test objectives were successfully accomplished.

The STS-41D mission, the first for *Discovery*, OV-103, was scheduled for launch on June 25, 1984, and June 26, 1984, and August 29, 1984. The attempted launch on June 25, 1984, was scrubbed because General Purpose Computer (GPC) number five, which contained the backup flight software, exhibited two memory parity errors at T-32 minutes. At T-20 minutes, the launch was scrubbed because the problem, which was subsequently diagnosed as contamination of an integrated circuit, could not be corrected without hardware removal and replacement.

The launch was rescheduled for June 26, 1984, and all aspects of the countdown were nominal until T-4 seconds when irregular operation of the main fuel valve on Space Shuttle Main Engine (SSME) number three resulted in an engine shutdown (abort) condition, which resulted in the safing of all vehicle systems as designed. As a result of the abort, the decision was made to roll the vehicle back to the Vehicle Assembly Building (VAB) and remanifest the mission, combining the payloads from 41F with 41D. A new launch date of August 29, 1984, was established. However, the launch was delayed for 24 hours because of a timing problem between the flight software and the Master Events Controllers (MEC's). Tests showed that under certain worst case timing conditions, the MEC's would not process certain critical event commands and, as a result could prevent separation of the Solid Rocket Boosters (SRB's) and External Tank (ET) as well as other vital operations. A software patch was developed, tested, and incorporated in *Discovery's* computer software to work around the timing problem, and allow the launch to proceed on August 30.

The final countdown again proceeded very smoothly for the planned launch at 8:35 a.m. EDT. However, the launch was delayed six minutes and 50 seconds at T-9 minutes because of a problem with the ground launch sequencer and two private aircraft that were flying in the restricted area for launch operations. Lift-off occurred at 243:12:41:50 G.M.T. from Launch Complex 39A at Kennedy Space Center (KSC) on August 30, 1984, and the mission was successfully concluded with a landing at Edwards Air Force Base (AFB), lakebed runway 17 at 249:13:37:54 G.M.T. on September 5, 1984.

The crew for this flight was Henry W. Hartsfield, Jr., Commander; Michael L. Coats, Pilot; Steven A. Hawley, Richard M. Mullane, and Judith A. Resnik, Mission Specialists; and Charles D. Walker, Payload Specialist from McDonnell Douglas Corporation, St. Louis, Missouri.

The ascent phase was normal in all respects. The SRB head pressures and burn rates were normal with SRB separation occurring within 0.14 second of the predicted. Main Propulsion System (MPS) and engine performance were as predicted with all thrust values indicating repeatable performance. Main Engine Cutoff (MECO) occurred 0.3 second earlier than predicted. The orbital parameters at MECO were as predicted. The Orbital Maneuvering System (OMS)-1 and 2 thrusting maneuvers placed the vehicle in a near circular orbit at 160 nautical miles (184 statute miles).

The first day of STS-41D mission was very successful. The deployment of the SBS-D satellite was completed very smoothly and the 87-second firing of the Payload Assist Module (PAM) motor was completed satisfactorily. The failures that occurred the first day were minor and had no impact on the flight. The most significant failures were that Cathode Ray Tube (CRT)-2 went blank and Fuel Cell one cell performance monitor ceased operating. The Inflight Maintenance (IFM) procedure for placing CRT-4 in the CRT-2 position was performed on the fourth day. As a result of the fuel cell one performance monitor failure, main bus A and B were tied together during on-orbit operations so that fuel cell one and two performance could be compared.

The second day of the STS-41D mission was satisfactory with no new Orbiter anomalies defined during the period. Payload deployment activities were nominal. The SYNCOM IV-2 satellite was successfully deployed using a technique referred to as a "frisbee deploy." Also, SYNCOM IV-2 was the first satellite specifically designed to fly on Space Shuttle. All planned testing for the second day was satisfactorily completed.

The third day of the STS-41D mission proceeded very smoothly with no new Orbiter anomalies or problems defined during this period. All Orbiter subsystems continued to operate satisfactorily. Deployment of the third satellite, TELSTAR 3-C, as well as its perigee burn, were completed satisfactorily. Postflight reports of the three deployed satellites indicate all three are on station in the desired geosynchronous orbit. The OAST-1 Solar Array Experiment operations were successful with the array deployed to 70 percent for dynamic tests.

The fourth day of the STS-41D was completed successfully. All planned payload activities were accomplished and damping tests of the 100-percent deployed solar array produced better than predicted results, thus allowing shopping list items to be accomplished in addition to the planned items.

As a result of the data review of the supply water dump at approximately 68 hours Mission Elapsed Time (MET), it was determined that ice had formed around the supply dump nozzle. There also were indications that ice had formed around the waste water dump nozzle, but it was believed that the ice did not remain. The Remote Manipulator System (RMS) was deployed and the RMS TV showed a large column of ice over the supply nozzle. A waste dump was attempted with TV coverage; ice buildup was observed and the waste dump was terminated.

The fifth day of the STS-41D mission was completed with all Orbiter subsystems and experiment systems operating satisfactorily, but a major concern existed over the ice formation on the supply and waste dump nozzles. A TV scan showed that the amount of ice was considerably less than the amount observed about 24 hours earlier. Primary Reaction Control System (PRCS) thrusters were thrusted in an unsuccessful attempt to dislodge the ice. The cabin was depressurized from 14.7 to 10.2 psia to provide for a potential contingency Extravehicular Activity (EVA) in the event the RMS operation was unsuccessful in removing the ice. Subsequently, early on the sixth day, the RMS was used to remove the ice from the supply dump nozzle, but the ice still remained on the waste dump nozzle. The cabin was repressurized to 14.7 psia. A subsequent TV survey of the dump nozzles after extended sun exposure and repeated nozzle heater cycles showed that the remaining ice was essentially gone.

All planned OAST-1 activities were completed and the solar array was retracted and, locked down. The crew completed the flight control system checkout using Auxiliary Power Unit (APU)-2 satisfactorily. Final activities with the CFES were ended just prior to the final sleep period with 85 percent of the samples processed.

The crew was awakened early on entry day because of an oxygen leak about 13 kilograms per hour (30 pounds per hour) in the Environmental Control and Life Support System (ECLSS). The crew performed the necessary malfunction procedures and were able to isolate the leak and stop the flow of oxygen to that point. This leak did not impact the entry day activities, but did cause the loss of redundancy in that system.

The crew completed all activities required for entry and performed the deorbit maneuver at 249:12:36:20.2 G.M.T. The entry was normal and all Programmed Test Input (PTI) maneuvers were performed. After completing the Heading Alignment Circle (HAC) turn angle of 251 degrees, the Orbiter was guided to a landing at Edwards AFB. Rollout required approximately 3,130 meters (10,270 feet). An inspection after landing revealed the right main gear strut had lost its pressure, a condition that caused the Orbiter to pull to the right after nose gear touchdown. The STS-41D mission was successfully concluded at 249:13:38:54 G.M.T., when the Orbiter came to a stop on Edwards AFB lakebed runway 17.

SYNCOM-IV-2. The SYNCOM-IV-2 satellite was deployed at 244:13:16:27 G.M.T. within one second of the planned time. This SYNCOM-IV-2 satellite was the first that was specifically designed to fly on the Space Transportation System. Also, the deployment technique, named "frisbee deploy," was different from that used on previous satellites. The RMS TV was again used to monitor the successful perigee motor firing. All major planned maneuvers were successfully completed and the satellite is on station at 105 degrees West longitude. The Ultra High Frequency (UHF) antennas were deployed and checkout of the satellite is in progress. All aspects of the Orbiter operation for this deployment were normal.

TELSTAR 3-C. The TELSTAR 3-C satellite was deployed at 245:13:25:52 G.M.T., again within one second of the planned time. The satellite is now in geosynchronous orbit with all major maneuvers completed. The satellite is in good health with all antennas and solar panels deployed, and the initial checkout has begun. All Orbiter systems operations in conjunction with the deployment were normal.

Continuous Flow Electrophoresis System (CFES)-III. The CFES operations were satisfactory; however, only 85-percent of the samples were processed. The CFES shut down during the crew's first sleep period, but sample operations were successfully restarted on day two. In addition, the CFES had two instrumentation failures, and two faulty carrier degassers (one was replaced using inflight maintenance procedures and the second was replaced by a plumbing change which moved the degasser on the anode side functionally to the cathode side). Also, operations during the change from 14.7 to the 10.2 psia cabin pressure on day five caused a shutdown. These problems resulted in the less than 100-percent completion of sample processing. Orbiter system operations, other than the change in cabin pressure, were normal and had no impact on CFES operations.

Office of Aeronautics and Space Technology (OAST)-1 Solar Array Experiment. The OAST-1 solar array experiment performance was excellent with tests from the shopping list being completed in addition to the planned tests. The solar array extensions and retractions to both 70-percent and 100-percent were successful. The dynamics test at 70-percent and 100-percent extension provided good data and indicated that the deflections were less than expected due to the damping characteristics of the array. The dynamic augmentation tests at both extension positions were also successful. The solar cell calibration facility testing was satisfactorily completed. Also, on the final day of array operations, four dynamic tests at 70-percent extension and 150-percent of the excitation pulse used previously were successfully completed.

Radiation Monitoring Equipment (RME). The hand-held radiation monitor and the pocket RME meter were operated as planned during the mission. The hand-held device was operated four times and the pocket device was operated for two periods as planned.

Cloud Photography Experiment. The cloud photography equipment operations were nominal. Over 450 photographs of excellent quality were taken of clouds.

IMAX 70 mm Camera. The IMAX camera and voice recorder were used to document operations with the OAST-1 solar array experiment, and photograph crew and payload bay activities. A total of two magazines and six rolls of film were exposed during the mission. The camera jammed during photography of the SYNCOM IV-2 deployment activities, but the crew was able to clear the jam and continue using the camera for the remainder of the mission. One of the floodlights failed during in-cabin photography. The resulting photography, based on reduced lighting, was grainier than expected, but was acceptable.

Student Experiment. The student experiment, Indium Crystal Growth, operations were less than desired because of a power and display problem. This problem caused early terminations of data collection activities, resulting in only two hours operation out of the six hours planned. The crew provided live Closed Circuit Television (CCTV) coverage and an excellent narration of experiment activities. This experiment did result in the first ever heavy-metal single crystal growth from a float zone melt.

Solid Rocket Booster (SRB). All SRB systems performed as expected. The SRB prelaunch countdown was nominal with no problems noted. Performance of both Solid Rocket Motors (SRM's) was near predicted values and well within the allowed envelopes. Head pressures and propellant burn rates were as predicted. Thrust imbalance was within specification throughout SRB operation. Preliminary indications are that the SRB's separated approximately 0.14-second earlier than predicted.

The SRB recovery system operated nominally, with both SRB's reported to be floating in the normal manner approximately 2.4 miles apart. Reports from the recovery ships indicated that all main parachutes deployed. Both frustums were recovered, and also all parachutes were recovered and had only minimal damage.

External Tank (ET). All ET systems performed as expected. No Thermal Protection System (TPS) anomalies were observed. Normal icing was reported in the waived areas, and no acreage ice was reported. The only problem reported was the continued failure of the two nose cone temperature sensors that had failed on the earlier launch attempts. This problem had no effect on ET performance. All ullage pressure transducers were in the normal operating band throughout prepressurization and the flight. After separation, the tumble was noted on tracking radars, and the impact was within the planned footprint.

Space Shuttle Main Engine (SSME). All SSME parameters appeared nominal during the prelaunch countdown and compared well with prelaunch parameters that were observed during the previous STS-41D launch abort on June 26, 1984.

All valves functioned satisfactorily, meeting the newly adopted Launch Commit Criteria (LCC). Performance at start, mainstage, shutdown and propellant dump was satisfactory. The initial thrust buildup of main engine three, although within specification, was slower than desired. High Pressure Fuel Turbopump (HPFTP) and High Pressure Oxidizer Turbopump (HPOTP) temperatures appeared to be very close to predictions. There were no anomalies identified.

Main Propulsion System (MPS). Overall performance of the MPS was excellent, both during prelaunch operations and the abort. Liquid oxygen and liquid hydrogen loading was accomplished as planned with no stop flows or reverts. Propellent loads were near the predicted values. There were no hazardous gas leaks of any significance.

The engine start buildups and transitions to mainstage were within specifications. Engine operation and performance during mainstage appeared satisfactory. During steady state performance, ET/Orbiter pressures and temperatures and

Orbiter/SSME pressures and ratio and thrust values from the flight indicate repeatable engine performance. Power level throttling operation appeared normal. Engine shutdown was satisfactory. MECO occurred approximately 0.3 second earlier than predicted.

41D (STS-14) TIMELINE

Day of Year	G.M.T.* HR:Min:Sec	Event
243	12:36:58	APU (Auxiliary Power Unit) No. 1 activation
	12:36:59	APU No. 2 activation
	12:37:00	APU No. 3 activation
	12:41:22.29	Solid Rocket Booster (SRB) Hydraulic Power Unit (HPU) activation command
	12:41:43.43	Main Propulsion System (MPS) start command
	12:41:50	SRB ignition command from General Purpose Computer (GPC) liftoff
	12:42:09.14	Main engine throttle down command to 84 percent thrust
	12:42:20.02	Main engine throttle down command to 65 percent thrust
	12:42:40	Maximum dynamic pressure (max q)
	12:42:57.62	Main engine throttle up command to 104 percent thrust
	12:43:54.5	SRB separation command
	12:49:28.80	Main engine throttle down command for 3 "g" acceleration
	12:50:25.2	Main Engine Cutoff (MECO) command
	12:50:43.8	External Tank (ET) separation
	12:52:25.5	Orbital Maneuvering System (OMS)-1 ignition
	12:54:59.1	OMS-1 cutoff
	12:56:10	APU-1 deactivation
	12:56:11	APU-2 deactivation
	12:56:12	APU-3 deactivation
	13:26:39.7	OMS-2 ignition
	13:28:45.9	OMS-2 cutoff
	20:40:18	Satellite Business System (SBS)-D deploy

Day of Year	G.M.T.* HR:Min:Sec	Event
	20:55:18	OMS-3 ignition
	20:55:31	OMS-3 cutoff
244	13:16:27	SYNCOM IV-2 deploy
	13:31:26	OMS-4 ignition
	13:31:35	OMS-4 cutoff
245	13:25:52	Telstar-3-C deploy
	13:39:38	OMS-5 ignition
	13:39:50	OMS-5 cutoff
	15:13:25	OMS-6 ignition
	15:13:46	OMS-6 cutoff
248	11:41:45	OPS-8 Flight Control System (FCS) checkout and APU-2 activation
	11:45:00	APU-2 deactivation
249	12;31:22	APU-3 activation
	12:36:20.2	Deorbit maneuver ignition
	12:39:07	Deorbit maneuver cutoff
	12:54:05	APU-1 activation
	12:54:06	APU-2 activation
	13:07:03	Entry interface
	13:26;33	End blackout
	13:31:19.3	Terminal Area Energy Management (TAEM)
	13:37:54	Main landing gear contact
	13:38:08	Nose landing gear contact
	13:38:54	Wheels stop
	14:00:02	APU deactivation complete

*G.M.T.—Subtract 4 hours for EDT
5 hours for CDT
6 hours for MDT
7 hours for PDT

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41G (STS-17) SUMMARY

The major objectives of the 41G mission were to successfully deploy the Earth Radiation Budget Satellite (ERBS), and to conduct operations of the Office of Space and Terrestrial Applications (OSTA)-3 experiments; Large Format Camera (LFC), Orbital Refueling System (ORS), Canadian experiments (CANEX) and the IMAX camera. All 14 detailed test objectives, as well as 11 supplementary test objectives were successfully accomplished. OAST-3 experiments, with exception of only partial success on the Shuttle Imaging Radar (SIR)-B, were successfully completed.

Liftoff of *Challenger* on its sixth flight occurred at 279:11:03 G.M.T. from Launch Complex 39A at Kennedy Space Center on October 5, 1984, and the mission was successfully concluded with a landing at Kennedy Space Center runway 33 at 287:16:26:33 G.M.T. on October 13, 1984.

The crew for this flight were Robert L. Crippen, Commander; Jon A. McBride, Pilot; Sally K. Ride, Kathryn D. Sullivan, and David C. Leetsma, Mission Specialists; Paul D. Scully-Power, Payload Specialist; and Marc Garneau, Canadian Payload Specialist.

The ascent phase was normal in all respects; however, on orbit the crew reported that a section of felt reusable surface insulation (FRSI) was missing from the starboard Orbital Maneuvering System (OMS)/Reaction Control System (RCS) pod, and some thermal protection system (TPS) tiles had minor damage. The loss and damage did not impact the mission. All other Orbiter subsystems performed satisfactorily during ascent.

The Solid Rocket Boosters (SRB's) performed satisfactorily. The propellant burn rates were essentially as predicted and a satisfactory SRB separation occurred 0.27 second later than predicted. The external tank subsystems performed as expected and no TPS anomalies were observed. The Main Propulsion System (MPS) performance was excellent with main engine cutoff (MECO) occurring at the predicted time.

The first day of the STS-41G mission was very active. The ERBS (Earth Radiation Budget Satellite) was released about two hours 50 minutes later than planned because the solar array on the satellite did not deploy when commanded. After exposure to the Sun, the solar arrays deployed, and the satellite was released in a very stable attitude with rates of less than 0.01 degree per second. Primary Reaction Control System (PRCS) thruster R3R (right yaw) was automatically deselected at 279:11:26 G.M.T. The thruster remained deselected for the remainder of the mission. At 279:23:54 G.M.T., a Ku-band antenna bypass message was noted and, coincident with this message, the Ku-band Radio Frequency (RF), power went to zero. The Ku-band power cable in Avionics Bay 3A in the aft middeck of the crew compartment was disconnected to remove all Ku-band antenna drive signals and leave the antenna in a selected position. The Orbiter was then maneuvered to aim the antenna at the Tracking and Data Relay Satellite (TDRS).

STS-41G activities during the second day included performing troubleshooting and inflight maintenance procedures on the Ku-band and SIR-B antennas, in addition to the planned payload activities.

The difficulties in refolding and latching the SIR-B antenna delayed the OMS-3 maneuver. The Remote Manipulator System (RMS) arm end effector was used to push the outer antenna leaf into position so it could be latched.

Orbital Refueling System (ORS) transfer number one was successfully completed with 31 kilograms (70 pounds) of hydrazine transferred in approximately 25 minutes. Review of available data indicates that the ORS performed nominally.

STS-41G activities during the third day included successful data dumps from the High Data Rate Recorder (HDRR) through the Ku-band antenna that was being pointed using Orbiter attitude control. A decision was made to delay the extravehicular activity (EVA) from day five to day seven so that the Ku-band antenna could be stowed later in the mission and thereby allow more SIR-B data to be collected and dumped through TDRS. Two extremely successful ORS fuel transfers were also performed. ERBS reported a successful transfer from TDRS to ground station communications and that their test calibration burns worked precisely as planned.

The Flash Evaporator System (FES) shut down on primary A controller. Numerous attempts to re-establish control using primary A system were unsuccessful. One attempt on the primary B controller was also unsuccessful.

Science accomplishments were the major activities during the fourth day of the STS-41G mission. Some SIR-B activities were lost as a result of the temporary loss of TDRS because the HDRR could not be dumped. This outage caused a loss of telemetry data for all experiments since data and communications occurred only over ground stations, even through several additional ground stations had been added.

After conditioning the flash evaporator by using the high temperature set point for the Freon loop, an attempt to restart the evaporator using controller B resulted in dislodging the ice around the evaporator.

During the fifth day, another activation attempt of the FES using the B controller resulted in restoration of satisfactory FES operation. Soon after the FES was activated, the loop set point was lowered to 41.5°F and immediately the cabin and payload coolant loop temperatures began to decrease with the payload loop stabilizing at about 44°F and the cabin at 77°F.

The ORS had two successful transfers followed by a successful "staged depressurization."

The sixth day of the STS-41G mission was spent collecting payload data and preparing the Extravehicular Mobility Units (EMU's) for the planned EVA on day seven. Included in these preparations was the lowering of the cabin pressure from 14.7 to 10.2 psia.

A very successful three-hour 27-minute EVA was conducted during the seventh day by Kathryn Sullivan and David Leetsma. Payload activities during the seventh day were near the planned levels except for the SIR-B which completed only 35 percent of the planned data takes.

The ORS ball valve modification kit installation was successfully accomplished according to plan during the EVA. Following the EVA, leak checks of the ORS modification kit valve showed no leaks. In addition, the EVA astronauts positioned the Ku-band antenna successfully for gimbal lock and pinning. Once pinned, the antenna was then redeployed for further use.

A problem developed when Cathode Ray Tube (CRT) number two went blank. Data evaluation did not isolate the source of the problem. The crew reloaded the software and CRT two was successfully brought back on-line. However, after less than one hour of operation, CRT two again went blank. The cables of Display

Electronics Unit (DEU) two and DEU four were interchanged and the CRT operated satisfactorily for the remainder of the flight.

On the eighth day, final stowage and preparations were completed for entry and landing at Kennedy Space Center. The flight control system checkout using Auxiliary Power Unit (APU) three was successfully completed with three minutes 11 seconds run time on the APU. All Orbiter systems continued to operate satisfactorily.

The final ORS hydrazine transfers were successfully completed using the plumbing and connections made during the EVA. Over 100 percent of the planned mission objectives for this experiment were completed flawlessly.

With all preparations for entry completed, the deorbit maneuver was performed at 287:15:30:00 G.M.T. The entry was normal in all respects with all Programed Test Inputs (PTI's) being performed as planned. After completing the Heading Alignment Circle (HAC) turn angle of 190 degrees, the final approach to the Shuttle Landing Facility at KSC was initiated. Main gear touchdown occurred at 287:16:26:33 G.M.T. about 449 meters (1,639 feet) past the runway threshold. The nose gear touched at 287:16:26:47 G.M.T. and the Orbiter rollout required 3,033 meters (9,952 feet).

Payloads and Experiments. The cargo configuration for STS-41G was comprised of four primary payloads, eight Getaway Special (GAS) canisters, four middeck experiments and the series of experiments associated with Canada (CANEX) and operated by the Canadian payload specialist. The primary payloads were the Earth Radiation Budget Satellite (ERBS), the Large Format Camera (LFC), the Orbital Refueling System (ORS), and the Office of Space and Terrestrial Applications (OSTA)-3 experiments. OSTA-3 consisted of three major components and these were the Shuttle Imaging Radar System (SIR)-B, the Measurement of Air Pollution from Satellites (MAPS), and the Feature Identification and Location Experiments (FILE). The GAS canisters contained experiments from Utah State University, Kayser Threde from West Germany, the Alabama Space and Rocket Center, the USAF and Naval Research Labs, Marshall-McShane, the Goddard Space Flight Center, and the McDonnell-Douglas Company. The middeck experiments were the IMAX camera, the Auroral Photographic Experiment (APE), the Radiation Monitoring Experiment (RME), and the Thermoluminescent Dosimeter (TLD). The Canadian Experiments (CANEX) experiments consisted of five activities and these were the Space Vision System Experiment Development Tests (VISET), the Advanced Composite Materials Exposure (ACOMEX), the Orbiter Glow and Atmospheric Emissions (OGLOW) measurements, the Sun Photometer Earth Atmosphere Measurements (SPEAM), and the Space Adaptation Syndrome Supplemental Experiments (SASSE).

Earth Radiation Budget Satellite (ERBS). Following the launch, orbital insertion, and payload activation activities, the ERBS was prepared for deployment. The ERBS deployment was delayed from orbit six to orbit nine because of thermally induced problems that delayed deployment of the ERBS antenna. The deployment was accomplished with acceptable tipoff rates. On flight day three, the initial ERBS maneuver Reaction Control System (RCS) calibration maneuver of three hours duration placed the ERBS in a 228 nautical mile (262 statute mile) orbit. Subsequent planned burns successfully placed the ERBS in its final 352 nautical mile (405 statute mile) orbit.

Orbital Refueling System (ORS). The ORS contained 85 kilograms (189 pounds) of hydrazine and a total of six transfers were successfully completed with no anomalies. An EVA was used to safely attach a flexline to a typical satellite valve in the payload hardware. Following the EVA, the system was safely leak tested and approximately 58 kilograms (130 pounds) of hydrazine were transferred through the valve. No anomalies were encountered during the EVA and the crew safely accomplished the tasks with no hydrazine contamination. The data acquired during the transfers are being evaluated. The successful accomplishment of the transfers demonstrated the feasibility of on-orbit refueling of satellites from an ORS-type tanker system.

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS (OSTA)-3 EXPERIMENTS

Shuttle Imaging Radar (SIR)-B. A total of nine hours of digital data and eight hours of optically recorded data were acquired during the mission. Prior to launch, it was anticipated that 42 hours of digital data and eight hours of optically recorded data would be acquired. Two instrument anomalies were encountered and these involved the folding of the SIR-B antenna prior to latching and the amount of back scattered power observed in the radar telemetry signals. The first anomaly was corrected by a revised procedure for driving the leaves of the antenna into their pre-latch positions. The second anomaly was attributed to an intermittent reduction in transmitted power and compensation was made by boosting the gain of the radar receiver during on-orbit operations. Preliminary processing of selected SIR-B images at the Jet Propulsion Laboratory (JPL) indicates that data of generally high quality were acquired throughout the mission.

Measurement of Air Pollution from Satellites (MAPS). The MAPS sensor functioned normally throughout the mission. Data collection was suspended for 10 hours during the middle of the mission due to thermal fluctuations in the coolant loop used to stabilize the MAPS operating temperature. Two globally synoptic surveys of atmospheric carbon monoxide concentration were conducted at the beginning and end of the mission on flight days one to three and days seven to eight, respectively. These surveys were conducted at a spatial resolution of 10 degrees by 10 degrees and from 57 degrees north latitude to 57 degrees south latitude. The two data sets provide a unique opportunity to study temporal variations in carbon monoxide distribution on a global basis for the first time. Successful airborne under-flights to acquire in situ measurements of carbon monoxide concentration during the mission were performed on the east and west coasts of the United States. Data acquired by these airborne sensors will be used to evaluate sensor performance for calibration purposes. The MAPS experiment was considered to be a complete success.

Feature Identification and Location Experiment (FILE). The FILE instrument operated nominally and image data were acquired over a range of natural environments. This experiment was considered to be a complete success.

Large Format Camera (LFC). A total of 2,300 photographic frames were obtained, as originally planned. High-priority coverage of Mt. Everest in Nepal was acquired. A special roll maneuver was performed during flight day eight to obtain oblique photography of hurricane Josephine off the eastern coast of the United States. The LFC experiment was considered to be a complete success.

GETAWAY SPECIAL CANISTERS (GAS)

The groups of getaway special canisters were operated as preflight planned.

AURORAL PHOTOGRAPHY EXPERIMENT (APE)

The APE consisted of crew-conducted photography from the aft flight deck to document Orbiter encounters with the auroral zone. The experiment used standard 35-mm camera equipment supplemented by a USAF-provided image intensifier and filter assembly. Results obtained from STS 41-G are over 200 excellent photographs showing the Earth's aurora and Orbiter glow. These photographs are currently being analyzed by the USAF Geophysics Laboratory to determine the extent and duration of Orbiter exposure to the high-energy electron flux which creates the Earth's aurora. All activities on STS-41G were a complete success.

IMAX

All IMAX photography was accomplished as planned during the mission.

THERMOLUMINESCENT INDICATOR (TLD)

The Hungarian TLD experiment was successfully accomplished. The six dosimeters were unstowed and located next to the United States passive radiation dosimeters (PRD's) at about three hours into the mission. The dosimeters were then collected and read at six different time during the flight. There were no problems or anomalies reported. Preliminary postflight results indicate that the TLD measurements were in excellent agreement with the PRD's.

CANADIAN EXPERIMENTS (CANEX)

Space Vision System Experiment Development Tests. From the daily verbal reports and the successful analysis of downlinked video from the experiment, it was concluded that all objectives were achieved.

Advanced Composite Materials Exposure. Over 90 percent of mission objectives (exposure and observation of the specimen) were met.

Orbiter Glow and Atmospheric Emissions. Seventy-five percent of all objectives and 100 percent of all prime objectives were met.

Sun Photometer Earth Atmosphere Measurements. All sun photometer, high sun, and sunset measurements required were obtained. Sunrise readings were unsuccessful.

Space Adaptation Supplemental Experiments. All on-orbit tests were completed as planned. Entry and postlanding tests were completed.

Solid Rocket Booster (SRB). All SRB systems performed as expected. The SRB prelaunch countdown was nominal with no problems noted. Performance of both solid rocket motors was close to the predicted values and well within the allowed envelopes.

Propellant burn rates were essentially as predicted. Preliminary indications are that the SRB separation occurred approximately 0.27 second later than predicted. The SRB recovery system performed nominally, and both SRB's were reported floating in the normal manner. All parachutes were recovered with no indication of damage.

External Tank (ET). All ET systems performed as expected. There were no prelaunch Launch Commit Criteria (LCC) violations. No Thermal Protection System (TPS) anomalies were observed. There was no acreage ice, only some minor frost spots. It was observed that there was more frost than usual on the liquid hydrogen feedline. This occurrence had no effect on flight performance. Impact of the tank was within the predicted footprint.

Space Shuttle Main Engine (SSME). SSME performance data followed trends which were similar to those observed during previous flights. Ice/frost inspection for indicated three engines appeared better than previously seen. All mainstage SSME flight data were nominal. The High Pressure Oxidizer Turbopump (HPOTP) and High Pressure Fuel Turbopump (HPFTP) turbine discharge temperatures compared favorably with predicted values. SSME start and cutoff appeared to be normal.

Main Propulsion System (MPS). Overall performance of the MPS was excellent. Liquid oxygen and liquid hydrogen loading was accomplished as planned. Liquid oxygen and liquid hydrogen loads relative to predicted values were about 680 kilograms (1,500 pounds) and 272 kilograms (600 pounds) low, respectively.

Ascent performance appeared to be normal. Main Engine Cutoff (MECO) was near the predicted time. Two MPS measurement failures occurred and these were both minor in nature and had no impact on the flight.

41G (STS-17) TIMELINE

Day of Year	G.M.T.* HR:Min:Sec	Event
279	10:58:10	APU No. 3 activation
	10:58:11	APU No. 2 activation
	10:58:12	APU (Auxiliary Power Unit) No. 1 activation
	11:02:32.7	Solid Rocket Booster (SRB) Hydraulic Power Unit (HPU) activation command
	11:02:53.4	Main Propulsion System (MPS) start command
	11:03:00	SRB ignition command
	11:03:18.4	Main engine throttle down command to 92 percent thrust
	11;03:26	Main engine throttle down command to 65 percent thrust
	11:03:51	Maximum dynamic pressure (max q)
	11:03:58	Main engine throttle up command to 100 percent thrust
	11:05:04	SRB separation command
	11:10:52	Main engine throttle down command for 3 "g" acceleration
	11:11:50.8	Main Engine Cutoff Command (MECO)
	11:12:08.4	External Tank (ET) separation
	11:13:50.5	Orbital Maneuvering System (OMS)-1 ignition
	11:16:04	OMS-1 cutoff
	11:16:57	APU deactivation
	11:49:30	OMS-2 ignition
	11:51:54	OMS-2 cutoff
	22:18:22	Earth Radiation Budget Satellite (ERBS) release
285	15:38:09	Begin Extravehicular Activity (EVA)
	19:05:00	Terminate EVA
286	13:46:04	Flight control system checkout
287	15:25:01	APU-2 activation
	15:30:00	Deorbit maneuver ignition (OMS)
	15:32:22	Deorbit maneuver cutoff
	15:42:09	APU-1 and APU-3 activation
	15:55:04	Entry interface
	16:12:00	End blackout
	16:20:12	Terminal Area Energy Management (TAEM)
	16:26:33	Main landing gear contact
	16:26:47	Nose landing gear contact
	16:27:32	Wheels stop
	16:37:00	APU deactivation

*G.M.T.—Subtract 4 hours for EDT
5 hours for CDT
6 hours for MDT
7 hours for PDT

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51A SUMMARY

The primary objectives of the 51-A mission were to successfully deploy the SYNCOM IV-1 and TELESAT-H (ANIK D-2) satellites, retrieve the PALAPA-B2 and WESTAR VI satellites which did not achieve the proper transfer orbit after deployment from *Challenger* due to the Payload Assist Module (PAM)-D perigee kick motor associated with each satellite during the 41-B mission, February 3 to 11, 1984, and perform the planned operations of 3 M's Diffusive Mixing of Organic Solutions (DMOS) experiment and the Radiation Monitoring Equipment (RME). Two extravehicular activity (EVA) periods were conducted, one during the retrieval of PALAPA-B2 and one during the retrieval of WESTAR VI. Eight detailed test objectives (DTO's) and four detailed supplementary objectives (DSO's) were completed during the mission.

The launch of *Discovery* on its second flight, the fourteenth flight of a Space Shuttle mission, was scheduled for launch on November 7, 1984. The launch was scrubbed during the planned hold at T-20 minutes, due to predicted winds-aloft would apply shear loads in excess of design limits of the vehicle. The launch was rescheduled for November 8, 1984, and all conditions were satisfactory for the rescheduled launch. The final countdown culminated in a successful launch at 313:12:15:00 G.M.T., from Launch Complex 39 at Kennedy Space Center on November 8, 1984, and the mission was successfully concluded with a landing at Kennedy Space Center runway 33 at 321:11:59:56 G.M.T. on November 16, 1984.

The crew for this flight were Frederick H. Hauck, Commander; David M. Walker, Pilot; Joseph P. Allen, Anna L. Fisher and Dale A. Gardner, Mission Specialists.

The ascent phase was nominal in all respects. The solid rocket booster (SRB) motor performance was near predicted levels. External tank (ET) and main propulsion system (MPS) performance was nominal. Normal orbital conditions were achieved at main engine cutoff (MECO), which occurred 513 seconds after lift-off. Following the satisfactory orbital maneuvering system (OMS)-1 and 2 maneuvers, *Challenger* was in the planned 150 by 160 nautical mile (172 by 184 statute mile) orbit.

Performance of all subsystems was normal throughout the first day. Telemetry data indicated that cathode ray tube (CRT) No. 4 had apparently failed. The crew recycled power to the unit, and shortly thereafter, the display began flashing on and off. The CRT was turned off and not used for the rest of the mission. The second day of the mission was completed as planned, and no new Orbiter problems were identified. All payload and experiment activities were completed. The Telesat-H (Anik D2)/payload assist module (PAM)-D spacecraft was deployed at 1:08:49:32 MET (mission elapsed time), within one second of the designated time. Although the PAM-D perigee kick motor (PKM) firing could not be observed by the crew using the remote manipulator system (RMS) wrist camera against the daylight background, data received through the Tanique/Brazil tracking station showed

Telesat-H at the expected location and in good health. Later data indicated that the spacecraft was in the desired geosynchronous orbit.

The third day of the mission was completed as planned. One maneuver was performed to raise the orbit to 169 by 171 nautical miles, (194 by 196 statute miles) and a second maneuver (plane change) was made in preparation for rendezvous with the PALAPA-B2 spacecraft on day five.

All SYNCOM IV-1 spacecraft predeployment operations were executed in accordance with the checklist. SYNCOM IV-1 spacecraft was deployed at 315:12:56:07 G.M.T. Automatic SYNCOM IV-1 omni antenna deployment and SYNCOM IV-1 spin-up was confirmed by the crew. A nominal 51-second PKM firing was accomplished and observed with the RMS wrist camera. Later data indicated that the spacecraft had achieved the desired geosynchronous orbital conditions.

The three extravehicular mobility units (EMU's) were checked out and only one problem was noted. Each of the two EMU light assemblies displayed a similar problem—the failure of the left-side light to operate. An inflight maintenance (IFM) procedure was developed for replacing the logic batteries with spares from other equipment. The replacement was successful.

The first of four waste water dumps was performed. The quantity reduction to 10.4 percent was completed between 315:17:00 and 315:17:50 G.M.T., by performing five short dump cycles. The dumps were stopped each time as soon as small icicles formed. The RMS wrist camera was used to view and record the dump.

The fourth day of the mission was satisfactory with only one new problem being encountered. This problem was found in the S-band antenna system when both antenna switches and the switch beam control electronics were all powered simultaneously. However, this anomaly caused no impact to the mission. Three maneuvers were performed and the apogee was raised to 174 nautical miles (200 statute miles). These maneuvers were a 1.8 meters per second (6 feet per second) phasing maneuver, a 9.2 meters per second (30.2 feet per second) coelliptic maneuver, and a 0.8 meter per second (2.7 feet per second) phasing maneuver performed between 316:11:56:18.4 and 316:19:52:54.5 G.M.T.

In preparation for the EVA on day five, the water tank dump and refill was successfully performed on EMU-1 and EMU-2, battery charges were topped off, and the cabin was depressurized to 10.2 psia for the 24-hour prebreathing period required prior to extravehicular activity (EVA). The second waste water dump was performed between 316:17:40 and 316:18:16 G.M.T. The tank was dumped to 18 percent, about 11.1 kilograms (24.5 pounds).

The fifth day of the STS 51-A mission was highlighted by the successful retrieval and berthing of the PALAPA-B2 spacecraft during a six-hour EVA. In preparation for the rendezvous with PALAPA-B2 a series of nominal phasing and braking maneuvers was performed using both the orbital maneuvering system (OMS) and reaction control system (RCS).

The retrieval of PALAPA-B2 spacecraft, although successful, was not accomplished using the primary procedures. Extravehicular activity (EV)-1 crewmen flew the manned maneuvering unit (MMU) and was able to insert the apogee kick motor capture device (stinger) into the PALAPA-B2 AKM and achieve a hard grapple. The spacecraft was then stopped from rotating and maneuvered into position to be grappled by the RMS. The MMU performance was nominal during the docking and the EVA. The antenna bridge structure, or A-frame, could not be attached as planned to the PALAPA-B2 spacecraft because of interference between the bracket crossmember and a waveguide on PALAPA-B2. Consequently, an alternate plan for backup retrieval of the spacecraft was used. EV-1 manually manipulated the spacecraft while EV-2 removed the stinger and attached the spacecraft adapter. Once this was accomplished, the spacecraft berthing was manually completed by both astronauts.

The sixth day of STS 51-A was a low-activity day in preparation for the second planned EVA on the seventh day. All Orbiter systems continued to operate properly. The third waste water dump to 12 percent remaining was completed at 318:10:15 G.M.T., with no problems reported. The necessary EMU maintenance and recharge activities were also completed.

The major activity on the seventh day of the STS 51-A mission was the successful retrieval of the second spacecraft, WESTAR-VI during a five hour 43 minute EVA. All Orbiter systems continued to operate properly. The crew reported at about 319:09:00 G.M.T. that neither of the aft payload-bay floodlights would operate. The crew performed a requested test, but the lights still did not operate. Since the forward lights worked properly, the light loss did not impact the EVA operations. The retrieval of WESTAR-VI was accomplished using a manual berthing procedure. As with PALAPA-B2 the antenna bridge structure was not used. One crewman, while using the manipulator foot restraint (MFR) on the RMS, manually maneuvered WESTAR-VI into position and aligned the spacecraft for berthing. Berthing of the spacecraft was completed with no problems encountered. All MMU systems operated nominally during EVA-2.

At 319:16:15 G.M.T., the final waste water dump to 18 percent remaining was performed.

The crew reported at 320:05:42 G.M.T., that a "hit" of some type occurred on window number seven (W7) resulting in an impact area about 1/32 inches in diameter. A structural margin of 24 percent (positive) still existed and this condition did not affect the mission.

The on-orbit flight control system (FCS) checkout began at 320:08:18:16 G.M.T., and ran for four minutes 19 seconds using auxiliary power (APU) system No. 3. At APU startup, several bubbles and a slightly low chamber pressure were noted; however, the chamber pressure came up when the load increased. The checkout went smoothly without any problems.

The STS 51-A mission progressed satisfactorily during the last full day on orbit. All Orbiter systems functioned as designed. All planned experiments and payload activities were completed as well as final stowage.

The deorbit maneuver was performed at 321:10:55:00 G.M.T. for 184 seconds. The entry was normal and all programmed test input (PTI) maneuvers were completed. After completing the 304-degree heading alignment circle (HAC) turn angle, the Orbiter was guided to a landing at the Shuttle Landing Facility on runway 33. Rollout required about 2,883 meters (9,461 feet). An inspection after landing revealed that the Orbiter was in excellent condition and the tile and thermal protection system had experienced only insignificant damage during the STS 51-A mission.

Telesat-H (Anik-D2) Deployment. The Telesat-H (Anik-D2) spacecraft was deployed from the Orbiter at the planned time of 01:08:49:32 MET. The PAM-D thrusting maneuver was nominal and the spacecraft was acquired by the ground tracking network on the first transfer orbit. Attempts to observe the PAM-D thrusting maneuver with the RMS wrist camera were unsuccessful because of the unfavorable sun angle.

Subsequent spacecraft operations, including the apogee motor thrusting maneuver, were all normal, and the spacecraft is on its assigned station in geosynchronous orbit. The spacecraft has been checked out and is operational.

During the predeployment sequence while opening the sunshield, the sunshield stopped its opening movement for two seconds midway through the cycle. A slight (0.1 amp) current increase was also noted at the same time. All other sunshield opening and closing activities were nominal and postflight attempts to reproduce the anomaly have been unsuccessful.

SYNCOM-IV-1 (Leasat) Deployment. The second Space Transportation System (STS) launched SYNCOM IV-1 Leasat deployment was successfully accomplished as planned at 02:00:41:07 MET. Deployment preparations were nominal including pulling of the four cradle-to-spacecraft restraint pins, and arming and firing of the deployment mechanism pyrotechnics. The Orbiter rates at deployment were essentially zero with pitch at +0.004 degrees per second being the only axis above +0.001 degrees per second.

A nominal perigee motor thrusting maneuver occurred 45 minutes after deployment and the spacecraft was acquired by the ground tracking network during the first transfer orbit. (The thrusting maneuver was observed with the RMS wrist camera.) Subsequently, several liquid apogee motor (LAM) firings were accomplished to place the spacecraft in geosynchronous orbit over the equator. The spacecraft is on-station, and has undergone spacecraft and communications-payload checkout.

PALAPA-B2 Retrieval. The recovery operations began with the completion of the first rendezvous at about 317:13:00 G.M.T. The rendezvous was normal and the EVA egress began at 04:01:10:00 MET. The EVA operations proceeded as planned and the spacecraft was captured by the MMU crewman (EV-1) and grappled by the RMS. When the second crewman attempted to install the antenna bridge structure, it was found that an obstruction between the two common bracket posts on the spacecraft prevented the installation. The alternate procedure was used and this required the EV-1 crewman to stand in the portable foot restraint and manually hold the spacecraft while the EV-2 crewman installed the adapter. The spacecraft was then manually berthed in the payload retention latch assemblies (PRLA's) and the latches closed.

Westar-IV Retrieval. For the retrieval of the Westar-IV, a decision was made to omit the antenna bridge structure and repeat the PALAPA-B2 retrieval procedure with a change in that the EV-2 crewman would be in the MFR on the RMS, and would thus be in a better position to manually handle the spacecraft after capture. Positioning of the spacecraft was aided by the RMS operator and by leaving the omni antenna still attached until after berthing. Capture by the EV-1 crewman was normal as was the adapter installation and berthing.

Diffusive Mixing of Organic Solutions (DMOS) Experiment. 3 M's DMOS payload experienced hardware problems inflight which precluded some of the internal cells from operating properly. The stepper motor that opened the valves between chambers experienced a larger torque than the capability of the motor. Crystals were grown in three of the six chambers and both quality and quantity of these crystals were described as 99 percent perfect and an unqualified success.

Radiation Monitoring Equipment (RME). The RME payload experienced no problems inflight. Postflight analysis indicates that good data were collected.

Extravehicular Activity (EVA). Two periods of EVA were planned and completed during the STS 51-A mission. One period was required for the retrieval of each of the two Hughes 376 spacecraft, PALAPA-B2 and Westar-IV. The total time for both of the EVA periods was 11 hours and 53 minutes. All EMU and MMU systems operated as designed with no problems or anomalies during either period.

First EVA. The first EVA took place on schedule on flight day five with hatch opening at 317:13:25 G.M.T. and hatch closing at 317:19:25 G.M.T.. EVA preparations proceeded nominally with the exception of the EMU helmet-light battery problem, which was discovered during suit checkout on flight day three. The power switch was in the "on" position and this had caused the batteries to discharge. The crew used an IFM procedure to wire other batteries that were onboard into the EMU lights. The lights then functioned normally for the duration of the mission.

The first major activity during EVA-1 was the checkout of the MMU located on the port side of the payload bay. After the donning and successful MMU checkout, plus the attachment of the apogee kick motor capture device (ACD), the EV-1 crewman began the translation to the PALAPA-B2 spacecraft. Following the successful docking, the MMU thrusters were used to stop the spacecraft from its 12 degree per second spin rate and re-orient the vehicle to a position suitable for RMS capture.

After grappling PALAPA-B2, the RMS lowered the spacecraft into the payload bay with EV-1 and the MMU/ACD still attached. EV-2 cut the omni antenna with the shears provided, and an attempt was made to attach the common bracket clamps to PALAPA-B2 so that the antenna bridge structure (ABS) or "A-Frame" could be attached. At this point, EV-2 found that the common bracket clamps could not be attached to PALAPA-B2. A waveguide assembly protruded farther outboard on PALAPA-B2 than had been expected and prevented the common bracket clamps from being mounted on PALAPA's common brackets.

The crew changed to a practiced backup procedure. EV-1 disconnected the MMU from the ACD in PALAPA-B2, and doffed the MMU in its mounting station. EV-1 then got into the portable foot restraint (PFR), which had been positioned on the starboard side of the Westar-VI pallet, and held on to the top of PALAPA-B2 after it was released by the RMS. EV-1 positioned PALAPA-B2 so that EV-2 could remove the ACD, install the AKM nozzle cover and attach the Hughes 376 adapter assembly to the bottom of PALAPA-B2. Together, the two crewmembers then manually maneuvered PALAPA-B2 into the payload retention latch assemblies (PRLA's) where it was secured for return.

Second EVA. During day six, the EMU's were serviced and the procedures to be used for the second EVA were reviewed. Because of the possibility that the configuration of the waveguide on Westar-VI was the same as PALAPA-B2, the decision was made to forego the use of the A-frame completely and to manually handle the spacecraft after it had been stabilized by the MMU in a manner similar to that done during the first EVA. The primary difference in the plan for the second EVA was to have EV-1 positioned in the manipulator foot restraint (MFR) on the RMS instead of being in the portable foot restraint on the side of the pallet. This would allow him to be more optimally positioned by the RMS to handle the spacecraft, thereby reducing the EVA workload and minimizing the risk of damaging the solar panels on the spacecraft. The use of the MMU and ACD was still required because of the inherent danger of the spinning satellite to the Orbiter and to the EV crewman in the MFR.

The second EVA began at 319:11:08 G.M.T. and lasted approximately five hours 43 minutes. The EVA was completed with no significant anomalies at 319:16:51 G.M.T. The alternate procedures were satisfactory for the successful retrieval of the Westar-VI spacecraft.

Solid Rocket Booster (SRB). All SRB systems performed as expected. The SRB prelaunch countdown was nominal with no problems noted. Performance of both solid rocket motors was near predicted values and well within the allowed envelopes. Propellant burn rates were also near predicted values. Preliminary indications are that SRB separation occurred within 0.37 second of the predicted time. The SRB recovery system performed nominally, with both SRB's impacting within 13 seconds of each other and floating in the normal manner 2.6 miles apart.

External Tank (ET). All ET systems performed as expected. There were no ET preflight or flight anomalies, nor was there any significant frost buildup. The only ice observed was on the line bellows and brackets in waived areas, which is normal. Nose cone temperature measurements were different from one another by four to eight degrees F, but this is within required limits.

The ET impacted in the Indian Ocean at about 28.11 degrees south latitude and 78.43 degrees east longitude.

Space Shuttle Main Engine (SSME). SSME performance data followed trends which were similar to those observed during previous flights. The high pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) turbine discharge temperatures during mainstage compared favorably with predicted values.

During prelaunch operations, the HPFTP discharge temperature on engine 3 decayed from a maximum of 540 degrees R to a minimum of 397 degrees R when the tank was pressurized at 43.7 to 46.7 psia. When tank pressure was vented, the temperature went back up to approximately 420 degrees R and stabilized until prepressurization occurred at T-90 seconds. The HPFTP temperature then dropped to approximately 391 degrees R on channel A and 400 degrees R on channel B, but these levels did not cause a start or flight problem.

Main Propulsion System (MPS). Overall performance of the MPS was excellent. Liquid oxygen and liquid hydrogen loading was accomplished as planned with no stop flows or anomalies. Liquid oxygen and liquid hydrogen loads relative to predicted values were about 630 kilograms (1,390 pounds) and 381 kilograms (840 pounds) low, respectively. No significant hydrogen concentrations were observed.

Ascent performance was normal and MECO was near the predicted time.

51A TIMELINE

Day of Year	G.M.T.* HR:Min:Sec	Event
313	12:10:09	Auxiliary Power Unit (APU) No. 1 activation
	12:10:10	APU No. 2 activation
	12:10:11	APU No. 3 activation
	12:14:32.5	Solid Rocket Booster (SRB) Hydraulic Power Unit (HPU) activation command
	12:14:53.4	Main Propulsion System (MPS) start command
	12:15:00	SRB ignition command liftoff
	12:15:14.6	Main engine throttle down command to 89 percent thrust
	12:15:28.4	Main engine throttle down command to 67 percent thrust
	12:15:51	Maximum dynamic pressure (max Q)
	12:16:07.1	Main engine throttle up command to 104 percent thrust
	12:17:05	SRB separation command
	12:22:38.2	Main engine down command for 3 "g" acceleration
	12:23:33.7	Main Engine Cutoff (MECO)
	12:23:51.3	External Tank (ET) separation
	12:25:33	Orbital Maneuvering System (OMS)-1 ignition
	12:28:04	OMS-1 cutoff
	12:29:27	APU No. 3 deactivation
	12:29:28	APU No. 2 deactivation
	12:29:32	APU No. 1 deactivation
	12:59:43	OMS-2 ignition
	13:01:38	OMS-2 cutoff
314	21:04:32	TELESAT-H/Payload Assist Module (PAM)-D deployment
315	12:56:07	Syncom IV-1 deployment
317	13:25:00	Extravehicular Activity (EVA) one start
	18:13:00	PALAPA-B2 retrieval
	19:25:00	EVA one termination
319	11:08:00	EVA two start
	14:59:00	WESTAR-VI retrieval
	16:51:00	EVA two termination
320	08:18:16	Flight control system checkout and APU No. 3 start
	08:22:35	APU No. 3 deactivation
321	10:49:54	APU No. 2 activation
	10:55:00	Deorbit maneuver ignition
	10:58:04	Deorbit maneuver cutoff
	11:17:16	APU No. 1 activation
	11:17:18	APU No. 3 activation
	11:28:58	Entry Interface (EI)
	11:43:49	End blackout
	11:53:20	Thermal Area Energy Management (TAEM)
	11:59:56	Main landing gear contact
	12:00:09	Nose landing gear contact
	12:00:54	Wheels stop
	12:21:19	APU deactivation

*G.M.T.—Subtract 5 hours for EST
6 hours for CST
7 hours for MST
8 hours for PST