

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

**SPACE SHUTTLE  
MISSION  
STS-54**

**PRESS KIT  
JANUARY 1993**



**TRACKING AND DATA RELAY SATELLITE  
DIFFUSE X-RAY SPECTROMETER**

## **STS-54 INSIGNIA**

*STS054-S-001 -- The mission insignia depicts the American bald eagle soaring above the Earth and is emblematic of the space shuttle Endeavour in service to the United States and the world. The eagle is clutching an eight-pointed star in its talons and is placing this larger star among a constellation of four others, representing the placement of the fifth Tracking and Data Relay Satellite into orbit among the four already in service. The blackness of space -- with stars conspicuously absent -- represents our other primary mission in carrying the Diffuse X-Ray Spectrometer to orbit to conduct astronomical observations of invisible X-Ray sources within the Milky Way Galaxy. The depiction of Earth showing our home continent of North America is an expression of the crew's and NASA's intention that the medical and scientific experiments conducted on board be for the benefit of mankind. The clouds and blue of the Earth represent the crew's part in NASA's Mission to Planet Earth in conducting Earth observation photography.*

*The NASA insignia design for space shuttle flights is reserved for use by the astronauts and for other official use as the NASA Administrator may authorize. Public availability has been approved only in the form of illustrations by the various news media. When and if there is any change in this policy, which we do not anticipate, it will be publicly announced.*

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## **MEDIA SERVICES INFORMATION**

### **NASA Select Television Transmission**

NASA Select television is available on Satcom F-2R, Transponder 13, located at 72 degrees west longitude, frequency 3960.0 MHz, audio 6.8 MHz.

The schedule for television transmissions from the orbiter and mission briefings will be available during the mission at Kennedy Space Center, FL; Marshall Space Flight Center, Huntsville, AL; Ames-Dryden Flight Research Facility, Edwards, CA; Johnson Space Center, Houston, and NASA Headquarters, Washington, DC. The television schedule will be updated to reflect changes dictated by mission operations.

Television schedules also may be obtained by calling COMSTOR 713/483-5817. COMSTOR is a computer data-base service requiring the use of a telephone modem. A voice update of the television schedule is updated daily at noon Eastern time.

### **Status Reports**

Status reports on countdown and mission progress, on-orbit activities and landing operations will be produced by the appropriate NASA news center.

### **Briefings**

A mission press briefing schedule will be issued prior to launch. During the mission, status briefings by a flight director or mission operations representative and when appropriate, the science team will occur at least once per day. The updated NASA Select television schedule will indicate when mission briefings are planned.

## STS-54 QUICK LOOK

Launch Date/Site: Jan. 13, 1993/Kennedy Space Center, FL -- Pad 39B  
Launch Time: 8:52 a.m. EST  
Orbiter: Endeavour (OV-105) - 3rd Flight  
Orbit/Inclination: 160 n.m./28.45 degrees  
Mission Duration: 5 days, 0 hours, 23 minutes, 32 seconds  
Landing Time/Date: 8:34 a.m. EST, Jan. 19, 1993  
Primary Landing Site: Kennedy Space Center, FL

Abort Landing Sites: Return To Launch Site Abort - KSC, FL  
Transatlantic Abort Landing - Banjul, The Gambia  
Ben Guerir, Morocco  
Moron, Spain  
Abort-Once-Around - Edwards AFB, CA; KSC/White Sands, NM

Crew: John Casper - Commander  
Don McMonagle - Pilot  
Mario Runco Jr. - MS1 (EV2)  
Greg Harbaugh - MS2 (EV1)  
Susan Helms - MS3

Cargo Bay Payloads: Tracking and Data Relay Satellite-F  
Diffuse X-ray Spectrometer

Middeck Payloads: Commercial Generic Bioprocessing Apparatus  
Chromosome and Plant Cell Division in Space Experiment  
Physiological and Anatomical Rodent Experiment  
Space Acceleration Measurement System  
Solid Surface Combustion Experiment

## STS-54 SUMMARY TIMELINE

### **Flight Day 1**

Launch/post insertion  
TDRS-F deploy (nominal deploy is 6 hours, 13 minutes MET)  
Separation burn (178 n.m. x 162 n.m. orbit)  
DXS activation

### **Flight Day 2**

DXS operations  
Circularization burn (162 n.m. x 162 n.m. orbit)  
CGBA operations  
Medical DSOs

### **Flight Day 3**

DXS operations  
CGBA operations  
SSCE operations  
CHROMEX/PARE operations

### **Flight Day 4**

DXS operations  
CGBA operations  
Medical DSOs  
CHROMEX/PARE operations

### **Flight Day 5**

DXS operations  
EVA

### **Flight Day 6**

Flight Control Systems checkout  
Cabin stow

### **Flight Day 7**

Deorbit Preparation  
Deorbit Burn  
Entry  
Landing

## STS-54 VEHICLE AND PAYLOAD WEIGHTS

	<u>Pounds</u>
Orbiter (Endeavour) Empty and three SSMEs	173,174
Tracking and Data Relay Satellite-F (TDRS-F)	5,586
Two-Stage Inertial Upper Stage (IUS)	32,670
Diffuse X-ray Spectrometer (DXS)	2,625
Medical Detailed Supplementary Objectives (DSOs)	34
Total Vehicle at Solid Rocket Booster Ignition	4,525,222
Orbiter Landing Weight	205,000



## STS-54 ORBITAL EVENTS SUMMARY

<b>Event</b>	<b>Elapsed Time</b>	<b>Velocity change</b>	<b>Orbit (n.m.)</b>
Launch	0:00:00:00	N/A	N/A
OMS-2	0:00:42:00	221 fps	163x160
TDRS deploy	0:06:13:00	N/A	163 x 160
Sep 1	0:06:14:00	2.2 fps	162 x 160
OMS-3	0:06:28:00	31 fps	178 x 162
OMS-4	1:02:09:00	28 fps	162 x 161
Deorbit	5:22:32:00	306 fps	N/A
Landing	5:23:32:00	N/A	N/A

## **SPACE SHUTTLE ABORT MODES**

Space Shuttle launch abort philosophy aims toward a safe and intact recovery of the flight crew, orbiter and its payload. Abort modes include:

- Abort-To-Orbit (ATO) -- Partial loss of main engine thrust late enough to permit reaching a minimal 105-nautical mile orbit with orbital maneuvering system engines.
- Abort-Once-Around (AOA) -- Earlier main engine shutdown with the capability to allow one orbit around before landing at either Edwards Air Force Base, Calif., White Sands Space Harbor, NM, or the Shuttle Landing Facility (SLF) at the Kennedy Space Center, FL.
- Transatlantic Abort Landing (TAL) -- Loss of one or more main engines midway through powered flight would force a landing at either Banjul, The Gambia; Ben Guerir, Morocco; or Moron, Spain.
- Return-To-Launch-Site (RTL) -- Early shutdown of one or more engines, without enough energy to reach Banjul, would result in a pitch around and thrust back toward KSC until within gliding distance of the Shuttle Landing Facility.

STS-54 contingency landing sites are Edwards Air Force Base, the Kennedy Space Center, White Sands Space Harbor, Banjul, Ben Guerir and Moron.

## **STS-54 PRELAUNCH PROCESSING**

Processing of Endeavour began with its landing at KSC after the STS-47 mission. It was deserviced from its previous flight and prepared for the upcoming STS-54 mission. Endeavour spent a total of 64 calendar days in the Orbiter Processing Facility.

The Space Shuttle Endeavour was rolled out of the Vehicle Assembly Building for Pad 39-B on Dec. 3. The TDRS-F/IUS-13 was installed into the orbiter's payload bay the following day.

A standard 43-hour launch countdown is scheduled to begin 3 days prior to launch. During the countdown, the orbiter's fuel cell storage tanks and all orbiter systems will be prepared for flight.

About 9 hours before launch, the external tank will be filled with its flight load of a half million gallons of liquid oxygen and liquid hydrogen propellants. About 2 and one-half hours before liftoff, the flight crew will begin taking their assigned seats in the crew cabin.

Endeavour's end-of-mission landing is planned at Kennedy Space Center's Shuttle Landing Facility. Endeavour's next flight, STS-57, targeted for May 1993, is a planned 7-day mission which will involve the SPACEHAB-1 payload and the retrieval of the EURECA satellite.

## **TRACKING DATA RELAY SATELLITE-F (TDRS-F)**

### **History**

The Tracking and Data Relay Satellite System (TDRSS) is a space-based network that provides communications, tracking, telemetry, data acquisition and command services essential to the Space Shuttle and low-Earth orbital spacecraft missions. All Shuttle missions and nearly all NASA spacecraft in Earth orbit require TDRSS's support capabilities for mission success.

The TDRSS was initiated following studies in the early 1970s which showed that a system of telecommunications satellites, operated from a single ground station, could better meet the requirements of NASA missions. In addition, the system was seen as a means of halting the spiraling costs of upgrading and operating a network of tracking and communications ground stations located around the world.

The TDRSS has enabled NASA to cut telecommunications costs by as much as 60 percent while increased data acquisition and communications with Earth-orbital spacecraft from 15 to 85 percent -- and in some cases to 100 percent -- depending on a spacecraft's orbital position.

In addition to the Shuttle, TDRSS customers include the Compton Gamma Ray Observatory, Upper Atmosphere Research Satellite, Hubble Space Telescope, Cosmic Background Explorer, Extreme Ultraviolet Explorer, TOPEX-Poseidon, both Landsat spacecrafts and other non-NASA missions. Among future TDRSS-dependent missions are Space Station Freedom (SSF) and the Earth Observation System (EOS). It is estimated that over \$70 billion in space missions through the end of this decade are TDRSS-dependent.

The TDRSS consists of two major elements: A constellation of three geosynchronous satellites -- two operational and one in ready reserve -- and a ground terminal located at White Sands, NM. A second TDRSS ground terminal is under development to eliminate a critical single point of failure.

To meet the growing demand for communications capabilities for future missions, such as SSF and the EOS, increased TDRSS capacity will be required to meet these additional mission requirements.

### **Current Status**

The Tracking and Data Relay Satellite (TDRS-6) is the sixth in a series of communications spacecraft planned for the TDRSS.

TDRS-1, has exceeded its design life of 7 years and is continuing to provide limited services. TDRS-2 was lost in the Challenger accident. TDRSs 3-5 are operating, but only two are fully functional. In the event of a malfunction of one of these fully operational TDRS, the absence of a third fully operational satellite in ready reserve would severely impact orbiting customers for nearly a year before an emergency replenishment launch could be conducted.

The successful launch and checkout of TDRS-6 will give NASA the essential requirement of having two fully operational satellites and a fully operational ready reserve capability. This will assure that NASA communications, telemetry and data acquisition capabilities required by space missions will not be jeopardized.

Following the successful launch and checkout of TDRS-6, the TDRSS constellation will be reconfigured. Because of the flexible capability of the TDRSS, one TDRS spacecraft will provide service to the Compton Gamma Ray Observatory (GRO), including real-time transmission of scientific data. This is required because of a problem with the GRO's tape recorders. To accommodate this activity, NASA will operate TDRS-1

through an existing station at Tidbinbilla, Australia, moving TDRS-1 from 171 degrees west longitude to 85 degrees east longitude (over the Indian Ocean south of Ceylon).

Data from GRO will be relayed to the ground terminal at White Sands, via an Intelsat satellite. From White Sands, the data will be sent to the Goddard Space Flight Center, Greenbelt, MD. Control of the TDRS spacecraft will remain at White Sands.

### **TDRS SPACECRAFT LAUNCH AND OPERATIONAL STATUS**

<u>Spacecraft</u>	<u>Mission</u>	<u>Date</u>	<u>Status</u>
TDRS-1	STS-6	April 5, 1983	Partially functional
TDRS-2	STS-51L	January 1986	Destroyed
TDRS-3	STS-26	Sept. 29, 1988	Partially functional
TDRS-4	STS-29	March 13, 1989	Fully functional
TDRS-5	STS-43	August 2, 1991	Fully functional

### **TDRS SPACECRAFT CURRENT AND RECONFIGURED POSITION**

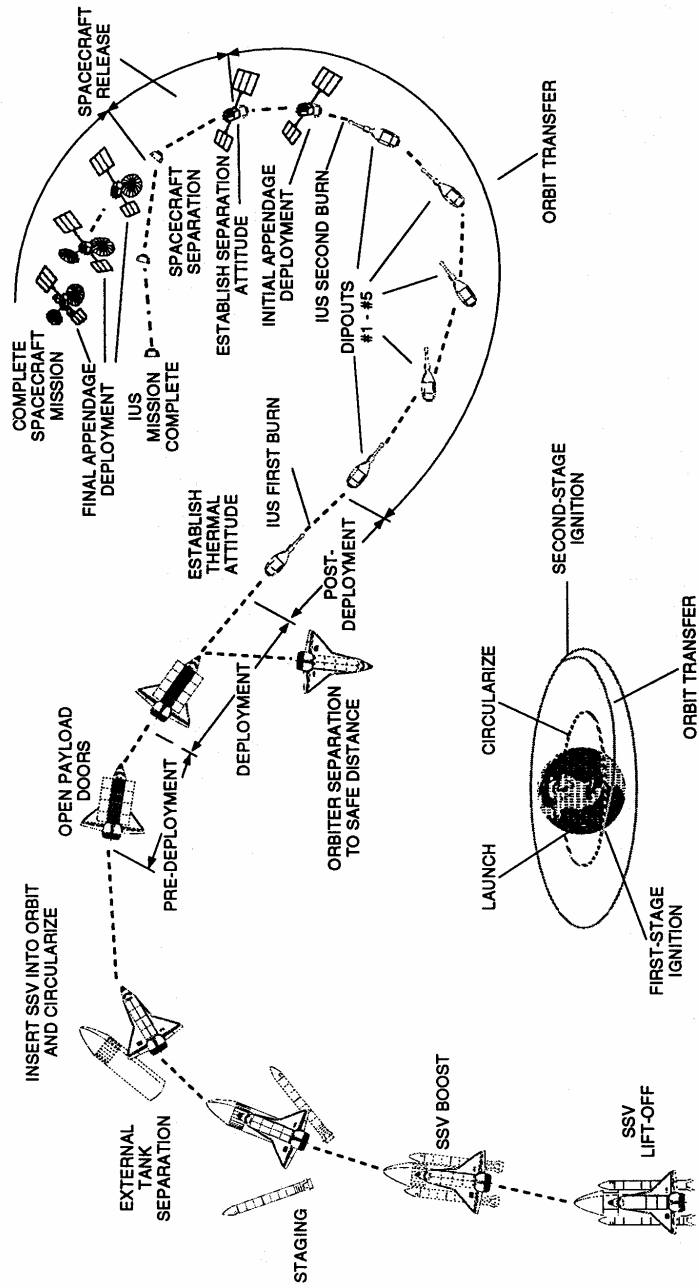
#### **Current Position**

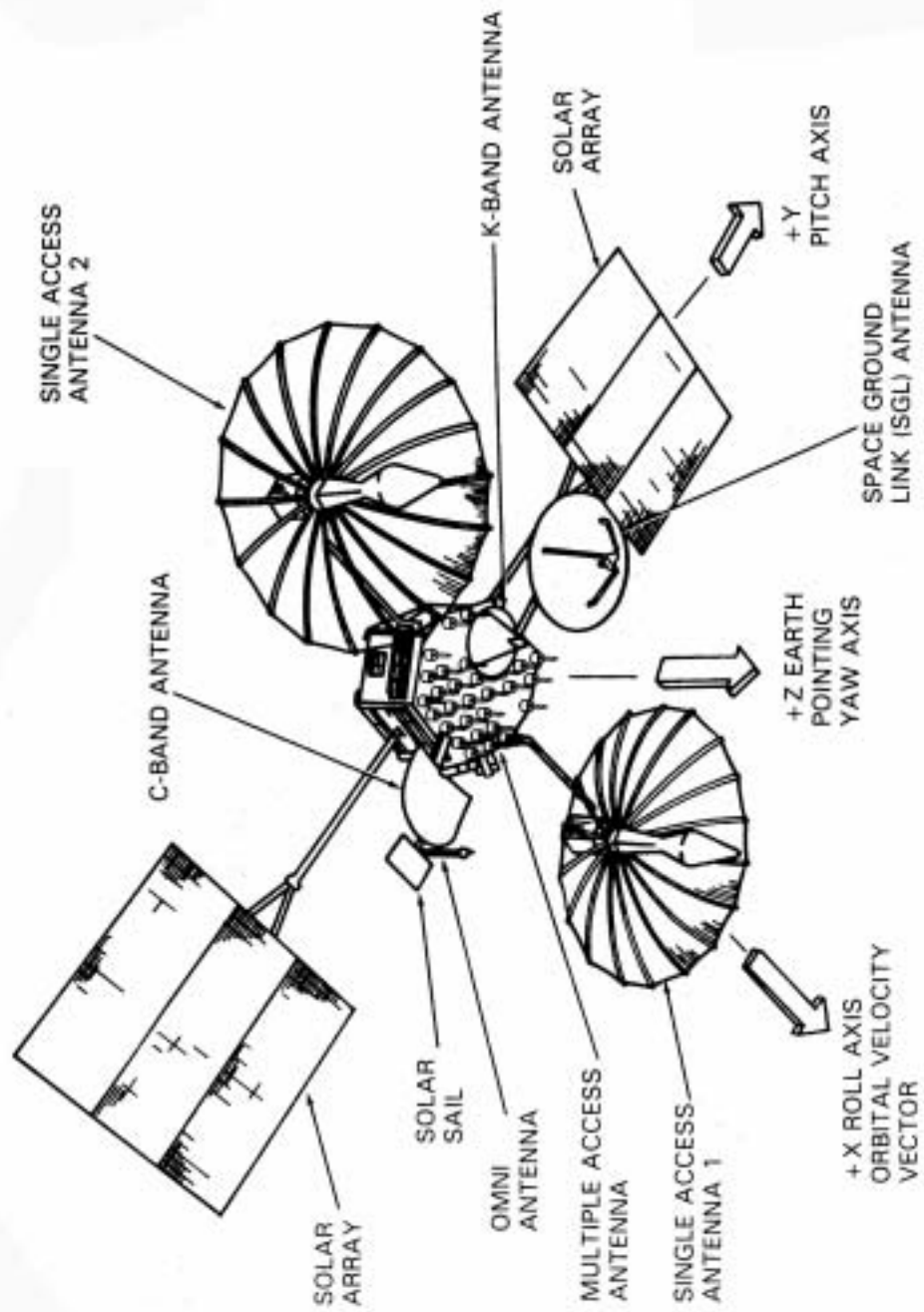
TDRS-1 171 degrees west (East of Gilbert Islands and South of Hawaii)  
TDRS-3 62 degrees west  
TDRS-4 41 degrees west (over the Atlantic Ocean off Brazil)  
TDRS-5 174 degrees west (East of Gilbert Islands and South of Hawaii)

#### **Reconfigured Position after TDRS-F (6 on orbit)**

TDRS-1 85 degrees east  
TDRS-3 171 degrees west  
TDRS-4 41 degrees west  
TDRS-5 174 degrees west  
TDRS-6 62 degrees west

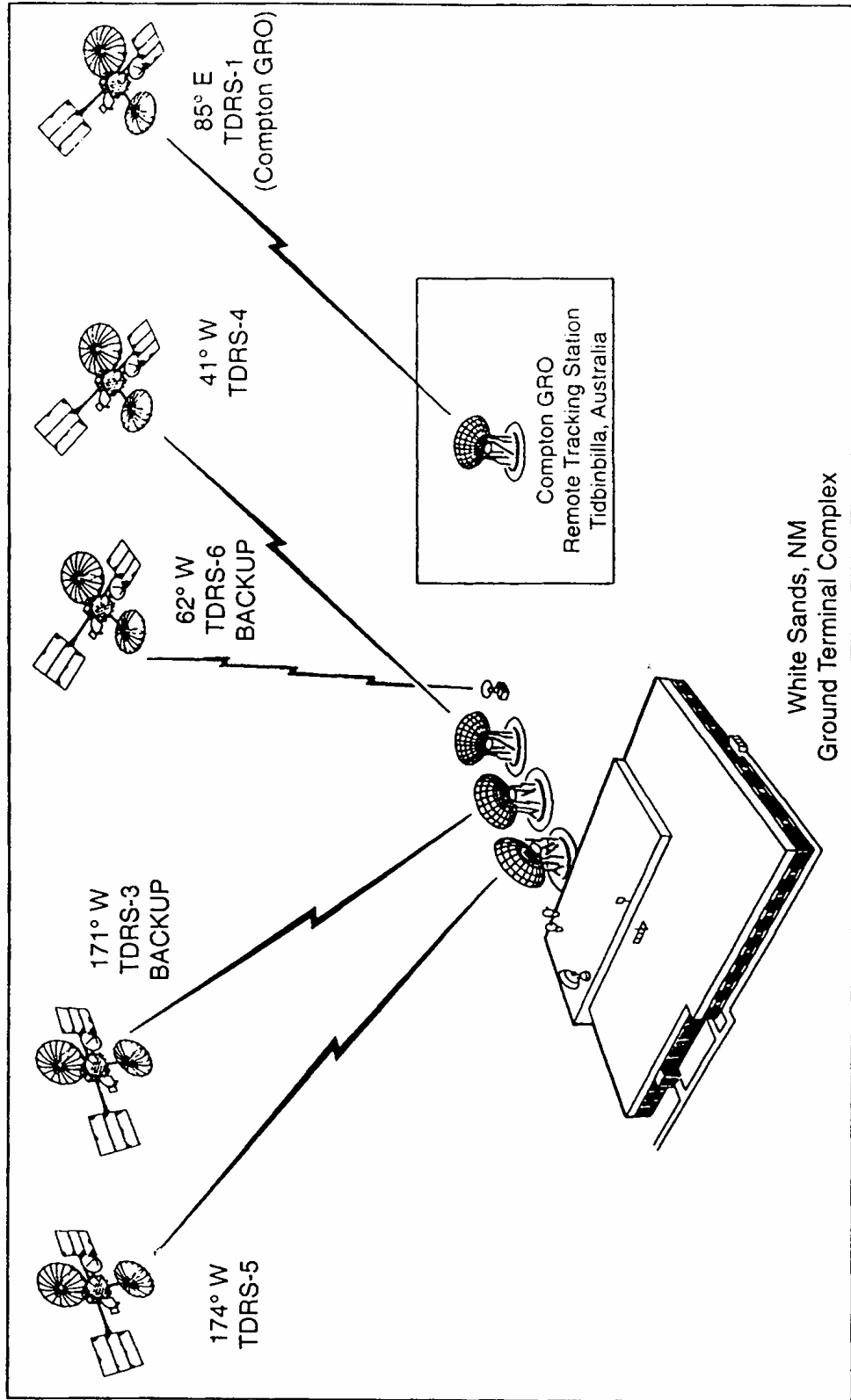
# TDRS Deployment Sequence





**TDRS SPACECRAFT ON-ORBIT CONFIGURATION**

**WITH FIVE SATELLITES - 1993**





## **Deployment Sequence**

TDRS-6 will be deployed from Endeavour cargo bay approximately 6 hours after launch on orbit 5 over the Pacific Ocean north of Hawaii. Injection burn to geostationary orbit will be initiated at 77 degrees east longitude (Indian Ocean, south of India), placing the satellite in orbit at 178 degrees west longitude (over the Pacific near the Gilbert Islands).

The STS-54 crew elevates the Inertial Upper Stage/TDRS (IUS/TDRS) to 29 degrees in the payload bay for preliminary tests and then raises it to 58 degrees for deployment. A spring-loaded ejection system is used for deploying the IUS/TDRS.

The first burn of the IUS booster will take place 1 hour after deployment or about 7 hours after STS-54 launch. The IUS second and final burn, to circularize the orbit, will take place 5.5 hours after the first burn, approximately 12.5 hours into the mission. Separation of the booster and satellite will occur at 13 hours after launch.

Upon reaching geostationary orbit, the deployment of TDRS appendages and antennas is started. The total time required for the deployment sequence is 8-9 hours:

1. Deploy solar arrays.
2. Deploy space-ground link boom.
3. Deploy C-band boom.
4. Separation of IUS and TDRS.
5. Release single access booms.
6. Position single access antennas.
7. Open single access antennas.

During steps 5, 6 and 7, Earth acquisition is taking place concurrently.

TDRS is three-axis stabilized with the multiple access body, fixed antennas pointing constantly at the Earth while the solar arrays track the sun.

## **Communication System**

TDRS satellites do not process customer traffic in either direction. Rather, they operate as "bent pipe" repeaters, relaying signals and data between the user spacecraft and the ground terminal and vice versa.

Nominally, the TDRSS is intended to meet the requirements of up to 24 customer spacecraft, including the Space Shuttle, simultaneously. It provides two types of service: multiple access which can relay data from as many as 20 low data rate (100 bits per second to 50 kilobits per second) customer satellites simultaneously and single access antennas which provide two high data rate channels to 300 megabits per second from both the east and west locations.

The White Sands Ground Terminal (WSGT) provides a location with a clear line-of-sight to the TDRSSs and a place where rain conditions have limited interference with the availability of the Ku-band uplink and downlink channels. The WSGT is operated for NASA by GTE Government Systems Corp., Needham Heights, Mass.

Co-located at White Sands is the NASA Ground Terminal operated by Bendix Field Engineering Corp., Columbia, MD. This terminal provides the interface between WSGT and other primary network elements located at NASA's Goddard Space Flight Center, MD.

Facilities at GSFC include the Network Control Center (NCC) which provides system scheduling and is the focal point for NASA communications and the WSGT and TDRSS users; the Flight Dynamics Facility which provides the network with antenna pointing information for user spacecraft and the TDRSSs and the NASA Communications Network (NASCOM) which provides the common carrier interface through Earth terminals at Goddard, White Sands and the Johnson Space Center, Houston.

The NCC console operators monitor network performances, schedule emergency interfaces, isolate faults in the system, account for system use, test the system and conduct simulations.

The user services available from the space network are provided through NASCOM, a global system providing operational communications support to all NASA projects. NASCOM offers voice, data and teletype links with the space network, the Ground Spaceflight Tracking and Data Network and the user spacecraft control centers.

NASA's Office of Space Communications, Washington, DC, has overall management responsibility of these tracking, data acquisition and communications facilities.

### **TDRS Components**

TDRSSs are composed of three distinct modules -- an equipment module, a communications payload module and an antenna module. The modular design reduces the cost of individual design and construction efforts that, in turn, lower the cost of each satellite.

The equipment module housing the subsystems that operate the satellite is located in the lower hexagon of the spacecraft. The attitude control subsystem stabilizes the satellite to provide accurate antenna pointing and proper orientation of the solar panels to the sun. The electrical power subsystems consists of two solar panels that provide a 10-year power supply of approximately 1,700 watts. The thermal control subsystem consists of surface coatings and controlled electric heaters.

The payload module is composed of the electronic equipment required to provide communications between the user spacecraft and the ground. The receivers and transmitters for single access services are mounted in compartments on the back of the single-access antennas.

The antenna module is composed of seven antenna systems: two single-access, the multiple access array, space-to-ground link and the S-band omni for satellite health and housekeeping. Commercial K-band and C-band antennas round out the complement.

For single-access service, the TDRSSs have dual-feed S-band, Ku-band parabolic (umbrella-like) antennas. These antennas are free to be positioned in two axis, directing the radio beam to orbiting user spacecraft below. These antennas primarily relay communications to and from user spacecraft. The high data rates provided by these antennas are available to users on a time-shared basis. Each antenna is capable of supporting two user spacecraft services simultaneously -- one at S-band and one at Ku-band-provided both users are within the beam width of the antenna.

The multiple access antenna array is hard-mounted in one position on the surface of the antenna module facing the Earth. Another antenna, a 6.5-foot (2-meter) parabolic reflector, provides the prime link for relaying transmissions to and from the ground terminal at Ku-band.

## **Project Support**

TRW Space & Electronics Group, Redondo Beach, Calif., is the prime spacecraft contractor. Ground operations at the White Sands complex are conducted by GTE Government Systems Corp., Needham Heights, Mass., and Bendix Field Engineering Corp., Columbia, MD.

## **INERTIAL UPPER STAGE (IUS)**

The Inertial Upper Stage (IUS) will be used with the Space Shuttle to transport NASA's sixth Tracking and Data Relay Satellite (TDRS-F) to geosynchronous orbit, some 22,300 statute miles (35,880 km) from Earth.

### **Background**

The IUS was originally designed as a temporary stand-in for a reusable space tug, and the IUS was named the Interim Upper Stage. The word "Inertial" (signifying the guidance technique) later replaced "Interim" when it was determined that the IUS would be needed through the 1990's. In addition to the TDRS missions, the IUS was utilized for the Magellan, Galileo and Ulysses planetary missions.

The IUS was developed and built under contract to the Air Force Systems Command's Space Division. The Space Division is executive agent for all Department of Defense activities pertaining to the Space Shuttle system and provides the IUS to NASA for Space Shuttle use. Boeing Aerospace Company, Seattle, was selected in August 1976 to build the IUS.

### **Specifications**

IUS-13, to be used on mission STS-54, is a two-stage rocket. Each stage has a solid rocket motor, preferred over liquid-fueled engines for their relative simplicity, high reliability, low cost and safety.

The IUS is 17 feet (5.18 meters) long and 9.25 feet (2.8 m) in diameter. It consists of an aft skirt; an aft stage solid rocket motor containing 21,400 pounds (9,707 kg) of propellant generating approximately 42,000 pounds (188,496 Newtons) of thrust; an interstage; a forward stage solid rocket motor with 6,000 pounds (2,722 kg) of propellant generating approximately 18,000 pounds (80,784 Newtons) of thrust and an equipment support section.

The equipment support section contains the avionics which provide guidance, navigation, control, telemetry, command and data management, reaction control and electrical power. All mission-critical components of the avionics system, along with thrust vector actuators, reaction control thrusters, motor igniter and pyrotechnic stage separation equipment are redundant to assure reliability of better than 98 percent.

### **Airborne Support Equipment**

The IUS Airborne Support Equipment (ASE) is the mechanical, avionics, and structural equipment located in the orbiter. The ASE supports the IUS and the TDRS-F in the orbiter payload bay and elevates the IUS/TDRS for final checkout and deployment from the orbiter.

The IUS ASE consists of the structure, aft tilt frame actuator, batteries, electronics and cabling to support the IUS/TDRS combination. These ASE subsystems enable the deployment of the combined vehicle; provide, distribute and/or control electrical power to the IUS and satellite and serve as communication conduits between the IUS and/or satellite and the orbiter.

### **IUS Structure**

The IUS structure is capable of supporting the loads generated internally and also by the cantilevered spacecraft during orbiter operations and the IUS free flight. In addition, the structure physically supports all the equipment and solid rocket motors within the IUS, and provides the mechanisms for IUS stage

separation. The major structural assemblies of the two-stage IUS are the equipment support section, interstage and aft skirt. It is made of aluminum skin-stringer construction with longerons and ring frames.

### **Equipment Support Section**

The Equipment Support Section houses the majority of the IUS avionics. The top of the equipment support section contains the spacecraft interface mounting ring and electrical interface connector segment for mating and integrating the spacecraft with the IUS. Thermal isolation is provided by a multi-layer insulation blanket across the interface between the IUS and TDRS.

### **IUS Avionics Subsystems**

The avionics subsystems consist of the telemetry, tracking and command subsystems; guidance and navigation subsystem; data management; thrust vector control and electrical power subsystems. These subsystems include all electronic and electrical hardware used to perform all computations, signal conditioning, data processing and formatting associated with navigation, guidance, control, data and redundancy management. The IUS avionics subsystems also provide the equipment for communications with the orbiter and ground stations as well as electrical power distribution.

Attitude control in response to guidance commands is provided by thrust vectoring during powered flight and by reaction control thrusters while coasting.

Attitude is compared with guidance commands to generate error signals. During solid motor firing, these commands gimbal the IUS's movable nozzle to provide the desired attitude pitch and yaw control. The IUS's roll axis thrusters maintain roll control. While coasting, the error signals are processed in the computer to generate thruster commands to maintain the vehicle's altitude or to maneuver the vehicle.

The IUS electrical power subsystem consists of avionics batteries, IUS power distribution units, power transfer unit, utility batteries, pyrotechnic switching unit, IUS wiring harness and umbilical, and staging connectors. The IUS avionics system distributes electrical power to the IUS/TDRS interface connector for all mission phases from prelaunch to spacecraft separation.

### **IUS Solid Rocket Motors**

The IUS uses a large and a small solid rocket motor employing movable nozzles for thrust vector control. The nozzles provide up to 4 degrees of steering on the large motor and 7 degrees on the small motor. The large motor is the longest thrusting duration solid rocket motor ever developed for space, with the capability to thrust as long as 150 seconds. Mission requirements and constraints (such as weight) can be met by tailoring the amount of solid propellant carried.

### **Reaction Control System**

The reaction control system controls the IUS/TDRS's attitude during coasting; roll control during SRM thrustings and velocity impulses for accurate orbit injection.

As a minimum, the IUS includes one reaction control fuel tank with a capacity of 120 pounds (54.4 kg) of hydrazine. Production options are available to add a second or third tank. IUS-13 will carry two tanks, each with 120 pounds (54.4 kg) of fuel.

To avoid spacecraft contamination, the IUS has no forward facing thrusters. The reaction control system also provides the velocities for spacing between several spacecraft deployments and for avoiding collision or contamination after the spacecraft separates.

### **IUS-to-Spacecraft Interfaces**

The TDRS spacecraft is physically attached to the IUS at eight attachment points, providing substantial load-carrying capability while minimizing the transfer of heat across the connecting points. Power, command and data transmission between the two are provided by several IUS interface connectors.

In addition, the IUS provides an insulation blanket of multiple layers of double-aluminized Kapton and polyester net spacers across the IUS/TDRS interface. The outer layer of the blanket, facing the TDRS spacecraft, is a special Teflon-coated fabric called Beta cloth. The blankets are vented toward and into the IUS cavity, which in turn is vented to the orbiter payload bay. There is no gas flow between the spacecraft and the IUS. The thermal blankets are grounded to the IUS structure to prevent electrostatic charge buildup.

### **Flight Sequence**

After the orbiter payload bay doors are opened in orbit, the orbiter will maintain a preselected attitude to keep the payload within thermal requirements and constraints.

On-orbit predeployment checkout begins, followed by an IUS command link check and spacecraft communications command check. Orbiter trim maneuvers normally are performed at this time.

Forward payload restraints will be released and the aft frame of the airborne support equipment will tilt the IUS/TDRS to 29 degrees. This will extend the TDRS into space just outside the orbiter payload bay, allowing direct communication with Earth during systems checkout. The orbiter will then be maneuvered to the deployment attitude. If a problem has developed within the spacecraft or IUS, the IUS and its payload can be restowed.

Prior to deployment, the spacecraft electrical power source will be switched from orbiter power to IUS internal power by the orbiter flight crew. After verifying that the spacecraft is on IUS internal power and that all IUS/TDRS predeployment operations have been successfully completed, a GO/NO-GO decision for IUS/TDRS deployment will be sent to the crew.

When the orbiter flight crew is given a GO decision, they will activate the pyrotechnics that separates the IUS/TDRS umbilical cables. The crew will then command the electromechanical tilt actuator to raise the tilt table to a 58-degree deployment position.

The orbiter's RCS thrusters will be inhibited and a pyrotechnic separation device initiated to physically separate the IUS/spacecraft combination from the tilt table. Compressed springs provide the force to jettison the IUS/TDRS from the orbiter payload bay at approximately 0.10 meters (4.2 inches) per second. The deployment is normally performed in the shadow of the orbiter or in Earth eclipse.

The tilt table will be lowered to minus 6 degrees after IUS and its spacecraft are deployed. Approximately 19 minutes after IUS/TDRS deployment, the orbiter's engines will be ignited to move the orbiter away from the IUS/TDRS.

At this point, the IUS/TDRS is controlled by the IUS onboard computers. Approximately 10 minutes after the IUS/TDRS is ejected from the orbiter, the IUS onboard computer will send out signals used by the IUS and/or TDRS to begin mission sequence events. This signal also will enable the reaction control system. All

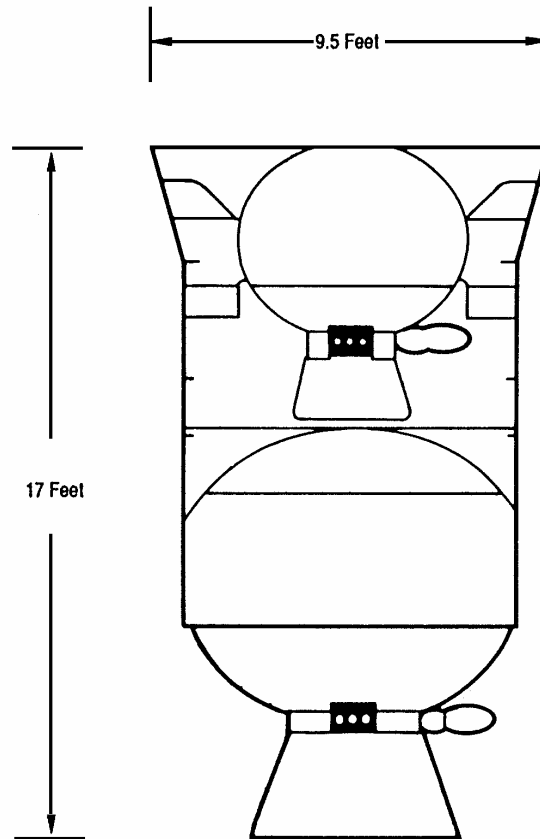
subsequent operations will be sequenced by the IUS computer, from transfer orbit injection through spacecraft separation and IUS deactivation.

After the RCS has been activated, the IUS will maneuver to the required thermal attitude and perform any required spacecraft thermal control maneuvers.

At approximately 45 minutes after ejection from the orbiter, the pyrotechnic inhibits for the first solid rocket motor will be removed. The belly of the orbiter has been oriented towards the IUS/TDRS combination to protect the orbiter windows from the IUS's plume. The IUS will recompute the first ignition time and maneuvers necessary to attain the proper attitude for the first thrusting period.

When the proper transfer orbit opportunity is reached, the IUS computer will send the signal to ignite the first stage motor. This is expected at approximately 60 minutes after deployment (L+7 hours, 13 minutes). After firing approximately 146 seconds and prior to reaching the apogee point of its trajectory, the IUS first stage will expend its fuel. While coasting, the IUS will perform any maneuvers needed by TDRS for thermal protection or communications. When this is completed, the IUS first stage and interstage will be separated from the IUS second stage.

Approximately 6 hours, 12 minutes after deployment at approximately L+12:30, the second stage motor will be ignited, thrusting for about 108 seconds. After burn is complete, the IUS stabilizes the TDRS while the solar arrays and two antennas are deployed. The IUS second stage will separate and perform a final collision/contamination avoidance maneuver before deactivating.



*Inertial Upper Stage Booster*

## **DIFFUSE X-RAY SPECTROMETER (DXS)**

The Diffuse X-ray Spectrometer (DXS) addresses a fundamental question of present-day astrophysics -- what is the origin and nature of the interstellar medium, the matter that fills the space between stars?

The DXS will study the hottest components of the interstellar medium, gases at temperatures at approximately 1 million degrees Kelvin, by detecting the x-rays emitted there. By measuring the gas temperature and composition, the DXS will provide important clues to the origin, evolution and physical state of this constituent of the Milky Way galaxy.

The hot interstellar medium is one phase in the life cycle of the material in this galaxy. By studying this life cycle, the DXS scientists hope to learn more about the way the mass and energy of the galaxy are redistributed as it evolves. A better understanding of the evolution of the galaxy is one of the steps toward understanding the nature and evolution of galaxies, which contain most of the visible matter in the Universe.

The DXS, developed by the University of Wisconsin, Madison, consists of two identical instruments, one mounted to each side of the Shuttle cargo bay. A DXS instrument consists of a detector, its associated gas supply and electronics. Each instrument is mounted to a 200-pound (91-kg) plate, which is attached to the side of the Shuttle bay.

These plates are part of the Goddard Space Flight Center's Shuttle Payload of Opportunity Carrier (SPOC) standard hardware, which is part of the Hitchhiker carrier system.

The Hitchhiker system provides real-time communications between the payload and customers in the Hitchhiker control center at Goddard Space Flight Center, Greenbelt, MD. The carrier system is modular and expandable in accordance with payload requirements. Hitchhikers were created to provide a quick reaction and low-cost capability for flying small payloads in the Shuttle payload bay.

### **DXS Science**

A large percentage of x-rays from space do not originate from specific objects like stars or galaxies, but from some source that appears to be distributed over the entire sky. Astronomers have found that these emissions fall into two types: high-energy or "hard" x-rays that may be the unresolved emissions from a collection of distant galaxies and low-energy or "soft" x-rays that are not yet well understood. DXS will study the latter.

Because low energy x-rays cannot travel more than a few hundred light years in interstellar space before they are absorbed, most of the diffuse soft x-ray background observed must have originated in the Milky Way galaxy from the vicinity of Earth's solar system.

The DXS measures the arrival direction and wavelength of incident low energy x-rays in the wavelength range of 42 to 84 angstroms -- an angstrom is one ten-thousandth of a millimeter. From this information, the DXS scientists will be able to determine the spectrum (brightness at each wavelength) of the diffuse soft x-ray background from each of several regions of the sky.

By analyzing these spectral features, scientists can identify the temperature, the ionization state and the elements which constitute this plasma. From these data they can tell whether the plasma is young and heated in the last 100,000 years or old and heated millions of years ago.

Previous experiments were not capable of measuring the spectrum of the diffuse soft x-ray background. With its spectral determination capability, the DXS will make this type of measurement possible for the first time.



## **DXS Operations**

Once the Shuttle is on orbit and the payload bay doors are open, a crew member will activate the experiment. DXS will be operated from Goddard's Payload Operations Control Center (POCC). University of Wisconsin personnel at Goddard will control and monitor the DXS, and Goddard personnel will monitor and control the operations of the Hitchhiker carrier support hardware.

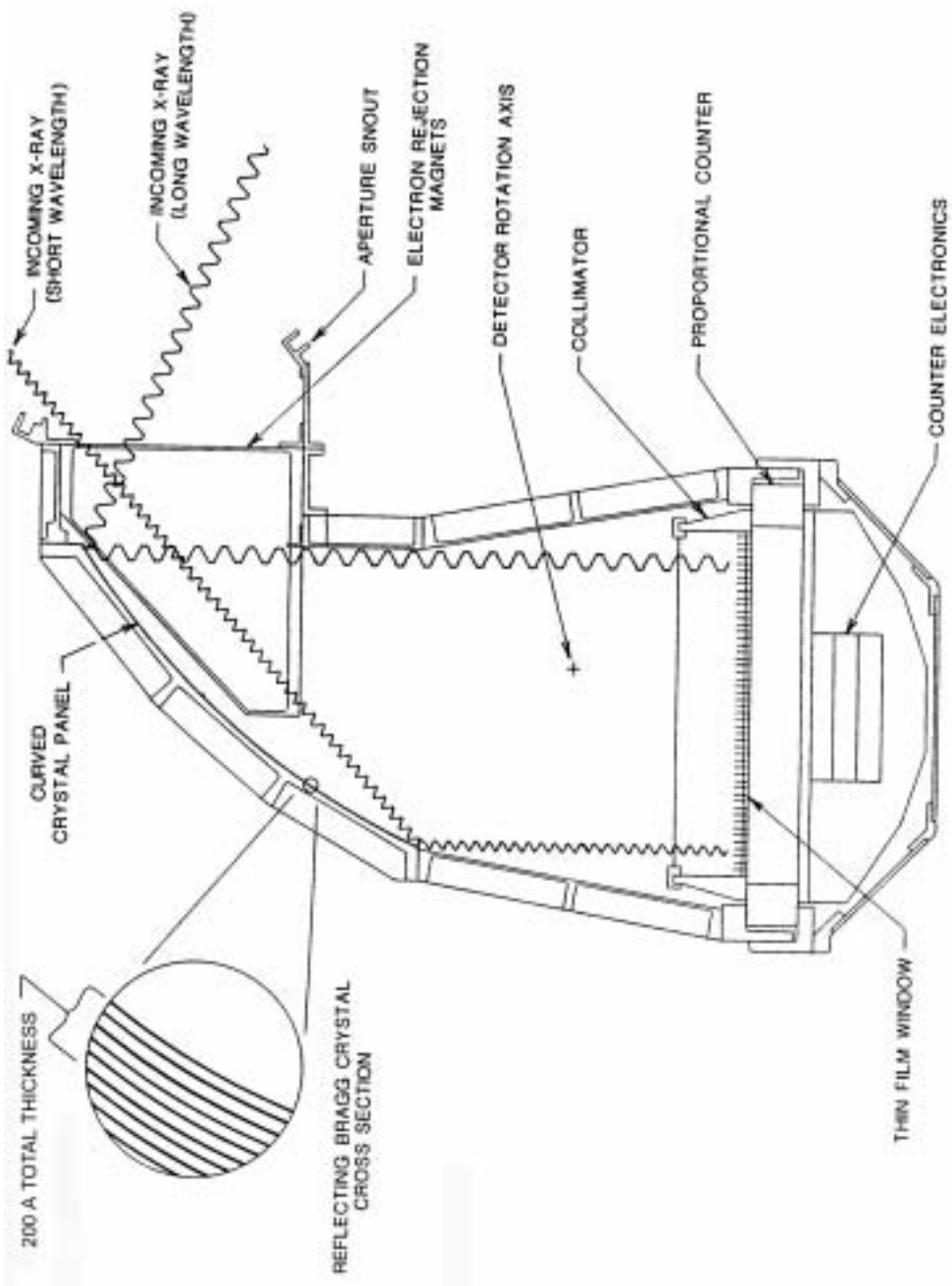
The DXS instruments will collect x-ray data during approximately 64 orbital nights over 4 flight days. In the orbit day periods throughout the mission, the DXS will perform sensor calibrations and will periodically replenish the detectors' gas supply. Goddard's Flight Dynamics Facility and the Spacelab Data Processing Facility will assist the DXS POCC operations and data processing activities.

After the Shuttle lands, the DXS instruments will be transported to the University of Wisconsin for post-flight testing and calibration.

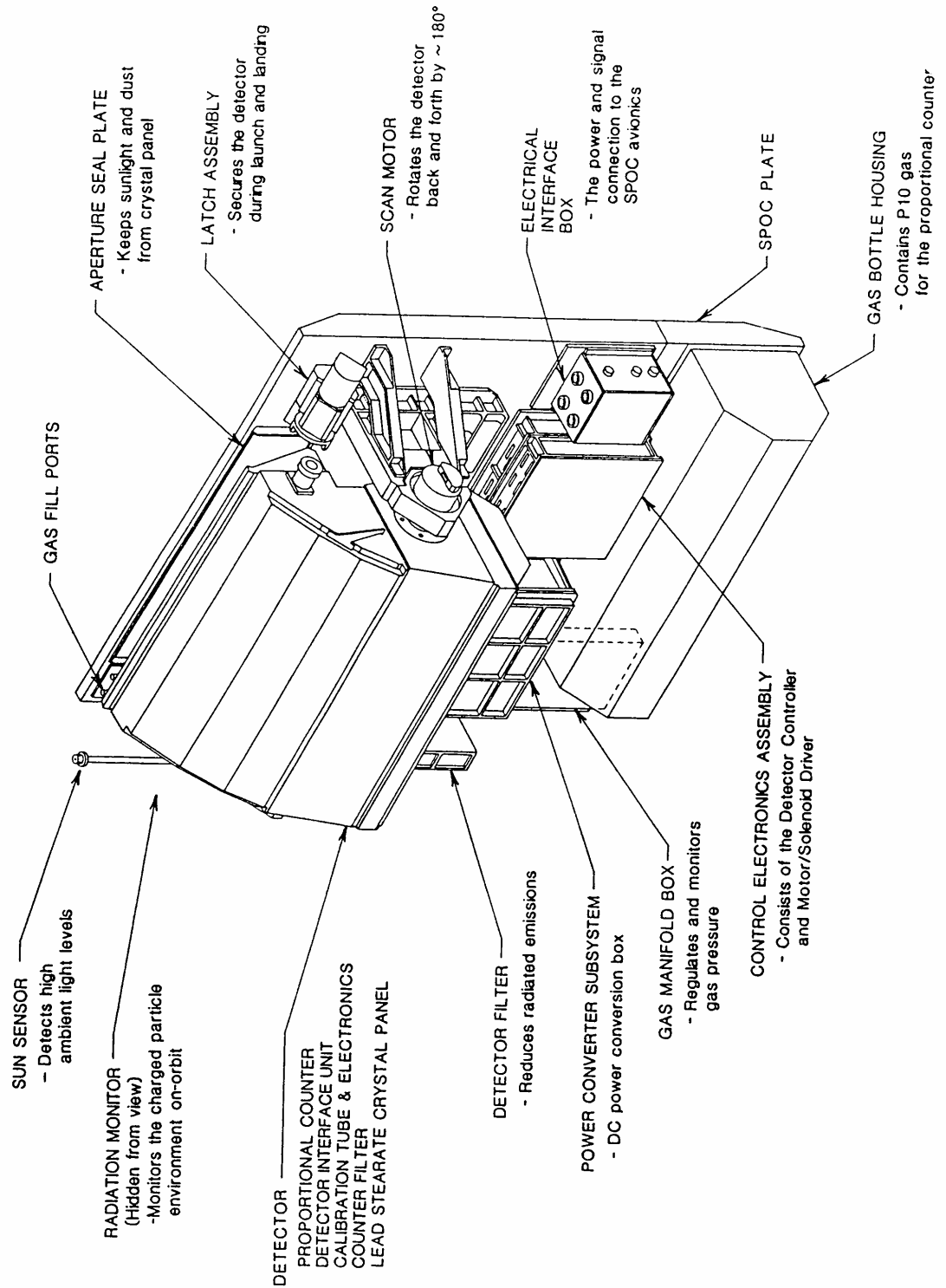
## **DXS History**

The DXS investigation was proposed and selected in response to a 1978 announcement of opportunity to conduct scientific investigations aboard the Space Shuttle. NASA selected DXS and four other astrophysics investigations, including three ultraviolet instruments and one x-ray telescope that flew in December 1990 on the STS-35/Astro-1 mission. All have scientific objectives and requirements that can be accomplished in a 5-10 day Shuttle mission.

DXS was originally manifested to fly with the Broad Band X-ray Telescope (BBXRT) on the second Shuttle High Energy Astrophysics Laboratory flight. In the re-manifesting that followed the Challenger accident, BBXRT flew on Astro-1, and DXS moved to STS-54.



DXS DETECTOR ASSEMBLY



## **STS-54 EVA TEST OBJECTIVE**

On the fifth day of the STS-54 flight, Mission Specialists Greg Harbaugh and Mario Runco Jr., will perform the first in a series of test spacewalks to be conducted on Shuttle missions during the years leading up to the construction of Space Station Freedom, scheduled to begin in early 1996.

Harbaugh will be designated Extravehicular Crew Member 1 (EV1) and Runco will be EV2. Mission Specialist Susan Helms will assist with the spacewalk from inside Endeavour's cabin as the intravehicular activity crew member (IV), tracking the progress of Harbaugh and Runco as they move through various tasks in the cargo bay.

The spacewalk tests are designed to refine training methods for future spacewalks, expand the experience of ground controllers, instructors and astronauts and aid in better understanding the differences between true weightlessness and the underwater facility used to train crew members.

During the STS-54 spacewalk, Runco and Harbaugh will evaluate how well they adapt to spacewalking, test their abilities to move about the cargo bay with and without carrying items, test the ability to climb into a foot restraint without handholds and test their ability to align a large object in weightlessness.

The spacewalk is the lowest priority test being performed on STS-54. No extra cargo has been added to the flight for the test, and it will not have any impact on the other payloads aboard Endeavour.

To simulate carrying a large object, the astronauts will carry one another: to evaluate how well large tools can be used, they will work with a tool already aboard Endeavour designed to manually raise the tilt table for the Tracking and Data Relay Satellite's Inertial Upper Stage booster; to simulate how well they can align an object, they will attempt to place each other into the brackets in Endeavour's airlock that hold the spacesuit backpacks when not in use.

Flight controllers expect many of these tasks to be awkward for the spacewalkers, and finding out just how difficult they will be is one goal of the tests. Information from this spacewalk test will be combined with information from many more that will follow to refine the understanding of difficulties involved with spacewalk work.

## **DEVELOPMENTAL AND PHYSIOLOGICAL PROCESSES INFLUENCING SEED PRODUCTION IN MICROGRAVITY (CHROMEX-4)**

Principal Investigator Dr. Mary Musgrave, Louisiana State University

CHROMEX-4 is designed to gain an understanding of the reproductive abnormalities which apparently occur in plants exposed to microgravity, and to determine whether changes in developmental processes may be due to spaceflight conditions, especially microgravity. This experiment also will help understanding how gravity influences fertilization and development on Earth.

To date, only a few studies have been conducted on developing seeds in space, and they all showed very poor seed production. NASA would like to use plants as a source of food and atmospheric cleansing for astronauts staying in space for extended periods of time. Seed production is vital if crops like wheat and rice are to be utilized for food.

The effects of microgravity on the seed production of *Arabidopsis thaliana* will be studied. *Arabidopsis thaliana* is a small, cress-type plant with white flowers. Its small size, small genome and short life cycle (45 days) make it ideal for gene mapping studies. It was chosen because it is small enough to fit in the flight hardware, and its rapid life cycle and numerous flowers will ensure that a maximum number of reproductive stages can be observed in a limited number \*of plants. *Arabidopsis* seeds will be planted preflight so that 14-day-old plants, capable of producing seeds, can be flown.

These plants will be flown inside the Plant Growth Unit (PGU), a closed system that provides day/night lighting located in the orbiter middeck. The PGU will hold six Plant Growth Chambers (PGCs), each of which will contain six plants. The PGCs provide structural and nutritional support to the plants while on orbit.

The PGU replaces one standard middeck locker and requires 28 volts of power from the orbiter. This hardware provides lighting, limited temperature control and data acquisition for post-flight analysis. The PGU has previously flown on STS-3, -51F, -29 and -41.

Following the flight, the flowers and developing seeds will be preserved and their structures will be subjected to gross morphological and histological analysis to determine the locations and life cycle stages of reproductive abnormality. These structures will be examined in detail by electron-microscopy.

The remaining plant tissue also will be analyzed for soluble carbohydrate, starch and chlorophyll. Sections of roots and leaves would examine other physiological processes that might be affected as a result of exposure to microgravity. All data will be compared with data gathered from 1g ground controls conducted at a later date using identical hardware.

Dr. Mary Musgrave of Louisiana State University is the Principal Investigator. The experiment is sponsored by the Life Sciences Division of NASA's Office of Space Science and Application. The experiment is managed by the Kennedy Space Center.

## COMMERCIAL GENERIC BIOPROCESSING APPARATUS (CGBA)

The Commercial Generic Bioprocessing Apparatus (CGBA) payload is sponsored by NASA's Office of Advanced Concepts and Technology and is developed by BioServe Space Technologies, a NASA Center for the Commercial Development of Space (CCDS) at the University of Colorado, Boulder. The purpose of the CGBA is to allow a wide variety of sophisticated biomaterials, life sciences and biotechnology investigations to be performed in one apparatus in the microgravity environment.

### Commercial Investigations

During the STS-54 mission, the CGBA will support 28 separate commercial investigations, loosely classified in three application areas: biomedical testing and drug development, controlled ecological life support system (CELSS) and agricultural development and manufacture of biological-based materials.

**Biomedical Testing and Drug Development:** To collect information on how microgravity affects biological organisms, the CGBA will include 12 biomedical test models. Of the 12 test models, five are related to immune disorders.

One will investigate the process in which certain cells engulf and destroy foreign materials (phagocytosis); another will study bone marrow cell cultures; two others will study the ability of the immune system to respond to infectious-type materials (lymphocyte and T-cell induction) and one will investigate the ability of immune cells to kill infectious cells (TNF-Mediated Cytotoxicity).

The other seven test models -- which are related to bone and developmental disorders, wound healing, cancer and cellular disorders -- will investigate bone tissue formation, brine shrimp development, pancreas and lung development, tissue regeneration, inhibition of cell division processes, stimulation of cell division processes and the ability of protein channels to pass materials through cell membranes.

Test model results will provide information to better understand diseases and disorders that affect human health, including cancer, osteoporosis and AIDS. In the future, these models may be used for the development and testing of new drugs to treat these diseases.

**CELSS Development:** To gain knowledge on how microgravity affects micro-organisms, small animal systems, algae and higher plant life. The CGBA will include 10 ecological test systems. Four test systems will examine miniature wasp and fruit fly development, seed germination and seedling processes for CELSS studies.

Another four test systems will investigate bacterial products and processes and bacterial colonies for waste management applications. Two other systems (Triiodid and Zirconium Peroxide) will study new materials to control build-up of unwanted bacteria and other micro-organisms.

Test system results will provide research information with many commercial applications. For example, evaluating higher plant growth in microgravity could lead to new commercial opportunities in controlled agriculture applications. Test systems that alter micro-organisms or animal cells to produce important pharmaceuticals later could be returned to Earth for large-scale production. Similarly, it may be possible to manipulate agricultural materials to produce valuable seed stocks.

**Biomaterials Products and Processes:** The CGBA also will be used to investigate six different biomaterials products and processes. Two investigations will attempt to grow large protein and RNA crystals to yield information for use in commercial drug development. A third investigation will evaluate the assembly of virus shells for use in a commercially-developed drug delivery system.

Another investigation will attempt to form a homogenous matrix of special light-sensitive biological molecules called bacteriorhodopsin. Such a matrix may be used in novel electronic mass storage systems associated with computers. A fifth experiment will use bacteria to form magnetosomes (tiny magnets) for potential use in advanced electronics. A sixth investigation will use fibrin clot materials as a model of potentially implantable materials that could be developed commercially as replacements for skin, tendons, blood vessels and even cornea.

Results from the 28 investigations will be considered in determining subsequent steps toward commercialization. STS-54 marks the second of six CGBA flights. Future flights will continue to focus on selecting and developing investigations that show the greatest commercial potential.

### **Flight Hardware**

The CGBA consists of 192 Fluids Processing Apparatuses (FPAs) and 24 Group Activation Packs (GAPs). Each GAP will house eight FPAs. The FPAs will contain biological sample materials which are mixed on-orbit to begin and end an experiment. Individual experiments will use two to 12 FPAs each.

Half of the FPAs and GAPs will be stored in the orbiter middeck in two Commercial Refrigerator Incubator Modules (CRIM). The other half will be stored in a standard stowage locker. Each CRIM holds six GAPs and will be operated at 37 degrees Celsius (98.6 degrees F. -- mammalian body temperature) to support cell culture investigations.

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

The FPAs are operated by a plunger mechanism that will be depressed on-orbit, causing the chambers of precursor fluid and the stoppers to move forward inside the glass barrel. When a specific stopper reaches an indentation in the glass barrel, initiation fluid from the second chamber is injected into the first chamber, activating the biological process.

Once processing is complete, the plunger will again be depressed until the termination fluid in the third chamber is injected across the bypass in the glass barrel into the first chamber.

GAP: The GAP consists of a 4-inch diameter plastic cylinder and two aluminum endcaps. Eight FPAs will be contained around the inside circumference of the GAP cylinder. A crank extends into one end of the GAP and attaches to a metal pressure plate. By rotating the crank, the plate will advance and depress the eight FPA plungers simultaneously.

### **On-orbit Operations**

Mission Specialists Susan Helms and Greg Harbaugh are the primary and backup crew members, respectively, responsible for CGBA operations. Upon reaching orbit, they will initiate the various investigations by attaching a crank handle to each GAP.

Turning the crank will cause an internal plate to advance and push the plungers on the contained FPAs. This action causes the fluids in the forward chambers of each FPA to mix. Most of the GAPs will be activated on either the first or second flight day.

The crew will terminate the investigations in a manner similar to activation. Attaching and turning the GAP crank will cause further depression of the FPA plungers causing the fluid in the rear chamber to mix with the

processed biological materials. This fluid typically will stop the process or "fix" the sample for return to Earth in a preserved state. Each of the 24 GAPs will be terminated at different time points during the mission. In this manner, sample materials can be processed from as little as 2 hours to nearly the entire mission duration.

For most of the investigations, simultaneous ground controls will be run. Using identical hardware and sample fluids and materials, ground personnel will activate and terminate FPAs in parallel with the flight crew. Synchronization will be accomplished based on indications from the crew as to when specific GAPs are operated. A temperature controlled environment at NASA's Kennedy Space Center will be used to duplicate flight conditions.

After Endeavor has landed, the CRIMs and stowage locker will be turned over to BioServe personnel for deintegration. Some sample processing will be performed at Kennedy. Most FPAs will be shipped or hand-carried back to the sponsoring labs for detailed analysis.

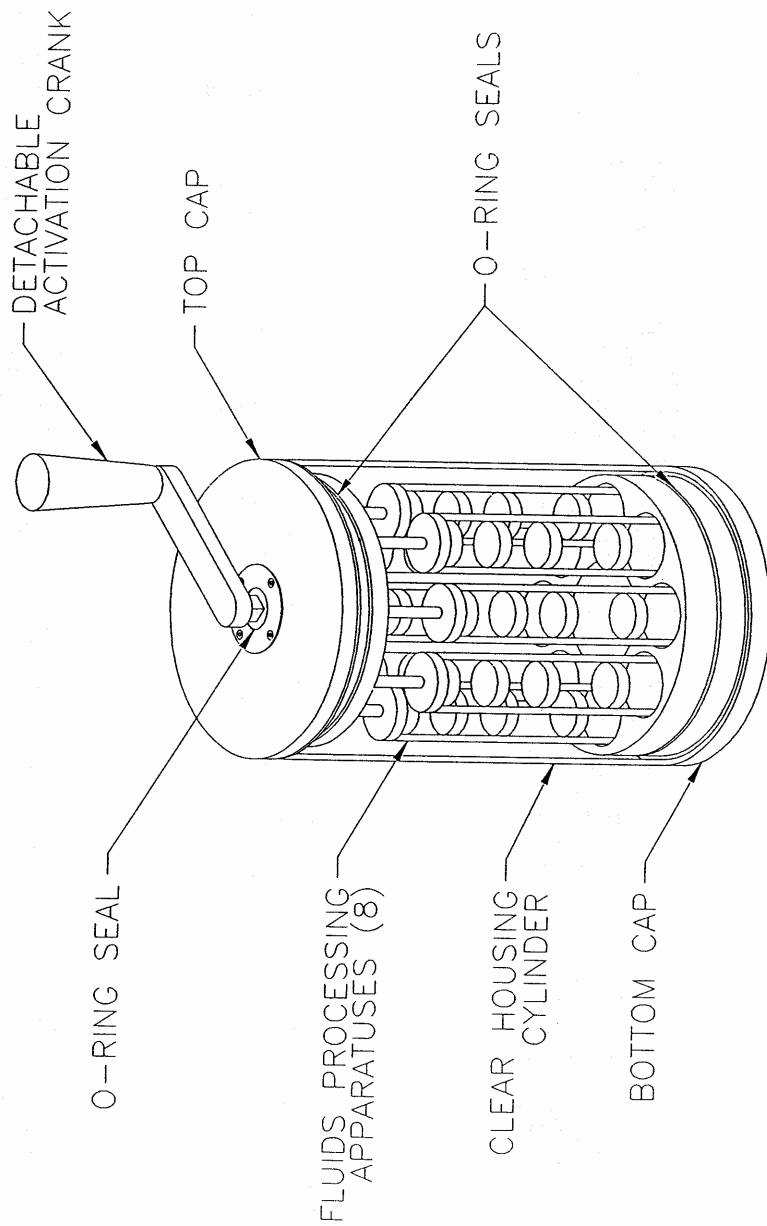
Dr. Marvin Luttges, Director of the BioServe CCDS, is Program Manager for CGBA. Drs. Louis Stodieck and Michael Robinson, also of BioServe, are responsible for mission management.



## Commercial Generic Bioprocessing Apparatus (CGBA) Experiments

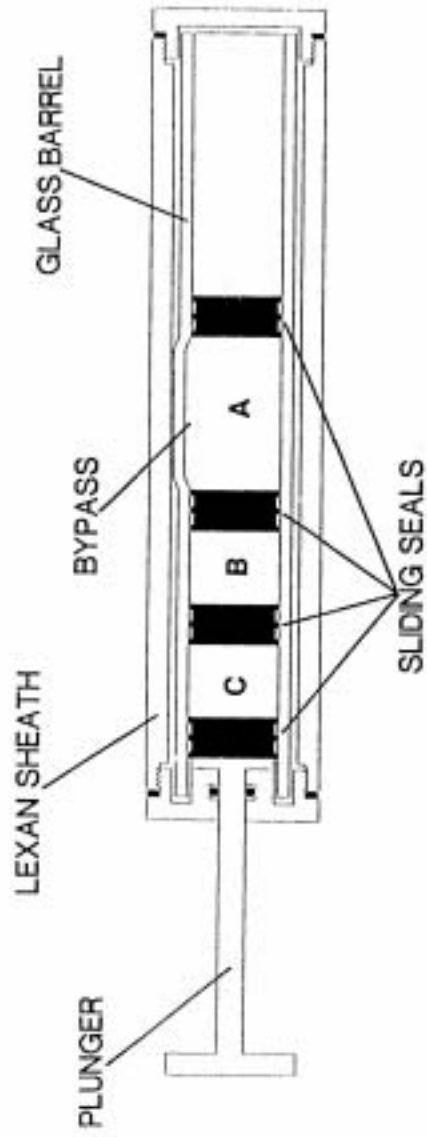
Experiment	PI Affiliation	Experiment Description	Commercial Application
Lymphocyte Induction Process	U. of Alabama in Huntsville	Examine immune system's ability to respond to infectious-type materials.	Immune Disorders
T-Cell Induction Test Model	Kansas State U.	Examines immune system's ability to respond to infectious-type materials.	Immune Disorders
TNF-Mediated Cytotoxicity Test Model	Kansas State U.	Examines immune cells' ability to kill infectious cells.	Immune Disorders
Bone Marrow Cell Culture Test System	Kansas State U.	Studies bone marrow cultures in microgravity.	Immune Disorders
Phagocytosis Process Testing	U. of Rochester	Investigates process in which certain cells engulf and destroy foreign materials.	Immune Disorders
Bone Organ Culture Test Model	Kansas State U.	Studies bone tissue formation in microgravity.	Bone Disorders
Pancreas and Lung Development Tests	Kansas State U.	Examines lung and pancreas development in microgravity.	Development Disorders
Regeneration Test Model	Spaceport Florida	Investigates tissue regeneration in microgravity.	Wound Healing Testing
Brine Shrimp Test System	Kansas State U.	Examines brine shrimp development in microgravity.	Development Disorders
Inhibitor Protein Test Model	Kansas State U.	Studies inhibition of cell division processes.	Cancer
Gap Junction Processes	Kansas State U.	Investigates ability of protein channels to pass materials through cell membranes	Cellular Disorders
Cell Division Processes	U. of Colorado	Studies stimulation of cell division processes.	Cellular Disorders
Seed Germination Products	U. of Colorado	Studies seed germination in microgravity.	Controlled Ecological Life Support System (CELSS) Studies
Seeding Processes	Kansas State U.	Examines seedling processes in microgravity.	CELSS Studies
Miniature Wasp Test System	U. of Colorado	Investigates miniature wasp development in microgravity.	CELSS Studies
Fruit Fly Test System	Kansas State U.	Examines fruit fly development in microgravity.	CELSS Studies
Bacterial Products and Processes	U. of Colorado	Studies bacterial products, processes and colonies in microgravity.	Waste Management
Bacterial Products and Processes	Kansas State U.	Studies bacterial products, processes and colonies in microgravity.	Waste Management
Bacterial Colony Test System	U. of Colorado	Studies bacterial products, processes and colonies in microgravity.	Waste Management
Triiodid Product Testing	U. of Colorado	Investigates new materials to control build-up of unwanted bacteria and other micro-organisms.	Microbial Control.
Zirconium Peroxide Product Testing	Kansas State U.	Investigates new materials to control build-up of unwanted bacteria and other micro-organisms.	Microbial Control.
Virus Capsid Product	Kansas State U.	Evaluates assembly of virus shells.	Drug Delivery System
Protein Crystal Morphology Products	U. of Colorado	Growth of large protein crystals.	Drug Development
RNA Crystal Growth Products	U. of Colorado	Growth of large RNA crystals.	Drug Development
Bacteriorhodopsin Biomatrix Products	Syracuse U.	Formation of homogeneous matrix using special light-sensitive biological molecules.	Data Mass Storage
Magnetosome Assembly Processes	U. of Colorado	Formation of magnetosomes (tiny magnets) using bacteria.	Advanced Electronics
Fibrin Clot Materials	U. of Colorado	Use of fibrin clot materials as a model of potentially implantable materials.	Synthetic Implants

**Commercial Generic Bioprocessing Apparatus**  
Group Activation Pack



# Commercial Generic Bioprocessing Apparatus

Fluids Processing Apparatus



CHAMBER A - PRECURSOR MATERIAL  
CHAMBER B - INITIATION FLUID  
CHAMBER C - TERMINATION FLUID

## **PHYSIOLOGICAL AND ANATOMICAL RODENT EXPERIMENT .02**

Principal Investigator Kenneth M. Baldwin, Ph.D.  
Department of Physiology and Biophysics  
University of California, Irvine

Co-Investigator Vincent J. Caiozzo, Ph.D.  
Department of Orthopedic Surgery, College of Medicine  
University of California, Irvine

The second Physiological and Anatomical Rodent Experiment (PARE.02) is a secondary payload flight experiment located in a Space Shuttle's mid-deck locker.

The goal of PARE.02 is to determine the extent to which short-term exposure to microgravity alters the size, strength and endurance capacity (stamina) of skeletal muscles normally used to help support the body against the force of gravity.

The study, managed by NASA's Ames Research Center, Mountain View, Calif., will use rodents because their muscles are known to respond rapidly to altered gravity forces.

When individuals are exposed to the microgravity of space, there appears to be a significant loss in muscle mass. This appears to be because the muscle must no longer exert a sufficient level of force, which produces a signal to the body to conserve mass. However, the loss of muscle mass hinders one's capability to function when returning to Earth. All movement patterns are difficult, and the individual may be prone to accidents because of this instability. Scientists need to find the extent to which the muscle atrophies, what impact the atrophy process has on muscle performance and how to prevent the atrophy from occurring.

Second, the problem of muscle atrophy is similar in part to what is seen on Earth during the normal aging. As one gets older, he/she becomes less physically active and the degree of muscle disuse is exaggerated. This leads to the same problems as occur during exposure to microgravity. Thus, if the problem of atrophy in space can be solved, scientists should have a good insight for maintaining the muscle system in a more viable condition as humans age.

Millions of dollars are spent annually to treat older individuals with injuries and disabilities resulting from the general problem of muscle and bone weakness, particularly in the female population.

The information derived from such a project has obvious practical relevance to the entire health care industry. Any insight that can be generated to prevent body dysfunction and injury, as well as to rehabilitate the musculoskeletal system from the effects of disuse atrophy, are very important to the broad range population base of our society.

With the advent of the Space Shuttle program and Spacelab, it is now possible to expose both humans and animals to the unique environment of microgravity. In this way scientists can begin to partition out the specific effects of gravity in regulating the structural and functional properties of the organ systems of the body.

The Shuttle makes it possible for life to exist in a new environment that is entirely foreign to the body, thereby enabling scientists to understand how the force of gravity normally impacts health and well-being.

This is the second phase of this research experiment. The first studied the effects of microgravity on how the muscle cells process the food humans eat and transform the food into the energy necessary to enable the muscles to function. The experiment distinguished that the muscles isolated from animals exposed to zero gravity had a reduced capacity to process fat substrate while retaining a normal capacity to process carbohydrate for energy.

This finding has important implications if it occurs in the intact individual, because it would force a person to use his/her energy stores of carbohydrate at a faster rate. When this occurs the muscle loses its stamina and the individual cannot sustain physical activity for as long a time.

The PARE.02 project will examine the extent to which the muscle loses its stamina after exposure to microgravity for 6 days.

NASA's Ames Research Center provides payload and science management and support for PARE.02. The project is sponsored by the Life Sciences Division of NASA's Office of Space Science and Applications.

## **SOLID SURFACE COMBUSTION EXPERIMENT (SSCE)**

Principal Investigator Professor Robert A. Altenkirch  
Dean of Engineering, Mississippi State University

The purpose of the SSCE is to study the physical and chemical mechanisms of flame propagation over solid fuels in the absence of gravity-driven buoyant or externally-imposed airflows. The controlling mechanisms of flame propagation in microgravity are different than in normal gravity.

On Earth, gravity causes the air heated by the flame to rise. This air flow, called buoyant convection, feeds oxygen to the flame and cools the fire, creating competing effects. In microgravity, this flow is absent. Therefore, the fire is sustained only by the oxygen that it consumes as it migrates along the fuel's surface. The results of the SSCE have a practical application in the evaluation of spacecraft fire hazards, as well as providing a better understanding of flame propagation in microgravity and on Earth.

The SSCE occupies four standard lockers in the orbiter middeck. The experiment consists of two parts -- the chamber module and the camera module. The chamber module consists of a sealed combustion chamber which houses the sample and is filled with a combination of oxygen and nitrogen. The chamber has two perpendicular viewports -- one on the side and one on the top.

Two 16-mm color movie cameras mounted on the camera module record the combustion process through the viewports. In addition, thermocouples measure temperature data while a pressure transducer measures changes in chamber pressure. These data are stored in the experiment computer for post-flight analysis.

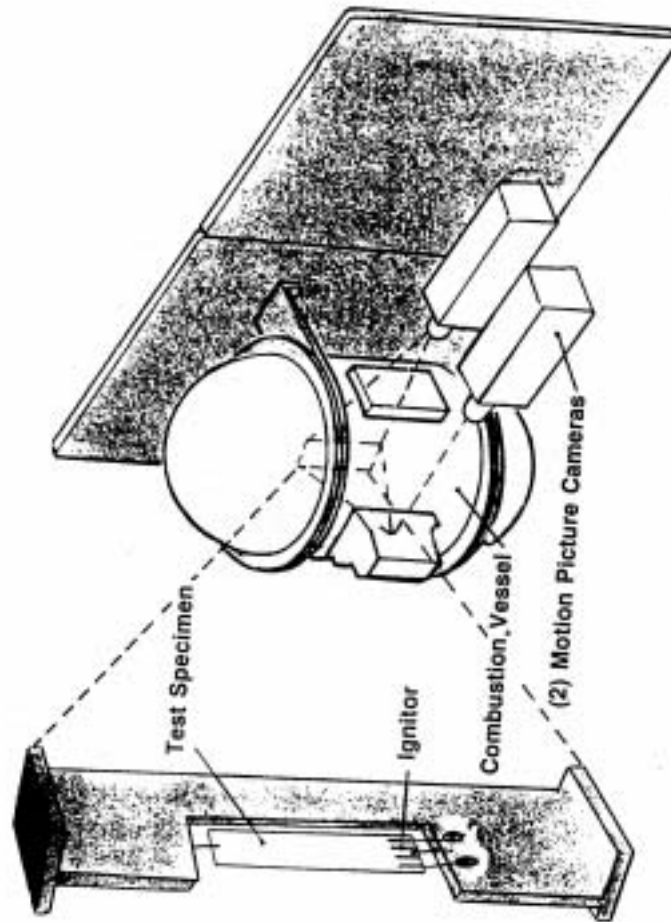
Ashless filter paper was tested on the first five flights with different mixtures of oxygen and nitrogen and with varying pressures. The final three tests will use polymethylmethacrylate (PMMA), commonly known as Plexiglas\*. Typically, one configuration will be tested per mission. For this mission, the chamber will contain a 35:65 ratio by volume of oxygen to nitrogen at a total pressure of 1.0 atmosphere.

A crew member provides power to the experiment and by activating a switch, the crew member ignites the fuel and data collection begins. After approximately 75 seconds, the sample self-extinguishes and data collection ceases. The entire process takes approximately 25 minutes.

This is the sixth in a series of eight experiments studying flame propagation in space. The experiment was flown aboard the STS-41, STS-40, STS-43, STS-50 and STS-47 Shuttle missions in October 1990, June 1991, August 1991, June 1992 and September 1992, respectively.

SSCE was conceived by Professor Robert A. Altenkirch, Dean of Engineering at Mississippi State University, and was built by the NASA Lewis Research Center, Cleveland. The project is sponsored by the NASA Microgravity Science and Applications Division of the Office of Space Science and Applications.

# SOLID SURFACE COMBUSTION EXPERIMENT (SSCE)



## **APPLICATION SPECIFIC PREPROGRAMMED EXPERIMENT CULTURE SYSTEM PHYSICS OF TOYS (ASPEC) PHYSICS OF TOYS**

The STS-54 mission will carry a collection of children's toys for an educational post-flight videotape on the Physics of Toys. A similar opportunity took place on STS-51D in April 1985, and the subsequent videotape of demonstrations conducted by the crew has become one of the most popular educational resources NASA has offered to schools.

Toys have long been used to help teach basic and advanced scientific principles and concepts of force, motion and energy. Many toys depend on these principles and concepts to function. Although teachers are able to anticipate what toys may do in space, free from the gravity vector, unexpected actions may be observed. The possibility of discovery turns Physics of Toys from just a collection of valuable science demonstrations into legitimate science experiments.

The tape to be created on STS-54 will feature new toys, toys that have been flown before and toys that children can make themselves. The tape will be available to schools in the Fall of 1993. The tape will use toys to teach some basic principles of science and math to students using an investigative approach. Children will be encouraged to investigate the same toys in the normal 1-gravity environment of Earth and then speculate on what those same toys will do in the microgravity of space flight.

In addition to the videotape, selected students in grades 3-5 from the crewmembers' hometowns will actively participate as investigators and will talk with the orbiting crew. Through telephone and television links, these students, while in their classrooms or other school facilities, will ask the crew questions about the Physics of Toys experiments. In preparation for this opportunity, NASA traveled to each of the schools involved and conducted pre-experiments with the toys.

The Physics of Toys experiment is scheduled around noon EST on flight day 3. The experiment will begin with a brief videotape showing highlights of the mission and a few of the coming events. There will be a brief introduction to the experiment and then the first crewmember will take questions. Only one school will be able to talk to a crewmember at a time. Each school will have approximately 8 minutes. The order of the crewmembers and schools is as follows.

- Sacred Heart School, Bronx, NY, will experiment with car and track and klacker balls. (Mario Runco)
- Thomas A. Edison Elementary School, Willoughby, Ohio, will experiment with a basketball and magnetic marbles. (Greg Harbaugh)
- Shaver Elementary School, Portland, Ore., will experiment with swimming toys and a flipping mouse. (Susan Helms)
- Westwood Heights Schools, Flint, Mich., will experiment with gravitrons and a balloon helicopter. (Donald McMonagle)

Any time remaining in the experiment after all schools have asked their questions will be filled with selected demonstration of flying toys by crew Commander John Casper.

## STS-54 CREWMEMBERS



*STS054-S-002 -- STS-54 Endeavour, Orbiter Vehicle (OV) 105, crewmembers, wearing launch and entry suits (LESs), pose for their official crew portrait on the flight deck of JSC's motion based (MB) shuttle mission simulator (SMS). Left to right are mission specialist Mario Runco Jr., mission commander John H. Casper, pilot Donald R. McMonagle, and mission specialists Susan J. Helms and Gregory J. Harbaugh. MB-SMS is located in JSC's Mission Simulation and Training Facility Bldg 5. Portrait made by NASA JSC contract photographer Scott A. Wickes.*

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## BIOGRAPHICAL DATA

**JOHN H. CASPER**, 48, Col., USAF, is Commander of Endeavour's third space mission. Selected to be an astronaut in 1984, Casper, from Gainesville, GA, is making his second Shuttle flight.

Casper served as Pilot on Atlantis' STS-36 mission in February 1990, which carried Department of Defense payloads and a number of secondary payloads.

A graduate of Chamblee High School in Chamblee, GA, in 1961, Casper received a bachelor of science degree in engineering science from the U.S. Air Force Academy in 1966 and a master of science degree in astronautics from Purdue University in 1967. He is a 1986 graduate of the Air Force Air War College.

Casper received his pilot wings at Reese Air Force Base, Texas, in 1968 and has logged more than 6,000 flying hours in 50 different aircraft. His first Shuttle mission lasted 106 hours.

**DONALD (DON) R. MCMONAGLE**, 38, Col., USAF, is Pilot of STS-54. Born in Flint, Mich., McMonagle was selected as a pilot astronaut in 1987 and made his first flight as a mission specialist aboard Discovery on STS-39 in April 1991, an unclassified Department of Defense mission.

McMonagle graduated from Hamady High School in Flint in 1970. He holds a bachelor of science degree in astronautical engineering from the U.S. Air Force Academy and a master of science in mechanical engineering from California State University, Fresno.

He graduated from pilot training at Columbus Air Force Base, Miss., in 1975 and has more than 4,200 hours of flying experience in a variety of aircraft, primarily the T-38, F-4, F-15 and F-16. He logged more than 199 hours in space on his first Shuttle mission.

**GREGORY (GREG) J. HARBAUGH**, 35, will serve as Mission Specialist 1. Before being selected as an astronaut in 1978, Harbaugh held engineering and technical management positions in various areas of Space Shuttle flight operations -- particularly data processing systems -- and supported real-time Shuttle operations from the JSC Mission Control Center for most of the flights from STS-1 to STS-51L.

Harbaugh, who considers Willoughby, Ohio, as his hometown, graduated from Willoughby South High School in 1974, received a bachelor of science degree in aeronautical and astronautical engineering from Purdue University in 1978 and a master of science degree in physical science from the University of Houston-Clear Lake in 1986.

Harbaugh flew as a mission specialist on STS-39 and was responsible for operation of the remote manipulator system robot arm and the Infrared Background Signature Survey spacecraft. With the completion of the mission, he had logged 199 hours in space.

## BIOGRAPHICAL DATA

**MARIO RUNCO JR.**, 39, Lt. Cdr., USN, will serve as Mission Specialist 2. From Yonkers, NY, Runco graduated from Cardinal Hayes High School in the Bronx, NY, in 1970.

He received a bachelor of science degree in meteorology and physical oceanography from City College of New York in 1974 and a master of science degree in meteorology from Rutgers University, New Brunswick, NJ, in 1976.

After graduating from Rutgers, Runco worked for a year as a research hydrologist conducting ground water surveys for the U.S. Geological Survey on Long Island, NY. He worked as a New Jersey State Trooper until entering the U.S. Navy in 1978 and being commissioned that same year.

He served in various Navy posts, being designated a Naval Surface Warfare Officer and conducting hydrographic and oceanography surveys of the Java Sea and Indian Ocean before joining NASA.

Runco served as a mission specialist aboard Atlantis on STS-44 in November 1991, which deployed the Defense Support Program satellite and conducted two Military Man in Space experiments, three radiation monitoring experiments and numerous medical tests. Runco logged more than 166 hours on that flight.

**SUSAN J. HELMS**, 33, Capt., USAF, will serve as Mission Specialist 3 on STS-54. From Portland, Ore., she was selected as an astronaut in 1990.

Helms graduated from Parkrose Senior High School in Portland in 1976, received a bachelor of science degree in aeronautical engineering from the U.S. Air Force Academy in 1980 and a master of science degree in aeronautics and astronautics from Stanford University in 1985.

Helms was an F-16 weapons separation engineer at Eglin Air Force Base, FL, and served as an assistant professor of aeronautics at the academy. In 1987, she attended Air Force Test Pilot School at Edwards Air Force Base, Calif. and worked as a flight test engineer and project officer on the CF-18 aircraft at CFB Cold Lake, Alberta, Canada. As a flight test engineer, she has flown in 30 different types of U.S. and Canadian military aircraft. This will be her first Space Shuttle flight.

## MISSION MANAGEMENT FOR STS-54

### NASA HEADQUARTERS, WASHINGTON, DC

#### Office of Space Flight

Jeremiah W. Pearson III	Associate Administrator
Brian O'Connor	Deputy Associate Administrator
Tom Utsman	Director, Space Shuttle
Leonard Nicholson	Manager, Space Shuttle
Brewster Shaw	Deputy Manager, Space Shuttle

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Robert Benson	Director, Flight Systems Division
David Jarrett	DXS Program Manager
Dr. Louis Kaluzienski	DXS Program Scientist

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Richard H. Ott, Director	Commercial Flight Experiments
Garland C. Misener	Chief, Flight Requirements & Accommodations

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Jerry Fitts	Deputy Associate Administrator
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Daniel Brandel	Manager, TDRSS Continuation
Raymond Newman	Manager, Ground Segment
Wilson Lundy	Manager, White Sands Space Network Complex

#### Office of Safety and Mission Quality

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Charles Mertz	(Acting) Deputy Associate Administrator
Richard Perry	Director, Programs Assurance

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John J. "Tip" Talone	Endeavour Flow Director
J. Robert Lang	Director, Vehicle Engineering
Al J. Parrish	Director of Safety Reliability and Quality Assurance
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P. Thomas Breakfield	Director, Shuttle Payload Operations
Joanne H. Morgan	Director, Payload Project Management
Roelof Schuiling	STS-54 Payload Processing Manager

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Alexander A. McCool	Manager, Shuttle Projects Office
Dr. George McDonough	Director, Science and Engineering
James H. Ehl	Director, Safety and Mission Assurance
Otto Goetz	Manager, Space Shuttle Main Engine Project
Victor Keith Henson	Manager, Redesigned Solid Rocket Motor Project
Cary H. Rutland	Manager, Solid Rocket Booster Project
Parker Counts	Manager, External Tank Project

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Paul J. Weitz	Deputy Director
Daniel Germany	Manager, Orbiter and GFE Projects
David Leestma	Director, Flight Crew Operations
Eugene F. Kranz	Director, Mission Operations
Henry O. Pohl	Director, Engineering
Charles S. Harlan	Director, Safety, Reliability and Quality Assurance

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Gerald Smith	Deputy Director
J. Harry Guin	Director, Propulsion Test Operations

## **AMES-DRYDEN FLIGHT RESEARCH FACILITY, EDWARDS, CA**

Kenneth J. Szalai	Director
T. G. Ayers	Deputy Director
James R. Phelps	Chief, Shuttle Support Office

**AMES RESEARCH CENTER, MOUNTAIN VIEW, CA**

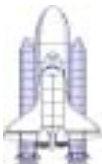



Dr. Dale L. Compton	Director
Victor L. Peterson	Deputy Director
Dr. Joseph C. Sharp	Director, Space Research

**GODDARD SPACE FLIGHT CENTER, GREENBELT, MD**

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Thomas E. Huber	Director, Engineering Directorate
Theodore C. Goldsmith	Project Manager, Shuttle Small Payloads
Steven C. Dunker	DXS Project Manager
Vernon J. Weyers	Director, Flight Projects
Dale L. Fahnestock	Director, Mission Operations and Data Systems
Daniel A. Spintman	Chief, Networks Division
Vaughn E. Turner	Chief, Communications Division
Charles Vanek	Project Manager, TDRS
Thomas E. Williams	Deputy Project Manager, TDRS
Anthony B. Comberiate	TDRS Manager
Gary A. Morse	Network Director

# SHUTTLE FLIGHTS AS OF JANUARY 1993

52 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 27 SINCE RETURN TO FLIGHT

				
STS-52 10/22/92 - 11/01/92		STS-53 12/02/92 - 12/09/92		
STS-50 06/25/92 - 07/09/92		STS-42 01/22/92 - 01/30/92		
STS-40 06/05/91 - 06/14/91		STS-48 09/12/91 - 09/18/91		
STS-35 12/02/90 - 12/10/90	STS-51L 01/28/86	STS-39 04/28/91 - 05/06/91	STS-46 07/31/92 - 08/08/92	
STS-32 01/09/90 - 01/20/90	STS-61A 10/30/85 - 11/06/85	STS-41 10/06/90 - 10/10/90	STS-45 03/24/92 - 04/02/92	
STS-28 08/08/89 - 08/13/89	STS-51F 07/29/85 - 08/06/85	STS-31 04/24/90 - 04/29/90	STS-44 11/24/91 - 12/01/91	
STS-61C 01/12/86 - 01/18/86	STS-51B 04/29/85 - 05/06/85	STS-33 11/22/89 - 11/27/89	STS-43 08/02/91 - 08/11/91	
STS-9 11/28/83 - 12/08/83	STS-41G 10/05/84 - 10/13/84	STS-29 03/13/89 - 03/18/89	STS-37 04/05/91 - 04/11/91	
STS-5 11/11/82 - 11/16/82	STS-41C 04/06/84 - 04/13/84	STS-26 09/29/88 - 10/03/88	STS-38 11/15/90 - 11/20/90	
STS-4 06/27/82 - 07/04/82	STS-41B 02/03/84 - 02/11/84	STS-51-I 08/27/85 - 09/03/85	STS-36 02/28/90 - 03/04/90	
STS-3 03/22/82 - 03/30/82	STS-8 08/30/83 - 09/05/83	STS-51G 06/17/85 - 06/24/85	STS-34 10/18/89 - 10/23/89	
STS-2 11/12/81 - 11/14/81	STS-7 06/18/83 - 06/24/83	STS-51D 04/12/85 - 04/19/85	STS-30 05/04/89 - 05/08/89	
STS-1 04/12/81 - 04/14/81	STS-6 04/04/83 - 04/09/83	STS-51C 01/24/85 - 01/27/85	STS-27 12/02/88 - 12/06/88	
		STS-51A 11/08/84 - 11/16/84	STS-61B 11/26/85 - 12/03/85	STS-47 09/12/92 - 09/20/92
		STS-41D 08/30/84 - 09/05/84	STS-51J 10/03/85 - 10/07/85	STS-49 05/07/92 - 05/16/92
				
<b>OV-102</b> Columbia (13 flights)	<b>OV-099</b> Challenger (10 flights)	<b>OV-103</b> Discovery (15 flights)	<b>OV-104</b> Atlantis (12 flights)	<b>OV-105</b> Endeavour (2 flights)