Apr 24th, 2:00 PM - 5:00 PM

Paper Session I-B - Science Payloads

Robert H. Benson

Director, Flight Systems Division, NASA Office of Space Science & Applications

Follow this and additional works at: https://commons.erau.edu/space-congress-proceedings

Scholarly Commons Citation

https://commons.erau.edu/space-congress-proceedings/proceedings-1990-27th/april-24-1990/14

This Event is brought to you for free and open access by the Conferences at Scholarly Commons. It has been accepted for inclusion in The Space Congress® Proceedings by an authorized administrator of Scholarly Commons. For more information, please contact commons@erau.edu, wolfe.309@erau.edu.
An Overview Of The Spacelab Program

by Robert H. Benson
Director,
Flight Systems Division
NASA Office of Space Science & Applications

The Flight Systems Division at NASA Headquarters in Washington, D.C., has overall management responsibility for OSSA Spacelab and Shuttle-attached payload flight programs. These programs include a variety of science and applications investigations carried in and on Shuttle payload carriers such as Spacelab modules and pallets, Multi-Purpose Equipment Support Structures (MPESS), Get Away Special (GAS) canisters, and Hitchhiker-G equipment platforms (see Figure 1).

In addition to the payload bay experiment carriers shown in Figure 1, science and applications experiments can be flown in standard stowage lockers in the crew compartment middeck. Locker space for experiments in the crew compartment is at a premium because these lockers must also contain food, clothing, crew personal effects, camera equipment, tools, etc. In an effort to maximize Shuttle science accommodations, a Middeck Accommodations Rack (MAR) that will provide space for an addition three middeck experiment lockers (and assorted stowage) has recently been developed (see Figure 2). The MAR will replace the Orbiter galley on selected flights, with the galley being reconfigured in a smaller form in lockers on the forward bulkhead of the middeck. A major advantage of the MAR system is its modularity, allowing for accommodation of odd- or large-sized experiments which would not normally fit into middeck locker space (see Figure 3).

Prior to January 1986, four dedicated Spacelab missions had flown. These were Spacelab 1 (module and pallet) in November 1983, Spacelab 3 (module and MPESS) in April 1985, Spacelab 2 (igloo, 3 pallets and a special support structure) in July 1985, and Spacelab D-1 (module and special support structure) in October 1985. In addition to these dedicated Shuttle flights, numerous single pallet and other attached payloads were also flown.

Based on the most recent NASA flight assignment manifest for the Space Shuttle (dated January 1990), sixteen more dedicated Spacelab missions are scheduled through the year 1995. In flight order, these missions are:

Astro-1 (STS-35)  SLS - 2 (STS-59)
SLS - 1 (STS-40)  IML - 2 (STS-62)
IML - 1 (STS-42)  SRL - 2 (STS-74)
ATLAS - 1 (STS-45)  USML - 2 (STS-78)
Spacelab - J (STS-47)  Spacelab - D3 (STS-81)
USML - 1 (STS-53)  SLS - 3 (STS-87)
Spacelab - D2 (STS-55)  IML - 3 (STS-90)
SRL - 1 (STS-57)  SRL - 3 (STS-96)

In addition to these dedicated flights, a number of Spacelab experiments are also flown on smaller carriers and share the payload bay with deployable satellites,
Figure 1. Spacelab & Attached Experiment Carriers for the Space Shuttle Payload Bay
Figure 2. The New Middeck Accommodations Rack (MAR)

CVTE System

Figure 3. The MAR Configured for the Crystals by Vapor Transport Experiment
commercial experiments, and Department of Defense payloads. These smaller Spacelab and Shuttle-attached payloads include ATLAS - 2, 3, 4, and 5 (reduced to a single pallet after ATLAS - 1); TSS - 1; USMP - 1, 2, 3, and 4; DXS, SPAS-ORFEUS and SPAS-CRISTA; and LITE - 1. There are also a number of middeck locker experiments planned. An explanation of the mission acronyms and a brief description of the dedicated missions is given below.

**Astro - 1**

Astro - 1 is an ultraviolet and x-ray astronomy Spacelab mission scheduled for launch in May, and is the first major Spacelab mission since the Shuttle's return to flight operations. At the time of the Challenger accident, the next launch was to have been Astro-1, at that time an igloo and two-pallet ultraviolet astronomy mission. During the two-and-a-half-year suspension of Shuttle flights, Astro-1 was reconfigured, removing a wide-field camera designed to photograph Halley's Comet and adding a large x-ray telescope with its own unique pointing system and carrier structure. This new telescope, the Broad Band X-Ray Telescope (BBXRT), will be used along with the uv telescopes to make simultaneous x-ray observations of celestial objects such as quasars, active galactic nuclei, supernova remnants, and stars. In a stroke of good fortune, Astro-1 will be in orbit near the time when the newly discovered Comet Austin makes its closest approach to Earth, and the uv telescopes will be used to investigate the comet at relatively close range.

There are three ultraviolet (uv) telescopes mounted together on an Instrument Pointing System (IPS) platform. This cluster of uv telescopes, the Ultraviolet Imaging Telescope (UIT), the Hopkins Ultraviolet Telescope (HUT), and the Wisconsin Uv Photopolarimetry Experiment (WUPPE), will be unlocked and raised into position once the Shuttle is in orbit and the payload bay doors have been opened. The uv telescopes are operated by Mission Specialists and Payload Specialists from the Orbiter's aft flight deck, while the BBXRT is controlled by a ground-based science team at the Marshall Space Flight Center in Alabama and from the Goddard Space Flight Center in Maryland. Figure 4 shows the new Astro-1 configuration, followed by photographs of the uv and x-ray telescopes during experiment integration.

In addition to the scientific investigations that will take place, the planned ten-day Astro-1 mission will be the first use of a new program known as Lessons From Space. Lessons From Space on Astro-1 will consist of a 20- to 30- minute crew lecture and demonstration that will be broadcast live to middle school and high school classes across the country. The lesson will deal primarily with astronomy, the electromagnetic spectrum, and the Astro-1 payload. It will include a question-and-answer session with students located at NASA's Marshall and Goddard Space Flight Centers. The live lecture will be supplemented with a teacher's guide and lesson plan and with additional shorter talks and demonstrations given throughout the mission, which will be taped for later distribution to hundreds of schools throughout the United States. By having the astronaut crew address basic themes such as "what is astronomy" and "why I became an astronomer," as well as more fundamental scientific principles such as diffraction and target selection, it is hoped that Lessons From Space will stimulate student interest in science, math, and engineering as possible career choices. It is anticipated that Lessons From Space will be incorporated into more Spacelab missions in the future on a non-interference basis with the scientific activities.
Figure 4. The Astro-1 Flight Configuration
Astro-1 Broad Band X-Ray Telescope Following Initial Integration at the Goddard Space Flight Center
SPACELAB LIFE SCIENCE (SLS) - 1

The Spacelab Life Science - 1 mission is devoted to life sciences research related to the future health, safety, and productivity of humans in space. A set of complimentary investigations will focus on observations of early physiological responses to weightlessness. The study of existing problems associated with weightlessness, such as acute fluid shift, cardiovascular adaptation, and space motion sickness, will foster new insights into the responsible physiological mechanisms. Research of this type is necessary to support long-term human operations in space, such as Space Station Freedom activities and manned lunar and Mars exploration.

The SLS-1 mission is the first in a series of Spacelab missions dedicated to life sciences research. Proposed by an international team of investigators, 18 primary and 11 secondary payload elements have been selected for flight. The secondary payload elements also contain materials science experiments, environmental monitoring, and hardware verification tests for equipment such as the Animal Enclosure Module and the Surgical Work Station. SLS-1 will also be the first use of Shuttle Middeck Experiment (SMIDEX) equipment, which will allow experiments originally configured for middeck stowage lockers to be flown in the Spacelab module.

An MPESS carrier loaded with Get Away Special (GAS) canisters will fly with SLS-1, however, these experiments will be almost fully automated and not directly related to the SLS-1 mission. SLS-1 is an eight-day mission with seven crewpersons. The flight configuration for SLS-1 (and also for IML-1 and Spacelab-J) is shown in Figure 5.

Figure 5. Flight Configuration for the SLS-1, IML-1, and Spacelab-J Missions
INTERNATIONAL MICROGRAVITY LABORATORY (IML) - 1

The IML Spacelab series will focus equally on materials and life sciences. The objective of the IML series is to establish a U.S. space laboratory program with long-term continuity to conduct scientific investigations that require the extended microgravity environment of space. IML will offer U.S. scientists access to flight hardware developed independently by NASA and other nations and will give the international scientific community access to Spacelab and its research capabilities. IML missions will fly at approximately two-year intervals so that scientists may modify hardware and build upon results from previous investigations, thus preparing for the Space Station era.

IML-1 consists largely of reflight of experiment hardware from previous Spacelab missions, involving over 200 scientists in the United States and 12 foreign countries. Like SLS-1, the IML-1 mission will also contain a GAS experiment MPESS carrying largely automated experiments (see Figure 5).

ATMOSPHERIC LABORATORY FOR APPLICATIONS AND SCIENCE (ATLAS) - 1

The ATLAS series of missions, scheduled to fly on an average of once a year, will investigate how the Earth's atmosphere and climate are affected by the Sun and by the products of man's industrial and agricultural activities. Specifically, ATLAS will measure long-term changes in the total energy radiated by the Sun over an entire 11-year solar cycle, determine variability in the solar spectrum, and measure the global distribution of key molecular species (such as ozone and carbon monoxide) in the middle atmosphere. The ATLAS program is part of NASA's Mission to Planet Earth, a unified study of the Earth and its biosphere from the deep interior of the planet to the outermost fringe of its atmosphere.

The first ATLAS mission will use two Spacelab pallets and an igloo (a pressurized container carrying Spacelab subsystem equipment) to accommodate a core payload of solar and atmospheric monitoring instruments plus reflights of some earlier Spacelab investigations. Experiments will be controlled by the crew from the Orbiter's aft flight deck. Follow-on missions will have a single pallet with only the core instrumentation. Foreign participation on ATLAS-1 includes West Germany, Belgium, France, and Japan. The ATLAS-1 flight configuration is shown in Figure 6.

SPACELAB - J (JAPAN)

The Spacelab-J mission is jointly sponsored by NASA and the National Space Development Agency of Japan (NASDA). NASA will be partially reimbursed for the cost of a dedicated Shuttle flight, including the use of the Spacelab systems. The Japanese will provide two Spacelab double racks of material science experiment facilities and one double rack for life science experiments. The remaining space in the module will be devoted to NASA material science and life science experiments, Spacelab avionics (computers, environmental control, etc.), common support equipment (video recorders, fluid pumps, etc.), and storage space for experiment materials and samples. Spacelab-J instruments include a variety of material furnaces, crystal growth facilities, an aquatic animal experiment unit, a free-flow electrophoresis unit, magnetic resonance imaging
Figure 6. ATLAS-1 Flight Configuration
equipment, and a space acceleration measurement system, to name only a few.

The external flight configuration for Spacelab-J, like those of IML-1 and SLS-1, consists of a Spacelab module and GAS experiment assembly (see Figure 5).

**SPACELAB - D2 (Deutsche 2)**

The Spacelab-D2 mission represents a Space Shuttle flight wherein the West German government has purchased from NASA the flight time, space, and resources of a complete Spacelab mission. The West German space organization, DLR, is responsible for mission management and initial experiment integration, including a number of European Space Agency investigations. The OSSA Flight Systems Division serves as the mission management representative to NASA and is coordinating the development and placement of three U.S. life science investigations on Spacelab-D2. The Spacelab-D2 flight configuration is very similar to those mentioned earlier, including a pressurized Spacelab module and a unique experiment support structure (similar to the U.S. MPESS) that will carry German material science experiments.

**UNITED STATES MICROGRAVITY LABORATORY (USML) - 1**

The USML Spacelab series is the national counterpart to the IML program. It offers the U.S. scientific and commercial communities access to Spacelab and its capabilities to conduct current microgravity research and to develop a science and technology base for future Space Station applications. USML-1 will be the first Space Shuttle payload to utilize the Extended Duration Orbiter (EDO) capability, which will permit Spacelab flight duration up to 16 days (a typical mission is now 7-10 days) through the use of additional cryogenic hydrogen and oxygen tankage in the Shuttle payload bay. The USML-1 mission is planned for 13 days in orbit. EDO flight time will gradually increase to the full 16 days over a number of missions as hardware verification and crew training and checkout is completed. It is envisioned that two EDO kits will eventually allow a Shuttle to remain in space for up to 28 days.

In addition to the module/EDO configuration, the U.S. Microgravity Science program will also conduct missions with the experiments mounted on a double MPESS structure, capable of using non-dedicated flights and flying with a variety of non-Spacelab payloads. The double MPESS configuration is designated as a United States Microgravity Payload (USMP). USMPs are controlled from the ground or by astronauts working from the Shuttle aft flight deck. Flight configurations for USML-1 and USMP-1 are shown in Figure 7.

**SPACE RADAR LABORATORY (SRL) - 1**

The Space Radar Laboratory carries a modified version of the Shuttle Imaging Radar (SIR) and the Measurement of Air Pollution from Satellites (MAPS) instruments which were carried on the second Shuttle flight (STS-2) in November 1982 and the thirteenth flight (STS-41G) in October 1984. SRL will acquire radar images of the Earth's surface to be used for making maps, interpreting geological features, and resource studies.
MAPS, a gas filter radiometer, will be used primarily to measure the global distribution of carbon dioxide in the troposphere. Both the SIR and MAPS instruments can operate during day and night segments of the Shuttle orbit.

The SRL-1 SIR-C side-looking radar antenna is carried into orbit in a folded stack on a single Spacelab pallet. MAPS is mounted on an MPESS. Both instruments can be controlled from the ground or the Shuttle's aft flight deck. Figure 8 shows the launch (stowed) and flight (deployed) configurations for SRL-1.

**SPACELAB GROUND SUPPORT**

While actual Spacelab missions are conducted for only 7-10 days, many months of preflight planning, integration, and testing activities take place for each flight. Figure 9 shows the four-year (average) development cycle associated with a typical dedicated Spacelab mission. Some key ground facilities associated with the Spacelab program are the Operations and Checkout (O&C) building at the Kennedy Space Center (KSC) in Florida, the Payload Operations Control Center at the Marshall Space Flight Center (MSFC) in Alabama, the Spacelab Data Processing Facility at the Goddard Space Flight Center (GSFC), and various Spacelab crew training facilities at MSFC and the Johnson Space Center (JSC) in Texas.

The Spacelab payload processing facilities at KSC are used to assure a safe and functional flight payload. They are housed in the O&C building in the KSC industrial area, which contains 600,000 square feet of offices, laboratories, astronaut quarters, and payload assembly and test areas. Actual hands-on mechanical and electrical experiment integration is performed primarily in the O&C building assembly & test area, a high-bay assembly line which supports experiment hardware staging, integration, verification, and post-mission deintegration. Experiment integration begins with installation of experiment hardware on flight carriers, verification of alignment, connection and verification of experiment interfaces, and test and checkout of individual experiment operations. The next step is Spacelab integration, which includes assembly of integrated experiment racks into the Spacelab module and connection of pallet or MPESS interfaces to form a complete flight payload. Mission sequence testing and final crew orientation training takes place following Spacelab integration. The O&C building assembly and test area includes orbiter aft flight deck simulators and user rooms linked to KSC computer and communication systems. The O&C high bay is also used to transfer the integrated payload to the payload canister/transporter, which delivers the payload to the Orbiter Processing Facility for final integration with the Space Shuttle Orbiter. Figure 10 shows the Spacelab missions which are and will be "in-flow" at KSC during the coming years.

The Payload Operations Control Center (POCC) at the Marshall Space Flight Center allows Spacelab users on the ground to support and interact with the onboard mission crew and provides a direct communications (audio and video) link between the crew and ground-based experiment developers and scientific experts. The POCC also provides ground command capability to operate experiments on the Spacelab, manage payload resources, and operate payload support equipment in conjunction with crew activities. A communications link through the POCC can be arranged to allow the experiment investigator to perform some or all operations from his home institution. The POCC is
Figure 8. SRL - 1 Launch (Stowed) and Flight (Deployed) Configurations
Figure 9. Typical Spacelab Mission Development Timeline
Figure 10. Spacelab Processing Flows at the Kennedy Space Center
also used for crew training and simulated space operations.

Besides the MSFC POCC and KSC O&C building, there are additional Spacelab training facilities located at the Marshall Space Flight Center and the Johnson Space Center. In addition to the POCC, MSFC also provides the Payload Crew Training Complex (PCTC). The PCTC contains computers, simulation director stations, mockups of the Spacelab module and pallets, an orbiter aft flight deck mockup, and all simulation equipment necessary to support complete mission or partial payload simulations. The PCTC is used primarily for mission specialist and payload specialist training associated with experiment operations on orbit.

There is also a Spacelab Simulator (SLS) facility located at the Johnson Space Center in Houston. The SLS facility consists of a full-scale high fidelity Spacelab module segment, subsystem racks, controls and displays, scientific airlock, and viewport. The SLS provides full-task training in operation of the Shuttle/Spacelab support subsystems for a full crew (commander, pilot, mission and payload specialists).

FUTURE PROGRAM ACTIVITIES

Spacelab and its flight and ground support systems were designed and fabricated jointly by NASA and the European Space Agency during the 1970s. The first flight unit was delivered to NASA in 1980, and verification flight tests took place in 1983 and 1985. As we approach the second decade of Spacelab operations, it is necessary to assess the changes that have taken place in the program over the past ten years. It is also necessary to plan for the next ten years, which will accommodate a backlog of science investigations resulting from the Shuttle downtime and will require significant science and technology testbed and transition activities as we approach the Space Station era.

In order to conduct a comprehensive analysis of the Spacelab program, the Flight Systems Division and the Shuttle Carrier Systems Division at NASA Headquarters have jointly formed the Spacelab Improvement Working Group (SIWG). The SIWG is tasked to identify and assess Spacelab and related support systems and procedures that will require upgrade or replacement over the next ten years. The SIWG is currently investigating outdated (circa 1970s) technology, failure rates and repair turnaround time, decreasing logistics support (some original equipment contractors are now out of business or no longer produce the specific hardware needed for maintenance and spares), and additional flight and ground support equipment necessary to meet increasing user requirements and support Space Station transition activities. The study involves Spacelab support offices at NASA Headquarters, Marshall Space Flight Center, Goddard Space Flight Center, Kennedy Space Center, and Johnson Space Center, and is scheduled to present its conclusions and recommendations to NASA management in December 1990.