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Spacelab Program Preparations for First Flight and Projected Utilization

James C. Harrington

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ABSTRACT

The initial flight of the European built Spacelab Pressure Module will introduce to the Space Transportation System capability a shirt sleeve laboratory environment that will serve a broad range of Science and Technology users. This paper provides a brief description of the maiden mission and a status report on the preparations for that mission. The planned utilization of the European provided Spacelab hardware, as reflected by the Spacelab Mission Manifest, will be discussed along with plans for developing dedicated discipline laboratories, a mixed cargo Spacelab pallet system and a capability for opportunity payloads and experiments.

INTRODUCTION

In 1973 ten nations of the free world set out to develop a sortie-mode laboratory facility as part of the U.S. Space Transportation System. This facility, the Spacelab, is today a reality. It provides a variety of configurations and services to science and applications users for in situ observation and control of experiments in a habitable, shirt-sleeve environment called the module, and remotely on a number of pallets which expose experiments directly to space. In addition, it provides ground facilities for direct inflight support, real-time and post-flight data evaluation and pre-flight preparation and processing. The free world has available to it a highly capable, versatile space laboratory facility to expand mankind's horizon. Today, I plan to discuss the preparation and status of the activities relating to the maiden Spacelab mission and the development of the Spacelab Operational Capability necessary to support the subsequent Spacelab flights. Included will be a preview of these planned Spacelab missions illustrating the Spacelab reuseability and multiple configuration capability. This capability is being enhanced by additions of mixed cargo capability and by handling payloads and experiments of opportunity.
space it is brought back to the Earth at the end of each mission and prepared for its next flight.

Modularity - To allow for flexibility, the Spacelab can be assembled from two cylindrical segments to form the pressurized module and from pallets to allow experiment mounting such that they are continually exposed to space.

Non-Astronauts - Instead of requiring highly trained pilot-type astronauts, the experiment operators on-board Spacelab will be a new breed of scientist or engineer called payload specialists. The only physical requirement is that the individual be able to pass an FAA Class III medical evaluation.

Spacelab was built in a modular fashion to satisfy the many needs of the space user community. The laboratory offers a range of basic standard services such as environmental control, data acquisition, data processing and command and control to users. The user is required to interface to these standard services through the use of Spacelab-provided mission dependent and experimenter-provided mission peculiar equipment.

The Spacelab module is usually placed toward the rear of the Orbiter's cargo bay to comply with the Orbiter center of gravity limits. Because of this, a multi-length tunnel between the Orbiter mid-deck and the Spacelab module is provided for ingress and egress.

The Orbiter has a pointing capability of approximately ± 0.5 degrees; however, the pointing accuracy of a Spacelab payload is often further degraded below this figure because of Orbiter-Spacelab misalignments and deformations. Occasionally the misalignments may cause the pointing accuracy to approach 2°. More precise experiment pointing can be achieved by the experiment providing high accuracy sensor reference data to the Orbiter's control system or by utilization of the Spacelab provided Instrument Pointing System (IPS).

Depending on the experiments flown on a given mission, the Spacelab flight configuration varies; however, it generally falls within one of the groups shown in figure 3.

Module Alone - A module can be made up of the either one or two cylindrical segments. Each segment is 2.7 meters long and 4 meters in diameter. Two segments, core and experiment, connected together are shown as a "long-module" while the core segment alone is called a "short-module". The module is a pressurized multi-purpose laboratory having a normal 14.7 psi atmosphere of oxygen and nitrogen. It has facilities and equipments similar to those available in Earth laboratories but adapted to zero gravity.

Pallets Alone - A pallet is an unpressurized platform for mounting instruments to be continually exposed to a space environment. Each pallet is approximately 2.9 meters long and 4 meters wide. A maximum of five pallets can be carried on a single mission. A pallet-only mission can offer the same command, data handling and power services as a module. Cooling is provided by cold plates. The pallet, in addition, offers "hard-points" for mounting heavy instruments.

Attached to the front end of the first pallet in a pallet train is an "igloo". This cylindrical container, which is pressurized and environmentally controlled, contains those components necessary to operate and control all Spacelab subsystems. The equipment or experiments on a pallet can be controlled from either the Orbiter Aft Flight Deck (AFD) or the Spacelab Payload Operators Control Center located in Houston.

Module Plus Pallets - The module plus pallets configuration makes maximum advantage of each of the previously discussed system attributes. It can be made up of a "long" or "short" pressurized module with up to three pallets. The data processing, command and control capabilities for this system are similar to those discussed above. The pallet systems are controlled from the module in this configuration.

The Orbiter, in all cases, provides power, cooling, oxygen supply, basic stabilization, communications, habitability and safety refuge.

MAJOR SPACELAB FACILITIES

Spacelab is a critical part of the Space Transportation System (STS) and is a direct extension of the Orbiter itself. As a part of the STS, Spacelab missions make use of many of STS elements and supporting systems including, for example, the Tracking and Data Relay Satellite System (TDRSS) and the Mission Control Center (MCC). However, in addition to these, Spacelab consists of many elements other than the flight hardware and its Ground Support Equipment (GSE). Figure 4 indentifies some of the major Spacelab facilities and indicates how they are utilized in the course of a mission.

DELIVERY OF THE ESA SPACELAB HARDWARE

The ESA provided Spacelab hardware currently undergoing test and checkout at the Kennedy Space Center O&C Building is the product of an extensive effort on the part of the European
Spacelab Consortium. This Hardware is the result of a development activity that began in the early 1970's, and as shown in figure 5 proceeded through the System Integration and Test phase performed at the ERNO plant in Bremen, Germany. Following a comprehensive review by ESA, NASA and NASA Contractor personnel, the results of the development, qualification and integration test activities were judged acceptable. These reviews in turn led to authorization of a series of hardware shipments to KSC. The major deliveries included the Spacelab Flight Unit Module in December, 1981 and the Spacelab Flight Unit Igloo and pallets in August, 1982. Figure 6 shows the flight unit module being unloaded from an USAF C-5A Aircraft at KSC. At present ESA has completed delivery of all elements of the First Flight Unit except for the Instrument Pointing System (IPS) which is scheduled for shipment to KSC in February 1984. It should be noted that a second set of Flight Hardware is currently undergoing fabrication and assembly by the Europeans under a NASA Follow-On-Production contract.

The importance of the delivery of the first pressure module, was marked by an official Acceptance Ceremony held at KSC on February 5, 1983. Participants included the Vice President of the United States George Bush shown in figure 7, along with other distinguished members of the European and American governments.

The delivery of this hardware to KSC marked the beginning of the SL-1 assembly and integration process within the United States. This test activity was made possible by the successful activation and operational readiness of the KSC O&C Building Spacelab Facility. This facility had undergone a drastic remodeling from the post-Apollo configuration to the checkout facility shown in figure 8.

The opportunity for experiments being carried aboard the Orbiter during the Orbital Flight Test Phase provided a demonstration of the usefulness of the Spacelab pallet in serving scientific investigation. Figure 9 shows the OSTA-1 payload, a collection of Earth viewing experiments which flew on STS-2, and the OSS-1 payload, a collection of astronomy, space plasma physics, and other experiments to measure Shuttle Environmental which flew on STS-3. During both these missions the Spacelab pallet and support systems contributed to the successful completion of the planned scientific operations.

**SPACELAB-1 VERIFICATION FLIGHT TEST MISSION**

The Spacelab Verification Flight Test (VFT) Program provides a demonstration that Spacelab complies with its specified design requirements.

The VFT program consists of the Spacelab-1 configuration of which is shown in Figure 10 and Spacelab-2, shown in figure 11. Specific tests are planned for the VFT missions to verify Spacelab structure, the Environmental Control System, the Command and Data Management System, the materials used and the habitability/crew support features. As can be seen in figure 12, the detailed VFT objectives for SL-1 explore the capability of these systems and their compatibility with the Orbiter. Inherent in these Detailed Test Objectives are a demonstration of Spacelab's ability to meet the user requirements which were prime drivers in the establishment of the Spacelab Design Requirements.

**SPACELAB 1 SCIENTIFIC INVESTIGATIONS**

An equally important objective of Spacelab 1 is the performance of scientific investigations. Coupling of these objectives, VFT and Science, was a key consideration in the choice of investigations for this mission so that the Spacelab subsystems were exercised as required to satisfy VFT objectives. With this in mind Spacelab 1 was established as a multi-discipline mission comprising five broad areas of investigation. These include Atmospheric Physics and Earth Observation, Space Plasma Physics, Astronomy and Solar Physics, Material Science and Technology, and Life Science. There are 39 different instruments and experiment facilities to be flown SL-1. At present, some 70 separate investigation are planned. This first mission being sponsored jointly by NASA and ESA will consist of a science payload approximately equally divided by NASA and ESA experiments in terms of weight, power and volume requirements. Figures 13, 14, 15, shows the locations of these instruments on SL-1.

**KSC PROCESSING ACTIVITIES**

Figure 14 provides the processing schedule for SL-1 and other related Spacelab 1 milestones. We are now well into the Level III/II Spacelab Integrated Tests. Prior to this time we have proceeded through the hardware Staging Phase, Level IV Experiment Integration, Spacelab Assembly and Subsystem Checkout and the early phases of the Level III/II Spacelab/Experiment Interface Verifications. Reference figure 15 for views of Spacelab Processing at KSC.

Following acceptance, the ESA provided Experiment Racks, Flight Pallet and other necessary SL components were assembled (Staged) into the configuration required to support the SL-1 experiments. Physical integration (Level IV) of the experiments in the SL-1 Racks and on the SL-1 pallet was started at the KSC Operations and Checkout Building in mid-April, 1982. ESA had obtained staged
Experiment Racks earlier and had initiated their experiment integration activity at the ERNO plant in Bremen, Germany.

Following delivery of the to ESA sponsored experiments KSC, the mechanical installation and assembly of the combined ESA/NASA experiments took place. This mechanical portion of Level IV integration was completed in early August 1982. In late August, power was applied and the Experiment Instrument Functional Interface Tests were initiated. Finally, the Mission Sequence Test, operation of the experiments in accord with selected portions of the on-orbit timeline, was conducted and the Level IV activity was successfully completed on December 10, 1982.

In parallel with the Level IV activity, the Spacelab Core Segment and Experiment Segment were installed in the Spacelab Test Stand and assembled. The Scientific Airlock was installed, the Spacelab subsystems were serviced, and the subsystem operation was verified using an Experiment Segment and Pallet Simulator (ESPS).

In January, 1983, the Level III/I Integration phase was initiated. Following transfer from the Level IV work stand, the integrated Experiment Rack and Floor Train was placed in Test Stand 2 and rolled into the Spacelab Module. The Module by this time contained the Control Center Rack, Work Bench Rack, Scientific Airlock and the Spacelab Window Adapter Assembly. The Module End Cone was then installed. Next the pallet mounted experiment complement was transferred to the Level III/I work stand and connected to the module.

Power was applied on January 29, 1983 and for the first time the Spacelab Systems mated with the flight experiment hardware were verified. Functional checkout of the Verification Flight Instrumentation System and other elements such as the Closed Circuit TV systems were also performed. The Spacelab Integrated tests were initiated on March 21, 1983. These activities involved checkout of Experiment/Spacelab interfaces, verification of the Experiment Computer Operations Software (ECOS)/Experiment Computer Application Software (ECAS) operating with the flight Experiment Computer and Experiments, EMI/EMC testing and the Mission Sequence Test (MST).

Following Level III/I, the Spacelab will be mated with the Spacelab Transfer Tunnel to verify physical and functional interfaces. The tunnel is then demated and the Spacelab Module and Pallet is transferred to the CITE stand where Spacelab/Orbiter Interface Tests are to be conducted. The CITE test is significant in that it is the first time that Spacelab will be operating with Orbiter hardware and software. Another significant portion of the CITE operation will be the Closed Loop Test. During this test the Payload Operations Control Center (POCC) command system will communicate with ECOS and experiments in the flight configuration.

Upon completion of the CITE activity, the Spacelab will be moved to the OPF and installed in Columbia (OV 102). This is expected to occur in early August 1983. Following Orbiter/Spacelab Interface Tests, the Orbiter Tunnel Adapter and Tunnel will be installed and interconnected. Next a MCC/POCC to Orbiter/Spacelab/Payload Interface Test will be performed. This test will be a STS end-to-end test which verifies data flow and command capability throughout the network. Following the tests in the OPF the Spacelab will be essentially dormant until SL-1 is launched and on-orbit. The Orbiter with Spacelab installed will be transferred to the VAB in late August with STS-9 rolled out to the PAD in early September 1983 with launch scheduled for September 30, 1983.

While problems were encountered during these periods of the SL-1 processing and many lessons were 'earned', they were for the most part the kinds of problems to be expected during the initial assembly and integration activity of Systems such as those on the Spacelab.

In parallel with the activities at KSC other Spacelab facilities elements have been prepared for the Spacelab Mission. Figure 4 which was shown earlier indicates how these major facilities are use. As part of STS, Spacelab will also use other STS elements including Payload Operations Control Center (POCC), Spacelab Simulator (SLS), Mission Control Center (MCC) and the Tracking and Data Relay Satellite System (TDRSS).

PAYLOAD OPERATIONS CONTROL CENTER (POCC)

The development of the Spacelab POCC, located on the second floor of building 30 adjacent to the STS Mission Control Center is nearing completion. This facility, with capabilities as shown in figure 16 will provide to the experimenters the ability to do realtime monitoring and control of their experiments within the constraints necessary to safeguard the STS and other payloads. A POCC mission Management Team, including experimenters will operate the POCC during the mission. Figure 17 shows that six user rooms will be used during SL-1. The POCC will also be used to support mission simulation and training exercises.
SPACELAB SIMULATOR (SLS)

The SLS is being used at JSC to train Mission and Payload Specialists in the operation of the basic SL subsystems and equipment (figure 18). This dynamic simulator will be used in conjunction with the Shuttle Mission Simulator for activation and control from the Orbiter Flight Desk as well as with the MCC and the POCC. Other flight crew training facilities at JSC include a Spacelab Single System Trainer and a Scientific Air Lock Simulator for Neutral Buoyancy EVA Contingency Training. The SLS has also been connected to the Spacelab Payload Crew Training Complex (PCTC) at MSFC to enhance integrated mission training involving not only members of the flight crew but also members of the Mission Support Team, the POCC Cadre and experimenters. Figure 19 shows the interconnection of these facilities.

SPACELAB DATA FLOW

While on-orbit the Spacelab will maintain nearly continuous contact with the POCC and the GSFC Spacelab Data Processing Facility (SLDPF) through the Orbiter/TDRS Ku-Band system. Figure 20 shows that this network will provide the capability to downlink high and low rate telemetry, analog or video and voice and also to uplink ground command and voice. This figure also shows how the elements of the network interconnect SL with the MCC, POCC, and the SLDPF. Activities are still proceeding toward establishing a two TDRSS for the S-1 mission. Development of the SLDPF is also proceeding well. This latter facility will record, demultiplex and appropriately tag the SL-1 experiment data. These data outputs are planned to be provided within 30 to 60 day period after the mission. Figure 21 provides the SLDPF characteristics.

INTEGRATED CREW TRAINING ACTIVITIES

The Spacelab-1 Mission is a 9-day mission scheduled for launch from KSC on September 30, 1983 and a landing at the DFRC on October 9, 1983. The crew for this mission consists of John Young, Commander, Brewster Shaw, Pilot, Owen Garriott, Mission Specialist, Robert Parker, Mission Specialist, Byron Lichtenberg, Payload Specialist and Ulf Merbold, Payload Specialist (figure 22). During the mission the crew will work in 12-hour three man shifts with the pilot or Commander on the Orbiter flight deck and a MS and PS in the Spacelab Module. The crew have been undergoing extensive training utilizing the experiment hardware. Figure 23 illustrates the Spacelab training flow that has been followed by the Flight Crew and the Flight Operations Support Team (FOST). The later part of the training phase will include the conduct of long duration mission simulations. The simulations will include participation by the Flight crew, the Flight Operations Support Team, the Payload Mission Management Team and Principal Investigators. The schedule for the final phase of the SLS/PCTC Integration and Crew Training is shown on Figure 24.

DFRC LANDING

The programmatic constraints on the period available for the OV-102 vehicle modifications resulted in the inability to incorporate all of the planned systems and capabilities. In particular, the incorporation of the "Heads up Display" Instrumentation is not planned for installation during the initial OV-102 modification period. This has resulted in the decision to land STS-9 at Dryden rather than at KSC as originally planned. It is presently planned to ferry the Orbiter with the Spacelab from DFRC to KSC using the Shuttle Carrier Aircraft. Spacelab 1 experiments which require early removal will be relocated to the mid-deck stowage lockers before landing. Except for removal of these experiments the Spacelab and Experiments will remain in the Orbiter Cargo bay. Preparations for and the conduct of the Ferry flights are expected to take 6 days with the Orbiter and Spacelab arriving at KSC approximately 9 days after the launch. Once at the KSC Orbiter Landing Facility, the Orbiter will be demated and transferred to the OPF where the Spacelab will be removed from the Orbiter and returned to the O&C building for Spacelab de-integration and experiment removal.

SPACELAB UTILIZATION

While we proceed with the preparations for the Spacelab-1 mission, a considerable amount of effort is being applied to the post SL-1 flights and the planning for other downstream missions. KSC has completed activation of the facilities test stand and control room necessary to support the Igloo Verification Flight (SL-2), and some racks have already been staged for the second Spacelab Module Flight (SL-3). Originally the Spacelab Operational Missions were to commence after completion of the two Verification Flight Test Missions, SL-1 and SL-2. However, development of the Instrument Pointing System and other programmatic considerations resulted in a flight sequence wherein the initial two dedicated Spacelab Flights will be Module Flights with the Igloo verification flight being the third Spacelab mission.

The SL-3 mission, which represents the first Spacelab Operational Mission, is scheduled for September 1984. The object of this mission is to conduct applications science and technology experimentation requiring a low gravity earth orbit environment and extended stable vehicle
attitude for environmental observation and material processing. This mission will also include the initial test flight of the Research Animal Holding Facility (RAHF). When operational, the RAHF will provide support during the mission for animals ranging in size from rodents to small primates.

The second VFT Mission, SL-2, will be the initial flight of the Igloo configuration and Instrument Pointing System. The configuration for this mission, which is currently scheduled for March 1985, will consist of an Igloo with a three pallet train and a special structure for a large cosmic ray experiment.

**SPACELAB MANIFEST**

The Spacelab Program elements which are reflected in the STS flight manifest include not only the missions already mentioned but other module and pallet type missions. The Spacelab Manifest (figure 25) provides a tabulation of all Spacelab Missions for STS flights through FY 1986. As shown this manifest is a combination of dedicated Module and Pallet Missions along with Spacelab Mixed Cargo flights. These latter missions utilize the Spacelab Pallet Systems and Special Structures. Present plans anticipate between 6-8 Spacelab Flights per year during FY 84 through FY 86.

**MIXED CARGO MISSIONS**

As mentioned earlier Spacelab is to be utilized in both the dedicated mode (missions where it occupies the whole cargo bay) and in a mixed cargo mode (where it shares the bay and the Orbiter resources with one or more payloads). In most cases these other payloads in the mixed cargo mode will be deployable payloads (e.g. communication satellites). The advantage of the mixed cargo mode is that it allows users to fly smaller, less expensive payloads, to share the launch costs with other Shuttle users and to enhance flight opportunities. The Spacelab mixed cargo mode is currently limited to pallet only configurations involving one or two pallets or special structures. Figure 26 displays the three available carriers that now make-up the Spacelab Pallet Systems (SPS). The MDM pallet system offers a standard pallet having minimal data services. The Igloo pallet system is an igloo and pallet configuration with the same data management, thermal control and similar power services as the standard pallet only Spacelab. The Mission Peculiar Equipment Support (MPESS) Structure is a structure with the user providing all support equipment. As stated earlier the MDM pallet system has already successfully flown on STS-2 and STS-3.

**CAPABILITIES FOR OPPORTUNITY PAYLOADS/EXPERIMENTS**

With the Shuttle/STS moving into the operational phase, it becomes increasingly important to exploit more fully the capabilities of both the vehicle and the crew and provide the user community rapid access and data turnaround at lower costs. It has been proposed by Lt. General Abrahamson, the Associate Administrator for Space Flights, that we undertake a program wherein either NASA or industry develop a mixed cargo carrier system with fixed capabilities and interfaces that would serve standby payloads and experiments. These standby payloads/experiments could be manifested and integrated into the Orbiter quickly and easily without undergoing extensive integration and review cycles.

A key element to the success of this program is the streamlining of both the STS and the Payload integration processes to accommodate such a Payload of Opportunity. We need to simplify the payload manifesting, integration and support process. As a goal, experiments wishing flight should be able to take advantage of "space-available" cargo opportunities, or to fill space created by last minute payload cancellations. It is believed that a quick reaction type carrier system with simplified payload processing requirements and paper work are keys to accomplishing this goal of rapid response.

The Office of Space Flight (OSF) is currently developing a plan for implementing a demonstration program called Hitchhiker with the intent on of proving the rapid access concept using an "icebreaker" payload on STS 17 with a turnaround or reflight of the payload occurring approximately 6 months later. Sponsoring Payload Offices are working closely with the OSF in the selection of a payload for the demonstration flight along with the identification of the Hitchhiker carrier requirements. Candidate experiments are to be offered by NASA/OSSA, DOD and NASA/OSF. Working with these offices the Program baseline envelope presented in figure 27 was developed.

**DEDICATED DISCIPLINE LABORATORY**

The Spacelab Flight Division has developed a concept for Spacelab Missions termed Dedicated Discipline Laboratory. The intent is to reduce the cost of implementing a given mission and increase flight opportunities for instruments. The concept involves grouping compatible payloads into an appropriate mission design with growth potential but which remain more or less integrated and assembled between succeeding missions. The discipline laboratory is expected to have the following characteristics:
- A collection of compatible science instruments built assuming Spacelab interfaces.

- Regularly flown at intervals on the order of six months to two years.

- Designed to allow evolution of individual instruments and the addition/deletion of the instruments without redesign of the entire payload or mission. Instruments can be either a primary investigation or facilities.

- Not disassembled from the Spacelab hardware between mission.

- Ultimately evolving in the long-term, to low earth orbiting facility currently referred to as the Space Station.

The idea of focusing on a series of discipline unique laboratories is being considered in the development and planning for the Shuttle and Spacelab utilization. The following laboratories suggest themselves as dedicated discipline labs: (1) the Space Biomedical Laboratory (now known as Spacelab 4), (2) Space Plasma Laboratory (now known as Spacelab 6); (3) Shuttle Telescopes for Astronomical Research Series (now known as OSS-5, 6, and 7); (4) Shuttle High Energy Astrophysics Laboratory (now known as OSS-2); (5) Shuttle Infrared Telescope Facility; (6) Solar Optical Telescope; (7) Material Science Laboratory; (8) Environmental Observation Laboratory; (9) Shuttle Radar Laboratory and (10) International Microgravity Laboratory (figure 28). More details on this concept and the consideration it is being given will be covered in a separate paper.

SUMMARY

Spacelab constitutes a unique program in that the System was designed and developed by ten cooperating European Nations through the efforts of over 20 European industrial contractors with NASA developing the Spacelab operational capability. To a large extent these European and American activities were done in parallel and involved many technical and managerial interfaces. The fact that the Spacelab processing activity in preparation for the first mission is proceeding as well as noted is a demonstration that ESA and NASA successfully meet the challenge provided by this unique program.

As with any first time activity, the assembly and checkout of Spacelab 1 by NASA, McDonnell Douglas Technical Services Company and the European Resident Team have encountered problems and difficulties. The success in resolving these problems has been the result of a cooperative attitude and effort by all organizations involved. Similar cooperation and progress is also being observed in other areas that are required for the mission. These include the POCC, SLS, SLDPF, TDRSS Network and Mission Support Team. Collectively these efforts will result in a successful Spacelab 1 Mission.

The culmination of the above efforts is not only the successful conduct of the VFT program and the multidiscipline science objectives of SL-1 but also the demonstration of a Spacelab Operational Capability. Future Spacelab users have been watching these activities with a high level of interest as they are anxious to proceed with their planned missions. Dependence on the Spacelab capability and the planned utilization is demonstrated by the Spacelab Traffic Model tabulated in figure 29. Efforts are underway to enhance the Spacelab flight opportunities through the addition of mixed cargo capability and the development of a system for handling payloads or experiments in a quick response manner whenever additional flight opportunities occur.

Another concept that is receiving a lot of attention is that of Dedicated Discipline Laboratories. With consideration that reflight is a key to improving utilization efficiency, Dedicated Discipline Laboratories are being planned for each of the major Spacelab User Science and Applications disciplines. One focus of these laboratories is the development of long term low earth orbiting facilities. While the Space Station architecture is yet to be defined, it is anticipated that the Space Task Team recognizes the investment that exists in the Spacelab Program and will take the opportunity to use this capability in the evolution of the Space Station.
**Spacelab Program Responsibilities and Contributions**

**ESA**
- Feasibility Studies
- Design and Development
- Engineering Model
- First Flight Unit
- Two Sets GSE
- Initial Set of Spares
- Sustaining Engineering through Two Flights
- Production of Follow-On Flight Units
- Integration of European Experiments

**NASA**
- Technical Support
- Managerial Support
- Tunnel Design and Development
- Operational Facilities
  - Crew Training Simulator
  - Experiment Integration
  - Checkout
  - Flight Control
  - Data Acquisition and Dissemination
  - Refurbishment

**Joint Effort**
- Requirements Determination
- Concept Selection
- Utilization
- Crews

Figure 1
Spacelab Program Responsibilities and Contributions
POSSIBLE SPACELAB FLIGHT CONFIGURATIONS

HARDWARE ELEMENTS IN ONE FLIGHT UNIT

CORE MODULE SEGMENT
EXPERIMENT MODULE SEGMENT
INSTRUMENT POINTING SYSTEM
SUBSYSTEM IGLOO
PALLETS SEGMENTS

Figure 3
Possible Spacelab Flight Configurations

MAJOR SPACELAB FACILITIES AND THEIR USE

Figure 4
Spacelab Facilities
### SPACELAB PROGRAM MASTER SCHEDULE

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#### Figure 5
Spacelab Program Master Schedule
Figure 6
Spacelab Engineering Model
Figure 7
Vice President Bush
Acceptance Ceremony
Figure 8
O&G Building Activities
SPACELAB PALLET FLIGHTS

STS-2
(OSTA-1)

STS-3
(OSS-1)

Figure 9
OSTA-1/OSS-1 Payload

NASA HQ ML83-1114(3)
3-2-83
SPACELAB CONFIGURATION
LONG MODULE/PALLET

THE DETAILED VFT FLIGHT TEST OBJECTIVES ARE TO VERIFY

- THE OPERATIONAL CAPABILITY OF THE ENVIRONMENTAL CONTROL
- THE OPERATIONAL CAPABILITY OF THE STRUCTURES SUBSYSTEM
- THE OPERATIONAL CAPABILITY OF THE COMMAND AND DATA MANAGEMENT SUBSYSTEMS
- THE HABITABILITY OF THE SPACELAB MODULE
- THE MODULE AND PALLETS ENVIRONMENT
- THE OPERATIONAL CAPABILITY OF THE ELECTRICAL POWER DISTRIBUTION SUBSYSTEM
- COMPATIBILITY OF SPACELAB EXTERIOR MATERIALS WITH THE SPACE ENVIRONMENT
- THAT THE ESTABLISHED CONTAMINATION LIMITS HAVE NOT BEEN EXCEEDED ON SENSITIVE OPTICAL SURFACES AND OTHER EXPERIMENTS
Figure 13A
SL-1 Instrument Locations
Figure 13B
SL-1 Instrument Locations
Figure 13C
SL-1 Instrument Locations
Figure 14
SL-1 Processing Schedule
Figure 15A
Views of SL Activity
Figure 15C
Views of SL Activity
Figure 15D
Views of SL Activity
Figure 15E
Views of SL Activity
Figure 15G
Views of SL Activity
POCC SERVICES

PROVIDES:
- GROUND BASED USER SUPPORT TO PAYLOAD CREW
- PAYLOAD ACTIVITY RESCHEDULING
- PAYLOAD CONTINGENCY ANALYSIS
- SCIENCE DATA MANAGEMENT

CAPABILITIES
- RECORDS REAL TIME DIGITAL DATA (to 50 MBS)
- DEMULTIPLEXES TELEMETRY DATA (16 CHANNELS)
  - PROVIDES UP TO 4 HRDM CHANNELS FOR DISPLAY
  - PROVIDES UP TO 9200 PARAMETERS/SEC
- STORES DATA ON DATA BASE FOR UP TO 24 HOURS
- RECORDS ANALOG/VIDEO DATA
- VIDEO DATA DISPLAYS
- PROVIDES LIMITED EXPERIMENT DATA PROCESSING

Figure 16
POCC Services

SPACELAB PAYLOAD OPERATIONS CONTROL CENTER (POCC)
2nd FLOOR BUILDING 30 JSC = 4000 SQ FT

Figure 17
POCC Layout
THE CREW OF STS—9
(SPACELAB I)

CREW COMMANDER
John W. Young

PILOT
Brewster H. Shaw, Jr.

MISSION SPECIALISTS
Owen K. Garriott  Robert A.R. Parker

PAYLOAD SPECIALISTS
Dr. Ulf Merbold  Dr. Byron K. Lichtenberg

Figure 22
Crew Montage
SPACELAB TRAINING FLOW

FLIGHT INDEPENDENT

CREW
- CDR/PLT
- MS

CLRM
- SYS DESCRIP
- SYS INTERFACES
- SYS CONSTRAINTS

SST
- D&C & SYS FAM
- DDU OPS
- IPS SYS FAM

MSFC
- PCTC/HOSC
- SIMS

SL/NBT
- 1-G FAM
- AIRLOCK OPS
- EMR TNG

SMS/SLS
- SAL EVA TNG
- SIMS
- INT ORB/SL TNG
- OPS PROC

FOST*
- FLT OPS SUP TEAM
- MCC CONTROLLERS
- POCC CONTROLLERS

CLRM
- GND OPS FAM
- COMM
- CMD
- DATA HANDLING

MCC/POCC
- HANDS-ON
- CONSOLE OPS

FLIGHT DEPENDENT

P/L CREW
- EXP HANDS-ON TNG
- MISSION PLANNING ACTIVITIES
- LEVEL IV ACTIVITIES

PAYLOAD DISCIPLINE TRAINING

TRAINED FLIGHT TEAM
- SL/ORBITER/EXP INTEGRATION TNG
- CREW INTEGRATION
- CREW/GROUND INTEG

TRAINERS
- SINGLE SYSTEM TRAINER
- SPACELAB SIMULATOR
- NBT - SPACELAB NEUTRAL BUOYANCY TRAINER
- SHUTTLE MISSION SIMULATOR

Figure 23
Spacelab Training Flow
## Space Lab Simulator/PCTC Integ and Training Schedule

<table>
<thead>
<tr>
<th>Milestones</th>
<th>1982</th>
<th>1983</th>
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<tr>
<td></td>
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<td>O</td>
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<tr>
<td>SMS/SLS Integ</td>
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<tr>
<td>JSC Acceptance of SLS</td>
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<td></td>
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<tr>
<td>SMS/SLS Ready for TNG</td>
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<td></td>
</tr>
<tr>
<td>Integrated SMS/SLS/POCC/MCC/PCTC Data Lines</td>
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<tr>
<td>Voice Link</td>
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<td></td>
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<tr>
<td>Software Dev (Design/Code/Test)</td>
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<tr>
<td>DCP Development</td>
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<tr>
<td>SMS/SLS/POCC/PCTC Integ HW/SW Integ/Test</td>
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<td>SLS/PCTC Crew Training</td>
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<tr>
<td>Voice Protocal/Paper SMS</td>
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<tr>
<td>SLS/PCTC/POCC Interfaces</td>
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<td>Joint Integrated SMS</td>
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<td>Long SM 1 (57 HRS) (60 10H)</td>
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<tr>
<td>Long SM 2 (67 HRS) (40 H)</td>
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<tr>
<td>Long SM 3 (67 HRS) (Launch)</td>
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![Figure 2](image1.png)

**Figure 2:** Spacelab Integrated Simulations and Training Schedule

---

## NASA Spacelab Manifest

![Figure 25](image2.png)

**Figure 25**

SL Manifest

IIB-121
SPACELAB PALLET SYSTEM

**MDM PALLET**
- **Structure**
  - Spacelab Pallet
  - Orbiter-Type (Pallet Mounted)
- **Load Capability**
  - 2500 Kg
  - 2.9 M (1 Pallet Only)

**IGLOO PALLET**
- **Structure**
  - Spacelab Pallet
  - Spacelab Igloo
- **Load Capability**
  - 2880 Kg
  - 2.9 M - 8.7 M (1-3 Pallets)

**MPE STRUCTURE**
- **Structure**
  - 'T' Structure
- **Load Capability**
  - None
  - 1818 Kg
  - 1.12 M

Figure 26
Spacelab Pallet System

HITCHHIKER DEMONSTRATION ENVELOPE

- **Payload Definition 6-Months Before Launch**
- **Generic PIP/Annexes**
- **Fixed Interfaces**
  - 1/4 Cargo Bay Resources
  - GPC Table Allocation
  - Coolant I/F Confined to First Cargo Bay Position
  - No Ground (POCC) Control
  - Optional Services Under Consideration
- **Meet STS-14 Mission Requirements**
- **Will Not Preclude EVA**

Figure 27
Hitchhiker Demonstration

IIB-122
Discipline Laboratories

Materials Science Lab

International Microgravity Lab

Earth Observation Mission

Space Biomedical Lab

Shuttle Radar Lab

Figure 28A
Dedicated Discipline Laboratories
Discipline Laboratories

Solar Optical Telescope

Shuttle Telescopes for Astronomical Research

Shuttle High Energy Astrophysics Lab

Space Plasma Lab

Shuttle Infrared Telescope

Figure 28B
Dedicated Discipline Laboratories
### Spacelab Traffic Model

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<tr>
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* Configuration Values:
- Dedicated Mission = 1
- 1st Igloo Flight = 1
- 1st Igloo Reflight = 1

Subsequent Igloo Reflights = \( h_i \)

MDM Pallets = \( h_i \)

COPE Missions = \( h_i \)

Spec. Structures = \( h_i \)

1/5/83

Figure 29

Spacelab Traffic Model