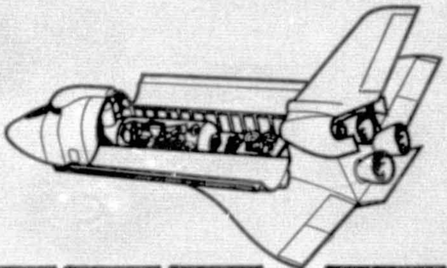
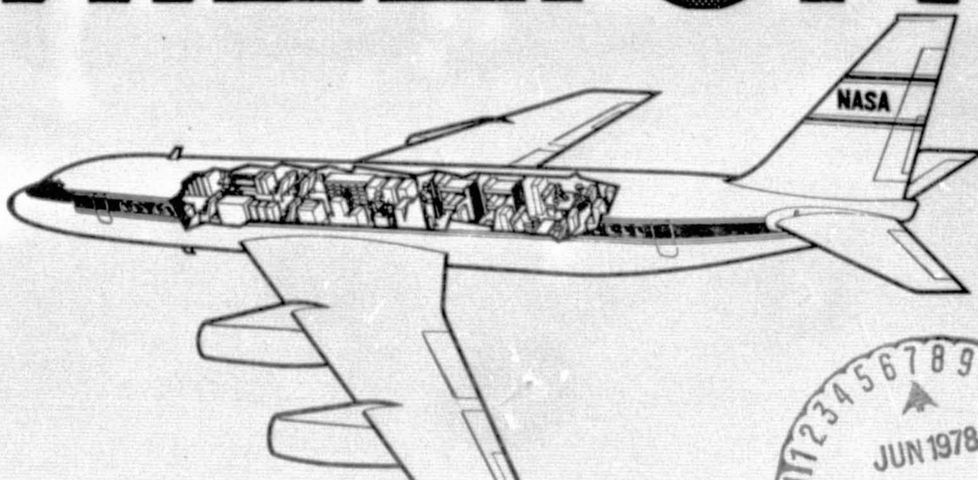
CR-152122

(NASA-CR-152122) NASA/ESA CV-990 SPACELAB SIMULATION (ASSESS 2) Final Report (Marvex Corp., Saratoga, Calif.) 198 p HC A09/MF A01 CSCL 22A
N78-23117
Unclas
G3/12 20257



ASSESS II MISSION



NASA/ESA CV-990
SPACELAB SIMULATION
(ASSESS II)

FINAL REPORT
CR-152122

JANUARY 1978

Approved by:

D.L. Anderson

J.O. Reller

NASA/Ames Research Center
Moffett Field, CA 94035

Prepared by:

D.R. Mulholland

G.M. Androes

J.F. Reeves

MARVEX CORPORATION
13066 Cumberland Drive
Saratoga, CA 95070
CONTRACT NAS 2-9514

TABLE OF CONTENTS

TABLE OF CONTENTS CONT.

LIST OF TABLES

LIST OF FIGURES

FOREWORD

This report presents details of the ASSESS II* Spacelab Simulation Mission sponsored jointly by NASA and ESA. The report is in three main sections. The first two cover background, organization, and implementation of the project, while the last sections contains conclusions relevant to Spacelab planning and discussion of activities that led to the specific conclusions.

Information for this report was obtained from detailed records of the official Observer Team employed by the MARVEX Corporation. Material was gathered by participation in all phases of the project, interviews and discussion with each project participant, an extensive mission debriefing, and the mission documentation.

*ASSESS is an acronym for Airborne Science/Spacelab Experiments System Simulation.

1. INTRODUCTION

Beginning in the 1980 time period, an advanced space transportation system will be used to conduct scientific experiments in the space environment using a laboratory (Spacelab) carried into orbit by the reusable Space Shuttle. Spacelab is being developed and constructed in Europe under direction of the European Space Agency (ESA). The Space Shuttle Orbiter is being built by the United States under management of the National Aeronautics and Space Administration (NASA). Spacelab is designed to be a versatile laboratory capable of accommodating a variety of experiments. The pressurized Spacelab module provides a shirtsleeve environment in which up to four Payload Specialists can operate experiments using basic resources provided by the laboratory.

NASA, Ames Research Center (ARC) has developed over many years a very efficient system for accommodation and operation of a wide range of experiments for airborne research using a variety of aircraft. The ARC approach, which is characterized by deep involvement of the individual Principal Investigators in development and operation of the scientific payload, has been very attractive to experimenters and is enthusiastically supported by the scientific community. It has similarities to the approach considered for Spacelab. Many Spacelab planners have felt that, with emergence of the Spacelab program, it is time to consider simpler and less costly techniques for manned space endeavors, and that the ARC approach in managing a payload is a desirable basis for development of payload operational concepts aboard the Shuttle/Spacelab. Thus, NASA management initiated the ASSESS Program in 1972 to evaluate and document management and operational practices developed and employed by the ARC Airborne Science Office (now the Medium Altitude Missions Branch) as these practices might apply to Spacelab (refs. 1-5).

To test the validity of the ARC approach to Spacelab, several missions simulating aspects of Spacelab operations have been conducted as part of the ASSESS Program. From 1972 to 1975 six Spacelab simulation missions were flown. Four relatively simple simulations were conducted aboard the Lear Jet aircraft (refs. 6-10) and two more complex aboard the CV-990 "Galileo II" (refs. 11-16). Each mission was designed to evaluate potential Shuttle/Spacelab concepts in increasing detail. The first four missions studied the operation of the payload by members of the Principal Investigator team associated with each experiment. The last two missions, one on each aircraft, explored experiment operation by a limited number of carefully selected experiment operators (Payload Specialists). These missions were managed at ARC. The second of these missions, using the CV-990 (fig. 1), in June 1975 was conducted jointly with the European Space Agency. It was the first extensive Spacelab simulation, and has become known as ASSESS I. The success of that mission (refs. 12-16) led to a second such mission (ASSESS II) with flights in May 1977, which is the subject of this report. For this second joint mission, emphasis was placed on development and exercise of management techniques planned for Spacelab using management participants from NASA and ESA who have responsibilities for Spacelab 1 which will be launched in 1980.

Figure 1. CV-990 Airborne Laboratory

2. ASSESS II BACKGROUND AND ORGANIZATION

2.1 Project Background

Initial approval to conduct ASSESS II as a joint mission sponsored by NASA Office of Applications (OA) and Office of Space Flight (OSF) and by ESA came in late 1975. Final approval was obtained in March 1976 and "launch" occurred 14 months later on May 16, 1977.

Both NASA and ESA set up management organizations according to Spacelab plans to test and evaluate interface activities. NASA/MSFC was assigned responsibility for the payload and appointed a Mission Manager. NASA/KSC was given responsibility for Launch Site Payload Processing, NASA/JSC was assigned Flight Operations, while ESA/SPICE handled all activities in Europe. All organizations worked closely with NASA/ARC where the integration and flight program were conducted using the CV-990 Airborne Laboratory.

Operational costs of the mission were shared between NASA and ESA. Experiments from the U.S. were totally funded by NASA. In Europe, basic experiment costs were nationally funded, with ESA providing additional funds necessary for the special requirements of the ASSESS mission.

The project studied the full range of Spacelab-type activities including the following items of special interest:

- Management interactions;
- Experiment selection;
- Hardware development, including design for centralized controls;
- Payload integration and checkout;
- Mission Specialist (M/S) and Payload Specialist (P/S) selection and training;
- Mission Control Center/Payload Operations Control Center reactions to ground and flight problems;
- Real-time interaction during flight between Principal Investigators (PIs) and the flight crew (M/S and P/Ss);
- Retrieval of scientific data and analysis;
- Documentation.

2.2 Mission Objectives

To maximize the utility of the ASSESS II Program for Spacelab, the following objectives were established:

a) Science related

- Evaluate experiment selection procedures;
- Maximize science data.

b) Management

- Study proposed NASA and ESA/SPICE Spacelab payload management concepts and interface relationships;
- Evaluate Mission Manager, Mission Specialist, and Payload Specialist roles in mission planning and implementation;
- Evaluate participation of PIs in mission planning and implementation;
- Evaluate utilization of an Investigators' Working Group (IWG) in mission planning and implementation.

c) Analytical Integration and Mission Planning

- Evaluate the methods and effectiveness of performing analytical system engineering, mission flight definition, and payload interface identification and control.

d) Payload Specialist Selection and Training

- Evaluate methodology of Payload Specialist selection and training;
- Determine practicability of using a PI as a Payload Specialist.

e) Mission Specialist Selection and Training

- Evaluate methodology for selection and assignment of a Mission Specialist;
- Evaluate the Mission Specialist responsiblities relative to the STS systems and the payload.

f) Ground Operations

- Understand and gain an appreciation of integration activities pertinent to Spacelab payloads;
- Identify ground operations and testing requirements for efficient experiment integration and checkout;
- Evaluate Mission Specialist, Payload Specialist, and PI involvement in experiment ground operations.

g) Mission Planning and Flight Operations

- Assess methods and degree of real-time experiment/mission planning for Spacelab missions;
- Evaluate concept of proxy operation and maintenance of experiments by P/Ss during flight operations;
- Evaluate POCC concept and operating procedures.

h) Documentation

- Develop and evaluate minimum cost documentation approach consistent with Spacelab payload requirements.

2.3 Project Guidelines

To fulfill the objectives of ASSESS II, the following guidelines were developed:

- Maximum Spacelab reality within funding limits and the limitations inherent with aircraft operation;
- Ten-day mission with payload crew confined to the aircraft and contiguous living quarters (see fig. 2) with one aircraft flight planned for each 24-hour period; the total of the aircraft flights and confined periods between flights to represent a single Spacelab mission;
- Payload crew to consist of two European Payload Specialists to operate the European experiments, two U.S. Payload Specialists to operate the NASA experiments, and one Mission Specialist; no cross-training between NASA and ESA experiments except for the ESA medical experiment involving all Payload Specialists;
- Communications with the ASSESS Spacelab crew to conform to actual Spacelab communications procedures as far as practicable; communication to be established between the ground and the aircraft throughout flight periods;
- Spacelab-like experiment control panels to be provided in the aircraft to centralize P/S management of experiment operations;
- The aircraft flight crew (pilot, copilot, flight engineer, and navigator) not to be included in the simulation exercise;
- A few unconstrained personnel (called ghosts) to participate in the flights to assure continuous operation of aircraft experiment support systems, where it was not practical to change them for operation from a centralized position.

2.4 Mission Management

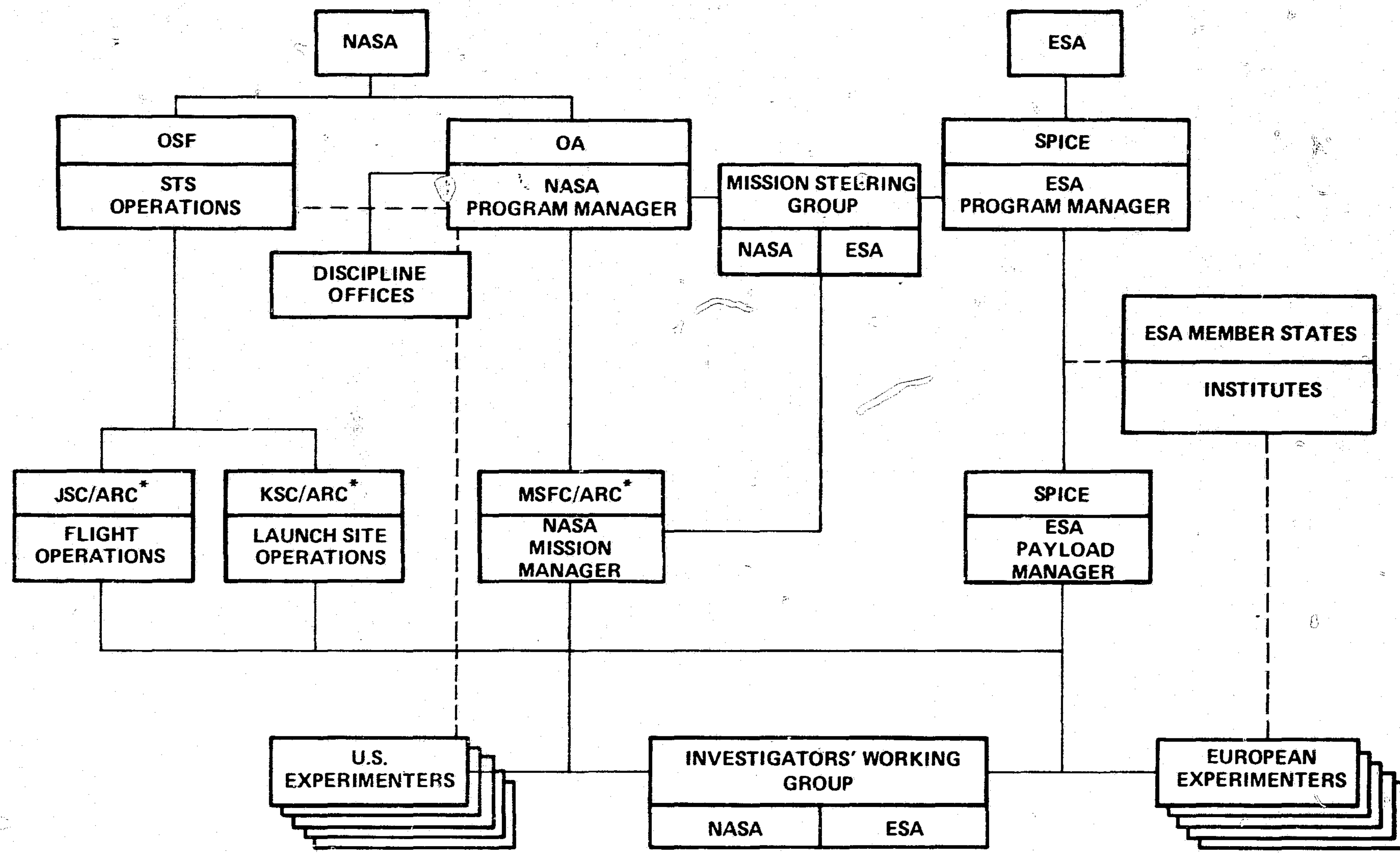
2.4.1 Management Structure and Responsibilities

Figure 3 shows the management structure, which, with the exception of the MSG, corresponds closely to that planned for early Spacelab missions.

In NASA Headquarters, the program was cosponsored by the Office of Applications (OA) and the Office of Space Flight (OSF). The participation of the Johnson Space Center (JSC) to handle flight operations and Kennedy Space Center (KSC) to handle launch site operations, was under the jurisdiction of OSF. The U.S. portion of the payload was sponsored by OA, where the discipline offices took part in the initial activities to select the payload experiments. A Program Manager was selected in OA to guide the project. A Mission Manager was selected at MSFC to handle overall project managment. Since the project was initiated and conducted at the Ames Research Center (ARC) utilizing the Ames CV-990 Airborne Laboratory, it was necessary that ARC participate strongly with JSC, KSC, and MSFC to carry out the mission.

In Europe, ESA activated a new organization called SPICE, located at the DFVLR laboratory, Porz-Wahn, Germany, to handle experiment integration and coordination activities in Europe. This organization is planned for Spacelab and was established in time to function for ASSESS II. A Program Manager was appointed at SPICE and under him a Payload Manager was selected who developed the ESA portion of the payload in Europe and worked closely with the NASA Mission Manager during integration and flight operations in the U.S.


PAYLOAD CREW
LIVING QUARTERS
Galileo II



* ARC SUPPORTED MSFC, KSC, AND JSC IN THEIR RESPECTIVE FUNCTIONS.

Figure 3. ASSESS II Management Structure

2.4.2 Mission Steering Group

A Mission Steering Group (MSG) was established at the beginning of the project with representatives from every major participating organization. The MSG was unique to ASSESS, and is not planned for Spacelab. Participating NASA Headquarters program offices were represented along with MSFC, JSC, KSC, ARC, ESA Headquarters, and ESA/SPICE. The MSG was cochaired by the NASA Program Manager from the Headquarters Office of Applications and the ESA Program Manager from SPICE.

Functions of the MSG were to provide overall guidance to the simulation in order to achieve maximum benefit for Spacelab planning. Accordingly, the MSG established the mission guidelines and provided an overall management forum for the resolution of intercenter/agency responsibilities.

2.4.3 Mission Manager

The Mission Manager at MSFC was assigned complete responsibility for the payload. His office was to be the single point of contact between experimenters and the project. Initially, the manager of Spacelab 2 from the Spacelab Payload Project Office at MSFC was assigned to manage ASSESS II. An Assistant Mission Manager, who had participated in earlier ASSESS missions, was also appointed from the Spacelab Payload Project Office. About four months before flight (January 1977), the ASSESS II mission management responsibility was transferred to an individual at MSFC who had been assigned to handle all OA Spacelab projects. At SPICE, ESA elected to have the same individual serve as both the Program Manager and the Mission Manager. He was aided by a deputy from ESTEC who functioned as Payload Manager and worked closely with the European experimenters throughout experiment development, integration, and flight operations.

2.4.4 Mission Scientists and Investigators' Working Group

MSFC appointed the Chief of the Solar Science Branch, Space Sciences Laboratory as the Mission Scientist and the Chief of the Optical Physics Branch of the same laboratory as his assistant. The Assistant Mission Scientist had served in the same capacity on ASSESS I. ESA appointed a staff astronomer from ESTEC, who had served as a Payload Specialist on ASSESS I, as their Mission Scientist, but did not appoint an assistant.

An Investigators' Working Group (IWG) was established early in the ASSESS II Project, and was made up of a PI from each experiment. The mission Scientist from MSFC chaired the IWG with the ESA Mission Scientist as cochairman. Functions of the IWG were to provide a forum for PI discussion and to make recommendations concerning science plans and priorities for the mission. NASA and ESA IWG members provided recommendations to their respective managements for Payload Specialist selection.

2.4.5 Mission Specialist

The ASSESS II mission was the first trial by NASA to identify and assign a Mission Specialist (M/S) to serve in a Spacelab-type activity. After substantial difficulty, a role was established and agreed to as follows:

- To act as the inflight alter ego of the Mission Manager and to be generally responsible for coordination and conduct of combined payload operations during flight;
- To be the single interface between the Payload Specialists and STS flight crew (pilot/copilot);
- To be responsible for all aircraft experiment-support systems such as power distribution, central data system, etc;
- Upon approval of the NASA Program Manager, to be trained to act as Payload Specialist and operate experiments during the flight mission;
- To work with the POCC, MCC, Payload Specialists, and Flight Commander (pilot) to solve inflight problems caused by equipment failures and/or flight conditions leading to changes of science priorities.

A scientist/astronaut from JSC was assigned to serve as M/S. Although he reported administratively to JSC, he was assigned to report directly to the Mission Manager at MSFC in accomplishment of the above assigned responsibilities for ASSESS II. The M/S was an astronomer who had previously served as a Payload Specialist during an earlier ASSESS Spacelab simulation (ref. 9, 10). A second scientist/astronaut from JSC was appointed as a backup. He also was an astronomer and had served as P/S on the ASSESS I mission (ref. 12-16).

2.4.6 Payload Specialists

Since the payload was about evenly divided between NASA and ESA, it was agreed that the flight crew would consist of four Payload Specialists (P/Ss), two from the U.S. and two from Europe, and that the ESA P/Ss would be responsible for the European experiments while the NASA P/Ss would handle the U.S. experiments. Thus, with only minor exceptions, there would be no cross-training responsibility. This segregated arrangement was chosen mainly to save travel costs for training and reduce individual commitments.

In the U.S. two P/Ss were selected from JPL. One was a radar technician and the other was a physicist who was also the PI for one of the payload experiments. No PI proposed candidates were selected for backup. Instead, also to reduce costs, the Assistant Mission Manager from MSFC, an aeronautical engineer, was assigned a second role to serve as the single backup P/S for the U.S.

In Europe, ESA selected four P/Ss, initially planning to identify two as prime P/Ss and two as backup. The four P/Ss were: a graduate student in physics from the University of Southampton, England; a staff astronomer from ESTEC who was formerly an airline pilot; an electrical engineer from DFVLR; and a physicist from DFVLR. The plan of selecting two as prime P/Ss and two as backup was altered somewhat before the mission actually got underway at ARC. (The final arrangement is discussed under Mission Implementation.)

Payload Specialist responsibility was to serve as the direct representative of the PI in operating the experiments during "Spacelab" flight with the goal of obtaining the best data possible. Thus, the P/Ss trained extensively for their assignments. During the "Spacelab" flight they operated their respective experiments to obtain high quality data according to plans determined before each data-take period. When necessary, they adjusted and repaired experiment malfunctions, using skills developed during their training periods, and communicated directly with the PIs via the POCC during the flight mission.

3. MISSION IMPLEMENTATION

This section details the events during implementation of the ASSESS II project, and provides support for conclusions given in Section 4. Significant events during implementation of the project are shown on the overall schedule, figure 4.

3.1 Flight Payload

3.1.1 Experiment Selection and Funding

In NASA, the Office of Applications (OA) decided to select experiments for ASSESS II from ongoing experiment programs, with emphasis on experiment prototypes destined for Spacelab that had previously flown on the CV-990. This was done particularly to save costs of instrument development, but also to take advantage of the ASSESS program to further develop experiments for approved applications programs. This eliminated the use of an Announcement of Opportunity. The OA Discipline Offices (see figure 3) were called upon to propose experiments. Final selection turned out to be a difficult and time consuming process. The OA ASSESS II Program Manager finally achieved a full baseline experiment selection about three months (June 1976) after official approval of the project, but funding was extremely tight and it was recognized that one or two experiments might have to be dropped. The baselined experimenters began work in earnest to modify their experiments for the ASSESS II "Spacelab" payload, but interactions within OA continued to delay full solidification of the NASA payload. Some experimenters slowed their efforts due to unresolved funding problems, and it was not until December 1976 that funds were finally distributed, almost nine months after NASA Headquarters project approval, and only five months before launch.

Approval and funding for the experiment from GSFC was still being held up after eleven months (until February 1977) for lack of an interagency decision regarding the data to be obtained. By that time all levels of management, as well as the PI, agreed that the experiment had to be dropped unless immediate approval was obtained. A decision was finally made to go ahead, but, as a result of the inordinately late decision, that experiment was in a crash mode of activity until the flight period.

In Europe, ESA issued an Announcement of Opportunity in December 1975 following preliminary project approval. The proposals were screened by the ESA science departments and reviewed by a special board. Final payload selection was announced by ESA in April 1976, one month following final ASSESS project go-ahead. Funding of the European experiments was handled on a national basis with ESA providing additional funds over and above the basic experiment costs to support activities peculiar to the ASSESS II Spacelab simulation.

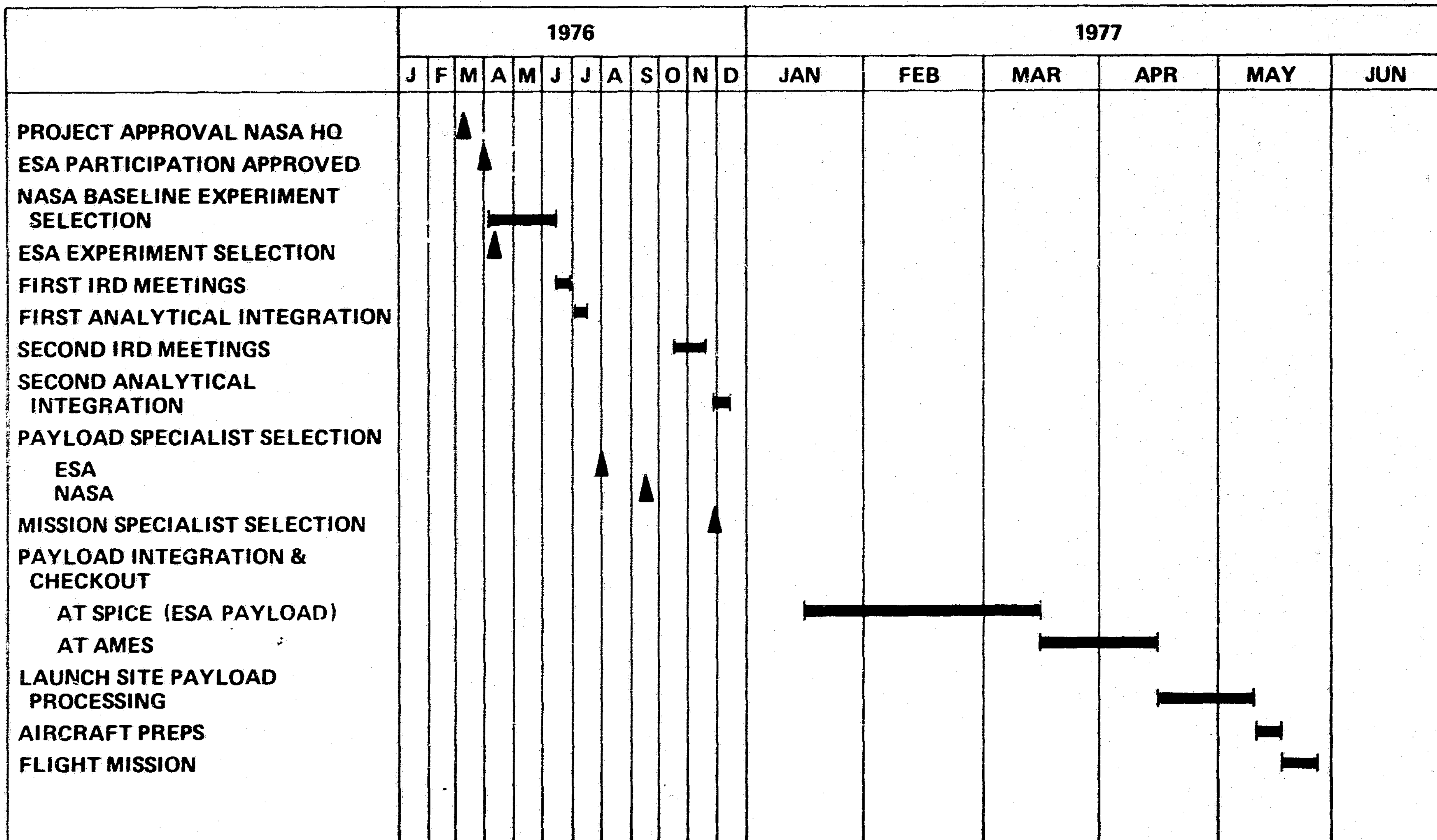


Figure 4. ASSESS II Schedule

3.1.2 Experiment Descriptions

The experiment payload consisted of ten scientific and application experiments - five from Europe and five from the U.S., plus one engineering-type experiment from ESA/ESTEC to measure EMI characteristics of the payload. Table 1 lists the experiments, showing the sponsoring organizations, the basic measurements performed, and a brief description of the instrumentation used. Particular note should be taken of the Experiment Designator; these designators will be used throughout this report in referring to individual experiments. Table 2 provides a brief background of the experiments.

All of the experiments except the CTM had flown in aircraft previous to ASSESS II. The CTM experiment had been used in a ground installation. The MED experimenter had obtained data from several subjects aboard a long commercial flight, but ASSESS required centralized design and periodic attachment of the self-carried units to the ADDAS interface. The IR telescope, AWS, and EMI from Europe had flown on ASSESS I. LIDAR, LAS, and AEES had flown on light aircraft. The other three experiments from JPL and LaRC had flown before on the CV-990. However, without exception, all experiments underwent significant modification in preparation for ASSESS II.

The infrared astronomy experiment involved three organizations from three countries - the telescope was supplied and managed by the Paris Observatory at Meudon (France), while two separate detectors from Germany (MPI) and The Netherlands (Groningen) were adapted to it, to be operated selectively by beam switching. The medical experiment from Germany acquired added scientific cooperation from NASA/ARC during latter phases of the project.

Figures 5a through 5j show the sensing and data handling components of most of the ASSESS II experiments. Items of particular interest are indicated in the illustrations and are discussed for each experiment as follows:

IRA (Infrared Astronomy) Figure 5a shows the Meudon telescope with both the Groningen and Max Planck detectors attached. The Groningen detector was mounted at the Cassegrain focus and moved with the telescope. The MPI detector was mounted at the Coudé focus and so did not move with the telescope. Both dewars were pumped during flight to achieve liquid helium temperatures of 2K or below at the detectors. A TV camera was mounted on the tracking telescope to provide the signal for the automatic tracking electronics.

AWS (Airglow Wave Structure) Figure 5b shows the two AWS TV cameras looking out either side of the aircraft along with associated equipment. Signals from the cameras were recorded at a slow frame rate on the video tape recorder. A small monitor was provided to aid in focussing the cameras.

LIDAR (Light Detection and Ranging) The laser transmitting and receiving optics for LIDAR were mounted in the forward cargo compartment (no photograph available), with data handling equipment in a separate rack in the main cabin (fig. 5c). In the original design of this experiment for a light aircraft the optical paths were open to the atmosphere. The CV-990 installation required

Table 1 - ASSESS II Experiments

Experiment Designator	Organization	Measurement	Instrumentation
IRA*	Paris Observatory - Meudon, France	--	30-cm open port Cassegrain telescope.
	University of Groningen - The Netherlands, and Paris Observatory - Meudon, France	Characteristics of galactic cold clouds and H II regions.	4-channel photometer. Bands: 17-20 μm 30-48 μm 70-95 μm 114-196 μm Detector: bolometer at 1.6 K
	Max Planck Institute for Physics and Astrophysics - Garching, Germany	Spectral features of forbidden transitions (Ne II, Ne III, H_2, and S III) in H II regions.	Tilting filter spectrometer. Bands: 12.8 μm (Ne II) 15.5 μm (Ne III) 28.0 μm (H_2) 18.7, 33.6 μm (S III). Bandwidth: 0.1 cm^{-1} Detector: bolometer at 1.5 K.

*NOTE: IRA was considered a single infrared astronomy experiment, even though it had multiple sponsorship. The telescope was supplied by the observatory at Meudon. One detector was supplied by the University of Groningen, producing data of interest to both Meudon and Groningen. A second detector was supplied by Max Plank Institute. Beam-switching optics directed signals to one detector at a time.

Table 1 continued

Experiment Designator	Organization	Measurement	Instrumentation
AWS	University of Southampton - Southampton, England	Radiation from stratospheric OH clouds.	Image-intensified, integrating near IR TV camera systems. Left and right viewing from passenger windows.
LIDAR	DFVLR, Institute for Physics of the Atmosphere - Oberpfaffenhofen, Germany	Mass concentration of aerosols below aircraft along extended flight paths.	Optical ($\lambda = 1.06$ μm) distance measuring radar (LIDAR). Return amplitude proportional to mass concentration of scattering aerosols. Detector: photodiode at ambient temperature.
MED	DFVLR, Institute for Flight Medicine - Bad Godesberg, Germany and NASA/ARC	Heart rate and body temperature in flight and electroencephalograms during sleep.	P/Ss instrumented with appropriate sensors and small tape recorders.
CTM	Capodimonte Observatory - Naples; University of Lecce and University of Florence, Italy	Absolute solar flux and temperature distribution in upper solar atmosphere (chromosphere) from spectra in 100 to 200 μm band. Emission of earth atmosphere in same waveband, for reference.	Michelson interferometer, non-collimated. Detector: germanium bolometer at 1.8 K. Calibration source at 77 K. Switch sun to calibration source at 10 Hz. Sun viewing via stabilized mirror. Field of view: $2^\circ \times 2^\circ$.
EMI	ESA/ESTEC - Noordwijk - The Netherlands.	EMI characteristics of aircraft systems and individual experiments.	EMI measuring equipment. Spectrum analyzer - dc to 500 MHz.

TABLE 1 continued

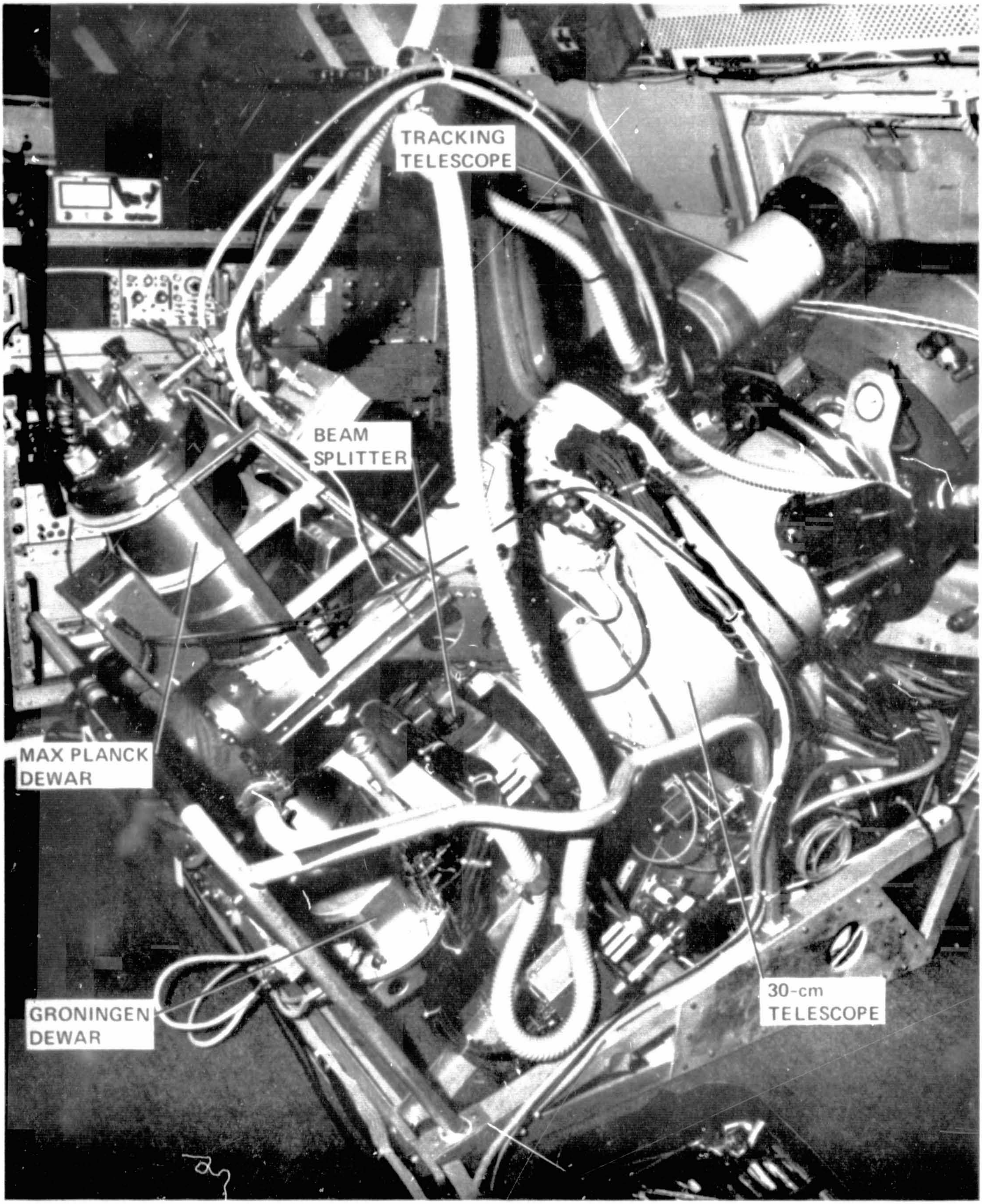
Experiment Designator	Organization	Measurement	Instrumentation
SAR	NASA/JPL - Pasadena, CA	Radar maps of terrain for earth resources feasibility study.	Two synthetic aperture mapping radar systems: X-band (3-cm waves); pulse of 1.25 µs, 50 kw peak. L-band (10-cm waves); pulse of 1.25 µs, 5 kw peak. Dual polarization antennas.
MLS	NASA/JPL - Pasadena, CA	Spectral lines emanating from trace atmospheric gases in the 100 to 200 GHz range. Concentrate on the 167 GHz line from chlorine monoxide.	Heterodyne radiometer/spectrometer; dual signal channel: #1 IF, 100 - 300 MHz, 36 channel filter bank produces line shape; #2 IF, $\pm$ 5 MHz, 256 channel Fast Fourier Transform spectrometer. Viewing: -2° and +30° (reference).
LAS	NASA/JPL - Pasadena, CA	Energy absorbed by O_3 from nadir directed pulses from a CO_2 laser to determine atmospheric ozone concentration.	Dual CO_2 lasers; chopped beams directed 3° forward of nadir; one laser tuned to O_3 absorption, other to O_3 window. Doppler shifted returns mixed with unshifted laser power to give IF. Photomixers: HgCdTe at 77 K.

Table 1 concluded

Experiment Designator	Organization	Measurement	Instrumentation
IHR	NASA/LaRC - Hampton, VA	Radiation absorbed by or emanating from atmospheric O_3 in the 9 - 12 µm band for lateral concentration and altitude profile determinations.	Heterodyne IR radiometer/spectrometer; dual signal channel: #1 IF, 100 - 1000 MHz, atmospheric window; #2 IF, 150 - 2150 MHz, 4-channel filter bank produces line shape. Solar viewing (O_3 absorption) via stabilized mirror; nadir to 45° viewing (O_3 emission) via external mirror. Photomixers at 77 K.
AEES	NASA/GSFC - Greenbelt, MD	Monitor usage of emergency RF and microwave communications bands.	Emergency locator transmitter channels: 121.5 MHz 243.0 MHz 406.0 MHz fixed frequency, nadir receiving; 0.4 - 12.4 GHz swept frequency, nadir or horizontal receiving.

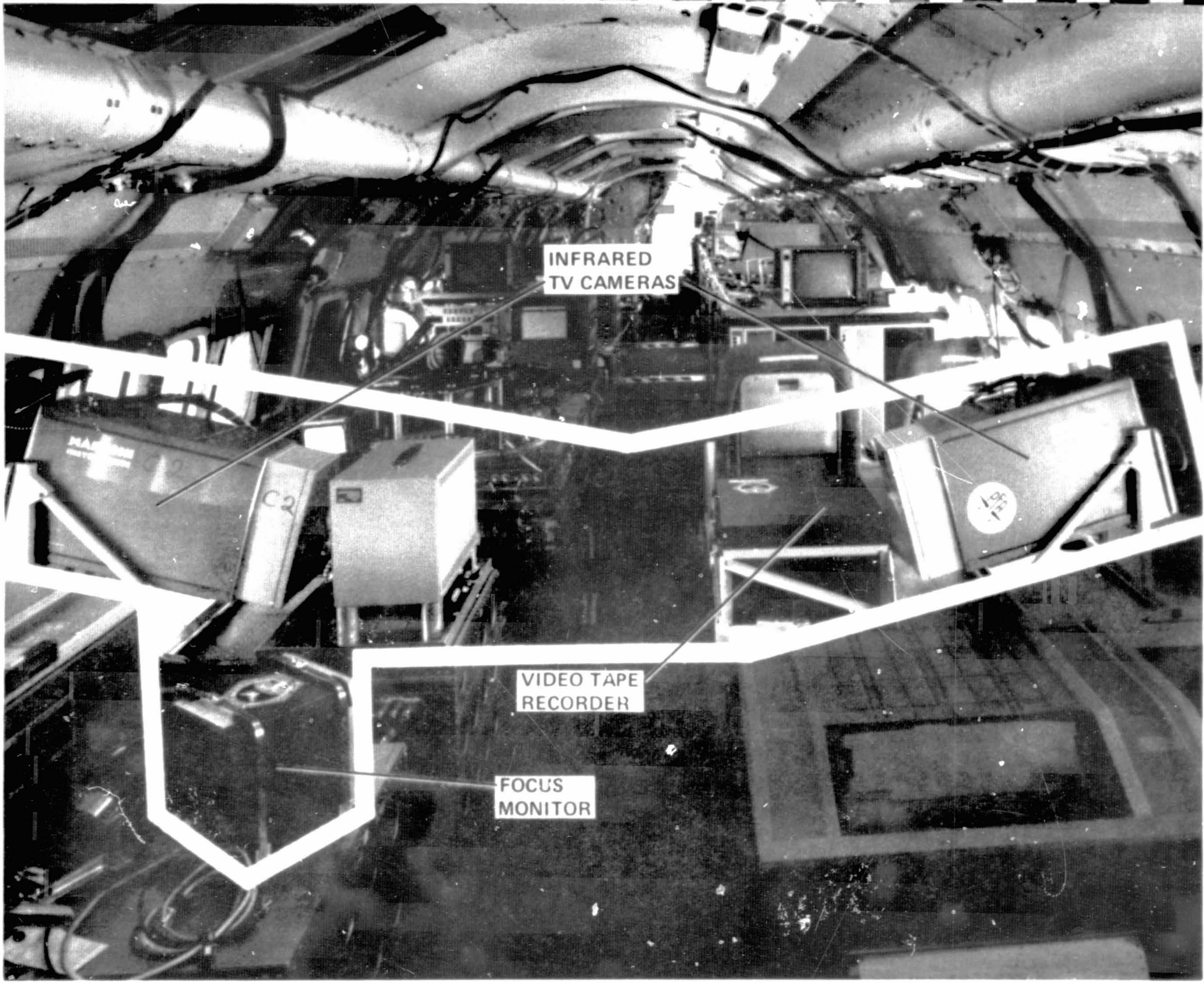
Table 2 - Background of ASSESS II Experiments

Experiment	Initial Development Date	Previous Flights	Modifications for ASSESS II
IRA (Meudon telescope)	1974	1974-76 (Caravelle and CV-990, ASSESS I)	Improve computer control.
(Groningen photometer)	--	1975 (CV-990, ASSESS I)	Add internal calibration source.
(Max Planck spectrometer)	1975	1976 (Balloon and light aircraft)	Change wavelength of passband.
AWS	1972	1975 (CV-990, ASSESS I)	Add second TV camera and disc memory. Extend controls to Spacelab rack.
LIDAR	1976	1976-77 (light aircraft)	Extend controls to Spacelab rack. Add backup laser. Change optical design. Add ADDAS interface.
MED	1970	1977 (Commercial jet)	Modify equipment to fit Spacelab rack. Add ADDAS interface.
CTM	1976	None	Remove reference detector. Simplify signals. Extend controls to Spacelab rack.
EMI	1974	1975 (CV-990, ASSESS I)	Automate signal selection. Add tape recorder.
SAR	1969	1970-77 (CV-990)	Extend controls to Spacelab rack.
MLS	1975	1975-76 (CV-990)	Extend controls to Spacelab rack. Automate to reduce PI duty cycle.
LAS	1974	1976-77 (light aircraft)	Extend controls to Spacelab rack. Add ADDAS interface. Modify gas flow system. Change to closed-port operations.
IHR	1976	1976 (CV-990)	Redesign laser package, power supplies, cooling, and gas flow. Extend controls to Spacelab rack. Delete experiment data system. Add ADDAS interface.
AEES	1976	1976 (light aircraft)	Extend controls to Spacelab rack. Reconfigure for CV-990. Delete spectrum analyzer.



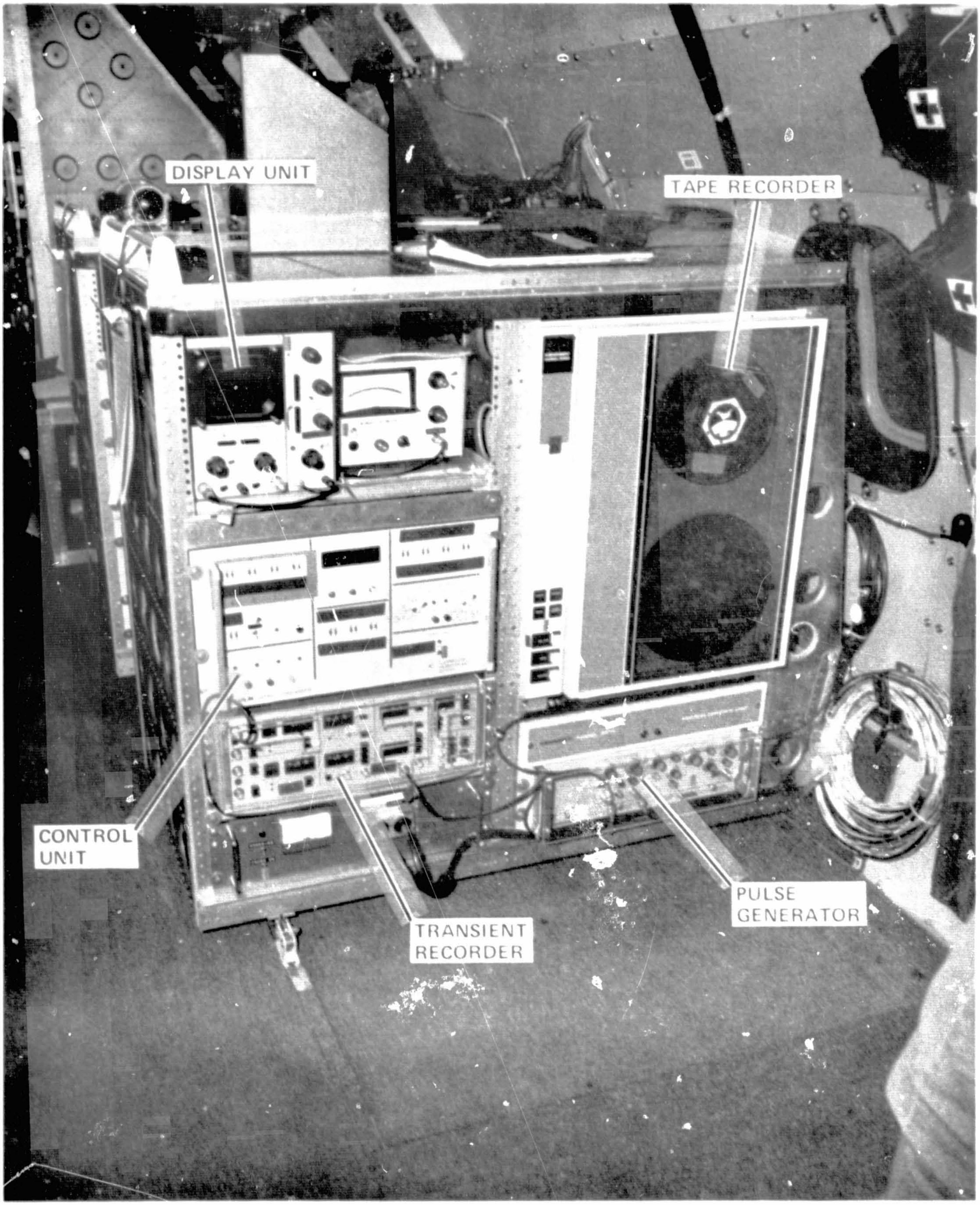
a. Infrared Astronomy Experiment

Figure 5. ASSESS II Experiments



b. Airglow Wave Structure Experiment

Figure 5 continued



c. LIDAR Data Handling Equipment

Figure 5 continued

provision of a suitable transmitting window to preserve cabin pressurization. The experiment was also electromagnetically shielded with screening to reduce EMI radiation measured during the ESA integration at Porz-Wahn (sec. 3.4.1). The LIDAR equipment included a backup laser that could be remotely switched into the experiment from the P/S operating position.

MED (Medical Experiment) Aside from sensors and small tape recorders worn by the payload crew, the airborne portion of the medical experiment consisted only of the monitor and ADDAS interface unit shown in figure 5d at the P/S position. The P/Ss periodically plugged their sensor systems into the control rack to monitor the measurements or feed inputs into the ADDAS system to provide recorded quick-look data for the PI.

CTM (Chromospheric Temperature Measurement) Main controls for the CTM experiment were mounted on one of the Spacelab racks as shown in figure 5d. The remainder of the equipment was mounted in the aft cabin as shown in figure 5e. (The dewar which housed the detector is not shown.) The dewar was pumped during flight to maintain a liquid helium temperature of 2K or lower at the detector. Other principal components of the experiment are indicated in the photograph.

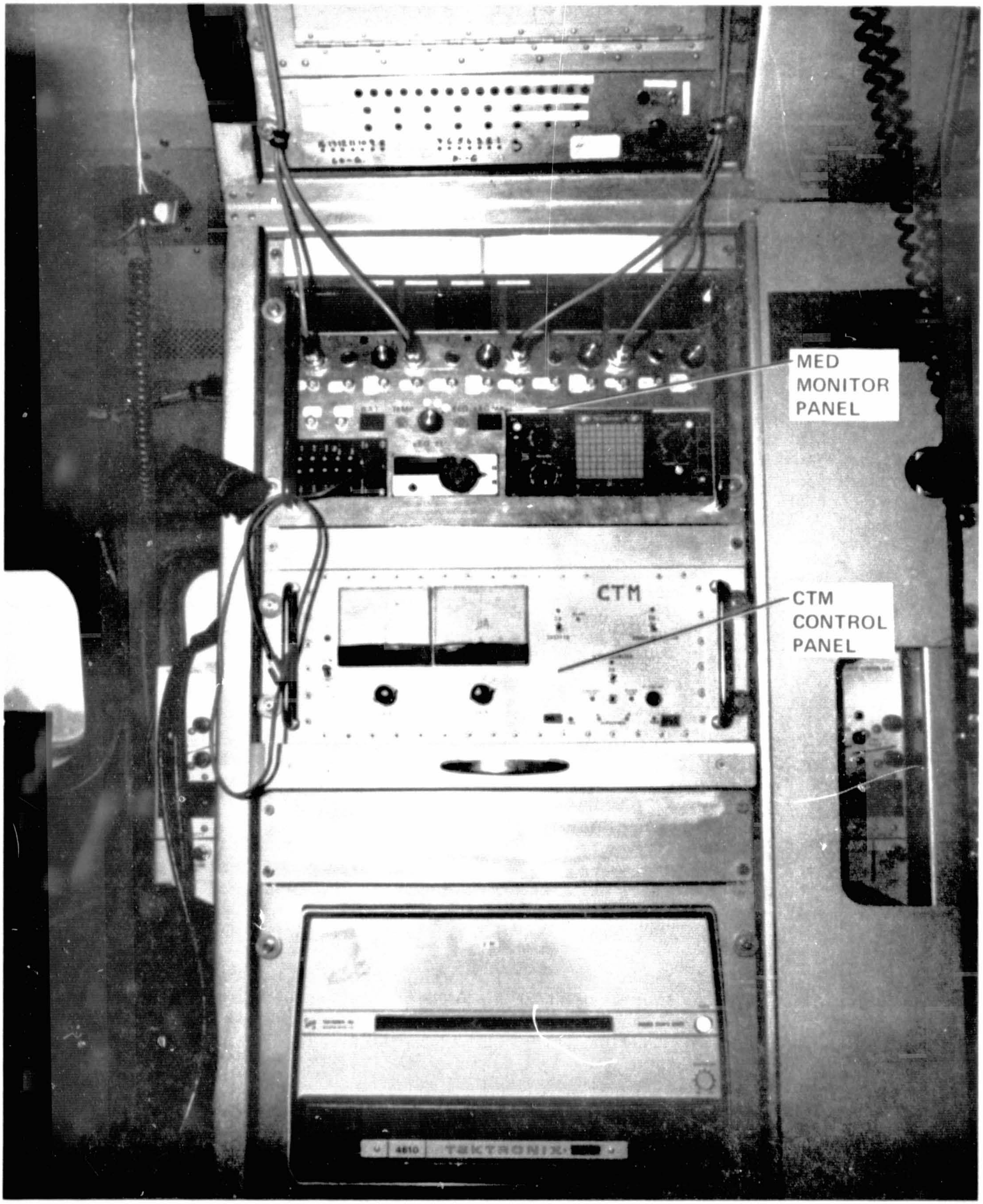
EMI (Electromagnetic Interference) EMI sensors, consisting of 15 current sensors and four voltage sensors, were located at various test points leading to the experiments and in the aircraft power supply. These probes were sampled sequentially and signals were frequency analyzed over the range from dc to 500 MHz using the equipment shown in figure 5f.

SAR (Synthetic Aperture Radar) Figure 5g shows a photograph of the radar generators and control electronics which was taken while the equipment was in a test area. The transmitters were located in the aft cargo hold during flight. Radar antennas were located on the rear door of the aft cargo compartment. Data was recorded on optical recorders (not shown) for later processing.

MLS (Microwave Limb Sounder) MLS equipment is shown in figure 5h. The radiometer/spectrometer was positioned at an angle to the window to avoid viewing the wingtip. The very low level output microwave signal was amplified by a special low-noise amplifier. Most operating functions for this experiment were controlled by a minicomputer located in one of the Spacelab racks.

LAS (Laser Absorption Spectometer) The main components of the LAS experiment are shown in figure 5i as mounted in the forward cargo compartment. The unit contained two lasers (a signal and a reference laser, the wavelengths of which were absorbed and passed by ozone, respectively), the optics for transmitting and receiving, and a dewar contained detector for each beam. The detectors were cooled to 77K by liquid nitrogen.

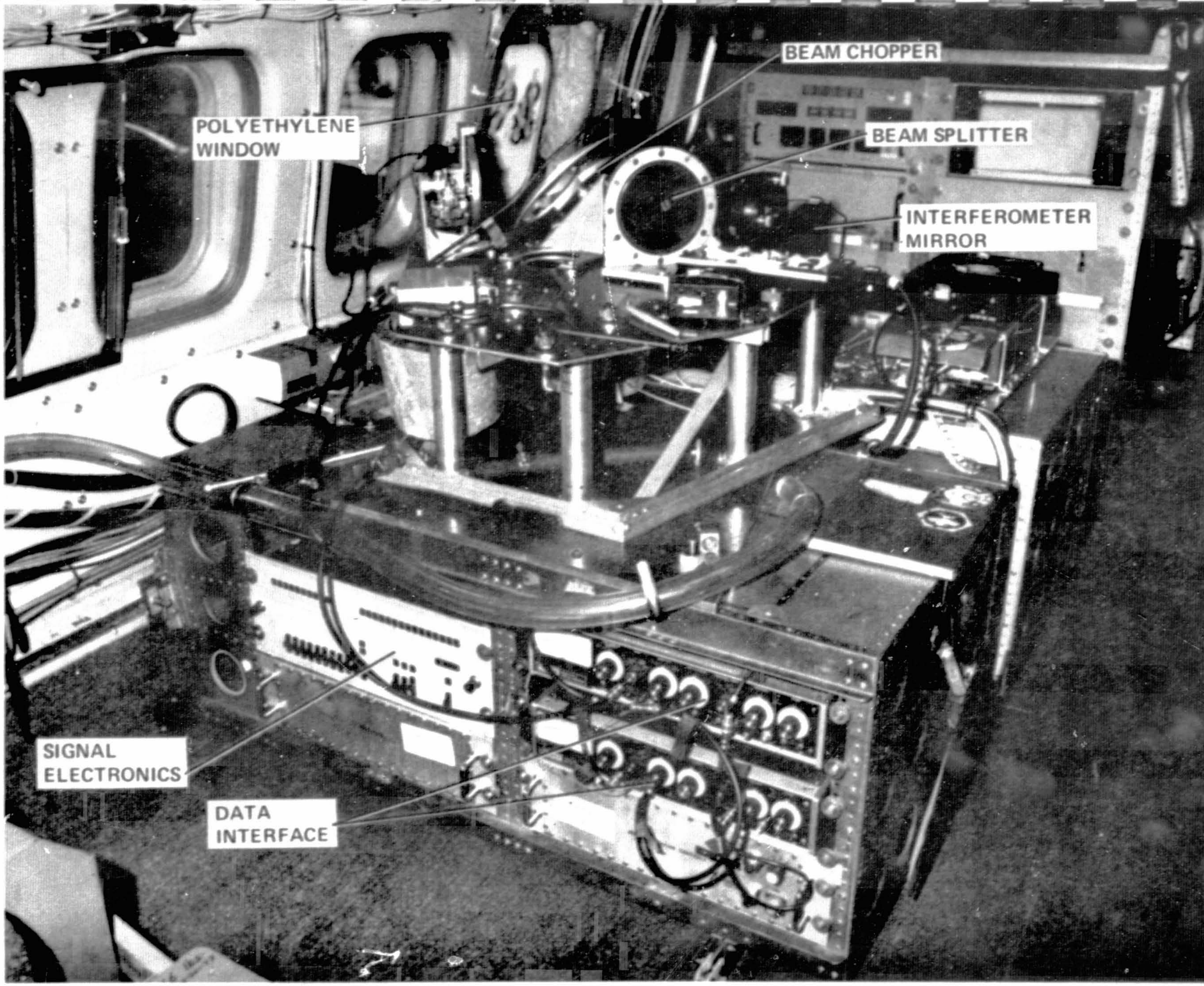
IHR (Infrared Heterodyne Radiometer) The IHR experiment is shown in figure 5j. This experiment, like the LAS, contained two lasers and dewar



d. Chromospheric Temperature Measurement Control and Medical Monitor Panels

Figure 5 continued

ORIGINAL PAGE IS
OF POOR QUALITY



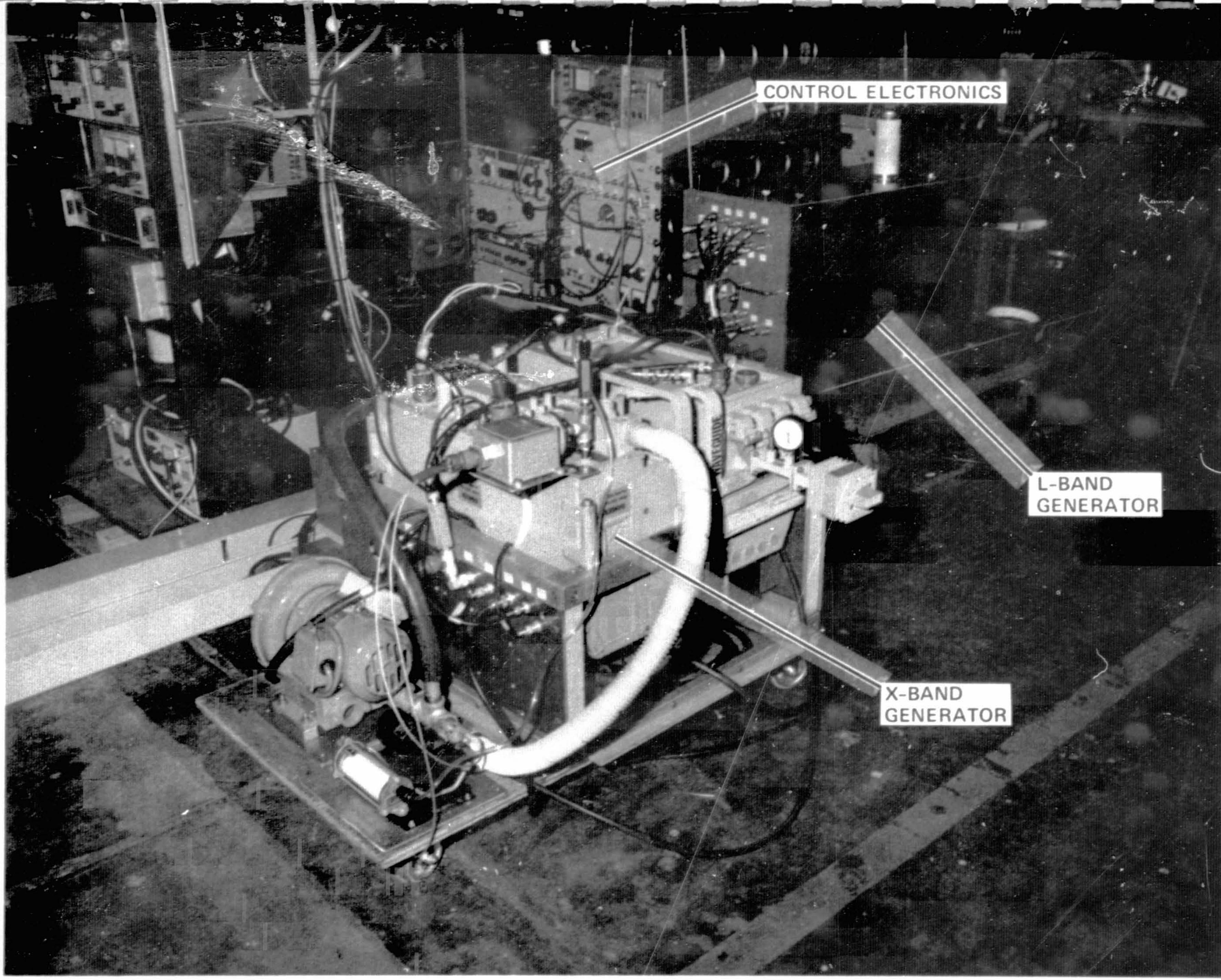
e. Chromospheric Temperature Measurement Experiment

Figure 5 continued

f. Electromagnetic Interference Experiment

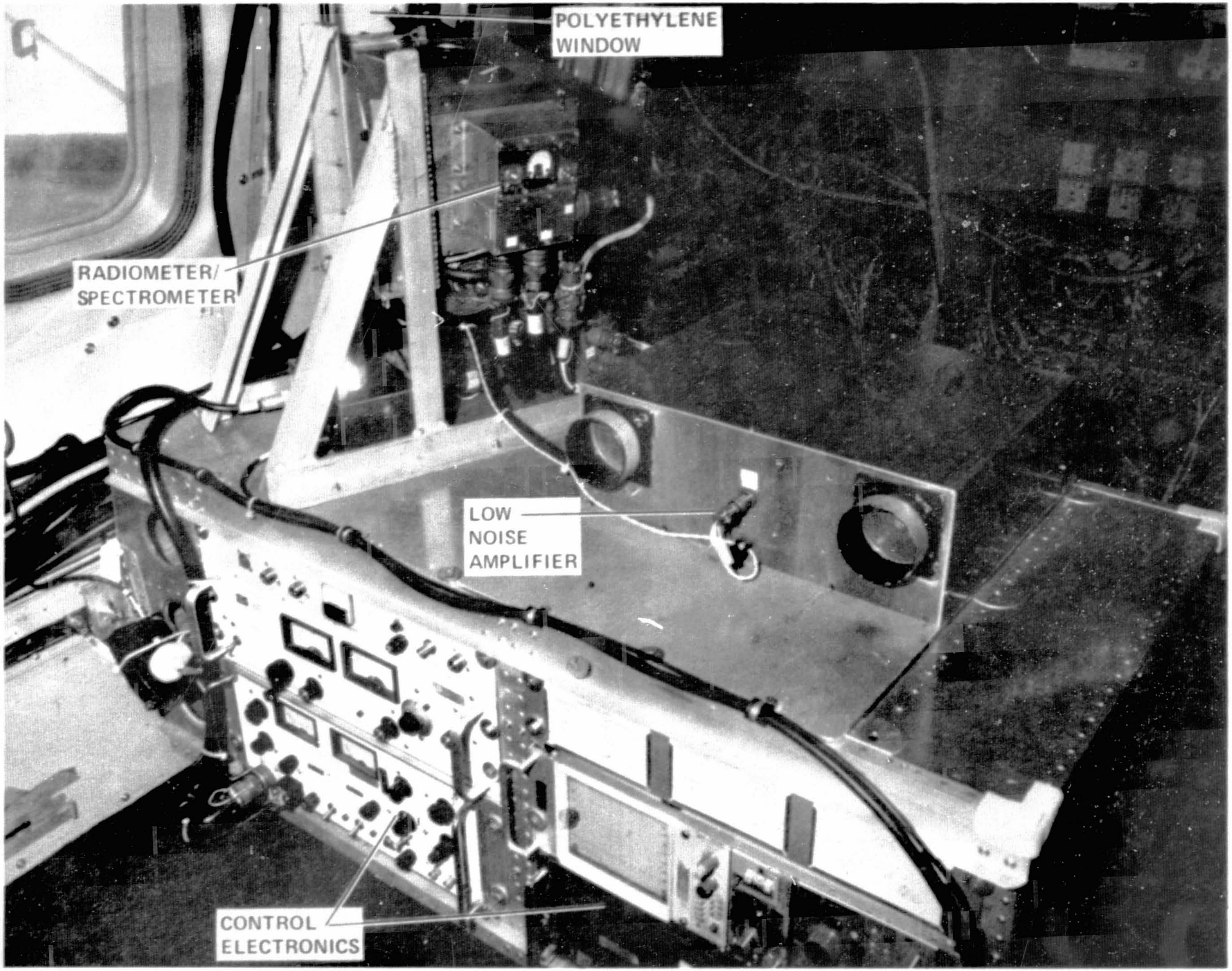
Figure 5 continued

ORIGINAL PAGE IS
OF POOR QUALITY



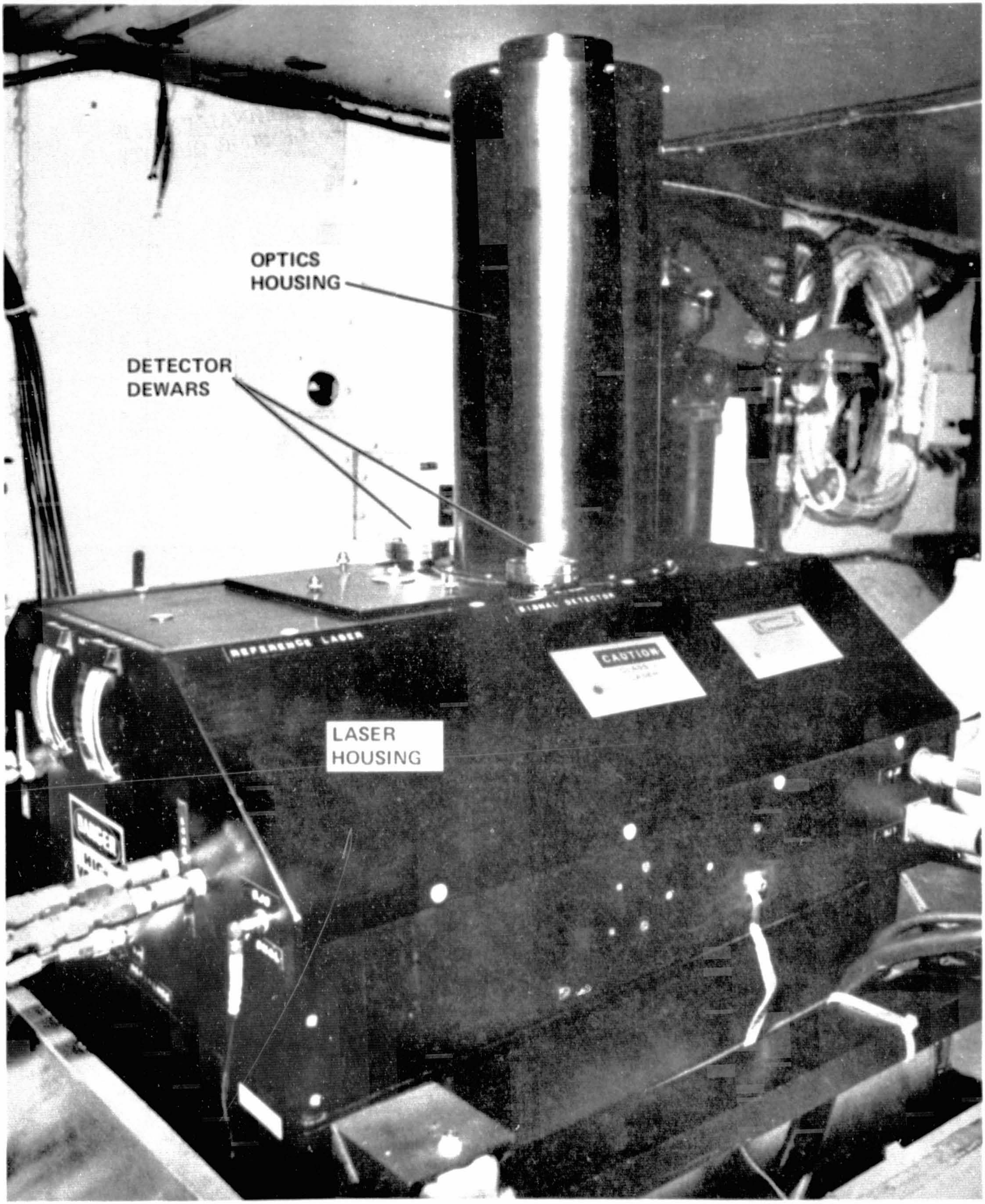
g. Synthetic Aperture Radar Experiment

Figure 5 continued



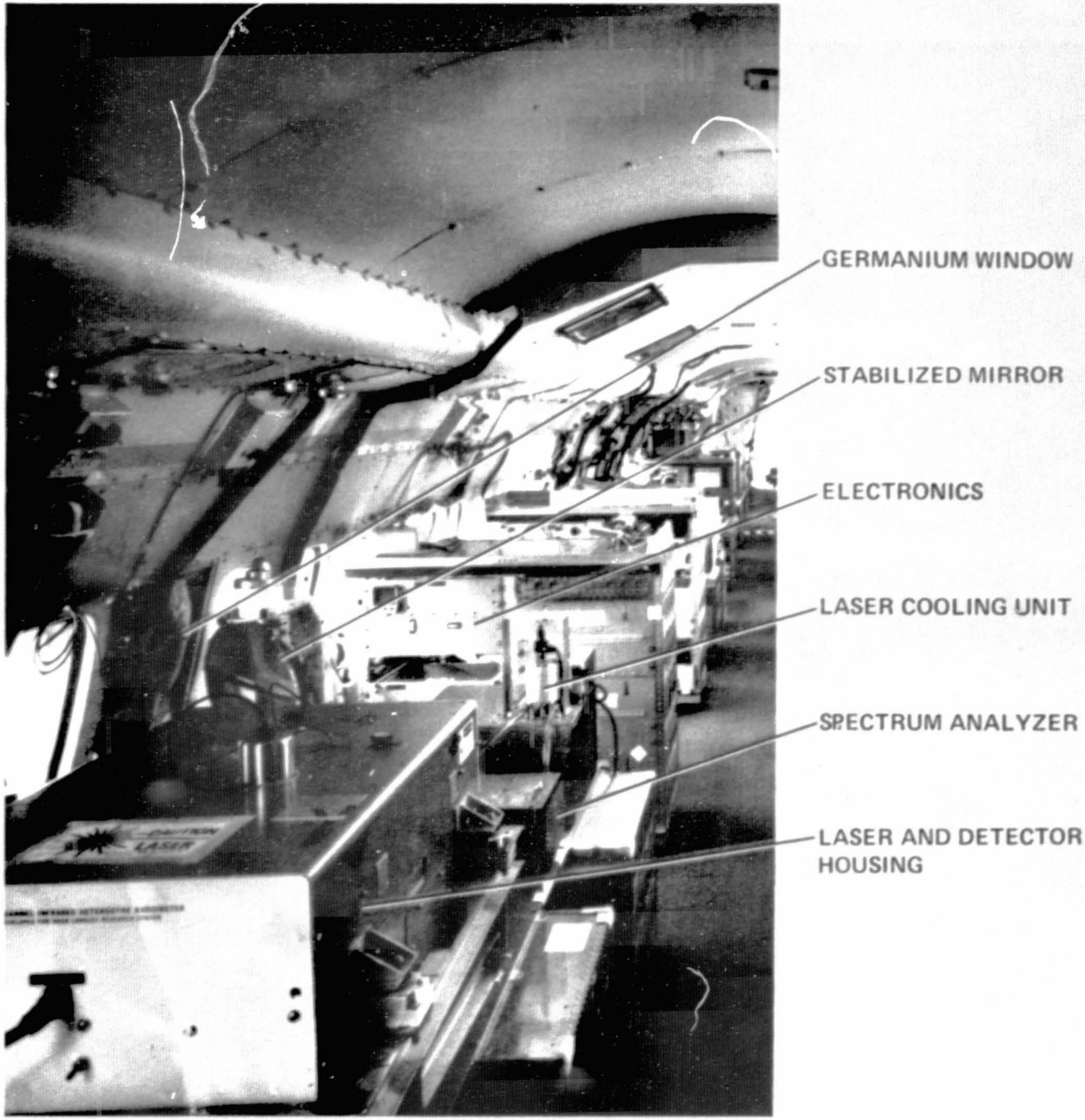
h. Microwave Limb Sounder Experiment

Figure 5 continued



i. Laser Absorption Spectrometer Detector System

Figure 5 continued



j. Infrared Heterodyne Radiometer Experiment

Figure 5 concluded

contained detectors. However, unlike the LAS, the IHR lasers were used as local oscillators in a heterodyne sense such that the local oscillator laser signal and the received signal were mixed to produce an intermediate frequency. Laser frequencies were chosen to be absorbed and passed by ozone. Detectors were cooled to 77K by liquid nitrogen. This experiment was also used to view the sun, using a stabilized mirror to direct the signal.

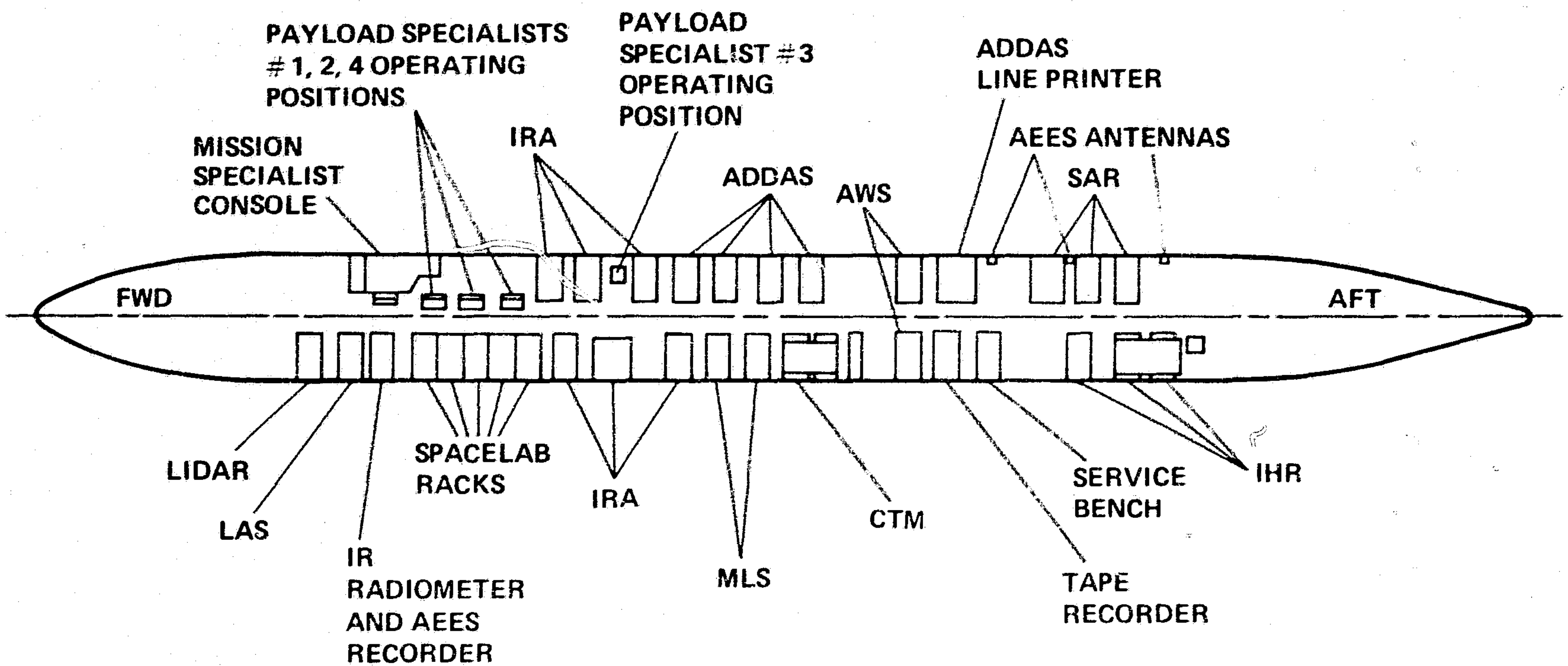
AEES (Airborne Electromagnetic Environment Survey) Antennas for the three fixed frequency receivers were mounted on passenger window blanks in the right rear of the aircraft, while those for the swept frequency receiver were mounted in the nadir general purpose pylon. Because of the high frequencies involved, the swept receiver was mounted in the rear cargo hold adjacent to the antennas. All other radio frequency related components were mounted in the Spacelab rack number 2.

3.1.3 Payload Configuration

Figure 6a shows the configuration of the payload as it was mounted in the CV-990 aircraft cabin. Additional equipment for some experiments was located in the cargo compartments (fig. 6b). A photograph of the payload looking aft in the aircraft cabin is shown in figure 7. Particular attention is called to the five Spacelab-type racks installed in the forward area to centralize controls of experiments. This was the main operating area for three of the four P/Ss.

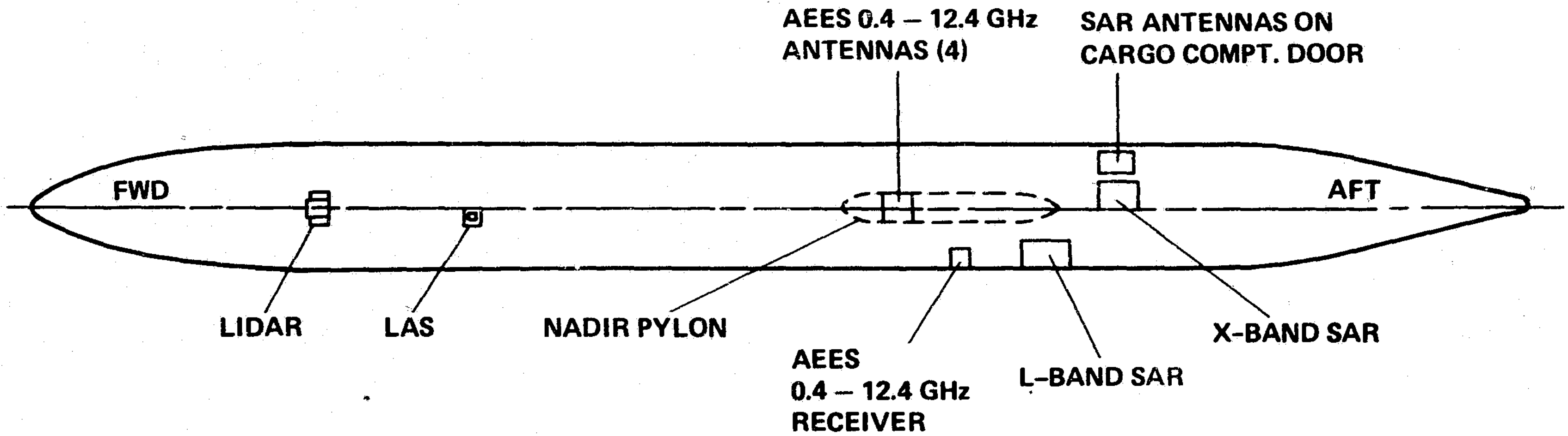
General features of the Spacelab-type racks built for this mission are shown in figure 8. These racks, while patterned after Spacelab rack design, had to be somewhat shorter to fit within the CV-990 cabin. The pullout writing surfaces included a shallow drawer in which the P/Ss could store frequently required references and log books. Some experiment components in these racks were mounted on drawer slides to allow front side access to internal parts in case of equipment problems. Figures 9a through 9c show photographs and equipment layouts for these racks. Guidelines applied in developing the layout of experiment components in the racks were the following: 1. The center of gravity and overturning moment of each rack had to be within specified limits, 2. the components for a given experiment were grouped as closely as possible, and 3. experiment groupings were arranged to permit each P/S the best possible access to the experiment controls for which he was assigned responsiblity. Using these guidelines, the analytical integration processes (section 3.3.2) initiated layouts for these racks. Achieving the final rack layout shown was an iterative process that continued up to the time of final installation.

Figures 9a through 9c also indicate the areas of responsiblity of P/Ss 1, 2, and 4 respectively. The MED experiment was the basic responsiblity of P/S 4, although the experiment required all of the flight crew to plug into the MED panel periodically. Rack 2 contained equipment to be operated by both P/Ss 1 and 2, but this area of physical interference led to little difficulty in operations.



a. Payload Installed in Aicraft Cabin

Figure 6. Payload Configuration



b. Cargo Area

Figure 6 concluded

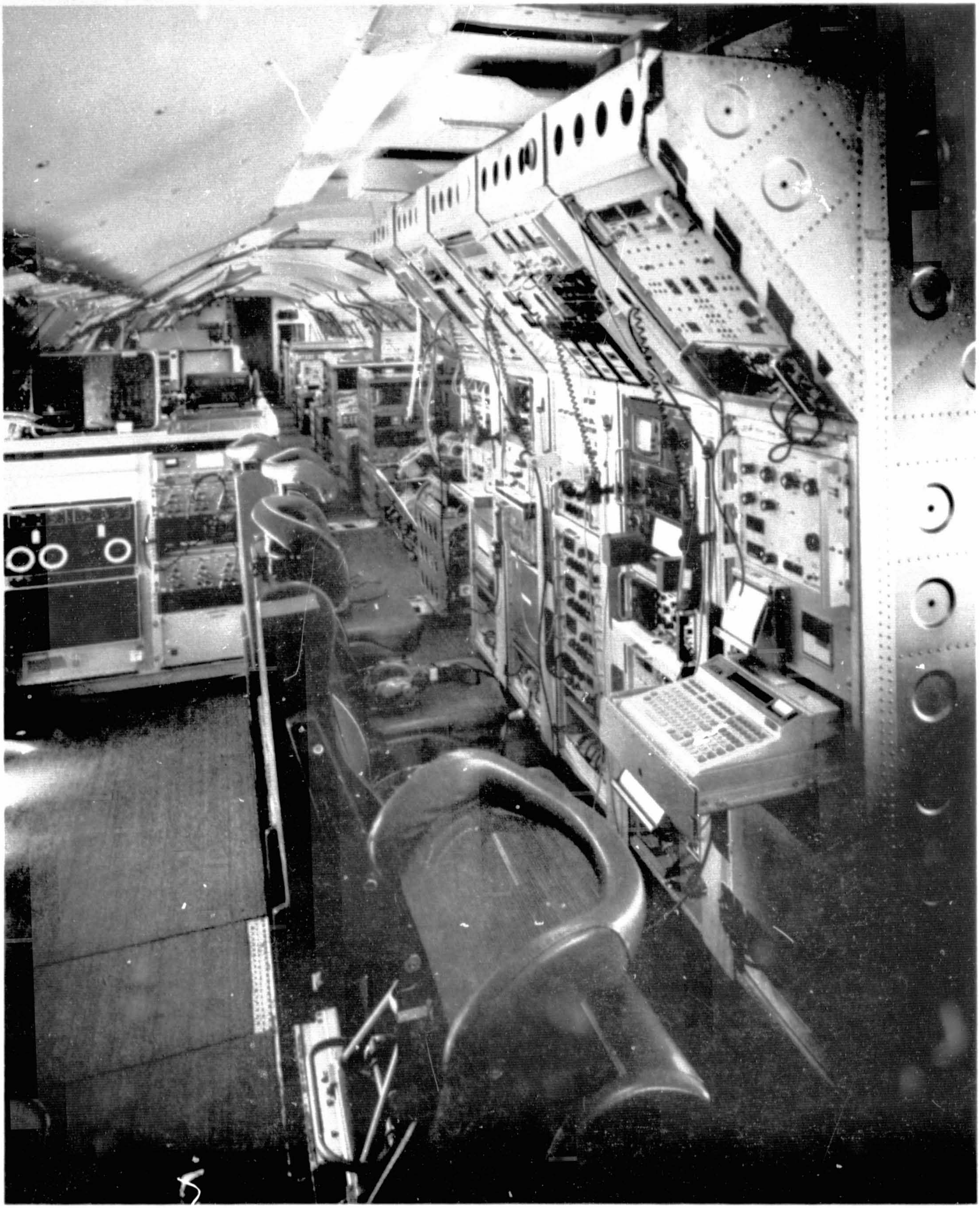


Figure 7. Payload Installed in Aircraft Cabin

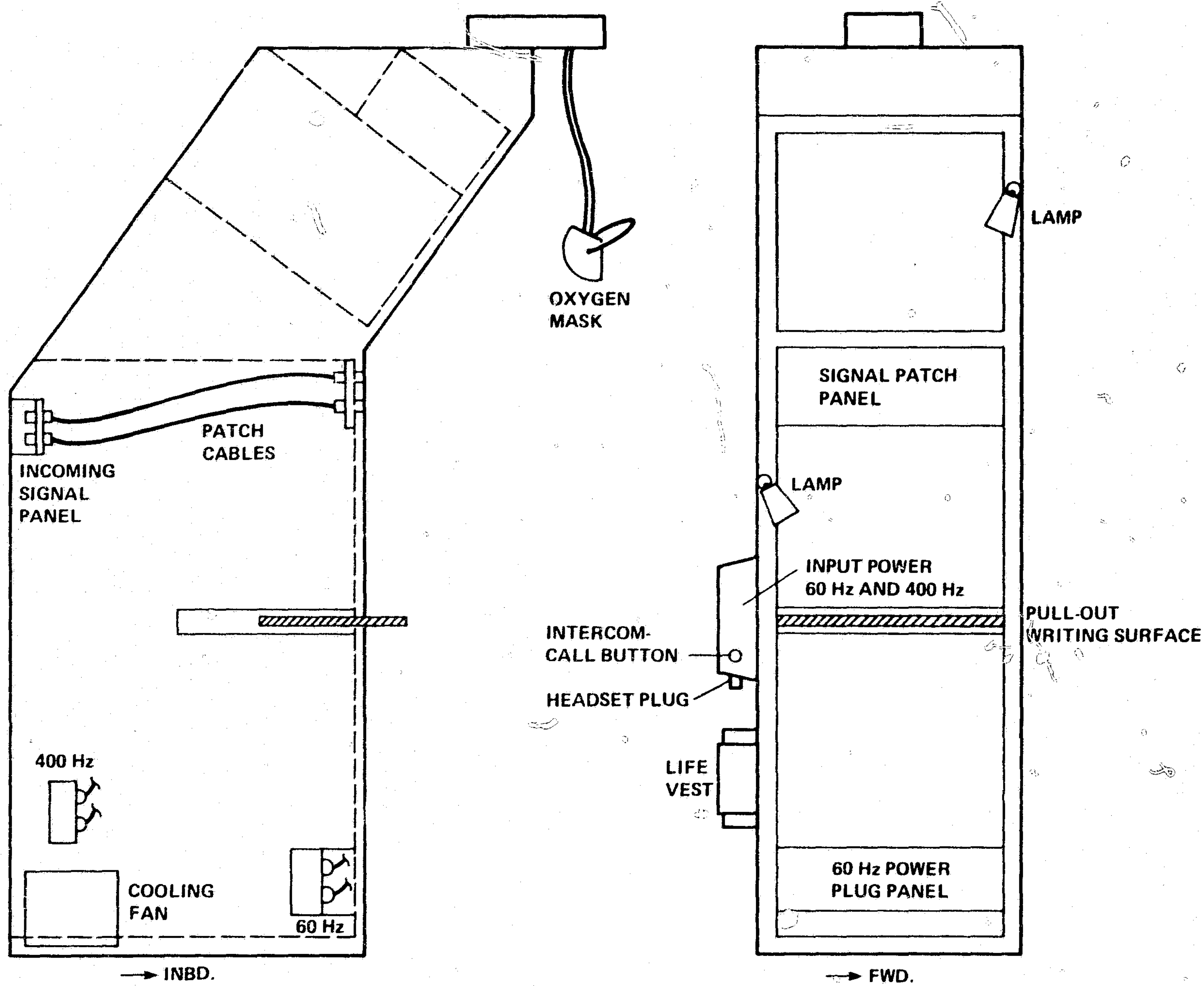
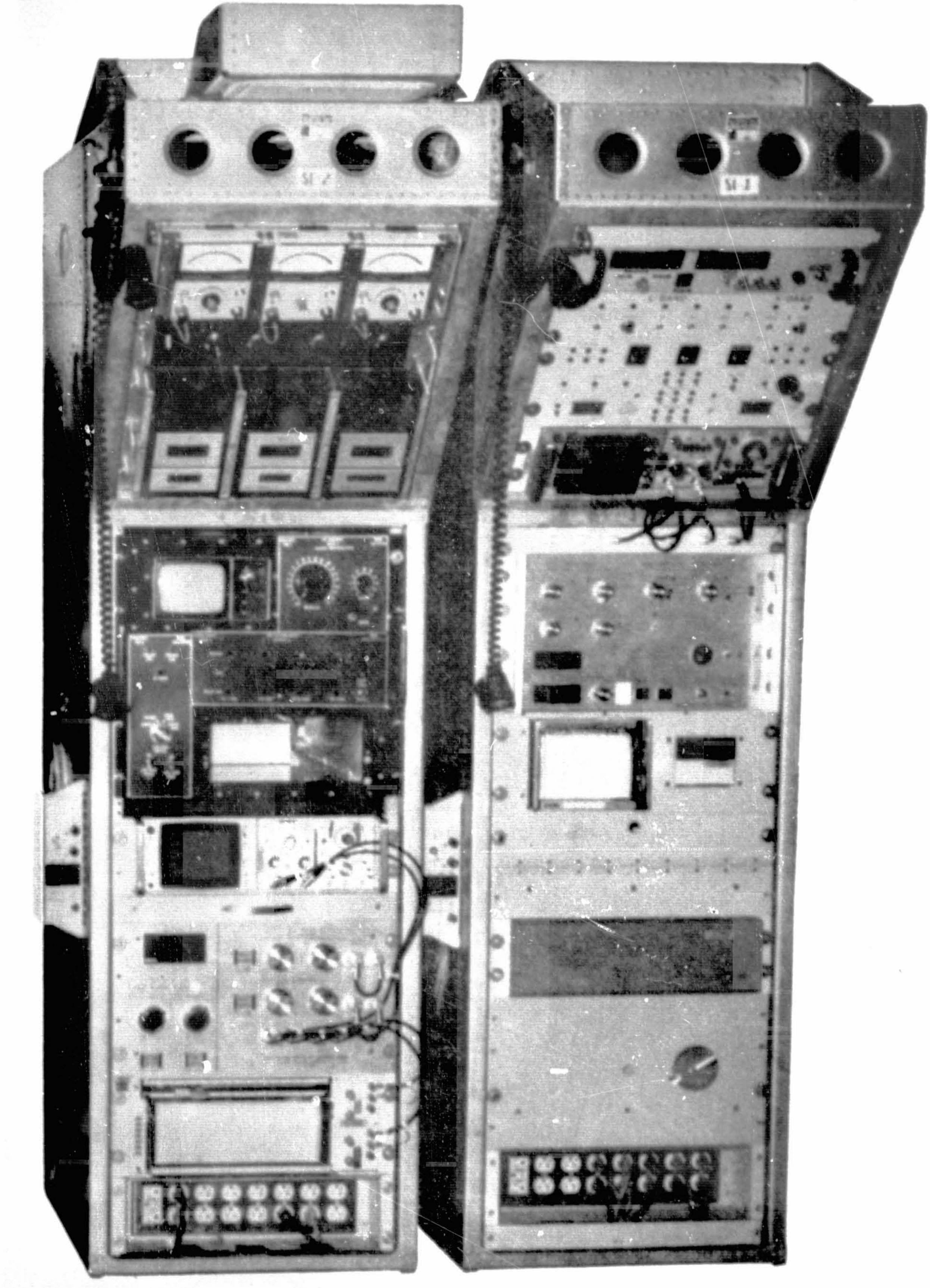


Figure 8. General Features of Spacelab-type Racks



RACK 2 RACK 1

a. Payload Specialist 1 Work Station

Figure 9. Layout of Centralized Experiment Control Stations

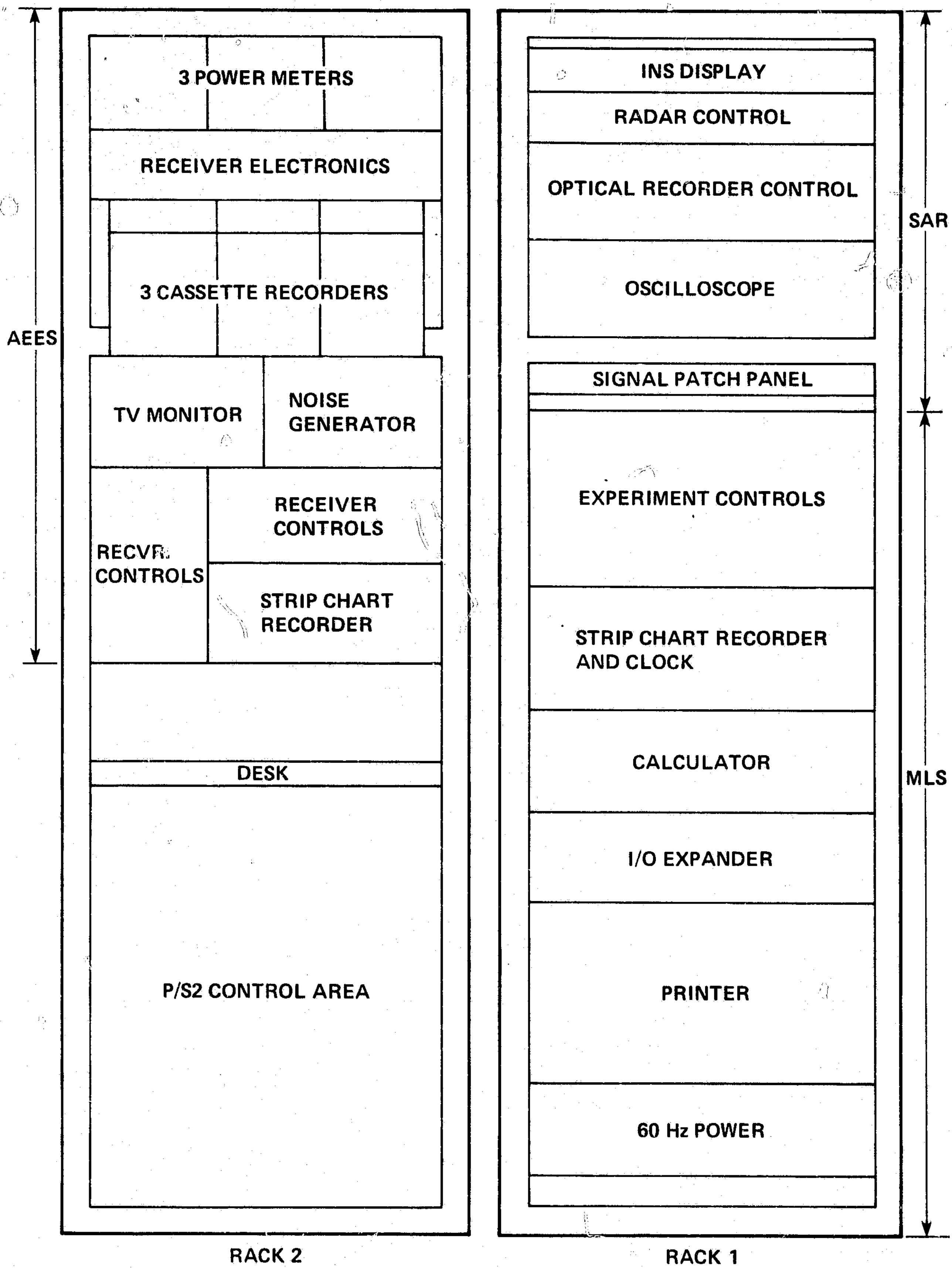
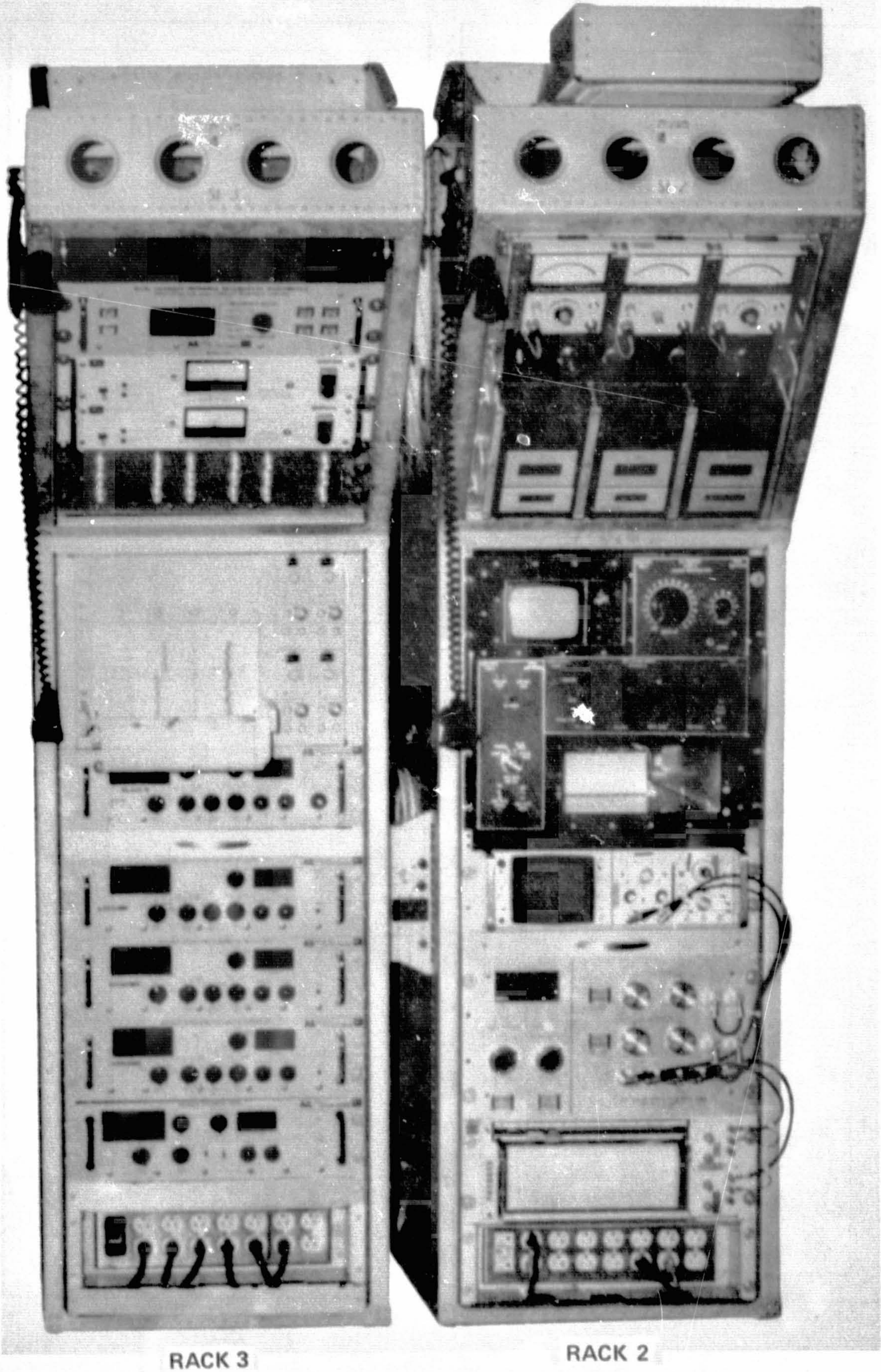


Figure 9a continued



b. Payload Specialist 2 Work Station

Figure 9 continued

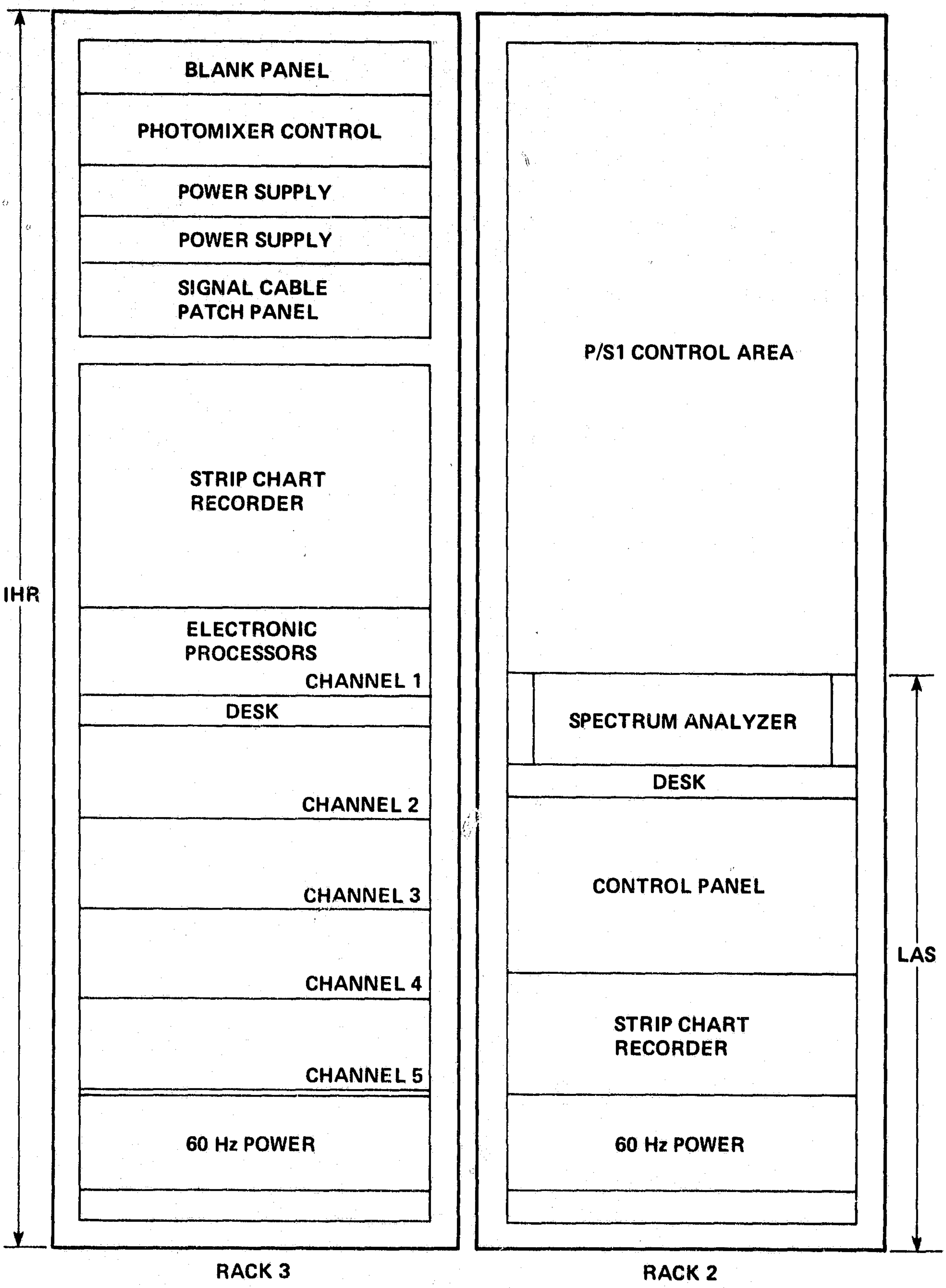
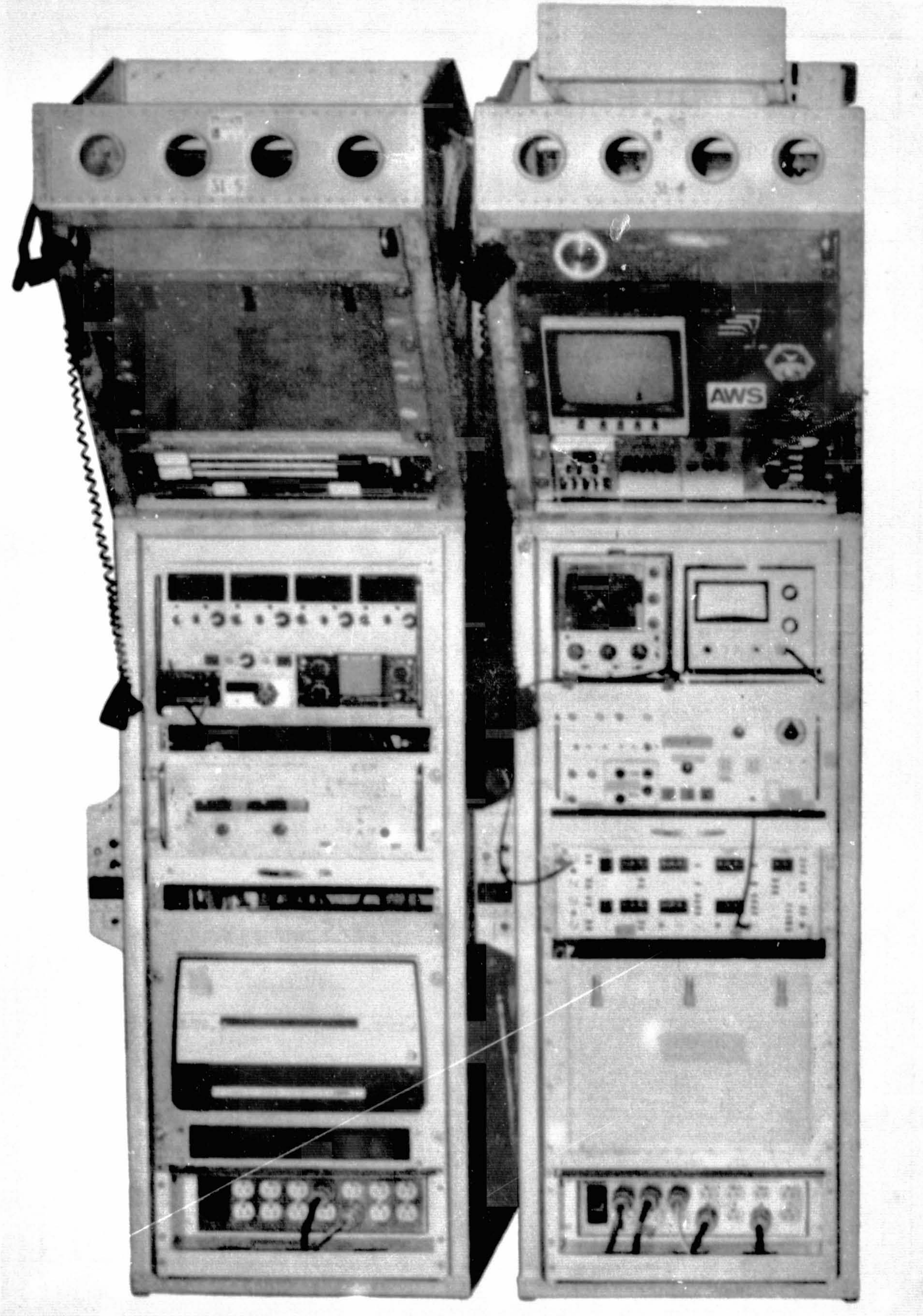


Figure 9b continued



RACK 5 RACK 4

c. Payload Specialist 4 Work Station

Figure 9 concluded

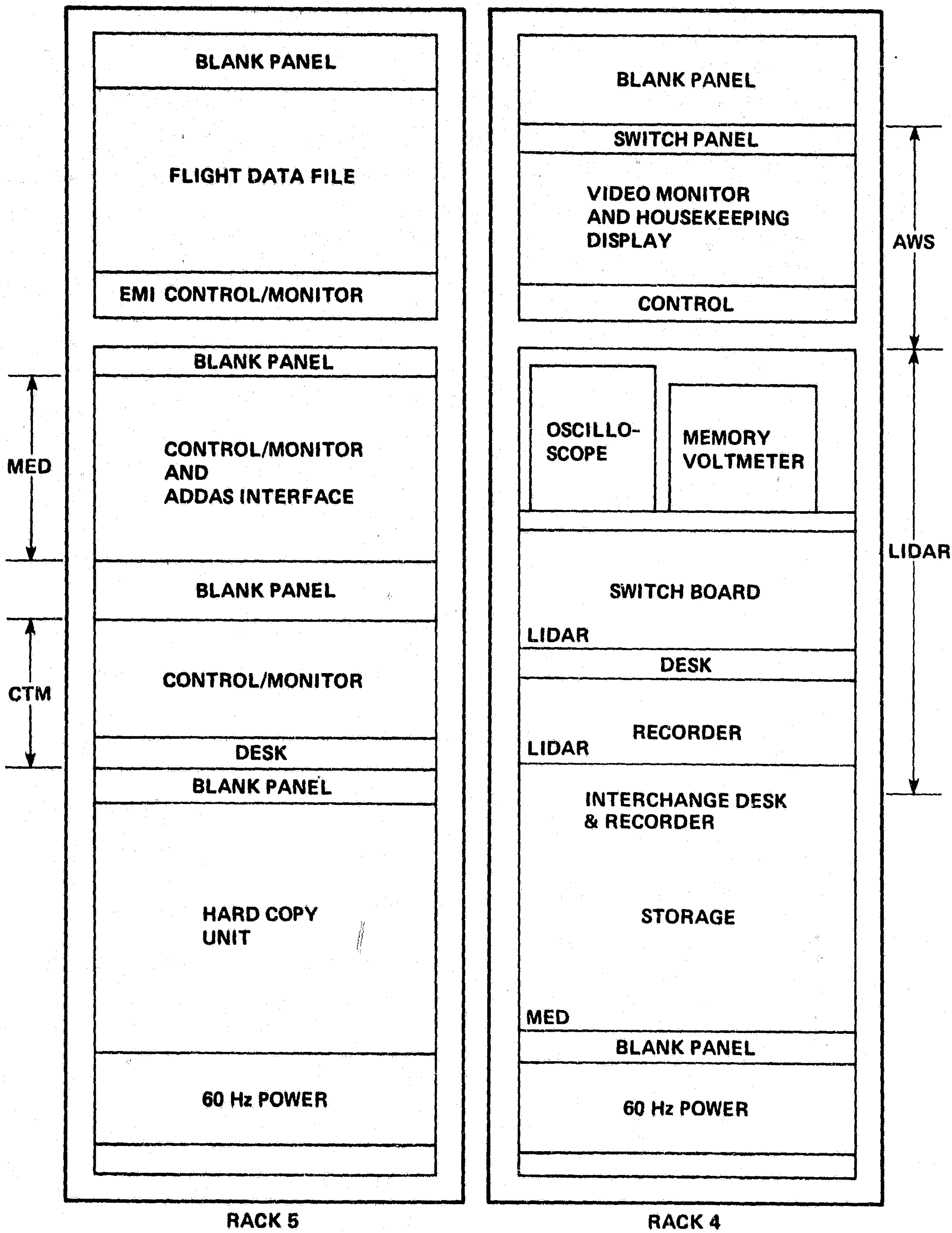


Figure 9c continued

P/S 3's sole experiment responsiblity was operation of the IRA (aside from participation in the MED experiment mentioned above). The extensive IRA equipment was contained in five CV-990 standard racks grouped around the telescope as shown in figure 6a. It was decided early in the ASSESS II project not to alter this arrangement which had originally been used for ASSESS I, because of the cost involved to move the necessary control equipment to Spacelab racks. It was logically grouped for P/S 3 operation of the IRA experiment so his main position was as shown in figure 6a instead of at the Spacelab racks with the other P/Ss.

3.2 Management Operations

The management organization for ASSESS II, shown in figure 3, appears complex with a large number of organizations involved. However, with the exception of ARC participation in ASSESS II and the Mission Steering Group, which is not planned for Spacelab, the remainder of the ASSESS II management organization closely represents the relationships presently envisioned to carry out a Spacelab mission with a combined NASA and ESA payload.

3.2.1 Mission Management

The Mission Manager concept for payload management is planned for Spacelab, and the application of this concept in ASSESS II was the first experience in exercising the concept throughout an entire Spacelab-like mission.

Serious efforts were made to handle all aspects of mission operations in a Spacelab-like manner. The Mission Manager at MSFC assumed overall responsiblity for the payload. System Level Payload Integration* and payload flight operations were carried out under MSFC management. Launch site integration, analogous Spacelab level III, II, and I, was managed by KSC. JSC set up a Mission Control Center at ARC and managed flight operations.

ESA/SPICE managed the ESA portion of the payload. While SPICE representatives worked hand-in-hand with U.S. participants to acquire and clarify interface data for final payload integration at ARC, they also worked closely with the European experimenters to prepare their experiments, and conducted an integration and flight operations simulation of the ESA portion of the payload before delivery to the U.S.

The Mission Manager initially appointed to the ASSESS II program was also the MSFC Mission Manager assigned to Spacelab 2. From the start, pressure of Spacelab 2 activities was such that he virtually had no time for ASSESS II

---

*Note: For the ASSESS II project as herein reported, System Level Payload Integration is analagous to the plan for Spacelab 1 to integrate and test the entire payload at MSFC prior to its shipment to the launch site at KSC. Some refer to this stage of integration as Level IV integration and this term is also used in this report for brevity.

related activities. Thus, the MSFC Assistant Mission Manager assumed responsibility for most ASSESS II activities with the Mission Manager participating in only highest level decisions. The Assistant Manager filled in well, but did not have sufficient authority to handle all problems effectively. Support for planning of ASSESS II slowed significantly and the final analytical integration was seriously deficient. (See section 3.3.2.) MSFC Management assigned a new Mission Manager in January 1977, but by that time many of the experimenters were bypassing the Mission Manager's staff and dealing directly with ARC to solve their integration problems in order to meet schedule.

The Mission Manager's staff was supported by personnel assigned from various divisions and branches at MSFC. The table below summarizes Mission Manager and staff effort used by MSFC to carry out their responsibilities.

Mission Management	18 man-months
Science	12
Engineering	1
Mission Planning	9
Ground Operations	20
POCC	19
	79 man-months

A support staff of 15 participated in the first analytical integration (section 3.3.2). The support dropped to a few key people between analytical integrations, but was augmented when the new Mission Manager became active. A total of 13 MSFC people participated during Systems Level Payload Integration effort at ARC (section 3.4.2).

Early in the ASSESS II project (March 1976) MSFC drew up a list of Mission Manager's responsibilities. These are given as follows:

- Determines compatibility of experiments in aircraft;
- Groups individual experiments and their objectives into common payloads;
- Does detailed planning of experiment placement into aircraft;
- Plans and executes design and fabrication of experiment interface hardware;
- Determines experimenters' data requirements, negotiates and schedules programmers for tasks, determines data distribution during and post flight;
- Develops Mission Schedule;
- Issues Mission Operations Plan;
- Does all interfacing with ESA management and experimenters;
- Selects and trains all Payload Specialists;
- Issues Premission Progress Reports;
- Conducts Flight Readiness Review;
- Postflight mission followup;
- Designs all common experiment control consoles.

Many of the above Mission Manager responsibilities which related to hardware and flight operations had to be handled jointly between MSFC and ARC, since ARC had responsibility for the aircraft and its operation. However, no written delegation of specific tasks was made to ARC, and as the project moved into the implementation phase, responsibility for hardware interface definition was not clearly established. As a result, much of the interface identification was not accomplished, and this led to significant operational problems.

Issuance of the Mission Operations Plan was proposed to be done by the Mission Manager, but was assigned to JSC by the Headquarters Program Manager. JSC issued the document under a revised title called the Mission Implementation Plan.

Of the other proposed Mission Manager responsibilities, selection and training of NASA and ESA P/Ss was handled independently by NASA/MSFC and ESA/SPICE until the P/Ss came together at ARC for total payload integration, at which time the MSFC mission men took charge of the P/S activities and flight operations. Project management progress reports were not issued. However, mission updates were presented by the Mission Manager at each of the five MSG meetings and at the two formal IWC meetings.

At ARC, 114.5 man-months were expended to support planning and operational functions for the payload as follows:

	Support of MSFC	Support of KSC	Support of JSC
Payload Management	36	0.5	3.5 man-months
Engineering Design	14.5	-	1
Data Systems	14	-	-
Shop Fabrication	15.5	6.5	-
Electronics Support	11	4	-
Inspection/Safety	2.5	1.5	-
Flight Planning	1	-	3
	94.5	12.5	7.5 man-months

KSC expended a total of approximately 22 man-months, and used a three-man launch site integration management team. They were supported by ARC, who provided essentially all of the effort to accomplish integration analogous to the contract launch support effort planned at KSC for Spacelab.

JSC also provided a three-man team to manage flight operations through the Mission Control Center at ARC. Flight operations necessarily required strong support by ARC for flight track planning. The JSC effort totalled approximately 12 man-months. JSC issued the Mission Implementation Plan in February 1977.

Within NASA, the payload mission management effort at MSFC and ARC totalled 173.5 man-months. The KSC effort combined with ARC support to handle launch site integration was 34.5 man-months, and the JSC effort together with ARC support to manage flight operations was 19.5 man-months, for a NASA total of 227.5 man-months for payload planning and operational functions. This total does not include PI activities, some additional support at ARC to provide facilities for the ASSESS project, and aircraft maintenance not properly chargeable to the above functions.

The ESA management effort at SPICE was conducted through their Payload Manager as shown in figure 10. SPICE arranged to have DFVLR construct a CV-990 mockup, complete with crew living facilities and a POCC, at the DFVLR laboratory Porz-Wahn, Germany. DFVLR also provided major support effort to integrate and test the ESA experiments there and to conduct simulated flight operations. ESA concentrated a five-man team at ARC beginning with the arrival of their experiments. Essentially all ESA payload interfacing was handled through the ESA Payload Manager, with an ESA objective of shielding the European experimenters from complexities of multi-organizational responsiblities within NASA. Thus, formal requirements to and from ESA experimenters were handled through a single ESA interface. Total European involvement through SPICE (not including experimenters) was reported to total about 35 man-months.

3.2.2 Mission Steering Group

A precedent had been established on earlier ASSESS missions where a steering group was used to set simulation guidelines for overall conduct of the mission. Thus, for ASSESS II it was a logical development to create an MSG, and it was made up of representatives from all participating organizations. With the payload divided almost equally between NASA and ESA, it was agreed that the group would be cochaired by the NASA and ESA Program Managers. Five MSG meetings were held during the course of the ASSESS II project, and because of the significant interest in the function of this group, minutes of the five meetings are included as Appendix A.

During early phases of the project the MSG operated smoothly and successfully. Mission guidelines and objectives were established and roles of the various participants were clarified. It must be recognized that the ASSESS II mission was breaking new ground relative to Spacelab management, and, whereas much discussion had taken place regarding Spacelab management, this mission was the first real attempt to organize and completely carry out a comprehensive simulation of Spacelab-type activities with participants who were to be later involved in Spacelab. Thus, as expected, some issues regarding roles and missions of various groups were sensitive, and substantial jockeying and negotiation occurred, since it was generally recognized that precedents could be established which would carry through to Spacelab.

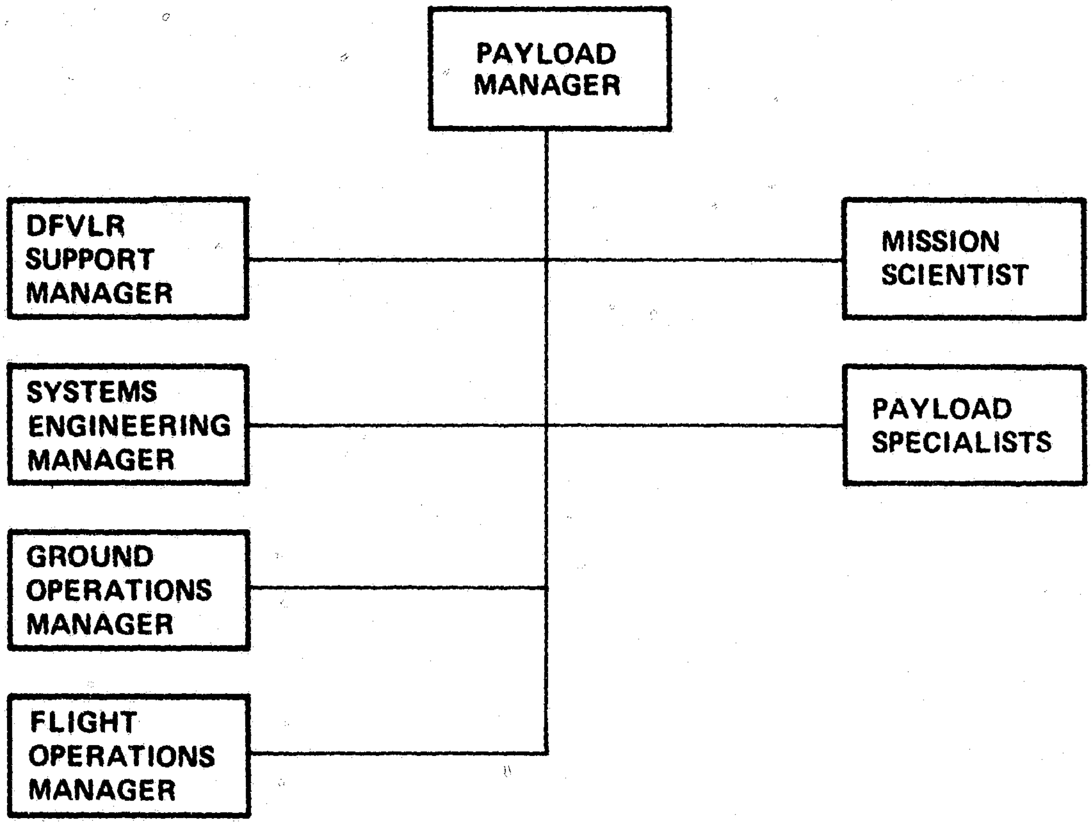


Figure 10. ESA/SPICE Management Structure

Major issues addressed by the MSG were:

- Mission objectives;
- Mission guidelines;
- Management structure and responsiblities;
- Division of the payload between NASA and ESA;
- Division of P/S responsiblity between the NASA and ESA portions of the payload;
- Review and agreement on the overall schedule;
- Selection and role of the Mission Specialist;
- Guidelines for mission documentation;
- Division of Mission Scientist responsiblities between ESA and NASA during flight operations.

Most of the above topics were aired and a consensus of agreement was established within the MSG without significant problems. However, the selection and role of the M/S and the guidelines for mission documentation became issues of contention. A complete impasse developed between MSFC and JSC on the M/S issue and the problem was finally solved independently by the NASA Program Manager who worked a solution through NASA Headquarters organizational channels and finally achieved MSFC and JSC concurrence (see section 3.3.4.1). The documentation issue was considered important since a major objective of the mission had been established to achieve an efficient documentation pattern for Spacelab. It was difficult to foresee the total project documentation needs early in the project, but the MSG nevertheless established an overall documentation plan as a guideline (see section 3.6).

In general, the opportunity afforded by the MSG for all participants to review progress and discuss problem areas was welcomed by everyone. It appeared that the M/S and documentation discussions were fruitful even though neither of these subjects was fully resolved by the MSG. Some participants stated that this was the only means by which they were aware of total mission activity. However, there is a fine line between the best intentioned plan for a steering group to establish guidelines and provide a forum to address problem areas, and a Mission Manager's responsiblity to implement the mission. Even though the MSG was set up only for ASSESS and is not planned for Spacelab, the question of the usefulness and desirability for such a group for Spacelab mission came up for consideration. There was strong disagreement on this point which is discussed further under Conclusions (section 4.3).

3.2.3 Mission Scientists and the Investigators' Working Group

The IWG meetings were the only opportunities for PIs to meet together for reports from the mission management staff as to plans and progress, and for the PIs to discuss their mutual problems. ESA/SPICE and NASA/MSFC initiated early independent meetings of the European and U.S. PIs about one year before flight to acquaint them with initial plans for the project. No formal record of those meetings was made. Later, two basic IWG meetings were held that all PIs were expected to attend. Specific action items were addressed and minutes of those meetings were prepared.

The first basic IWG meeting, held at Porz-Wahn in July 1976, was a well attended meeting. Mission management presented elements of the entire payload and mission operation. Plans had been developed sufficiently by that time to show an early layout of experiment hardware in the CV-990, an early version of possible flight tracks, and many other details which resulted in lively discussion both among the PIs and between the PIs and mission management planners. A number of problems were identified and many solutions were negotiated. One case of cooperative experiment endeavor between European and U.S. PIs resulted.

It was at this meeting that the PIs were informed that, like Spacelab, there would be no flight checkout of any experiments on the CV-990 prior to the constrained flight period representing a Spacelab flight. Thus, they were committed to successful integration and thorough ground checkout to insure flight success. Also, at this meeting an executive session of the PIs alone was conducted under the chairmanship of the NASA and ESA Mission Scientists to establish their recommendations to management for the NASA and ESA Payload Specialists. Credentials of each proposed P/S were aired, and the PIs discussed the required capabilities to handle each experiment in conjunction with P/S background and experience. Results of this exercise were considered inconclusive, since the PI sponsoring a given P/S was biased in his favor, and it was difficult for other PIs to gain a balanced judgment of the proposed P/S's abilities and aptitudes.

The second and final IWG meeting was held at MSFC in December 1976 following concentrated effort by mission management to establish firm payload integration and flight planning information. Unfortunately, the increasing problem with availability of travel funds resulted in poor attendance by the PIs. Only one ESA experimenter (LIDAR) was able to attend, and the ESA experimenters were generally represented by the ESA Mission Scientist. While he did an excellent job representing their interests, there was little opportunity to address their problems first hand or react to the plans being pursued.

In general, the IWG meetings were very successful. The early partial IWGs held in Europe and the U.S. were appropriate, and a fruitful exchange occurred between mission management and the PIs. There was no real need to expend resources to bring all the PIs together at that early point in time. Two full meetings of the IWG seemed about right for the mission and they were scheduled at optimum times. The only serious deficiency in the IWG approach for ASSESS II was the lack of attendance at the second meeting held in December 1976. By that time a more extensive interchange with the PIs should have occurred.

Further details of the two basic IWG meetings are given in the minutes which are reproduced as Appendix B.

In addition to chairing the IWG meetings, the Mission Scientists also very actively participated in the process of collecting information for the Investigator Requirements Documents (IRDs). Both the U.S. Mission Scientist and his assistant traveled with the mission management team during the first round of visits to the U.S. experimenters for IRD information. The Assistant Mission Scientist was particularly effective because of his earlier experience on ASSESS I. In the IRD update effort carried out in conjunction with the July IWG meeting in Porz-Wahn, both the U.S. and ESA Mission Scientists took part. The ESA Mission Scientist was the key ESA representative during the later round of visits to the European experimenters conducted in November 1976, and he did an excellent job in assisting the PIs and in negotiating a number of problem areas toward solution.

3.3 Mission Development

3.3.1 Investigator Requirements Document

The IRD represented a new approach to interfacing between mission management and the PIs. Previous space flight endeavors have usually involved an extensive series of documents to identify and tie down experiment needs between the experimenter and spacecraft management. For Spacelab, a plan has been established by MSFC to collect all interface information in one well organized document and to reduce the administrative burden on the PI to a minimum. Thus, for ASSESS II, the IRD was created to serve this purpose. (For Spacelab the document is now being called an Experiment Requirements Document - ERD). The Mission Manager's staff very hurriedly created the first IRD in a question and answer format. IRD subject areas were intended to cover every PI requirement from actual hardware data interfaces to operational data needs during flight operations and even furniture requirements to accommodate the PI and his staff. This first attempt to create an efficient document of this type was judged to be reasonably satisfactory, but with many shortcomings that needed to be improved.

The IRD outline was quite complete and a good attempt was made to word the questions in a manner to help the PI. Mission management recognized that face-to-face discussions would be required to complete the IRDs, but they mailed out the document to the PIs as a first step to acquaint them with the material. The space provided in the document to answer each question resulted in a bulky appearance, which elicited a negative reaction from many PIs upon first exposure since the job of answering all the questions looked formidable. Some experimenters made a good effort unilaterally to provide the needed data. Others put the IRD aside after cursory review and concentrated their efforts on more apparent experiment hardware development problems.

Two rounds of visits were made to nearly all PI laboratories to gain understanding of the experiment requirements and arrive at solutions. An early attempt to obtain IRD information was carried out by a NASA management team who visited the U.S. PIs in June 1976 in preparation for the first analytical integration effort in July. In Europe, an IRD was sent to each experimenter and then the ESA/SPICE Program Manager visited individual laboratories to expedite IRD action. The resultant IRDs were sent to the Mission Manager at MSFC in preparation for analytical integration.

A second and final round of discussions with each PI in the U.S. and in Europe, using IRDs of somewhat revised format, was carried out in November 1976 by a NASA management team (plus an ESA representative in Europe) in preparation for the second and final analytical integration activity. This was a very concentrated effort to complete the IRDs. Discussions were extensive and tedious, but extremely important since the information established would not only set the pattern of actions to be taken by the experimenter at his laboratory to prepare for the flight mission, but would also establish the pattern of actions to be taken by mission management in preparing to accommodate the experimenters upon arrival for integration and flight.

Several key problems became apparent as the meetings with each experimenter began to open up crucial areas. Some experimenters, especially those who were little experienced in operations away from their own laboratories, did not appreciate the multitude of interface items which had to be settled for benefit of their own successful experiment operation and conduct of their affairs during integration and flight. In many cases, initial hurried attempts to address complex issues soon settled down and it usually required not only extensive discussion with the PI but also substantial support from his staff as well to establish understanding. Completeness of the material covered by the IRDs did an excellent job of opening many subjects to the experimenters' attention and forced earlier planning than might have been the case. Some complication was introduced by foreign language difficulties when the U.S. mission management team visited European experimenters' laboratories, but this was not serious.

A significant shortcoming of the IRD format was the overlap in information requested in the various sections. This resulted in considerable waste of time during the field visits. Also, it became increasingly obvious that interpretation of the IRD language varied substantially, not only on an individual basis, but particularly between engineers on the mission management side and scientists on the PI side. Substantial improvement of the IRD format and wording of the specific questions are needed to make such a document efficiently useful for Spacelab. All experiments differ in their requirements - yet it is desirable to have only a single document format for general use with minimum redundancy. This is difficult, and it is to be expected that such a document for general Spacelab use will improve with experience.

It became painfully apparent that interviewer expertise in each technical area of carrier vehicle operation was needed in every meeting (i.e., mechanical, electrical, data handling, safety, etc.) Perhaps the most serious omission was not to include a data expert during any of the visits to the experimenters' laboratories. As the later integration effort developed at Porz-Wahn and ARC, this was an area of significant difficulty, and even though the problems were such that total solutions probably could not have been fully achieved in advance, a better understanding during the interface discussions would certainly have been beneficial.

The two rounds of IRD discussion seemed about right for the ASSESS II project, and even though much information was still lacking, understandings had reached a point where added or revised material could have been gathered by telephone discussion. Although some further communication occurred with experimenters to address specific problems, the IRDs were not updated. While the two sets of IRDs from the first and second interview efforts were never consolidated, these documents were the basis for the two analytical integrations conducted in July and December 1976. After that, with no further updating, the IRDs quickly became obsolete. Experimenters dealt directly with individual project managment personnel on a more informal basis (usually by telephone or TWX) to solve interface problems. Thus, the IRD approach which started quite well, was never carried to completion on ASSESS II, and no full record of interfaces for each experiment was available for reference.

Mission management was criticized by some of the experimenters because the IRDs were not cleaned up and fed back to the experimenters for their approval and use. As a result, the longhand versions were quickly duplicated and returned to all experimenters a few months before launch, but much of the material was hardly readable and no further interaction occurred with the experimenters regarding the IRDs.

In spite of the IRD difficulties, there seemed to be general agreement that the IRD approach is sound. Recommendations for improving the IRD process are given in section 4.4.2.

3.3.2 Analytical Integration

The two analytical integration efforts conducted in July and December 1976 were accomplished at MSFC by ad hoc groups enlisted at MSFC and supported by representatives from KSC, JSC, and ARC.

The first analytical integration effort took one week. It was well staffed and organized into five teams to address integrated mission planning (flight path planning), mission operations (POCC planning), payload specialist operations, ground operations (mainly preflight payload integration), and flight vehicle payload layout. MSFC applied 15 people to this effort supplemented by one from KSC and two from ARC. The preliminary information about the experiments then available from the IRDs permitted a good start in general planning for the mission and pinpointed areas where further information was needed.

With the initial input of ARC flight planners to set bounds for aircraft operation, and the PI desires expressed in the IRDs for experiment objectives, the flight planning group developed a variety of proposed aircraft flights, both day and night, to accommodate nearly all requirements. In conjunction with these plans, general timelines were developed for the payload flight crew (payload specialists) to carry out the necessary activities to prepare and operate the experiments, to obtain data, and allow for necessary periods of eat, sleep, and other personal requirements. Initial planning was accomplished for POCC operation. A first layout was prepared for physical accommodation of all experiments on the aircraft. Also, a good preliminary plan was worked out among MSFC, KSC, and ARC for integration of the payload on the hangar floor (corresponding to Spacelab Level IV integration) and integration of the payload onto the aircraft (corresponding to a combination of levels III, II, and I for Spacelab).

The second analytical integration at MSFC in December 1976 had the benefit of much better inputs from the just completed second version of IRDs resulting from a new round of discussions with the experimenters. Unfortunately, however, less manpower was available at MSFC for the second analytical integration than for the first. Thus, results of the second and final analytical integration effort were limited. The teams were organized much like the first effort. MSFC was able to assign only eight people to the task, supplemented again by a representative from KSC and four from ARC. By this time a Mission Specialist from JSC had been identified and he, along with the two U.S. P/Ss from JPL, actively pursued flight crew planning.

General results of the second analytical integration effort were: some refinement of payload integration activities, additional planning for the proposed flight tracks, further planning for payload configuration in the flight vehicle, extensive layout and operational planning for the POCC, and detailed preliminary planning for the M/S and U.S. P/S timelines. Some effort was made to identify documentation requirements for the overall project, but that effort was very limited.

Some work was done during the second analytical integration to establish plans for data transmission from the flight vehicle and to arrange for quick-look data processing in the POCC, but little effort was expended until much later to insure proper data interfacing and processing between the instruments and the onboard data processing system. No data system experts were brought into the IRD effort except very briefly during the IWG meeting in Europe. As stated earlier, no data experts participated in the IRD tours, therefore the information was incomplete so that total analytical integration of this area was not possible.

In summary, the two analytical integration efforts were successful as far as they went. It would have been better if the early large effort could have been spread to the second analytical integration period when IRD data then available would have permitted a greater depth of planning which by that time was sorely needed. Further concentrated analytical integration effort was also needed as flight time approached, but was not applied. The result was lack of completed flight and ground operations requirements documents from the Mission Manager to those who needed them until the need time had passed. With integration solutions necessarily being worked out on an individual-to-individual basis, total configuration of the payload was not identified in sufficient detail for flight vehicle integration. This led to some time consuming problem solving during flight vehicle integration. For ASSESS II, the payload was small enough so that most safety and configuration details which had not been fully identified could be successfully worked out on an ad hoc basis as payload installation proceeded. For Spacelab, analytical integration requirements obviously should be carried only to the extent necessary, and some level of informality is probably appropriate to save cost. However, the limited analytical integration effort and lack of payload interface identification on ASSESS II led to extensive informality which resulted in significant problems for almost every experiment.

3.3.2.1 Flight Planning for Disparate Objectives

The PIs were requested to enter in their IRDs the flight track parameters that they desired for their experiments during data-take periods, including all relevant requirements that would allow them to collect a complete package of scientific data during the ASSESS II mission. Parameters to be included were altitude, heading, profiles, patterns, desired objects of observation, etc. This was done, but with considerable variation in the level of detail. Only four PIs gave priorities among the possible flight tracks they desired, and only one gave exact coordinates for ground target overflights. In this section, the difficulty in satisfying diverse mission objectives is illustrated by a comparison between the PI flight requests in their IRDs and the flights which mission management finally was able to provide. While the ASSESS II experience in this regard was unique to aircraft operations, Spacelab can be expected to face similar difficulties, even though for different reasons, if the payload objectives cannot be well matched.

ASSESS II flight tracks can be categorized into those that required maximum altitude and exact heading (astronomical objects and solar viewing), those that required maximum altitude independent of heading (upper atmospheric physics), and those which had less severe altitude and heading requirements but required overflight of specific ground coordinates (nadir viewing experiments). Requirements to fly each of these flight track types were present in ASSESS II planning. Combination of the first and last type of objectives (astronomy and ground targets) was particularly difficult to achieve and led to most of the compromises of PI desires for nadir viewing. Astronomy was assigned high priority, thus overflights of specific targets could not always be accomplished. Tables 3 through 6 show experimenters' desires versus final flight plans.

It must be recognized that, as a starting point, the PIs were given complete latitude in requesting desired flight requirements, and this was proper to establish maximum bounds for flight planning consideration. Obviously, flight planners could not possibly accommodate all the requests and, using priorities established by mission management, they arranged the flights to allow the greatest possible opportunity for data retrieval. Thus, in some cases there was wide disparity between the original PI request and the actual flight opportunity.

The IR astronomy PIs (Meudon, Groningen, and MPI) submitted a list of IR targets in the IRDs with viewing priorities, but openly negotiated that they be allowed to add other objects of more consuming interest during the preflight period so long as the added objects had basically the same celestial coordinates (right ascension and declination) as those in the original list, so that previous plans would remain approximately valid. Accordingly, additional target names were submitted as late as December 1976, with specific IR targets in the galactic plane not named until after the second analytical integration (table 3). The planners were able to incoporate a reasonable number of first and second priority targets into the flight plans (the prime calibration sources, Jupiter and Mars, were simply not available during the mission). Real-time flight planning (section 3.5.1.1) modified viewing times in several instances and introduced two unplanned activities for "targets of opportunity".

Table 3 - Desired vs. Actual Observations -- IR Astronomy

Targets			Scheduled Viewing Time	
Priority	Requested in IRDs	Requested later	Analytical Integration	Actual Flight
1	Jupiter			
	Mars			
	M-17		235 min	265 min
	M-8		40	40
	Galactic plane		110	135
		K-350	65	65
		G-45	40	25
		Sagittarius A		
		ρ-Oph		
		Arcturus		
		R-Cr-A	90	90
		MonR2.		
		S-140	70	70
		S-88		
		S-235		
		ON-1		
		W-75		
		DR-21		
2	Saturn		185	180
	NGC-7000			
	IC-1396		25	60
	NGC-7027			
	IC-418			
	W-3			
	G-333.6-0.2			
3	NGC-1068			
	W-51			
		Venus	0	10
		Sun	0	10

Table 4 - Desired vs. Actual Observations for Solar Viewing Experiments

Experiment	Altitude - km		Flights	
	Desired	Actual	Desired	Actual
CTM	6.2	10.2, 10.8	As many as possible.	2 flights
IHR	4.6-12.3	10.2	Two flights with low sun elevation.	One flight instead of two.
		10.8	One flight with high sun elevation.	One flight as requested.

Table 5 - Desired vs. Actual Observations for Atmospheric Physics Experiments

Experiment	Altitude - km		Flights	
	Desired	Actual	Desired	Actual
AWS	As high as possible.	≥ 9.3	All night flights.	5 night 2 night-to-day Turned off at dawn; could not operate on day flights.
CTM	Any.	≥ 9.3	Day & night.	5 night 2 night-to-day 2 day
MLS	>9.3	≥ 9.3 generally	Day & night.	5 night 2 night-to-day 2 day

Two PIs expressed a desire to view the sun. CTM wanted all sun flights, if that had been possible, to determine the temperature of its chromosphere, and IHR wanted three sun flights to use the sun as a light source to study ozone in the earth's atmosphere. Table 4 shows their desires compared with what they were able to fly. CTM finally obtained only two sun viewing hours out of the total of 46 data-take hours.

The desires of PIs interested in physics of the upper atmosphere are listed in table 5. Their requests were easily incorporated into the flight plans since neither aircraft heading nor geographic position was important. However, as originally planned, AWS could not be operated in ambient light levels that approached daylight intensity, and therefore had to be turned off during 13 of the 46 data-take hours.

Requests of some of the PIs with nadir viewing experiments were considerably compromised. This was primarily because priority weighing for astronomy in most cases precluded the inefficient flight patterns necessary to divert over exact geographical sites not on the astronomy track, and particularly the inefficiency of performing vertical profiles over the geographical target, unless the target overflight occurred near the beginning or end of a flight period to eliminate the necessity to climb back to altitude.

Requests of PIs with nadir viewing experiments and results of integrated mission flight planning are listed in table 6. Few of their desires were fully incorporated into the flight plans. The IHR PI desired to study the diurnal formation of ozone in the Los Angeles area, and to calibrate his instrumentation he needed to do an altitude profile over a ground site simultaneous with release of an instrumented balloon (table 6a). Three overflights were correlated with ground-truth balloon releases, but no simultaneous altitude profiles were included in the flight plans. Three flights were requested in the Los Angeles area. The same track was to be flown each time, but at different times of day. As shown on the table, the IHR type of track over Los Angeles was scheduled only on flight eight. Transit flights over Los Angeles were scheduled on flights two and six, but they could not be made to match the IHR requirements. Thus, the IHR ground-truth calibrations were compromised, and ozone measurements over a heavily populated and industrial area (Los Angeles) were limited.

The LAS PI was also interested in ozone measurements over the Los Angeles area, as well as in four other areas (table 6b). His desires were considerably better met than those of the IHR PI. Four of the five areas of interest required direct traverses and could be included. The pattern flight requested over the Los Angeles area was finally fitted into the last flight.

The AEES PI specified three prioritized groups of cities to be monitored primarily during daylight hours (table 6c). Not all of the cities could be included, and only Los Angeles and San Francisco were measured during daylight.

Table 6 - Special Flight Characteristics - IRD Requests vs. Actual Flights

a. IHR EXPERIMENT

Targets		Altitude - km		Horizontal Pattern	
Requested	Actual	Requested	Actual	Requested	Actual
LA industrial area plus open farmland and water for reference.	Flight 2	9.1-12.2	10.7	Downwind at 0500, 0800, and 2200 hrs.	0200, not downwind.
	Flight 6	"	8.8	"	0100, not downwind.
	Flight 8	"	10.7-5.2 in 1.5 km steps.	"	0850, not overwater.
	Flight 9	"	9.4	"	1400, patterns for LAS, SAR, and LIDAR.
Ground truth Boulder, CO	Flight 1	Profile	11.3 only	No special request.	One pass.
Ground truth Great Falls, MT	Flights 3, 4, & 5	No special request.	10.1, 10.7, 10.7	No special request.	One pass.

Table 6 continued

b. LAS EXPERIMENT

Targets		Altitude - km		Horizontal Pattern	
Requested	Actual	Requested	Actual	Requested	Actual
Los Angeles, sunrise to sunset.	Flight 2 0200 hrs.	All data under 10.1	10.7	East to west with immediate retrace.	One south-to-north pass.
	Flight 6 0100 hrs.	"	8.8	"	One north-to-south pass.
	Flight 8 0850 hrs.	"	10.7 down to 5.2 in 1.5 km steps	"	Approx. east to west, no retrace.
	Flight 9 1505 hrs.	"	9.4	"	As requested.
Kitt Peak Observatory	No flight.	"		Single pass, ±10 km.	
San Diego	Flight 6	"	8.8	One pass.	As requested.
San Joaquin Valley	Flight 8	"	9.4	No special request.	One pass.
San Francisco Bay	Flight 8	"	5.2	No special request.	LIDAR pattern.
General: unpopulated areas, over clouds, over water.	Achieved.				

Table 6 continued

c. AEES EXPERIMENT

	Targets		Altitude - km		Horizontal Pattern	
	Requested	Actual	Requested	Actual	Requested	Actual
priority 1	Los Angeles, CA	Flights 2, 6, 8, 9	Above 7.6	Achieved, except profile on flight 8.	No special requests.	
priority 2	San Diego, CA	Flight 6	Above 7.6	8.8		
	Portland, OR	Flights 3,4	Above 7.6	11.3		
	Phoenix, AZ	Not flown				
priority 3	Denver, CO	Flight 1	Above 7.6	11.3		
	Salt Lake City, UT	Flight 3	Above 7.6	10.2		
	Albuquerque, NM	Not flown				

Table 6 continued

d. SAR EXPERIMENT

	Targets		Altitude - km		Horizontal Pattern	
	Requested	Actual	Requested	Actual	Requested	Actual
priority 1	Salt Lake Desert-Utah	Flight 3	7.6-12.2	10.2	Pattern specified.	As requested.
priority 2	Death Valley-CA	Flight 8	7.6-12.2	9.4	Pattern specified.	As requested.
priority 3	Ocean surface features	Flights 6&7	7.6-12.2	10.2	Pattern specified.	Not over specified area.
priority 4	LA basin	Flight 9	7.6-12.2	9.4	Pattern specified.	As requested.
priority 5	Salt seeps-Montana & North Dakota	Flight 3 Montana only	7.6-12.2	10.1	Pattern specified.	As requested.
priority 6	Crop identification-Kansas	No flight	7.6-12.2		Pattern specified.	

Table 6 concluded

e. LIDAR EXPERIMENT

Targets		Altitude - km		Horizontal Pattern	
Requested	Actual	Requested	Actual	Requested	Actual
Ground truth - Menlo Park, CA. At least once-beginning and end each flight.	End of flight 2.	Above 0.3 & under 5.0.	2.7	Within 5 km of target.	As requested.
Ground truth - Colstrip, MT	Flight 5	"	11.9	Single pass, any heading.	Two passes.
San Francisco	Flight 8	"	5.2	4-leg mapping pattern, downwind.	3 of 4 legs as requested.
Los Angeles or San Diego	Flight 2 LA	"	10.2	"	Single pass
	Flight 6 LA	"	8.8	"	Single pass
	Flight 8 LA	"	10.2 - 5.2	"	
	Flight 9 LA	"	9.4	Box pattern around city.	Box pattern as requested.
	Flight 6 SD	Above 0.3 & under 5.0.	8.8		Single pass.
Tucson, AZ	No flight.	"		"	

The SAR PI specified six targets, assigned each a priority, and provided exact coordinates of the pattern desired to be flown over each of the targets (table 6d). Most of the SAR targets were incorporated into flight plans. However, the priority 3 overwater flight requested was not accomplished because neither of the two overwater flights scheduled included the ground-truth site specified in the IRD, so were of little interest to the PI.

The LIDAR experimenter, whose instrument detected aerosols below the aircraft, wished to study the industrial environments of San Francisco and Los Angeles or San Diego using Tucson, Arizona as a nonindustrial reference, and to calibrate his instrumentation by comparing airborne observations with those made by ground based LIDAR systems in Menlo Park, California and Colstrip, Montana (table 6e). Aircraft altitude constraints for LIDAR were severe because laser safety considerations placed a lower limit of one kilometer on operational altitudes, and preferable altitudes dictated by instrument sensitivity were less than 4.8 km at night and 3.0 km during the day. Resultant flights for the LIDAR PI were a 5.2 km daylight flight over the San Francisco area in a pattern approximately as desired, and a proper box pattern over Los Angeles during daylight but at 9.4 km. The Tucson, Arizona reference measurement could not be included and the Colstrip, Montana calibration was flown at 11.9 km instead of the lower altitude requested.

Tables 3 through 6 indicate the complexity introduced into flight planning when the payload includes experiments from unrelated scientific disciplines. In general, PIs had to settle for less than they desired because, after extensive flight planning tradeoffs, it was impossible to include all facets of the PIs' requests into the flight tracks. Only the MLS PI achieved most of his objectives in the flight plans primarily because almost any flight path at high altitude, day or night, was suitable. Some PIs got complete data packages, but had to settle for fewer targets (IRA, SAR), or less time on prime target (CTM, AWS). Some data packages were compromised due to lack of desired ground-truth calibration (IHR, LIDAR) and one data package was severely compromised by not repeating a flight pattern at appropriate times (IHR).

3.3.3 Payload Specialist Selection and Training

All of the P/Ss were interviewed by the ASSESS II Observer Team and each ESA P/S was required by SPICE to submit a report about his experiences. Information from these sources as well as general observation of activities by the team has been used to prepare the following sections and the discussion in section 3.5.1 covering operational effectiveness of the P/Ss. Thus, the discussion regarding selection, training, and operations by the P/Ss represents their point of view as well as that of the observers.

An early ground rule was established for ASSESS II that ESA would select P/Ss specifically to operate the European experiments and NASA would select P/Ss to operate only the U.S. experiments. That decision was driven by funding limitations which precluded intercontinental travel for experiment operational training, but secondarily, there was hardly enough time in the schedule for P/S training on all the experiments, and also there was a real question as to whether it made sense to dilute P/S expertise too widely over many experiments. Only the European medical experiment involved all the P/Ss and it was agreed that the U.S. P/Ss would train for that, beginning with the integration period at ARC.

All P/S nominees for ASSESS II were required to meet Class III aviation flight crew standards. That was the only basic requirement. With the ground rule of separate responsibilities for the ESA and NASA P/Ss, ESA and NASA then each selected two P/Ss for flight so that, with the M/S, the payload flight crew totaled five. The selection and backup philosophy differed significantly between ESA and NASA as discussed in the following.

3.3.3.1 Selection of ESA Payload Specialists

ESA P/S candidates were nominated by participating PI organizations, DFVLR, and ESA. University of Southampton, England nominated two, DFVLR in Germany nominated six, and ESA nominated one. The PI and ESA nominations were made with operation of particular experiments in mind while DFVLR chose on the basis of generalized background qualifications (IR astronomy, solar physics, atmospheric physics, or medicine). Fluent English was considered an essential qualification.

ESA used three basic selection criteria as follows:

- Practical laboratory experience in the areas of electronics, optics, cryogenics, or astronomical observations;
- Scientific background appropriate to payload operations, sufficient to interpret data and make appropriate decisions;
- Flightworthiness, i.e., adequate physical well-being, team membership adaptability, and response to flight environment.

Flightworthiness was determined by a series of medical and psychological tests carried out by the DFVLR Institute of Aviation Medicine and Lufthansa (German Airline) Medical Office for Flight Personnel. The standards applied were those for Flight Engineers, taken to be the position most closely approximating that of a P/S. Results of the flightworthiness testing resulted in low ratings for three of the candidates.

The European PIs in an IWG meeting attempted to apply the first two criteria to recommend P/S candidates to ESA management, but the spread in rating for each candidate was wide as reflected by the fact that one PI would rate a certain candidate "best" while the next PI rated him "worst". Nevertheless, PI recommendations were given considerable weight in P/S selection.

ESA management, using the results of the medical and psychological tests along with recommendations from the European IWG, selected four P/Ss; a physicist and an electrical engineer from DFVLR, an astronomer from ESTEC and a physicist from the University of Southampton, England. The decision as to which of the four would be prime and backup P/Ss was deferred until integration of the payload at ARC.

3.3.3.2 Selection of NASA Payload Specialists

In NASA, mission management invited each of the PIs to nominate P/Ss. No restriction was made as to the number to be nominated. The LaRC PI for IHR made an inhouse nomination, and the AEES PI from GSFC nominated a contractor representative working on his experiment. At JPL, sponsor of the other three U.S. experiments, an organized laboratory approach was used to advertise for P/S candidates. Thirty-one candidates applied and JPL management narrowed the number to four, of whom two were nominated for prime P/S positions and two as backup. At this point, the NASA Program Manager and Mission Manager jointly decided that only two U.S. P/Ss would be chosen, and that the Assistant Mission Manager from MSFC would serve as the backup U.S. P/S. This eliminated the two JPL backup candidates. The U.S. IWG considered the remaining nominees, but almost simultaneously, the GSFC and LaRC nominees were withdrawn leaving only the two prime JPL candidates. The AEES experiment from GSFC had still not been authorized for the payload at this time and might have to be withdrawn, so that the AEES PI could not support his nominee. In addition, limitation of funds precluded directly paying a contractor's salary to participate as a P/S, so the non-NASA nominee proposed by GSFC would have had to be eliminated on that basis apart from the other reasons. The LaRC nominee was also withdrawn for lack of resource support. Unfortunately, these two withdrawals eliminated viable candidates proposed by PIs independent of the ability to perform as P/Ss. Thus, mission management merely accepted the two JPL prime candidates and assigned the Assistant Mission Manager as backup. One of the JPL candidates selected was PI on the LAS experiment. All were well qualified so that, apart from the unplanned selection process, there was general acceptance of the final result.

3.3.3.3 Payload Specialist Training

The NASA and ESA training approaches were similar in that each consisted of an initial study of experiment theory, followed by hands-on hardware training at the PI laboratories and finally, experiment and payload system training during integration. The ESA P/S training encompassed about 1150 hours each for four participants. The two prime NASA P/Ss trained approximately 900 hours each; the backup only about 500 hours.

Several factors caused significant differences between the NASA and ESA training activities. In NASA, three of the five experiments were at JPL where both prime P/Ss were located. Thus, productive and efficient involvement could take place on short notice. Because one P/S was also the PI on one of the JPL experiments and the other had participated in construction and operation of another of the JPL experiments, they were already well trained on two of the five U.S. experiments. The AEES experiment from GSFC was not authorized early enough for any training at the PI laboratory. Training for that experiment took place during the integration period.

In Europe, only one of the four P/Ss was directly involved in the background history of one experiment -- namely, the University of Southampton P/S who was responsible for construction of the AWS experiment. There was a longer period available to the ESA P/Ss for training since they were selected about six weeks earlier than the U.S. P/Ss, but a more significant difference was that the ESA payload integration and operation prior to shipment of the experiments to the U.S. provided almost eight weeks of concentrated training for the ESA P/Ss at SPICE.

The general training philosophy and schedules for P/Ss in Europe were established by ESA/SPICE. All P/Ss were scheduled to receive training on all European experiments so that each P/S would have a primary and secondary experiment operating responsibility. Subsequent to initial general training, the P/Ss considered prime for particular experiments received more detailed training on those experiments to the extent required to achieve operating proficiency. The training schedule was arranged so that all four P/S candidates received concurrent initial training at the PI laboratories. Prime operational training generally followed on a personally scheduled basis.

The ESA P/Ss attended an initial two day orientation at ESA/SPICE during which the training philosophy and schedule were established. ESA management had requested that the PIs supply each P/S with pertinent information on the background of their experiments for study prior to the first visits to PI laboratories. ESA left all other details of individual training programs to the PIs. The ESA P/Ss all reported that the original packages of background information contained much more material than was necessary for subsequent operation, and that they unwittingly spent too much time studying it. Also, they reported that they encountered considerable diversity in efficiency and usefulness of training programs at the various PI laboratories. Only one experiment (LIDAR) was sufficiently complete so that the instrument could be fully operated. It was installed on a light aircraft and several flights were made for training purposes. All other experiments lacked one or more important components until just prior to shipment to SPICE for integration. The P/Ss reported two instances where language comprehension proved to be a training obstacle. ESA P/Ss were unanimous in rating the period of European experiment integration activity at SPICE far superior to visits to PI laboratories for training purposes.

Initial NASA training philosophy included considerable cross-training for the P/Ss. However, when funding became a problem, plans for cross-training were reduced to only what could be accomplished at little or no additional cost. Prime experiment training plans were formulated at the introductory U.S. IWG meeting held in September 1976. General agreements were reached on duration of training and dates, where travel was involved. The exact dates for travel to PI laboratories were later arranged via consultation of the P/S directly with the PI. Also, mission management held a two-day orientation meeting for the U.S. P/Ss at MSFC to initiate the training process, and to provide them with suitable background material for home study.

Prime P/S training on the inhouse JPL experiments was arranged in a rather casual way and on a time-available basis. A little cross-training was included. Travel was involved on only two occasions; once to the IHR laboratory and once for both P/Ss to fly aboard the CV-990 in fall 1976 when the payload had two of the planned ASSESS II experiments aboard. Some cross-training also occurred while the P/Ss were with the CV-990 mission (approximately two days). The AEES experiment was not funded until February 1977 which precluded training on that experiment until Systems Level Integration at ARC.

The extra assignment of the NASA Assistant Mission Manager as the backup P/S required extensive travel for training, and presented a serious conflict, since he really did not have enough time to do justice to either responsibility. However, he was able to visit JPL for training on MLS and SAR, and got valuable inflight training by accompanying prior CV-990 missions when the payloads included earlier versions of the ASSESS II experiments. He made one flight with SAR and three flights with MLS and IHR. The early CV-990 flight training can be considered analogous to training on high-fidelity trainers which might be made available prior to Spacelab flight.

Several factors probably made the NASA home laboratory training more effective overall than in Europe. The NASA P/Ss were both already expert in the operation of one of their experiments. The experiments operated by one P/S were conceptually similar (LAS, IHR), and the laboratory training took place shortly before the shipment of the experiments to ARC when they were complete and approximately in their final flight configurations. Experiment similarities lessened new operational concepts and information to digest. The training situation (experiment configuration) was much more realistic with the instruments in final configuration.

Beginning with the System Level Integration at ARC, almost every mission related activity involved the P/Ss. This was the first opportunity for the P/Ss to work with the entire payload and served as excellent training. Both the ESA and NASA P/Ss were used extensively for integration and operation of the payload. At ARC the M/S was present from the beginning along with all the P/Ss. The M/S was very experienced and exhibited strong leadership qualities. He had participated with the ESA P/Ss at SPICE so that he was already well acquainted with their activities, and it was natural for the payload crew to pursue their training very rigorously as a team under his leadership.

During System Level Integration the P/Ss worked closely with the PIs who, at this stage, were responsible for integration and operation of their instruments. For Launch Site Payload Processing involving integration of the payload onto the aircraft, the responsibility was reversed, and the P/Ss were assigned prime responsibility for experiment integration and operation with the PIs participating only as needed. These two integration periods along with the ESA integration for ESA P/Ss, provided by far the most fruitful training for the entire flight crew.

At the onset of ARC integration activities, ESA had made a decision identifying the prime and backup P/Ss. Nevertheless, all four ESA P/Ss participated together to provide assistance and to achieve further training as well.

Mission independent training consisted mainly of safety briefings conducted by aircraft operations personnel at ARC prior to the flight period, involving both a safety lecture and onboard aircraft safety discussions. The mission independent training had very little analogy to Spacelab since Spacelab flight will entail much more mission unique training not applicable to the ASSESS program. Conversely, the experiment training was highly analogous to that expected for Spacelab.

The different approaches to payload training as well as the difference in total training time between the ESA and NASA P/Ss seemed to result in no difference in performance. The P/Ss as well as the PIs all expressed confidence in the ability of the payload crew to satisfactorily handle the experiments at the final Flight Readiness Review. Any differences in ability among the P/Ss seemed more directly related to individual capability and personality traits rather than to a lack of training.

In general, the overall P/S training was considered to be very good, and the only critical observation made by the P/Ss was that it would have been helpful if they could have participated early in operational design considerations. This same observation was made by the P/Ss after the ASSESS I mission.

3.3.4 Mission Specialist Selection and Training

3.3.4.1 Mission Specialist Selection

The selection of a M/S was a very difficult and sensitive process. Responsibilities of the position were the subject of extensive debate both privately and at management meetings during the early phases of the ASSESS II project. This paralleled a larger dispute on the same subject for Spacelab itself. The real question centered around the extent to which a representative of the STS organization should be involved in payload activities. It was recognized that some inflight responsibilities will exist in Spacelab for STS supplied payload support systems such as the central data system, power system, etc. Similar systems exist on the CV-990 so that the same problem had to be faced. Efforts to settle this issue in the MSG reached an impasse and, as a result, the NASA Program Manager initiated a solution through NASA Headquarters administrative channels (OA and OSF) which was accepted by the Mission Manager. Responsibilities thus assigned to the M/S are given in section 2.4.5.

The long delay in settling the M/S role postponed M/S nomination until December 1976 when JSC appointed a scientist/astronaut with expertise in astronomy to serve as M/S and a second scientist/astronaut with similar background as backup.

3.3.4.2 Mission Specialist Training

Both the prime M/S and the backup M/S had experience on earlier ASSESS missions, which, coupled with their extensive background and training as astronauts in the JSC program, equated to a high degree of training already accomplished for ASSESS II.

The prime M/S started participation in the second analytical integration activity at MSFC in December 1976 immediately following his assignment. While neither he nor the backup M/S spent time at PI facilities, they quickly developed an understanding of the experiments and the mission objectives. The M/S participated actively with the ESA P/Ss during one of the two flight simulation periods at SPICE. Both he and the backup M/S trained on carrier systems by accompanying a previous CV-990 mission (three flights). (The backup M/S received no other specific training.) During the integration period at ARC, the M/S participated in all operational activities and worked closely with all the P/Ss during their activities. In fact, he took on a leadership role for P/S training activities for which every P/S later expressed appreciation.

The M/S achieved proficiency in all responsibilities assigned to him except the central data system. He operated the power system, the surface temperature and atmospheric water vapor radiometers, the video camera and recorder system for cloud cover data, the EMI monitor system, and the ozone monitoring system. His late selection permitted only limited training on the complex central data and housekeeping systems where "ghost" participants were added to the payload crew, in accordance with the mission guidelines, to assist the M/S. Although an interactive data system terminal was available at the M/S station, it was not practical to extend all the controls for these systems to his operating position, so that it would not have been possible for him to handle these systems even if he had achieved full proficiency.

3.4 Mission Integration

Two discrete steps were planned by MSFC mission management for integration of the ASSESS II payload in preparation for flight. Analogous to their plan for integration of a Spacelab payload at MSFC, they proposed an ASSESS II System Level Payload Integration in a test area at ARC under jurisdiction of MSFC. This would be followed by Launch Site Payload Processing onto the aircraft under jurisdiction of KSC, analogous to the levels III, II and I planned for Spacelab by KSC.

ESA/SPICE made an independent decision to bring the European experiments together at SPICE for integration and operation because they felt strongly that this step was necessary to work out experiment hardware and operational problems before their lines of communication and support became too long and costly in the U.S. Conversely, ESA felt that once they had accomplished integration of their portion of the payload in Europe, very little time would be required to integrate their portion of the payload into the whole at ARC. In fact, they preferred to skip System Level Payload Integration and go directly to Launch Site Payload Processing on the flight vehicle to save their time and cost. The MSFC Mission Manager insisted on ESA participation in the System Level Integration in order to assure operation of the entire payload before turning it over to KSC for Launch Site Processing, but did agree to a shorter than initially planned period for European payload preflight integration at ARC.

3.4.1 ESA Payload Integration in Europe

The ASSESS II integration of the ESA portion of the payload at SPICE followed the format which they plan for Spacelab. ESA/SPICE arranged with DFVLR at Porz-Wahn, Germany to construct a full scale mockup of the CV-990 cabin to accommodate the European instruments (figures 11 and 12). Serious attempts were made to provide power and data handling systems similar to the planned CV-990 installation. They contracted with the ARC ADDAS computer contractor to participate throughout the SPICE integration to work programming and data handling problems. They borrowed ARC flight data hardware to assure a data system interface as much like the flight system as possible. DFVLR added living quarters to the simulator to accommodate the "flight crew". A screen room was built to solve EMI problems, and a full scale POCC was provided. ARC arranged to send a safety engineer to Porz-Wahn to advise ESA on experiment safety problems.

Activities at SPICE/DFVLR during the period from January 15 to March 15, 1977 included:

- Completion of experiment development and integration;
- ESA acceptance testing;
- EMI characterization and corrective action where necessary;
- Development and integration of experiment software;
- Experiment integration on system level;
- Flightworthiness verification;
- Interexperiment compatibility testing;
- Mission simulations;
- Training of flight and ground support personnel.

Experiments were brought sequentually into the acceptance testing/EMI testing area during the first month. Functional testing and some development changes were carried out first. Each experiment was then subjected to EMI testing with concomitant introduction of electrical grounding or screening alterations to meet minimum EMI requirements in accordance with Spacelab standards as measured by the ESTEC/EMI team.

After successful acceptance testing, experiments were integrated into a 30-foot long section of the full scale mockup of the CV-990 cabin. The configuration of each experiment was approximately as planned for the eventual aircraft installation, but distribution of the experiments in the mockup was somewhat different than planned for the aircraft. Relative positions of the ESA experiments were correct, but physical separation was much less than in the final flight configuration where the ESA experiments were interspersed with NASA experiments and the ADDAS. However, the interconnecting cables had been cut to fit the aircraft installation so that problems associated with cable length were addressed except for the effect of EMI problems later introduced at ARC by the balance of the payload. After completion of payload testing in the mockup, two flight simulation periods of three days each were conducted. During each period the crew was confined to the CV-990 mockup and the adjacent living quarters, and contacted the "ground" via the fully manned POCC. Thus, a full rehearsal of activities anticipated during the mission proper at ARC was carried out using the European complement of experiments.

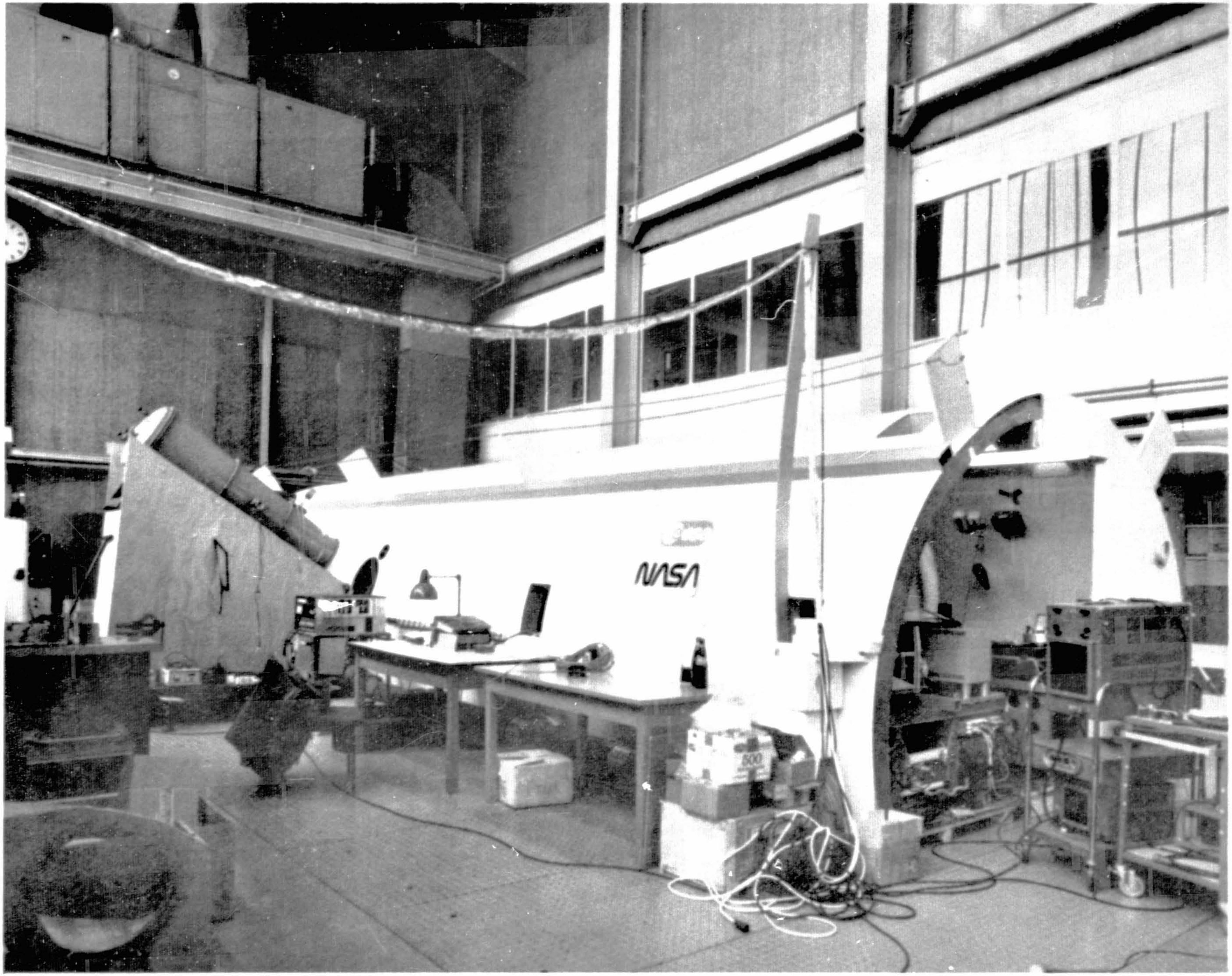


Figure 11. ESA CV-990 Mockup

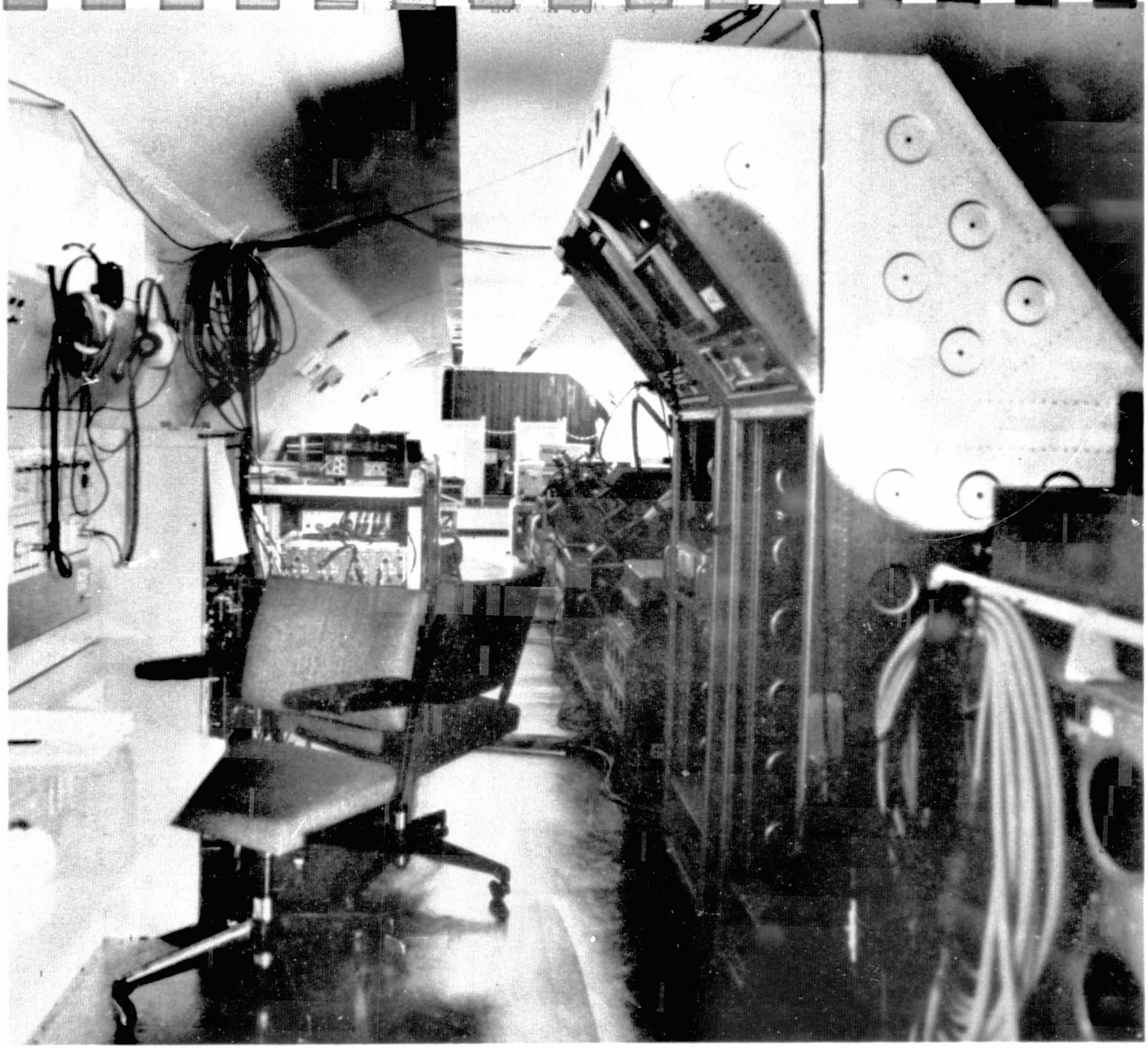


Figure 12. ESA Payload in CV-990 Mockup at ESA/SPICE

Numerous difficulties were encountered in attempting to implement software development and the central data system interface verification. In addition to lack of complete data interface information in the IRDs, another major reason for the data handling difficulties was that insufficient time was allowed for the data system contractor to assemble and check out the system used at SPICE. The components had never been operated as a system, and systems of such complexity have their own operational idiosyncrasies which had to be discovered and understood by the operator in addition to attempting to carry out the payload checkout activities. When problems arose during this period both the data system and the particular experiments were suspect. Hardware problems delayed significant software development until about the middle of February.

Integration of the experiments provided valuable P/S training, but the principal training activity was accomplished during the two mission simulations carried out March 1-3 and 6-9. During the first period the prime ESA P/S 3 and backup 4 were confined to the CV-990 mockup and living quarters together with the NASA M/S who had been invited to participate. The other two P/Ss performed communication tasks in the POCC. During the second confined period the P/S assignments were interchanged so that prime 4 and backup 3 were confined. The ESA Systems Engineering Manager took over the M/S role and was confined with the payload crew. Mission simulations were timelined according to the preliminary flight plans that had been developed by MSFC analytical integration activities.

During the periods not devoted specifically to checkout and payload integration at SPICE, ESA P/Ss in conjunction with PIs developed written operational procedures for each experiment. The mission simulations, which introduced timeline activities for the first time, brought about considerable refinement of the operational procedures.

In order to address safety issues early, an ARC safety engineer was sent to Porz-Wahn to participate in the ESA payload integration effort. Many minor and several major safety problems were identified there and solved. A few were recognized and deferred until final integration at ARC where aircraft installation geometry had to be considered. However, this early attention to the flight safety area, when lead time was available, was successful and eliminated the problems at a later time when they probably would have been critical.

The ESA simulation was conducted using European 50-Hz rather than 60-Hz power to be used later in the U.S. since only a small 60-Hz generator was available. Following the ESA simulation, each instrument was operated independently on 60-Hz to assure satisfactory operation with U.S. power.

3.4.2 System Level Payload Integration

System Level Payload Integration was the intial payload activity at ARC and accomplished total hardware and software integration with the "Spacelab" interface elements. This was the first time the entire payload was assembled as an entity. Integration was performed (figure 13) using a combined NASA/ESA

Figure 13. Payload Integration and Checkout Area at ARC

checkout team under the direction of the MSFC Ground Operations Manager. While the Ground Operations Manager was in charge of the overall activity, each PI had direct responsibility for his own experiment to insure that it operated and interfaced properly with the balance of the system. He was expected to provide the test requirements and whatever stimulation equipment was necessary for his experiment. The M/S and the P/Ss along with the MSFC and ARC support groups were available, in addition to his own staff, to help him as required. This approach was analogous to the MSFC plan for system level payload integration of the Spacelab 1 payload at MSFC.

3.4.2.1 Level IV Payload Checkout Unit

The payload checkout unit (PCU) employed on ASSESS II was far from a high-fidelity simulation of the carrier, but it did provide for considerably more than mere interface tests in the way of simulating the carrier environment. Simulated carrier systems (time codes, INS signals, etc.) were provided to the experiments that would receive them in flight; a central data processing unit similar to the aircraft system was used to process those signals that it would handle in flight; and the payload was nominally configured as it would be in flight. All systems were operated and signal channels were verified. Where possible, real signal sources were used to produce prime data channel signals equivalent to those expected in flight.

Electric power distribution in the PCU was handled through a small distribution panel similar to the one in the flight vehicle. The number of circuits was less than in the aircraft which meant that exact simulation of power distribution could not be made. However, only minor difficulties in interexperiment transient interference resulted. Electrical power used in the PCU was commercial power with excellent waveform, in contrast to the relatively poor waveform provided through electronic converters on the aircraft. This difference of fidelity caused no known problems.

The aircraft intercom system was also simulated for PCU operation. Headsets identical to those used in the aircraft were available. The intercom system was not used as much as it should have been because of inadequate audio power and because it was simple to communicate directly in the PCU environment. Little was lost by lack of use of the intercom except a bit of training and discipline in its use.

The principal difference between the PCU and the aircraft system was in the Airborne Digital Data Aquisition System (ADDAS) simulator provided to check data interfaces and data processing. Because of funding limitations, some desired equipment could not be obtained and the aircraft ADDAS installation could not be exactly duplicated. As a result, the simulator required somewhat different programming than the flight system which precluded a complete check of software developed for the flight mission. This was a serious deficiency that could not be avoided.

3.4.2.2 Management and Schedule of Level IV Integration

The ground operation schedule for Level IV integration (figure 14) went through a series of major and finally rather minor iterations between the MSFC Ground Operations Manager, KSC, SPICE (who represented the European experimenters), and the U.S. experimenters. Flight dates were never slipped, but the Level IV experiment integration sequence was changed to accommodate changes in delivery dates of the U.S. experiments. ESA/SPICE negotiated a date for delivery of all their experiments at one time, and they delivered as promised.

Standard CV-990 racks had been sent to all NASA and ESA experimenters who requested them. Three Spacelab-type racks had also been shipped, two to ESA/SPICE for their integration at DFVLR, and one to the IHR PI whose control equipment filled the entire space. Thus the various experiments arrived with most components already installed or ready for assembly. There were a few exceptions which had to be corrected for safety reasons. The control components for four of the U. S. experiments had to be integrated into Spacelab racks 1 and 2 as part of the level IV integration activity.

The sequence of activities for each experiment was:

- Experiment delivery and inspection; PI specification of instrument status including identification of all known problems or open items;
- Physical, electrical, and data system mating to the PCU;
- Specific tests, calibrations, alignments, and software verification as specified by the PI to assure him of satisfactory experiment operation.

Integration and operation of the European experiments at SPICE, together with the fact that they were all delivered simultaneously and accompanied by a well organized team of ESA personnel (consisting of four P/Ss, and the experimenters' staffs as well as SPICE personnel), led to rapid integration of the European experiments in about one week. Conversely, the U.S. experiments were delivered sequentially without benefit of any earlier integration effort and with only two U.S. P/Ss to assist the PIs, so that integration of the U.S. experiments required about twice as long.

Following integration and operation of the individual experiments, an Experiment Functional and Compatibility Test was conducted to ferret out EMI problems between experiments or between the experiments and the PCU when the equipment was operated as a full payload. This was the first time the entire payload was operated together and the tests required about two days. After the function and compatibility test was completed, a Mission Sequence Test was conducted for one day using the payload flight crew, consisting of the M/S and four P/Ss, to operate the experiments in several combinations similar to planned flight modes. The purpose of this test was to exercise the actual operational timelines that had been proposed for flight to identify operational and timeline problems which might require alteration of plans for the flight period. The final step in the Level IV integration was a Payload Hardware Readiness Review at which operational readiness of each experiment was discussed by the PI. He was required to certify experiment status, and document

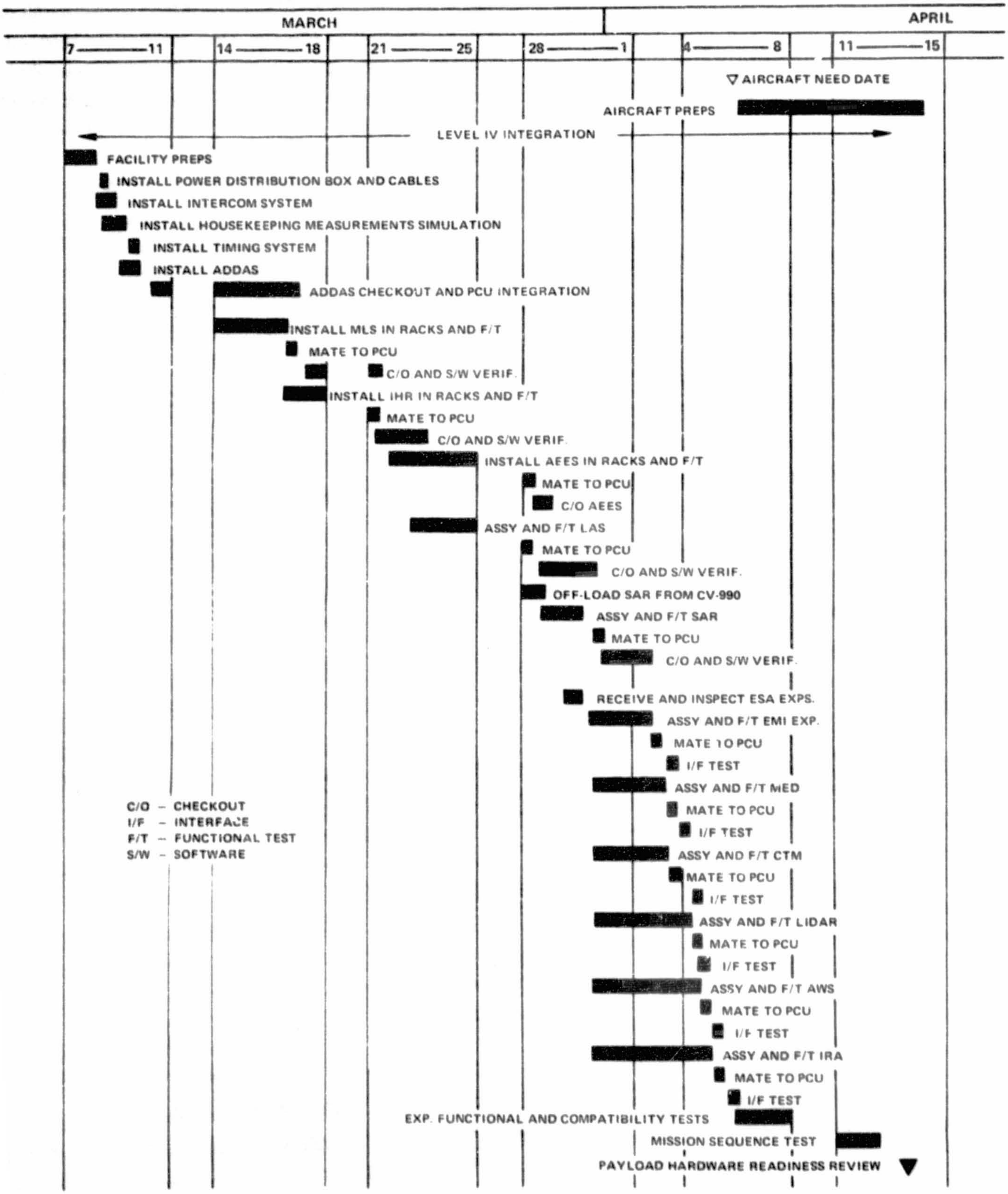


Figure 14. System Level Payload Processing Schedule

any open items. In turn, the MSFC Ground Operations Manager reviewed status of the entire payload, certified its total status, and passed a complete list of open items to the KSC Ground Operations Manager in preparation for Launch Site Payload Processing.

The entire Systems Level Payload Integration was carried out under close supervision of the MSFC Ground Operations Manager. He held a daily meeting throughout the entire integration period. In addition to overall reference to the general schedule, a 72-hour schedule and a daily schedule were formalized and presented to all participants on a regular daily basis. Changes to the short term schedules were made and discussed as required. In general (except for the first weekend after all the European experiments arrived), the overall schedule was based on a regular 8-hour shift, and it was deliberately intended that daily and weekend overtime would be used to insure schedule success. As expected, substantial overtime was required.

In addition to the activity schedules, four basic working documents were used during the integration as follows:

Discrepancy Report: To report minor problems which could be easily corrected.

Problem Report: To report major discrepancies such as failed hardware or design problems. The form stated the problem and proposed steps for resolution.

Interim Problem Report: Same form as the Problem Report (above), but related to test failures. The form stated the problem and provided for troubleshooting activities.

Work Authorization Document: Authorized unplanned activities such as special tests. Included instructions and a record of accomplishment.

Based on initiation of these documents by PIs or PCU personnel, and the overall integration schedules, management worked out the daily schedule of activities. Any matter necessitating initiation of one of the above documents became the subject of an "open item" and was worked off in a prioritized manner. The Ground Operations Manager maintained a complete log of open items and noted progress toward their closure in making out the daily schedule of PCU activities. After an experiment was integrated with the PCU, the PI could work on his experiment as required, carrying out planned activities or, for unplanned activities, through the initiation of one of the above documents.

In addition to the log of open items kept by PCU personnel, the PIs were requested to maintain a daily log of activities. To ensure a common format, logs were supplied by the Ground Operations Manager. The purpose of these logs was to provide a source of background information which would be helpful in resolving later possible inflight problems. However, as PIs received no specific instruction for filling out the logs, entries made were at a level of detail drastically less than desired by management. Management was aware of the deficiencies in these PI logs, but applied no pressure for greater completeness as the installation proceeded.

3.4.2.3 Open Items and Problems During Level IV Integration

Table 7 categorizes open items encountered during Level IV integration. Most of these were truly problems which had to be solved, but a few were merely required functions or tests such as calibration after the final aircraft installation. The disposition of open items was an activity which required time and had to be scheduled into the overall activity. The last column of the table shows a total of 71 open items identified when the experiments arrived at ARC. Some of these plus the additional problems which developed during the integration process resulted in a total of 99 open items which were addressed and closed during the integration period. Fifteen open items were passed on to KSC for action during launch site processing on the aircraft. Most, but not all of these, required the final aircraft configuration for proper action.

The large number of open items upon arrival of the experiments represent 62% of all the open items identified during Level IV integration. 41 of the 71 open items identified upon experiment arrival were for one reason or another purposely deferred by the PIs until arrival at ARC. Six open-on-delivery items could only be addressed using facilities available during PCU testing. Others were problems which the PI had not had time to close. Data problems were strongly related to the LIDAR and CTM/ADDAS interface problems which had been encountered during SPICE integration in Europe and were still open on arrival at ARC. The two facility/data problems passed to KSC were related to small subroutines which ADDAS was supposed to perform for various PIs. Two of the nine experiment problems passed on to KSC were missing hardware components caused by late funding which delayed procurement.

Perhaps the most disturbing aspect of Level IV integration became apparent immediately upon arrival of the experiments. Every experiment arrived at ARC with some part of it in a configuration different from that identified in the interface definitions contained in the IRDs and the resultant drawings and sketches which had been prepared as a part of the analytical integration process. It was to be expected that some unidentified changes would show up with the cessation of the formal IRD effort some six months before flight, but the changes were extensive. Some changes had been addressed but they were mainly problem areas where the experimenters had contacted ARC to achieve resolution. No attempt was made by mission management to track changes in experiment requirements during the four months prior to systems integration. Some experiments arrived with deleted components, others with added components. In many cases units had been interchanged. None of the changes could be judged as unjustified.

There appears to be some advantage for an experimenter to keep his hardware in a state of flux, with change more the rule than the exception, in order to fly the best possible equipment. This can and should be condoned within the limits of the schedule and resources to accommodate changes. Changes internal to the experiment may have no significant impact on integration, but changes which affect interfaces with the vehicle system or other experiments must be addressed and should be planned for.

Table 7 - Action Items During System Level Payload Integration

	Experiments	Interface	Checkout Facility	Safety Related	TOTAL
Incomplete Experiment Hardware Delivery					
Open on arrival	19	1	1	0	21
Closed in Level IV	17	1	1	0	19
Transferred to KSC	2	0	0	1	3
Data Systems					
Open on arrival	1	2	10	0	13
Closed in Level IV	10	9	12	0	31
Transferred to KSC	1	2	2	0	5
Mechanical					
Open on arrival	23	4	0	3	30
Closed in Level IV	21	5	1	3	30
Transferred to KSC	5	0	0	0	5
Power					
Open on arrival	2	0	0	0	2
Closed in Level IV	9	1	2	0	12
Transferred to KSC	1	1	0	0	2
Calibration					
Open on arrival	5	0	0	0	5
Closed in Level IV	7	0	0	0	7
Transferred to KSC	0	0	0	0	0
Summary of Actions					
Open on arrival	50	7	11	3	71
Closed in Level IV	64	16	16	3	99
Transferred to KSC	9	3	2	1	15

For the ASSESS II project, where only ten experiments were involved and substantial ARC experience in integrating airborne payloads was available, the problem of many changes was handled with required overtime. However the implications for Spacelab are much more significant, where many more experiments may be involved in a single payload, and delays to accomodate changes will be not only difficult to schedule, but also much more costly.

3.4.3 Launch Site Payload Processing

Launch Site Payload Processing (LSPP) was managed by KSC and involved installation and checkout of the payload in the aircraft, preparatory for flight. Activities included:

- Experiment installation;
- Experiment/aircraft interface verification;
- Equipment testing and calibration;
- Compatibility test;
- Mission sequence test;
- An Integrated Mission Simulation;
- Final preparation for launch.

The entire process was completed during a four-week period by a team composed of KSC, ARC, the M/S, P/Ss, and experimenter personnel. Significant features of the activity on board the aircraft were the considerable amount of experimental testing found to be necessary to insure achievement of payload objectives, and the large number of hardware and software problems encountered during experiment operations. Following integration and testing, special material was placed aboard the aircraft in accordance with a formal stowage list similar to preparation for space flight. This material included the flight data file, tools, test equipment, materials, and spare parts. The Integrated Mission Simulation was carried out over a 2-day period as a final checkout and training exercise. This was an all-up dress rehearsal involving the payload crew confined on the aircraft, and a fully staffed POCC and MCC all operating as if the aircraft was in flight. Finally, a Mission Readiness Review was held at which KSC certified to the Mission Manager that all payload requirements had been completed ready for launch.

3.4.3.1 Management and Schedule

The Launch Site Payload Processing schedule is given in figure 15. KSC used essentially the same procedure in managing the activities as was used for Level IV integration by MSFC. Eight-hour days were scheduled. Overtime was used to adhere to the schedule. Daily meetings were held to schedule and plan immediate events. All onboard activities were conducted under a uniform work control system in which all tasks were planned, scheduled, and documented. KSC used the following documents in addition to the daily schedules to control their work.

- Test Preparation Sheet - KSC language for a work authorization document for unplanned tests.

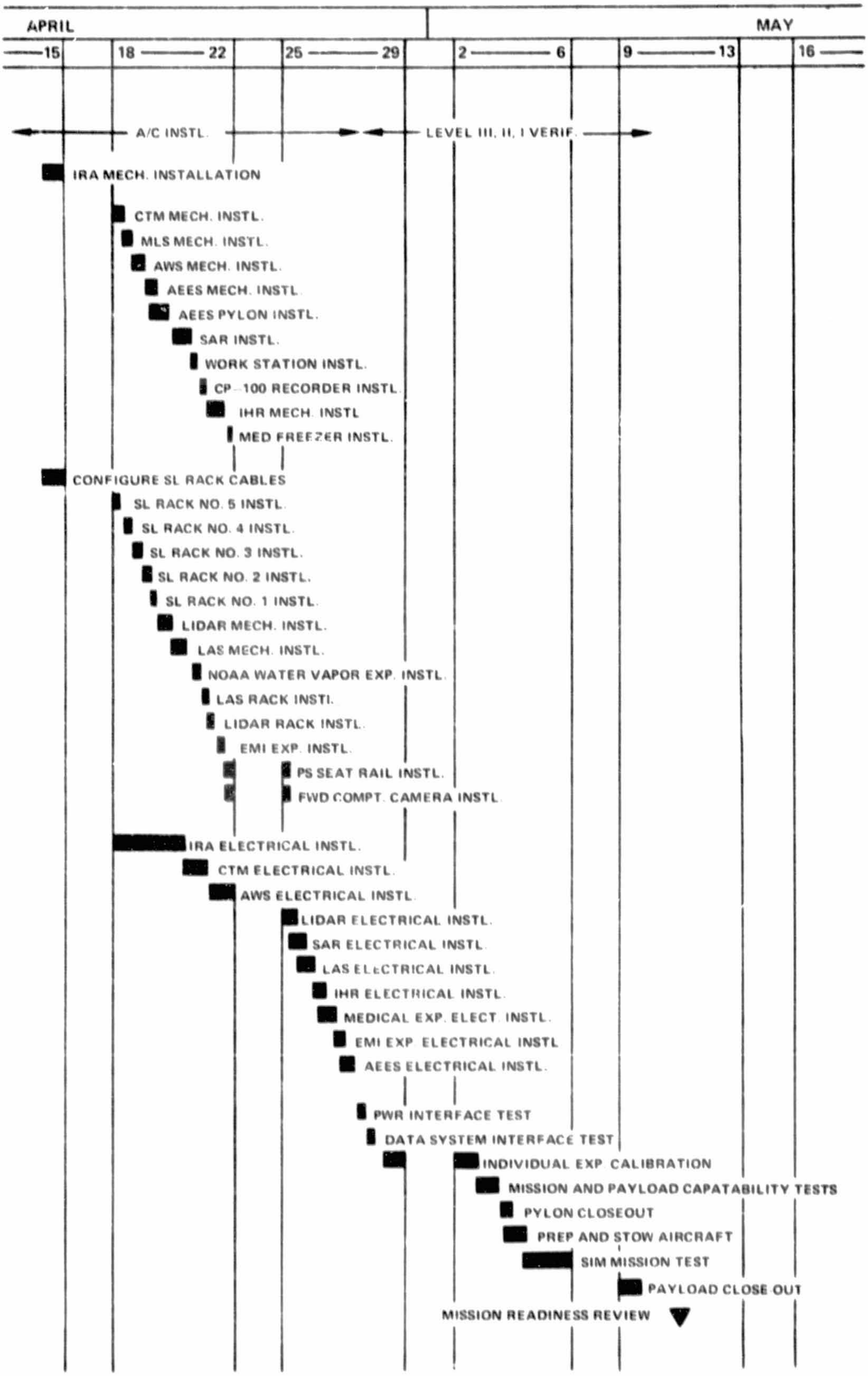


Figure 15. Launch Site Payload Processing Schedule

- Operational Checkout Procedure Deviation	-	Authorized changes in planned tests.
- Engineering Change Notice	-	Authorized adding, deleting or modifying hardware. Usually included engineering sketch.
- Problem Report	-	Major discrepancy. Required written description and proposed method of solution.
- Discrepancy Report Tag	-	Minor problem. Required little or no description or instructions for resolution.

All of the above documents required a sign off for completion by one of the three KSC management personnel.

KSC used a launch site managment team composed of the Launch Site Ground Operations Manager, an engineer, and a quality assurance expert. They were supported by the ARC aircraft technicians and shop personnel, similar to Spacelab plans to use a support contractor at KSC. In addition, all the P/Ss along with the M/S were heavily utilized by KSC to integrate and test the payload. Originally, KSC representatives established a ground rule that PIs and their staffs would not be involved in integration of experiments on the aircraft unless a special problem required their support. This is consistent with the rules at KSC, which they expect to maintain for Spacelab, that limit access to the flight vehicle to only those people who are mandatory to do the work. This access rule was not strongly enforced for ASSESS II, and the PI teams as well as P/Ss and the ARC support personnel often worked together in order to accomplish integration and checkout of the payload. As a result, it was not possible to fully evaluate the effectiveness of using the P/Ss to represent the PIs during integration since, without question, the use of PIs expedited the integration and testing activity.

It is expected that heavy participation by the P/Ss to represent the PIs during launch site integration would be of great benefit to the launch site contractor, and their intimate familiarity with the payload would negate the need for much detailed documentation. Since the P/Ss ultimately must fly with the resultant configuration, they are properly motivated both from the point of view of satisfactory experiment operation and safety.

3.4.3.2 Launch Site Payload Processing Actions

Ideally, Systems Level Integration and Testing (Level IV) would solve all problems internal to the experiments and incompatibilities between experiments, and would exercise all interfaces between experiments and duplicates of flight vehicle hardware and support systems. Thus, the mechanical installation and electrical hookup in the vehicle could proceed directly to final operational verification, compatibility testing, and in situ calibrations as required. However, this was hardly the case for ASSESS II, and cannot be expected for Spacelab because the fidelity of the Level IV integration is limited by the fidelity of the Level IV integration device (PCU). For ASSESS II, the PCU fidelity was not high, primarily because it was not cost effective to construct an extensive Level IV checkout system for a single mission.

Compatibility testing after installation aboard the flight carrier introduces several areas for consideration that do not exist during similar testing in Level IV integration. These are: 1) the effects of payload operation on flight carrier systems; 2) the effects of flight carrier systems operation on the payload; and 3) the possible effects on payload operation of shifting from PCU ground supplied power to flight carrier power.

In considering the first area for ASSESS II, mission management, along with cognizant aircraft systems personnel, reviewed payload operation and decided that specific tests for the effects of payload operation on aircraft systems would not need to be carried out. The aircraft systems were sufficiently protected to negate any forseeable problem. There was general concern in the second area among the PIs because operation of aircraft systems has occassionally had adverse effects on experiment operation and some of the experimenters were aware of a potential problem. However, only the AEES PI requested specific tests, and the Mission Manager took the position that all interested PIs would be allowed to monitor their experiment operation during aircraft/AEES testing. No incompatibilities were found during the AEES tests. In the third area, the Mission Manager decided that the PCU and aircraft power were sufficiently similar in voltage, frequency, and waveform so as to make a test of total payload operation under aircraft power unnecessary.

Because of the extensive experience at ARC with experiment to aircraft interfaces, these compatibility areas were of minor concern for ASSESS II. However, Orbiter and Spacelab systems are new, so that somewhat greater concern and testing will probably be required, more from the point of view of the effect on the carrier systems rather than the possible effect on the payload.

Table 8 summarizes the total items handled during LSPP, and Table 9 details the 15 items which were passed from Level IV integration to LSPP. The following is a categorization of the types of action required to address all the items, according to the documentation used by KSC:

- 36 Problem Reports - major discrepancies, three were inherited from Level IV;
- 37 Engineering Change Notices - alteration of hardware;
- 22 Test Preparation Sheets - authorized unplanned testing, four were inherited from Level IV;
- 12 Operational Checkout Procedure Deviations - changes in planned tests;
- 15 Discrepancy Report Tags - minor problems.

122 Total

Table 8 - Action Items During Launch Site Payload Processing

	Experiments	Interface	Payload Carrier	Safety Related	TOTAL
Open on delivery	9	3	2	1	15
Data systems	19	8	7	0	34
Mechanical	24	12	18	2	56
Power	6	8	8	1	23
Test changes	10	1	1	0	12
Open at launch	0	0	0	0	0
Totals	68	32	36	4	140

Table 9 - Problems Passed from Level IV Integration to Launch Site Payload Processing

Experiments	Problems
LAS	Shroud required for optics protection. Shop fabrication not finished before start of LSPP.
LAS	Replace gas cylinder to start flights with full supply.
MLS	Connector support required. Shop fabrication not finished before start of LSPP.
AEES	Strip chart recorder not delivered before start of LSPP.
MEUDON	Problems in loading experiment computer program.
MED	Cable too short. Fabrication not finished before start of LSPP.
IHR	Filter delivery from vendor did not occur before start of LSPP.
IHR	Calibration information required from PI. Not available before start of LSPP.
CTM	PI required recalibration of stabilized mirror in flight configuration.
Interfaces	
EMI	Power-on transients between AEES and several instruments. (Not resolved in Level IV, but did not occur on aircraft.)
EMI	AEES sensitive to SAR radar transmissions during Level IV. (Level IV facility not adequate to properly address the problem, did not occur on aircraft.)
ADDAS/LIDAR	Intermittent data transmission problem not solved at SPICE or during Level IV operations.
Payload Carrier	
ADDAS	IHR disc file malfunction.
ADDAS	Software required to program cloud cover TV record for IHR. (ADDAS workload caused the effort to be passed on to LSPP period.)
Safety Related	
EMI	Change to lock nuts required.

The total of 122 formal actions required is less than the 140 items shown on Table 8 because some actions took care of more than one type of item.

During the first two weeks of experiment installation, a number of unplanned tasks were required due to incomplete identification of payload requirements. These tasks included increased tests and calibration in the final flight configuration which were beyond the requirements initially identified by PIs in the IRDs. They were approved to maximize science return.

Not all of the 140 items faced during LSPP can be classed as problems, since some which were passed from Level IV and others that came up during LSPP were minor chores. The two inherited AEES EMI problems (table 9) merely disappeared with the shift to the aircraft environment.

Table 10 lists the major LSPP experiment operational problems. While only eight major problems are identified, they were each critical to the experiments and in most cases were time consuming in their solution. These major problems occurred in spite of extensive Level IV and SPICE testing, and are probably the types of problems to be expected during final integration of a Spacelab payload made up of many experiments.

For ASSESS II, no checkout flights by the payload crew were permitted, but standard ARC aircraft safety requirements dictated that a brief series of "pilot proficiency tests" be carried out before carrying passengers aloft for a regular flight mission. Two vibration related payload problems were detected after these flights that might otherwise have occurred during the "Spacelab flight" period.

Table 11 lists the significant problems which occurred during LSPP which probably could have been solved during Level IV if the PCU had been of sufficiently high fidelity. While for Spacelab the Level IV PCU will be of higher fidelity, this list illustrates the types of problems which can occur from inability to fully duplicate the flight systems and their characteristics.

It is appropriate to discuss briefly the importance of quick reaction shop facilities and staff to support the integration activities. This capability is required by all levels of integration, as was so evident in the support provided by DFVLR during SPICE integration in Europe and at ARC for Level IV integration. However, it is particularly important for launch site payload processing, because at this time every problem compounds the cost through overtime or lost time as the whole operation moves more toward serial activities performed by a large contingent of people. The ARC sheetmetal and electronic technician support, with their many years of experience, displayed a flexible and effective approach to problem solving during crisis scheduling to meet the flight date. Individual work orders were not required, but rather were grouped under a blanket order for the mission, coupled with accurate time and cost accounting. Verbal directions were sufficient, coupled with sketches as needed, and followed up by responsible safety inspection and sign off. Spacelab payload processing facilities will need that kind of support to solve last minute problems, and it can be done efficiently, and at low cost, if formality is replaced by flexibility, coupled with well identified assigned responsibility to avoid requirement for a chain of approvals.

Table 10 - Principal Launch Site Operational Problems

Experiment	Problem	Action Taken
IRA/Meudon	Computer program for telescope control operated erratically.	Same problem occurred during SPICE integration and during PCU testing. Manufacturer's representative serviced equipment, but did not completely eliminate problem.
	Coudé focus mirror servo out of alignment.	Technician realigned and did improve operation, but lacked IR source for proper verification.
AWS	One TV camera produced unstable picture.	AWS technician readjusted, but did not completely solve problem.
LIDAR	Data transmission to ADDAS occasionally out of synchronism with desired format.	Component manufacturer's representative serviced equipment, but did not completely solve problem.
CTM	Noisy lock-in amplifier.	Replaced by backup equipment.
	Data coupling equipment inoperative.	CTM technician readjusted, solving problem.
LAS	High noise level on signal cables.	Provide effective grounding for signal equipment in cargo area.
AEES	Scanning receiver failed.	Returned to manufacturer for repair. Reinstalled at last moment before flight period.

Table 11 - Launch Site Problems Related to Lack of Fidelity in Earlier Testing

Experiment or Facility	Problem	Action Taken	Comment
Facility	Grounding resistance between racks and mounting rails too high.	Add grounding straps to all racks.	Low resistance grounding system used in PCU.
LAS/ADDAS	ADDAS power signals interfere with LAS signal channel.	Relocate cables with greater separation.	Cables not in similar positions in PCU.
Facility	Unbalanced loads on power converters.	Redistribute loads.	No analog in PCU to separate converters.
LIDAR	Cables to cargo area too short for planned route.	Reroute cables.	Lack of physical fidelity in PCU.
IRA	Power noise on signal cables.	Separate cables.	Cables unrealistically far apart in PCU.
IRA CTM IHR LIDAR	Physical interference with crew movement around standard racks.	Add safety guards to prevent personnel contact of protruding items.	Problem did not arise in PCU because of easier personnel flow -- lack of physical fidelity in PCU.
Facility	Sharp edges on Spacelab rack drawers.	Smooth edges.	Not noticed in PCU because P/L chairs not accurately placed.
Facility	Spacelab rack panel lights actuated ground-fault interruptors.	Redesign light power circuit; add isolation transformers.	Circuit in PCU not suitable for use in aircraft.
MLS	Sensor placed incorrectly with respect to windows.	Reposition rack rearward.	Not evident in PCU for lack of windows.

3.4.3.3 Special Tests and Calibration Requirements for Experiments

For ASSESS II, the original management concept was that PIs would provide all requisite equipment, including artificial sources, for calibrating and checking performance of their equipment. This created problems during LSPP for two reasons. First, to provide satisfactory artificial sources can be costly and all the experimenters were very cost limited, but second, in most cases the PIs did not think far enough ahead to request special test requirements in the IRDs. Probably, if the IRD effort had been continued as the project progressed toward flight, more of the requirements would have been identified early enough to permit planned solution. However, experience of KSC personnel led them to provide sufficient schedule time to handle unplanned requirements which the PIs developed.

Many of the experiments were sky-looking and a realistic method of calibration is to use sky sources. This type of test appeals to PIs because it is relatively cheap for them and provides a direct check of experiment sensitivity. However, in most cases the final flight equipment configuration must be used for valid results. Therefore, such tests are best performed after launch site integration. Such tests could be performed with high fidelity simulators, or even during flight, but that would use valuable flight time otherwise better scheduled to obtain scientific data. For ASSESS II, a decision was made to use sky sources for the calibrations, and Table 12 summarizes these tests. They required four days during which the aircraft was parked outside and oriented to make specific sky targets available to the experimenters. Fortunately, good weather prevailed so that the sky targets were visible.

3.4.3.4. Mission Simulation Test

The all-up integrated Mission Simulation Test covered a continuous 31-hour period, and was considered a very valuable activity, not only to check out the entire system, but particularly as a training exercise for everyone involved. This was the first and only opportunity for the entire operation to be exercised as an entity before the "Spacelab flight". The test consisted of detailed activities as planned for two aircraft flights scheduled for the actual flight period, except that the aircraft was parked on the hangar apron. Communications were hard wired to the aircraft in addition to a radio link. The full cycle was exercised including payload preparation for flight, simulated payload flight operations, sleep cycle between data take periods, stowage, and preparation of the payload for landing. Some problems were artificially imposed by management to test the system.

Although everyone benefited from the training experience, perhaps the greatest benefit was derived by the flight crew. Their attempt to work to the preplanned timelines was severely tested. The Meudon computer problem was still real and required a work-around. The LIDAR data problem had not yet been resolved and tried the P/S's ability at trouble shooting. The AEES scanning receiver started out scanning poorly and finally quit. (This led to home laboratory repairs prior to the later flight period.) Initially the CTM

Table 12 - Special Testing Using Nonlaboratory Sources

Test	Requested in IRD	Comment
MLS sky calibration	No	Needed calibration of energy detected from trace gases existing in earth's upper atmosphere.
CTM sky calibration	Yes	Necessary for adjustment of temperature of reference body in experiment.
Meudon sky calibration	No	Sensitivity check.
IHR solar calibration	Yes	Needed to establish calibration factor associated with 1300 C internal reference source.
CTM solar calibration	No	Needed to establish a positive means of determining when the experiment was guiding properly on the sun.
IRA Polaris alignment	No	Needed to maximize optical alignment. Convenient infinitely distant point source.
IRA detector sky calibrations	No	Convenient source of known optical characteristics. IR intensity calibration.
IRA Saturn acquisition	No	Final check of target acquisition system.
AWS calibration	No	Calibration against night sky.

lock-in amplifiers would not lock onto the oscillating mirror reference signal. The P/S provided proper light shielding and achieved successful operation. Then it was found that the central data system would not accept CTM data when MPI was simultaneously sending data. This was not resolved during the test. Some human errors included: connection of MED heart sensors in reverse, which recorded a very low heart rate; improper setting of one experiment's central data system interface bias voltages, which showed up as distorted data; and failure to close a valve that depleted an experiment's gas supply for the balance of the tests. (Actually this was coupled with an equipment failure since the gas system should not have allowed so much gas to escape even though the supply valve was not closed.) These problem areas clearly illustrate the difficulties faced by the P/Ss, and the Mission Simulation Test experience was extremely valuable in helping them prepare for the rigors of later flight activities.

This first all-up experience for the M/S was also valuable. It was an excellent opportunity for him to further develop his own timeline activities, such as reminders to the crew for start and stop of data-take periods, the need to assist P/Ss during high activity periods, and operation of the experiment support systems. The stowage list was referred to several times and on two occasions assistance from "the ground" was required to locate needed items.

POCC and MCC operational procedures benefited significantly from the Simulated Mission Test. Also, several facility type problems were discovered and corrected as a result of the test. PI discipline on the communication links was poor at the beginning, but improved with training during the test period.

3.5 "Spacelab" Flight

Nine aircraft flights were distributed over ten successive days to simulate a total Spacelab mission. The payload flight crew, consisting of the four P/Ss and the M/S, were confined to the aircraft and the attached living quarters for the entire period except for brief moments to refill dewars. That process was handled outside the aircraft on the ground where there was more adequate space. For Spacelab, such refilling is not planned, since hold time for dewars will cover an entire Spacelab flight period.

Some support equipment aboard the aircraft and one experiment (IHR) were not automated to the extent planned for Spacelab. Therefore, "ghost" operators were used to maintain and operate the central data system and the gyro-controlled mirrors used for IHR and CTM and to reposition mirrors internal to the IHR. The ghost operators interacted minimally with the Spacelab flight crew, and performed tasks which would normally have been automated.

3.5.1 Payload Operations

The nine aircraft flights (data-take periods) totaled 53 flight hours, of which 46 were at altitude and therefore useful as data-take time. Preestablished timelines for P/S preparation and operation of experiments were used as baselines for pre-data-take periods and data-taking operations of the payload. Daily briefings and debriefings were conducted before and after data-take periods, from the MCC for flight operations and from the POCC for payload operations. As a data-take period proceeded, payload problems and flight conditions necessitated real time changes from the preplanned experiment operating periods. Communication was planned with the payload crew during flight as well as during ground based periods, but the radio communication link during flight was generally poor. The M/S coordinated communications to and from the payload crew. Communication blackout periods were scheduled into the overall timeline to represent those that will occur with Spacelab.

One change in ESA Payload Specialists was made during the flight period. This change was requested by ESA and accepted by NASA, wherein the P/S 4 backup replaced the prime P/S after flight six. It was significant only to the extent of a change in the learning curve for that position, which did seriously affect experiment operation.

Generally most experiments produced acceptable data, but many real-time problems occurred and were addressed by onboard and ground based personnel. Certain problems introduced varying degrees of alterations to flight plans during the flight period.

The overall mission activity schedule is shown in figure 16 and a listing of actual flight time is given in table 13. Basic flight plans were identified by color followed by a number designation to indicate a specific flight.

Immediately following close of the "Spacelab" flight mission an all-day debriefing was held. Each of the PIs, P/Ss, the M/S, and representatives from the various NASA centers and other organizations summarized their initial impressions of the program and its implications. Significant comments from the debriefing are incorporated into this report. A complete transcript is available at ARC.

3.5.1.1 Real-Time Flight Planning

The nine daily aircraft flight plans developed during the analytical integration effort worked out very well, and were used as a basis for specific real-time flight planning that occurred during the flight period. The most basic element which altered the original plans was the need to factor in real wind directions and velocities, in place of estimated values used earlier. Other major elements which altered earlier planning were the effects of experiment performance, which shifted PI priorities as the flights progressed, and scientific return, which altered target preferences to achieve maximum science return.

The general planned flight schedule is shown in figure 16, and was followed except for interchange of flights one and five. However, both of these flights were of the same basic type so that the daily timelines were little affected. This permutation was necessitated by a communications problem in the scheduling of a ground-truth balloon release for correlation of ozone measurements by IHR and LAS.

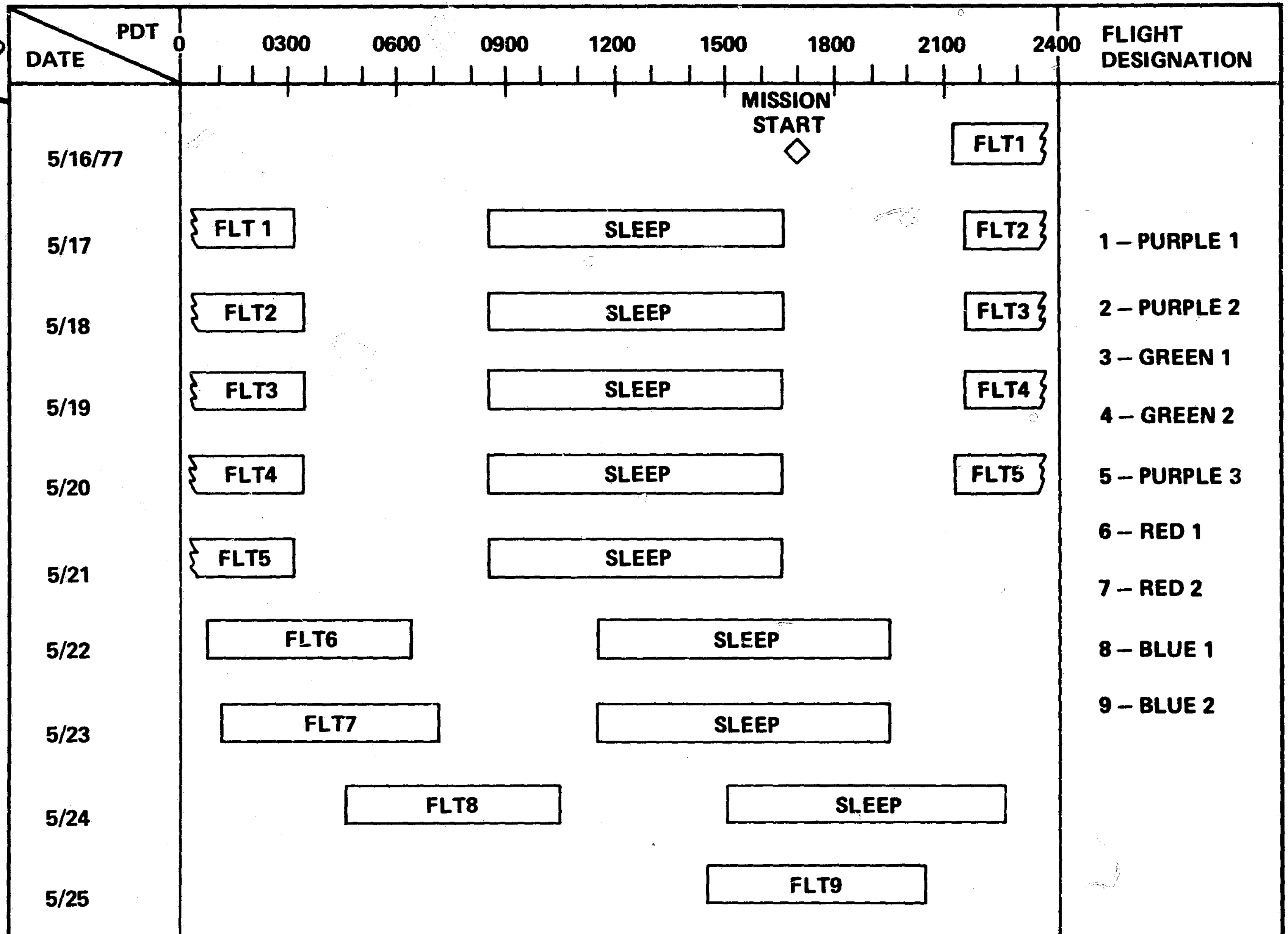


Figure 16. Daily Flight and Sleep Schedule

Table 13 - ASSESS II Daily Flight Schedule

Flight	Takeoff		Landing		Type of Flight
	Date	Time (PDT)	Date	Time (PDT)	
1	May 16	2125	May 17	0301	Night
2	May 17	2115	May 18	0305	Night
3	May 18	2118	May 19	0328	Night
4	May 19	2054	May 20	0303	Night
5	May 20	2039	May 21	0242	Night
6	May 22	0044	May 22	0643	Night to day
7	May 23	0111	May 23	0713	Night to day
8	May 24	0505	May 24	1040	Night to day
9	May 25	1412	May 25	2009	Day to night

Two types of real-time flight planning occurred. The first and most significant took place on a daily basis using results of debriefing of the flight crew after each flight. Using computers, the ground based planners then developed a specific plan for the next flight, factoring in new or altered PI requirements and updated weather predictions. Many different groups and individuals were involved in coordination of flight plans including logistics personnel, weather personnel, air traffic control, PIs, Mission Scientist, flight crew, Mission Manager, and others. The final plan which included a route map, a science priority chart for the payload crew, and a flight log and planning chart for the pilots, was passed to the aircraft approximately three hours before flight. The second type of iterative flight change was occassionally made by the flight crew during actual flight. This was coordinated with the MCC and POCC, and came about because of onboard changes in timeline activities usually caused by difficulties in experiment operation.

The combination of viewing certain astronomical targets and overflying specific ground targets made it difficult to make fundamental changes in specific flight plans, but as the mission progressed and the PIs assessed operational and scientific results, they utilized the POCC and MCC system to introduce certain changes which sought to enhance scientific return from the mission. The most significant of these changes is shown in figure 17 for the fourth data-take period. The initial plan for this flight did not include the pattern in the Salt Lake area which was to have been flown for SAR on flight three. However, because SAR was nonoperational on that flight, the pattern was rescheduled for the following day, at the expense of a lower priority SAR ground target, a salt seep in western North Dakota, which resulted in the considerable change in flight plan shown in figure 17. Other changes in plans involved lesser deviations from the original plans.

Only two significant changes in planned tracks were made during flight, and both were made with POCC approval. The first was the aborted Salt Lake pattern of flight three, and the other was during flight nine where the P/S did not have the LAS ready to operate at the start of the LAS scheduled track over Los Angeles. He requested that the subsequent LIDAR track be altered slightly to overfly the initial section of the LAS track. POCC gave approval and the change was carried out.

Each flight was planned very accurately and scheduled very tightly to achieve high efficiency of data return, and any change usually affected many succeeding events. As a result, the LIDAR was not calibrated during the mission. Overflight of the LIDAR ground-truth site at Colstrip, Montana was sandwiched between IRA data legs at an altitude considerably higher than preferred. Overflight of the Menlo Park, California LIDAR site for calibration was scheduled once (on flight two) but was not accomplished due to LIDAR equipment failure. It was never rescheduled because of a commitment to the already planned flight tracks and aircraft limitations. Also, as mentioned in section 3.3.2.1, the nonindustrial reference area at Tucson, Arizona was not overflown, because it could not be fitted into the flight planning without serious affects on other payload requirements.

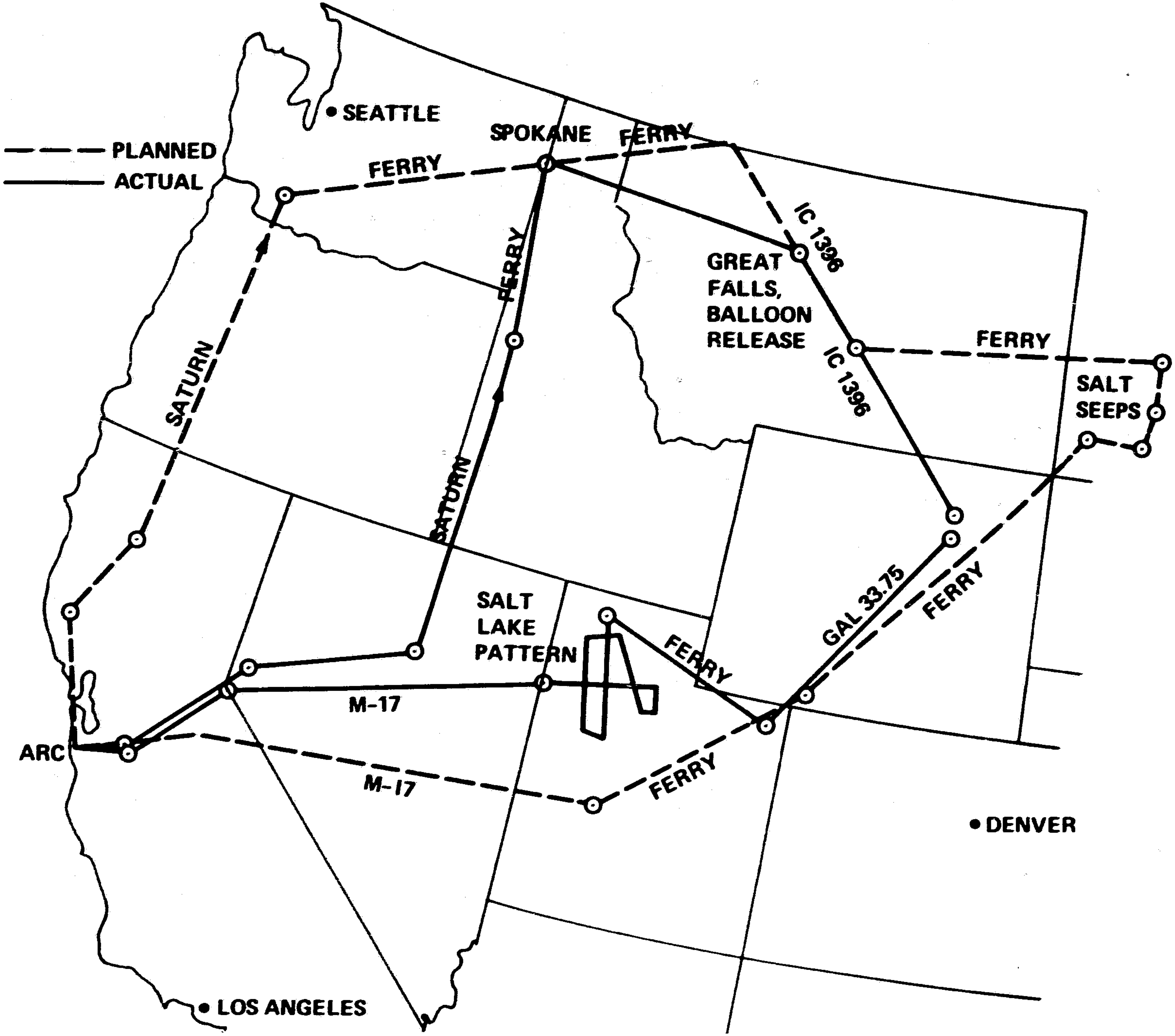


Figure 17. Planned versus Actual Flight Routes

3.5.1.2 Payload Flight Crew Activities

The following discussion of payload flight crew activities concentrates strongly on the unplanned activities and the problems encountered rather than on the routine tasks, in order to illustrate the types of payload crew activity to be expected, which cannot normally be planned for before flight.

3.5.1.2.1 Timelines and Operational Procedures

A realistic approach to handling experiment timelines was used in the ASSESS II mission. A complete package was developed prior to the start of the mission and was included in the onboard flight data file. An example of the planned inflight P/S timelines is given in figure 18 for one flight. Similar planned timelines for all flights were issued by Mission Management. The operational timeline shows the activities of each P/S to operate his group of experiments. The line for the medical experiment includes the loss-of-signal (LOS) periods. The Payload Activity Planner tried to avoid designating simultaneous prime operation of more than one experiment operated by a given P/S. This policy was successfully carried out except for frequent SAR/AEES simultaneous prime operation during day flights near the end of the mission.

The planned inflight timelines were subject to preflight review and change by the Mission Scientists and PIs in accordance with real-time changes in flight planning and specific instrument operational problems. These changes were part of the science planning activity for the next flight, but were not formalized into detailed experiment timelines. Rather, the overall agreement was reflected in an altered science priority chart and flight path plan which were read up from the POCC via MCC voice link to the M/S, who appropriately annotated his copy of the premission plans for the particular flight. By this means, flight objectives were dropped or added and the science priorities of the payload crew were altered.

Subsequently, the PIs and P/Ss worked out agreements that changed experiment timelines to accommodate the new requirements. These person-to-person agreements were not part of the formal record. In general, the P/S annotated his copy of the premission plan to reflect the desired changes. This informal approach worked effectively, yet allowed the P/S some latitude for inflight decisions. This was particularly true for P/S 2 who was also the PI for LAS. The co-PI of his experiment represented him in the POCC and agreed to the science plans for each flight, but continuing poor performance of his experiment eventually forced some deviations from planned operational priorities. Thus, P/S 2 followed operational priorities through the first four flights. During flights five through eight he used his own discretion in deviating from plan in attempting to resolve his experimental problems. During these flights the LAS was not operated in the planned mode. His attention to the experiment problems interfered with operation of the IHR, and finally near the end of flight eight it was turned completely off with the PI's preflight consent. Other deviations from planned science operating procedures included complete shutdown of experiments. SAR was shut down during flights one through four and LIDAR on flight two. Both were due to equipment failure, and the shutdowns were negotiated with the PIs. In another case, the P/S was asked by the SAR

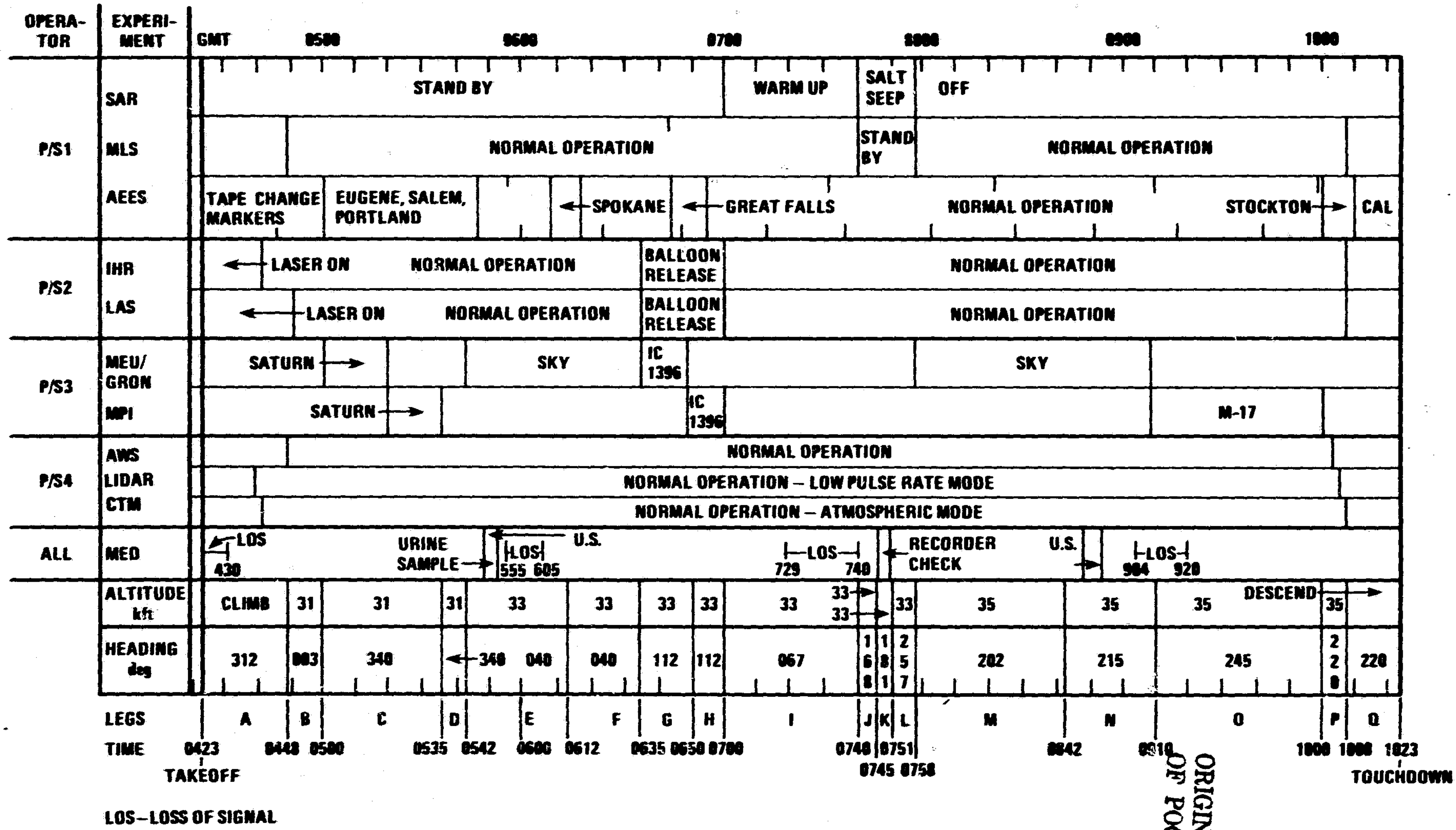


Figure 18. Typical Payload Crew Flight Timeline

PI to perform certain tests on that experiment. The P/S countered that he could not comply and also keep his other experiments in the planned operational mode. Permission was obtained from PIs in the POCC to put them in standby so that the SAR tests could be performed.

The use of printed timelines and procedures varied considerably among the members of the ASSESS II payload flight crew. The M/S occasionally referred to a timeline, but more frequently to the flight path map and the science chart. The P/Ss seldom referred to a planned timelines at all. They relied on the M/S for such information. The most frequent questions were "what data leg are we coming onto?" and "how much time to the end of this data leg?". The latter question was asked frequently by P/S 1 and P/S 3, both of whom operated computer controlled equipment. The use of printed equipment operating procedures in flight varied from none at all by P/S 1 (SAR, MLS, and AEES) to extensive use for most operations by P/S 4 (LIDAR, CTM, and AWS). P/S 2 used none for LAS, for which he was the PI, and only rarely for IHR. P/S 3 (IRA) began the mission using procedures for most operations, but apparently inflight training negated the need well before the end of the mission.

3.5.1.2.2 Mission Specialist Activities

The Mission Specialist had been assigned specific duties relative to payload operation when his position was established (section 2.4.5). His major responsibility, to act as the alter ego of the Mission Manager as a member of the payload flight crew, dictated that he be aware of the P/S activities and provide assistance when needed. He maintained surveillance of the experiment support systems as well as the experiment operations and communicated with the MCC and POCC, to report on progress during flight. He also kept the Mission Scientist fully informed regarding experiment status and problems. The P/Ss were extremely busy most of the time and appreciated the communication load being handled by the M/S so they would not be interrupted unless a problem required their participation.

The M/S logged experiment and experiment support system status, coordinated with the pilots and navigator as flights progressed, announced the beginning and end of each data leg and any deviations from plan for benefit of the MCC/POCC. The P/Ss also found it very beneficial to use his announcements to schedule their activities. This allowed them to concentrate on experiment operations without constant reference to flight progress. When problems developed, the M/S negotiated real-time solutions with inputs from the flight crew, the P/Ss and the ground elements as required.

In some cases the M/S made minor flight alteration decisions based on payload activity requirements. For example, the IRA experiment automatically carried out computer controlled raster scans of the target area. If a scan was interrupted, the information it contained was considerably reduced in value because it could not be computer averaged with other scans. To avoid interruption by aircraft turns, P/S 3 almost invariably requested another two to four minutes on a data leg to complete his scan. These requests were granted by the M/S without consulting the POCC if it appeared that the remainder of the flight path would not be significantly altered.

3.5.1.2.3 Payload Specialist Activities

The P/Ss were each assigned specific responsibilities for experiment operation. The following gives some detail to illustrate how each P/S spent his time. P/S 1, who handled SAR, AEES, and MLS, was able to remain at his Spacelab rack station much more consistently than the others. Even his extensive troubleshooting on SAR during the first four flights was on a component mounted in the Spacelab rack. P/S 1 was also much more driven by periodic duties than the others. The AEES experiment included four tape recorders, one with a 24-minute tape duration and three with 48-minute cycles. The P/S used two alarm bells, which he reset after each tape change, to remind himself that a tape change was imminent. Only two activities normally took P/S 1 away from his prime station; changing the sweep limits of the AEES swept receiver which was infrequent, and the 24-minute AEES tape change cycle. Little commute time was involved in the latter activity since the recorder was mounted close by. The 48-minute tape change cycle did not take P/S 1 from his control position.

P/S 2 spent considerable time at the IHR experiment. The PI occasionally requested that the mode of pollutant laser operation be shifted during flight. This required 30 to 40 minutes of concentrated work. Also, numerous efforts were made by the P/S to adjust operating parameters in an attempt to increase the low IHR reference laser power. For LAS, poor performance of the experiment and consequent troubleshooting efforts by P/S 2 frequently took him away from his central position. This was especially true on flights five through eight when he concentrated on resolution of the LAS problem. During these flights he spent considerable time in the forward cargo area making optical adjustments, on the laser package, with P/S 1 relaying to him the results as indicated by a stripchart recorder at the LAS central control position.

The P/S 3 timeline (IRA) was oriented almost entirely around the IRA observations of astronomical objects. In addition to the observations, he spent the balance of his time doing either internal calibrations at the start of each flight or measuring sky brightness. His operating position was centered among the several IRA racks of equipment and the telescope.

P/S 4 (AWS, CTM, and LIDAR) spent more time away from his control station than any other P/S. Two major factors brought this about; the right viewing AWS TV camera had a persistent poor focus problem (eventually both cameras), and the CTM centralization of controls was not sufficient for full operation of the experiment from the central control position. For AWS, efforts to correct the focus had to be performed at the cameras, and he spent much time during the early night flights working with the right viewing camera. Later, when both cameras started giving trouble, starting with flight six, he spent still more time at AWS. The experiment was turned off on flights eight and nine as planned which relieved the P/S workload. The CTM centralized controls allowed the P/S only to start and stop the linear motion mirror, the oscillating mirror, and the chopper wheel. Any other adjustments had to be made at the CTM rack, about 10 meters from the central control position. Also, while outputs of the lock-in amplifiers were displayed at the central position for quick-look information, the stripchart recorder, which required annotating if the record was to be meaningful, was at the CTM rack. Thus, especially during data legs of prime CTM interest, the P/S tended to remain at the CTM rack rather than travel frequently between it and his Spacelab rack station. The LIDAR required only occasional visits, except for the first flight when the P/S was seeing real-data for the first time and he spent some time at the noncentralized instrumentation to be sure he had all controls set properly.

3.5.1.2.4 Effectiveness of Central Controls

It was impractical to mount all experiment controls in the Spacelab-like racks for ASSESS II. Therefore, the major controls were centralized at the crew positions with ancillary equipment and detectors located throughout the cabin area. The extent of centralized control was such that well into the flight, after everything was turned on, and if experiments were operating normally, the P/S could remain quite constantly at his prime operating station at the Spacelab racks. During turnon of experiments, all three P/Ss had to be away from their prime stations for periods of 5-15 minutes, or longer if there were problems, to accomplish turnon procedures at each experiment station that contained components not mounted in the Spacelab racks. Experiment difficulties encountered during flight required P/Ss to spend more time than planned working with ancillary adjustment and control devices on the experiments per se, which were located at distances up to 20 meters from the central control station. Although the overall timelines were not significantly altered, and the science priorities were not changed, except on a few deliberate occassions, the functions within the blocks of time allocated to experiment operation were applied differently than planned to address problems. Some of this inefficiency of operation could probably have been eliminated with further redesign of the experiments than was practical for ASSESS II.

On Spacelab, experiment design will require centralization of all adjustment and control devices for experiments on the Spacelab control panels in the pressurized module, so that whatever actions are required will not involve the long distance traverses necessitated in ASSESS II. However, the problems encountered on ASSESS II illustrate the desirability of getting the P/Ss involved in the early design of experiment control layout to ease their workload during flight.

3.5.1.3 Experiment Performance

Many of the experiment problems encountered during ASSESS II are typical of the types of problems to be expected during Spacelab operations, and it seems appropriate to concentrate this discussion on the problem areas rather than the routine experiment operations for the benefit of Spacelab planning. While some of the problems are unique to aircraft operations or operation within the atmosphere, comparable problems may well be expected on Spacelab. Only representative experiment performance is discussed in this section. Appendix C gives added detail for each experiment.

In general, the payload performed quite satisfactorily during the flight mission although there were exceptions. Two experiments were of very marginal sensitivity through most of the mission and, although one was finally improved somewhat, the overall data return from both was very limited. A third could not be made to operate satisfactorily within mission constraints, but was restored to full capability at the sacrifice of its "Spacelab" status. All other experiments yielded a substantial science return for the PIs.

Many of the experiment difficulties were apparent during the first flight period. Also, it became quickly evident that several, though not all, of the operational problems could have been avoided with better check-out before flight. When the Systems Level Integration team turned the payload over to the Launch Site Integration team, they turned over 15 open items, but the solutions to those items seemed straightforward, and the payload was judged to be in good shape. Again following flight vehicle integration, all open items had been closed and the experiments were determined to be flight ready. The PIs had had complete access to their experiments for checkout. However, some aspect of almost every experiment evidenced less than optimum operation almost immediately after launch.

Of the experiment malfunctions which were related to insufficient preflight testing, perhaps the most serious was with SAR, where the two prime experiment data recorders would not function simultaneously with a consequence of no initial recorded data return. Repeated efforts by the P/S, with remote assistance from the PI in the POCC, failed to locate the difficulty. Only after a decision following flight four to declare the experiment a failure by Spacelab standards, and a member of the PI staff was allowed to go aboard, was it found that the recorders were improperly powered from two dc power sources which opposed each other. The fix was simple, but it was determined that preflight checkout had failed to operate both recorders simultaneously as planned for flight, and the malfunction was missed.

The SAR recorder problem illustrated the need in the Flight Data File for some insight within the experiments for purposes of troubleshooting. As stated earlier, it is the intention in the Spacelab era to leave responsibility for experiment operation in the domain of the PI. Accordingly, ASSESS II mission management did not request any information within experiments except for safety. Much time was spent by the payload crew during the flight mission trying to identify the SAR recorder problem in the flight vehicle electrical systems. With only a general electrical schematic of the experiment, the problem within the experiment might well have been quickly identified and fixed.

In the case of LIDAR, the P/S attempted (after flight one) to charge batteries while the instrument was turned on, which blew a fuse. The routine for daily battery charging was included in the P/S timeline, but was not exercised during preflight checkout. All data from flight two was lost, after which the source of the problem was identified and fixed.

For IRA an optics alignment problem became apparent during the first flight period and hampered experiment performance throughout the mission. During Systems Level Integration a test device was utilized to check the optics alignment, but somehow during flight vehicle integration the alignment apparently shifted. The ground based alignment system had been constructed for laboratory use and could not be utilized on the flight vehicle. While this problem can nominally be charged to lack of preflight testing, the omission of flight vehicle alignment was deliberately planned. Provision for a flight vehicle alignment device was not practical for ASSESS II, and previous similar installation experience had demonstrated that it was not needed. How the change of alignment occurred in this case was not determined.

Some additional difficulties showed up during the first flight which were associated with the flight environment and could not have been easily addressed during preflight testing. In the case of AEES, static electricity built up and periodically discharged from the antenna mounting plate producing noise interference on the signal channel. Grounding of the plate had not been specified for the installation and air seals around the plate isolated it. While the net result on data return did not turn out to be serious, the P/S spent inordinate time during the mission trying to identify and solve the problem which was suspected to be within the instrument system. The simple cause of the difficulty was discovered following the Spacelab simulation program.

The MLS experienced a basic sensitivity problem on the first and all succeeding flights. The experiment had been well automated, compared to its pre-ASSESS configuration, to reduce P/S workload. These changes apparently had an adverse effect on sensitivity that was not observed during tests at the home laboratory, and it was not planned to repeat these tests at ARC. When the problem surfaced for the first time in flight, it was recognized as serious, but the PI was not able to devise a work-around that could be implemented by the P/S during the mission. After the mission the PI was able to improve the sensitivity of the instrument by using a more complex manual mode of operation.

For LAS, early flight experience revealed that no laser signal was being reflected from the ground; a prerequisite for proper experiment operation. Aircraft motion, or a means to simulate it, was necessary to discover this problem. The P/S (who was also the PI for this experiment) made many adjustments throughout the flight period and was finally able to get some return signal, but the result was never as satisfactory as desired.

In the case of AWS, difficulty was experienced in maintaining focus on the IR cameras. Although they could be focused on the ground, one of the two cameras in particular, lost focus during flight. Despite considerable inflight effort to improve the focus, the P/S had only limited success. Since the cameras could be used only at night, at low ambient light levels, there were few opportunities to address the problem on the ground during the first half of the mission.

In general, the P/Ss did an excellent job in performing the routine experiment operations work, interspersed with concentrated periods of troubleshooting. The P/Ss, as well as the M/S, agreed that adjustment to the flight environment and the routine of operations required about three days. This is a high percentage of a mission period lasting only ten days. Unfortunately, the onslaught of operational problems showed up immediately after launch during initial experiment operations, based on ASSESS experience, and this is the period when the flight crew is the least acclimated and prepared to address difficulties. This same limitation will certainly apply to Spacelab, and probably to a greater degree with the added requirement for adjustment to zero-g.

3.5.1.4 Onboard Data Handling

The experimenters for ASSESS II had three choices in handling their data. They could provide for data processing wholly within their own experiment, they could interface with the central data system (ADDAS) which had significant storage and processing capacity, or they could use the CV-990 central data system in addition to their own systems. There were certain advantages in using the central data system because it interfaced with the aircraft systems to obtain housekeeping data such as airspeed, altitude, latitude, longitude, ambient temperature, etc. All experiments require certain of the housekeeping data for their data calculations, and interacting in real-time with the central system for this purpose was much more convenient than picking up that data in printed form after the flight mission for subsequent data processing. Another key value in using the central data system during ASSESS II was for quick-look by the PI in the POCC as the flight mission progressed. A ground rule of the ASSESS II mission permitted transmittal of basic data from the central data system to the POCC and a ground-based computer on a daily basis to simulate downlink of data from the Spacelab. However, a disadvantage in using central data system was the necessity to establish a proper interface between the central system and the experiment.

With the advent of minicomputers, there appears to be a tendency to build computer capacity into specific experiments. Although this increases experiment cost, it gives the PI more complete control of his own data handling, and the total data system can, theoretically, be perfected in the PI laboratory as the instrument is developed for flight, thus eliminating one of the most difficult and complex interfaces during integration. The use of an internal experiment data processor still leaves the experimenter an option to pass either all of his data, or representative data, to the central system for storage and possible quick-look opportunity. Storage of data in both the experiment and the central data system to increase confidence of success has been a growing practice with other CV-990 PIs.

Table 14 outlines the method of data handling used by each ASSESS II experiment and some indication of difficulties encountered. ESA/SPICE specifically encouraged the European experimenters to use the central data system to gain experience both for ESA and the experimenters. Thus, although LIDAR and the MED experiments both had internal experiment tape recorders, they interfaced with the central data system. The AWS camera outputs were recorded on video tape within the experiment.

Table 14 - Data Handling and Recording Methods

Experiment	PI Supplied	Central Data System		
		Experiment Data	Housekeeping Data	Data Display
IRA/Meudon	Video magnetic tape, digital magnetic tape, and minicomputer.	-	-	Water vapor overburden on CCTV, and line printer.
IRA/Groningen	Cassette magnetic tape.	-	-	-
IRA/Max Planck	-	1 channel, analog	7 channels, analog	Average spectra on CCTV and hard copy.
AWS	Integrated video magnetic tape for two cameras sequentially.	-	-	-
LIDAR	9 channel digital magnetic tape.	Digital	-	Aerosol spatial distribution, numerical array on hard copy.
MED	4 analog cassette tapes (one each P/S), 4 channels each.	8 channels analog, 1 digital	4 channels, analog	2 data to housekeeping channels, CCTV, and line printer.
STM	-	Digital	7 channels, analog	Fourier transforms on hard copy. Stabilized mirror position on CCTV.
SAR	2 film recorders - 4 channels total.	-	3 channels, analog	Housekeeping signals on CCTV and line printer.
MLS	15 channel digital cassette tape and minicomputer.	Digital	1 channel, analog	-
LAS	-	2 channels, analog	2 channels, analog	Ozone concentration on CCTV and line printer.

Table 14 concluded

Experiment	PI Supplied	Central Data System		
		Experiment Data	Housekeeping Data	Data Display
IHR	-	Digital	4 channels,	Sun azimuth and elevation, mirror position on CCTV and line printer.
AEES	Digital magnetic tape and 3 analog cassette tapes.	-	-	-

The infrared telescope system (IRA) used a complex interaction between self-contained equipment and the central data system. The telescope itself was controlled by an internal minicomputer system, and the target pictures were recorded on an internal video tape unit with TV display. The Meudon/Groningen sensor output was stored on experiment-contained digital magnetic tape on both reel-to-reel and cassette recorders (a separate record for each PI). Housekeeping data from the central data system was added into these tapes. The MPI sensor output was fed directly to the central data system for storage and processing to produce TV displays of average spectra along with hard copy reproduction for onboard reference.

Most of the U.S. experiments had interfaced with the central data system on previous CV-990 missions. This might be considered representative of reflights of experiments on Spacelab, where the problems of interfacing with the data system had been solved previously. In the case of AEES, the very late authorization for flight eliminated any possiblity of interfacing with the central data system. Their main interest in the central data system was aircraft position data which could be correlated later with their analog and digital tape records. The LAS had some early interface problems with the central data system, but these were minor and rather quickly solved.

The data recorders used on the ASSESS II payload all functioned quite well except in the case of SAR where the major power supply problem previously discussed prevented recorder operation. The IRA video recorder jammed, but was soon fixed by the P/S. Poor tape quality apparently prevented loading some tapes on the AEES, and the AWS video recorder required minor attention once during playback to the POCC.

The MLS minicomputer functioned quite well throughout the mission, but the IRA minicomputer, which was the newly developed portion of the equipment to control the telescope, gave considerable trouble. Several unscheduled interruptions negated the data cycle and required restart by the P/S.

The central data system faltered due to some internal timing problems on several occasions throughout the mission, but was usually brought back on line rather quickly by the ghost computer operator. One of these occurred in carrying out the CTM computing program during the early part of the mission, but was generally eliminated after the first few flights. Data for the MED experiment originated from sensors worn by each P/S, and it was necessary for them to plug into the central data system periodically at their main control stations to provide quick-look data for the PI. With their very busy schedule and extensive mobility, they did not feed data to the central data system as often as the PI desired. Thus, his quick-look data was sparse and only marginally adequate to maintain surveillance of his experiments. However, tape cassettes worn by each P/S had been used extensively in previous programs by the PI, and were very reliable in total retrieval of the MED data.

Although data handling interface problems were numerous during the integration periods and particularly during the early part of the flight mission, in general, data retrieval was very good from the onboard equipment. The problems that did occur illustrate the diligent effort required by the experiment staff and the flight crew.

3.5.2 Ground Operations

3.5.2.1 Payload Operations Control Center

A Payload Operations Control Center (POCC) was established at ARC for management of the payload during the flight period. It was organized and operated by MSFC in a manner similar to their plans for Spacelab 1. They staffed the POCC with a Payload Operations Director, a Payload Activity Planner, and an Operations Coordinator, along with the Mission Scientist and each PI or his representative from each experiment. Voice communications were provided to maintain contact among all elements of the POCC, with the payload crew, and the MCC throughout the flight mission.

A video downlink and a text uplink similar to the system planned for early Spacelab flights were also available to the POCC and were operated by the MCC. In the POCC, the Mission Scientist coordinated PI science requirements and science communications with POCC management and the payload flight crew.

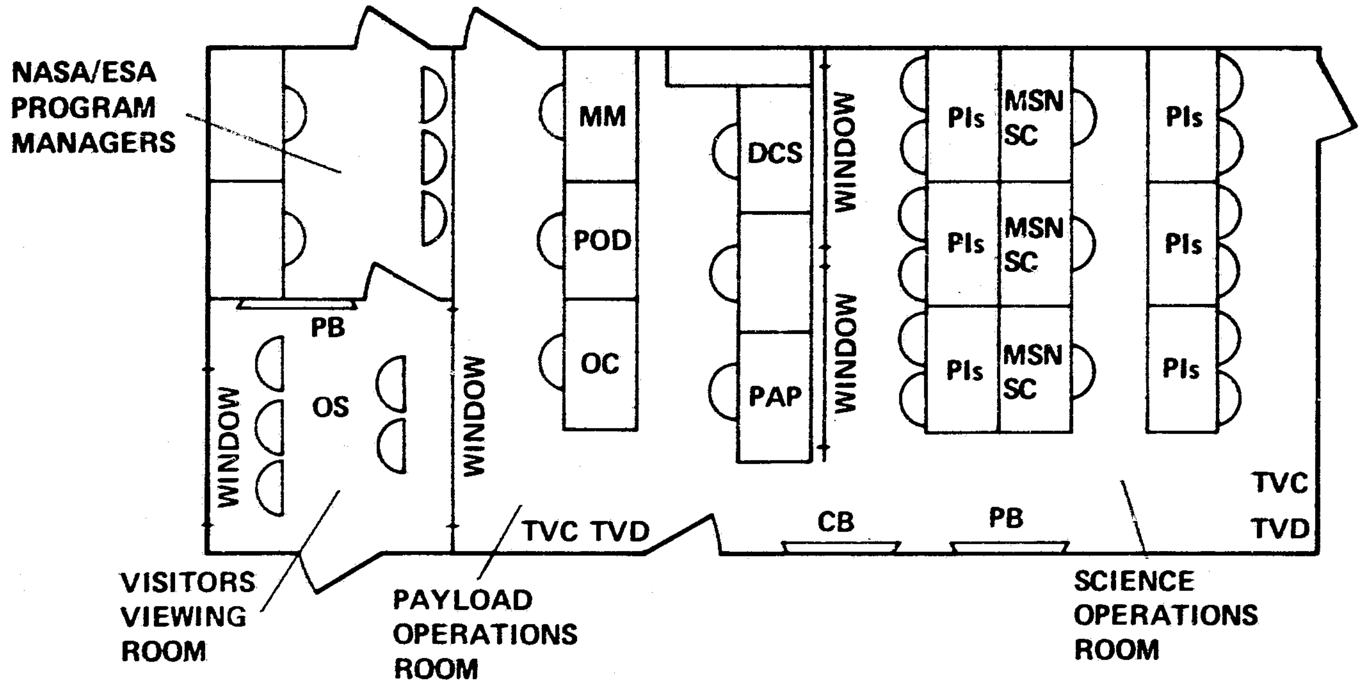
POCC operations consisted of:

- Updated payload planning on a daily basis;
- Briefing of the payload crew for each day's activities;
- Communications with the payload crew to address problem areas and coordinate decisions;
- Daily payload crew debriefing;
- Quick-look scientific data analysis by the PIs.

The floor plan of the POCC operational areas is shown in figure 19. Additional space in a contiguous area included a conference room, a data room, and a large office area for the PIs.

Organization and management for the POCC is shown in figure 20. General supervision of the POCC operation was provided by the Payload Operations Director (POD). This position was manned on a 24-hour basis by two MSFC personnel. The POD, in addition to overseeing the POCC staff, was the principal channel for communication with the Mission Control Center (MCC). The POD maintained a log of his activities and of all communications.

The Operations Coordinator was the primary communicator between the POCC and the payload flight crew. Thus, it was important that the Operations Coordinator be intimately familiar with the payloads. For ASSESS II, the ESA and NASA backup P/Ss were assigned to this position on a rotating basis. A detailed log of communications was maintained by the Operations Coordinator, somewhat duplicating that maintained by the POD. Two of the ESA backup P/Ss were nonnative speakers of English, and they had considerable difficulty, particularly because of the poor quality of the radio communications link to the aircraft. As a result, the POD assisted in handling much of the communication with the aircraft during flight.



LEGEND:

MM	MISSION MANAGER	CB	CHALK BOARD
POD	PAYLOAD OPERATIONS DIRECTOR	PB	PLOT BOARD
OC	OPERATIONS COORDINATOR	TVC	TV DIGITAL TIME MONITOR
PAP	PAYLOAD ACTIVITIES PLANNER	TVD	DOWNLINK TV MONITOR
DCS	DATA COMMUNICATIONS SPECIALIST	OS	OVERHEAD SPEAKER
MSN SC	MISSION SCIENTIST		
PIs	PRINCIPAL INVESTIGATORS		

Figure 19. Payload Operations Control Center Layout

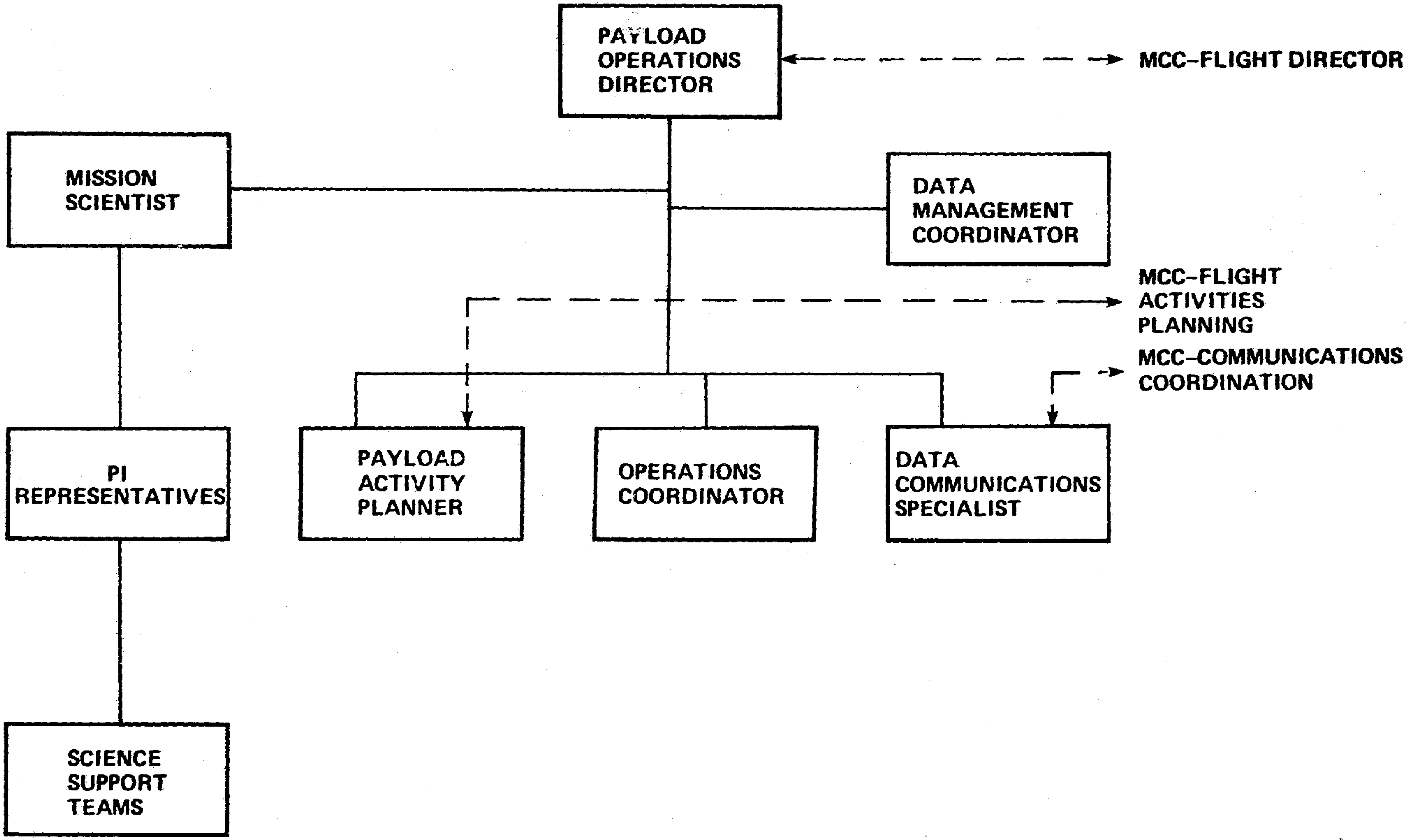


Figure 20. Payload Operations Control Center Organization

The Payload Activity Planner (PAP) was primarily responsible for the preparation of flight plans in consultation with the MCC, the Mission Manager, and the Mission Scientists representing the experimenters. The position was manned by two MSFC personnel nearly 24 hours a day. As described in section 3.5.1.1, preliminary flight plans were prepared in advance of the total mission. However, for each data period both updated weather information and updated science priorities were used to prepare a final daily flight plan. Figure 21 details the various steps and timing in the work of the Payload Activity Planners.

The position of Data Management Coordinator was handled by one data specialist supplied by ARC. He prepared and managed a schedule for use of ground based data handling and computation devices by the PIs after receipt of downlinked data following each flight. He was also responsible for collection and retention of all downlinked data for ultimate use by the PIs.

The position of Data Communication Specialist (DCS) was not manned during the simulation period to the extent planned. The DCS had been expected to handle the recorder for air/ground communications but this task was not justified during much of the flight period because of the air/ground link difficulty. Except for the handling and logging of data following each flight, there was little for this staff member to do.

The NASA and ESA Mission Scientists rotated assignment in the POCC. The Mission Scientist acted as the primary liaison between the PIs and the POCC payload managment and activity planning staff. During daily briefings and debriefings with the payload flight crew, the Mission Scientist was in charge of scheduled PI discussions with his counterpart P/S, and insured full understanding of total flight objectives. He coordinated science priorities with the PIs and established the list of priorities published by the POCC for each data-take period. Most of the planning activity took place during non-data-take periods. After each data-take period the NASA assistant Mission Scientist prepared a short science summary of the results attained by each experiment.

The PIs participated in POCC planning activities by providing, through the Mission Scientist, their requests for priorities and changes in operations plans. It had been planned that a member of each PI team would be in the POCC during the entire data-take period to track experiment operation and be available for problem consultation. However, this plan was negated due to the poor radio communication link, and it was agreed only that each PI or his representative need be quickly available if required. A representative of each experiment was present in the POCC for daily flight debriefing, and during these periods usually the PI would personally discuss his experiment with the cognizant P/S to the maximum extent that scheduled time would permit.

A position was provided in the POCC for the Mission Manager. It was purposely planned that he would have no direct operational responsibility so that he could maintain an overview and carry on discussions with the various operations personnel that led to decisions to be implemented by the POCC staff. Likewise space was provided in the POCC for the NASA and ESA Program Managers for observation and immediate consultation in case of a major mission problem.

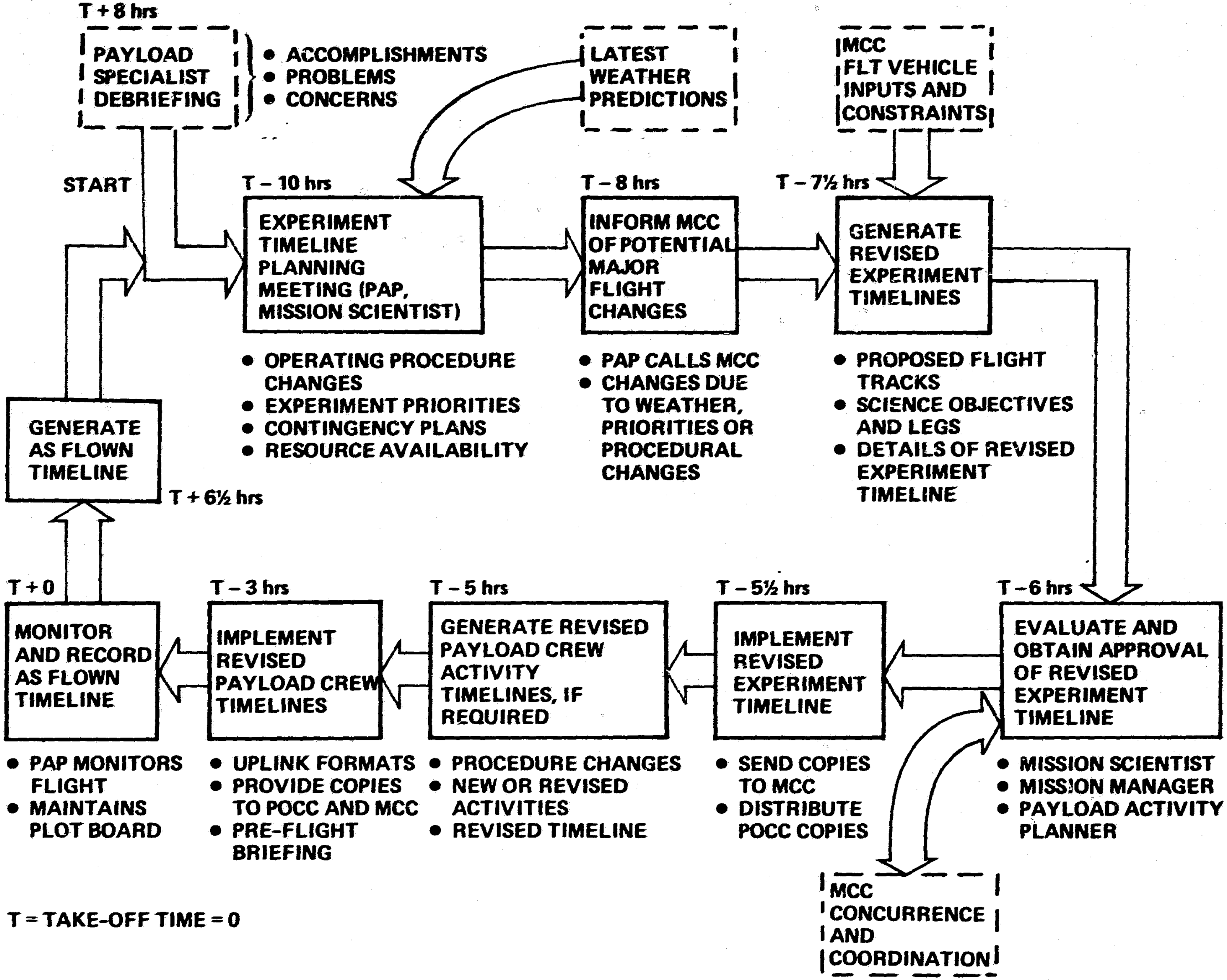


Figure 21. Payload Activity Planning Sequence

3.5.2.2 Mission Control Center

The Mission Control Center (MCC) was established to manage flight vehicle operations during the simulated Spacelab flight mission. It was located adjacent to, but separate from the POCC. Three JSC personnel staffed the MCC while ARC provided support to JSC in direct management of CV-990 flight operaions. The MCC was not closely analogous to Spacelab plans for an MCC because orbiter operations will be significantly different from CV-990 operations. However, an MCC was included in the ASSESS II project to complete organizational interactions and gain interactive experience with the Mission Management concept for payload operations. It was manned 17 hours per day with no coverage provided during the payload crew sleep period.

Activities performed by the MCC in its abbreviated version included the following:

- Aircraft flight plan development;
- Updating of Integrated Crew Activity Plan for each flight;
- Approval of flight passenger manifest;
- Management and coordination of overall mission timeline;
- Interfacing with flight vehicle ground crew;
- Coordination of food service for payload crew;
- Transmission of uplink messages;
- Receipt and distribution of downlinked data materials;
- Participating in briefing and debriefing of payload crew.

3.5.2.3 Quick-Look Data Assessment

During the data-take periods, activity in the POCC was relatively quiet due mainly to the communications problem between ground and the aircraft in flight. Upon landing, ground communications links were established and the postflight debriefing began with each experimenter allotted ten minutes for discussion with the payload crew about results from his experiment. This activity was under close supervision of the Mission Scientist in order to complete scheduled discussions within the timeline.

During postflight debriefing other simultaneous activity was occurring to downlink data. The AWS video signal was downlinked for PI perusal as a slow frame-rate signal which required less than an hour for the total flight record. A video monitor was used for this purpose. (The AWS equipment could also be used to transmit the Meudon video record, but no operational situation arose that made this necessary.) Simultaneous with the AWS video transmission, telemetry of data was simulated by physical removal from the aircraft of many data records as follows: central data system magnetic tape, memory disc, and houskeeping printout; AEES cassette, reel tapes, and a stripchart; SAR film; MLS cassette tapes and stripcharts; EMI digital data tape; Groningen cassette tapes; CTM stripchart; and IRA/Meudon data tape and hard copy record. IRA/Meudon video tapes and medical tapes were stored onboard until the end of the mission.

A computation facility was provided for the use by the PIs for limited data processing of quick-look flight data. This facility included a basic computer capability quite similar to the central data system computer onboard the aircraft, two interactive video computer terminals, and a hard copy printout unit for each computer terminal.

Immediately following the end of a daily flight, each PI submitted a request for specific data that he wished to examine for quick-look assessment. These data requests, in terms of data-slice time, were processed by computer personnel, who created a disc file for each flight, containing only the requested data slices. Construction of the quick-look disc file took place during the postflight debriefing, and was finished about the end of the debriefing period. This new file was then accessed by the PIs for examination of their data using the two video terminals located in the data analysis area adjacent to the POCC.

While the special disc files were being constructed, both MLS and IHR were reading out data directly from a storage disc recorded in flight. one on each POCC data terminal. MLS received numerical printouts of data at one-minute intervals from which a simple plot could be made. For IHR, the computer developed plots of any one of ten parameters selected by the PI.

The Medical experiment obtained a limited one-minute interval printout of P/S body temperatures and heart rates primarily as a check on the operation of their experiment equipment.

IRA/MPI obtained a numerical printout of signal strength from which to select complete scans of interest. Some selected data scans were plotted by the computer after a complex averaging process to smooth the data. The result was a group of points representing average signal strength at several wavelengths measured by the MPI tilting filter spectrometer.

The LIDAR presentation calculated by the computer was a matrix of numbers representing signal strength as a function of time. In addition, plots were calculated and presented on the video terminal.

LAS obtained a numerical presentation of data for inspection, from which plots were made of five experiment parameters as a function of time.

Once the special disc file became available, one of the computer terminals was used exclusively by CTM. Their program permitted examination of the operation of the lock-in amplifier by recreation of a stripchart record, tabulation of numerical data, and development of interferograms following a fast Fourier transformation of the raw data. The bulk of the time was used in calculation and examination of interferograms, each of which took a minute or more to be calculated and displayed on the terminal. Those that appeared satisfactory without excessive noise were preserved for later analysis by making hard copies.

The Groningen PI on the IRA had his own equipment for examination of his signal tapes and stripchart records. SAR did not inspect their experiment outputs in the POCC, but rather sent their records directly to JPL for processing.

The quick-look data processing and examination in the POCC worked out very well. The PIs were very pleased with the arrangement. Of course, data examination was of a preliminary nature for the primary purpose of checking equipment operation and for consideration of change during the next data-take period. Further examination of the data was left for attention at the PIs' home laboratories.

3.6 Documentation

A special objective of the ASSESS II mission was to simplify procedures and minimize the amount of paper work necessary to accomplish the mission, consistent with plans for Spacelab. Three aspects of ASSESS II management had a strong influence on documentation planning: 1) the centering of payload responsiblity in the Mission Manager, 2) full PI responsibility to develop good and reliable experiments, and 3) direct participation by both PIs and P/Ss in payload integration. These management features were the base potential for a low-level system of formal documentation, with face-to-face discussions and direct support of the best qualified personnel in place of detailed procedures and hardware verification required of the PI.

These considerations led to significant discussions in the Mission Steering Group, and a Baseline Documentation and Information Flow for ASSESS II was issued by the MSG about 10 months before flight. That documentation plan, shown in figure 22, represented an early viewpoint of optimistic desire for a very few documents to implement the mission. The plan was followed in a general sense, but many individual documents were prepared and issued. Little documentation planning and control was pursued by mission management, even though the documentation issue was a special objective of the mission.

ASSESS II addressed only the documentation requirements necessary to integrate and operate the payload. There was no intent, to evaluate flight vehicle documentation analogous to the orbiter system, except as it would pertain to interfaces with the payload components or their operation.

3.6.1 Document Classification

The actual documents issued by the various participants and used in the mission are listed in table 15. Top level interagency agreements between NASA and ESA Headquarters are not included. Also, ESA documentation used for ESA payload integration and checkout in Europe is not included. The documentation is divided into three classes as follows:

CLASS A Reference Documents - not mission unique

CLASS B Payload Interfacing Documents - mission unique

CLASS C Internal Working Documents

Much discussion about documentation took place in management echelons of NASA as the ASSESS II mission progressed. Referring to the three classes of documents listed above, little concern existed for CLASS A documents, which for Spacelab will be issued as handbook-type documents and will not constitute new documents for each mission. Also, there was little concern for CLASS C documents, which are internal working documents and do not materially affect other organizations. The CLASS B interfacing documents were of prime interest, because they are the type which can create extensive requirements on other organizations and compound cost.

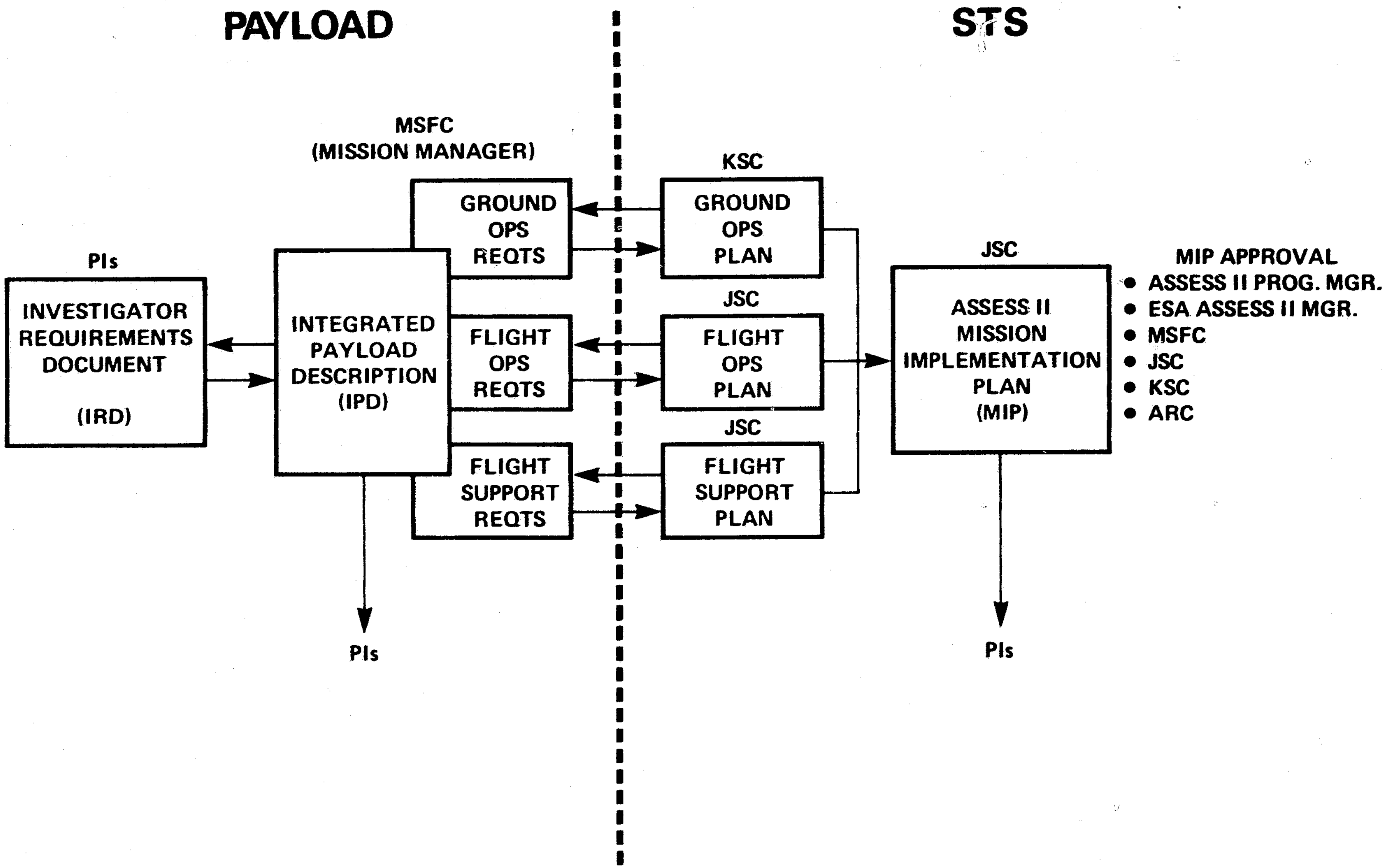


Figure 22. Baseline Documentation Plan

Table 15 - ASSESS II Documentation

CLASS A - Reference Documents

- STS Rules
- Ground Operations Reference Document
- Launch Site Implementation Plan (Part A)
- POCC Requirements
- POCC Operations Implementation Procedures
- POCC Operations Handbook
- MCC Console Handbook
- CV-990 Experimenters' Handbook

CLASS B - Payload Interfacing Documents

- Payload Mission Rules
- Mission Implementation Plan
- Investigator Requirements Documents (one per experiment)
- Experiment Drawings and Stress Analyses
- Payload Operation Procedures
- Payload Level IV and Launch Site Ground Operations Requirements Document
- Payload Configuration Drawing
- Experiment Installation Sketches
- Experiment Installation Cable Interconnect Diagrams
- Payload Flight Data File
- Payload Stowage List
- Level IV Integration Implementation Document
- Launch Site Integration Implementation Plan (Part B)
- Operation and Maintenance Instruction
- Payload Flight Definition Requirements Document
- Data Requirements Document
- Detailed Payload Crew Activity Plans
- Payload Operator Requirements and Preliminary Training Plan
- Payload Specialists Training Implementation Document
- Integrated Mission Simulation Plan
- Integrated Summary Crew Activity Plan
- CV-990 Daily Flight Plans

Table 15 continued

CLASS C - Internal Working Documents

Level IV Integration Processing

- Investigator Log (one per experiment)
- Diagrams and Procedures
- Test Procedures
- Problem Reports
- Test Preparation Sheets
- Discrepancy Reports
- Work Authorization Documents

POCC Operations

- Director's Log
- Payload Planner's Log
- Communicator's Log
- Final Flight Plans
- Science Plan Chart
- POCC Operations Timeline
- Payload Crew Timelines
- Data Slice Requests (one per experiment as required)
- Data Terminal Time Assignment
- Record of Data Offloaded from Aircraft
- As-Flown Data Logs (postflight)
- Science Summary Reports (postflight)

Launch Site Processing

- Problem Report
- Discrepancy Report Tag
- Engineering Change Notice
- Operational Checkout Procedure Deviation
- Test Preparation Sheet

MCC Operations

- MCC Console Log
- Flight Support Work Schedules
- Data Retrieval Log

3.6.2 Content of Documentation

3.6.2.1 Reference Documents (CLASS A)

Referring to the ASSESS II documents listed in table 15, most of the CLASS A documents are obviously handbook or reference type documents which would apply to successive missions, and would need only minor update from time to time. KSC issued a Launch Site Implementation Plan in two parts. Part A was handbook type information describing procedures by which they proposed to handle launch site activities. (Part B, found under CLASS B documents, described plans for the specific payload at hand.) The POCC Requirements document listed under CLASS A was the MSFC payload Mission Manager's general requirements for a more or less standardized POCC facility which would serve all payload missions. The POCC Operations Implementation Procedures and the POCC Operations Handbook were both one time type issuances and could have been combined.

3.6.2.2 Payload Interface Documents (CLASS B)

Probably the most basic interface documents for the ASSESS II mission were the Investigator Requirements Documents (IRDs) issued by the Mission Manager to each PI in questionnaire format with space provided for each answer. One IRD was prepared for each experiment, and they are discussed at length in section 3.3.1. The objective to create only one interfacing document between management and the experimenter appears to have been desirable and valid. Significant progress was made during ASSESS II in developing a format for the IRDs, but it quickly became apparent that much improvement is required in the format to eliminate redundancy and clarify the questions. The IRDs were well accepted by the experimenters, after the initial shock for some as to the number of requirements and interfaces which were important to specify, and had to be addressed sooner or later. It should be noted that the IRD did not go into details internal to the experiment; the selection and use of components (except for safety features) was a PI decision. Operational reliability was his responsibility and no justification or analysis was required.

Unfortunately, the IRDs did not get a full trial during ASSESS II. The two specific attempts to establish IRD information, which were several months apart, resulted in two separate IRDs with some difference in format and they were not consolidated. The IRD effort was terminated after the second analytical integration. Mission management filled out the IRDs in most cases, based on discussions with experimenters, but the completed documents were not fed back to all experimenters for concurrance until much later.

As plans for experiment integration developed, it was generally recognized that the IRDs should have been continually updated to be fully useful, but it was too late to recover that effort, and the balance of interface information which became available during the last five months before launch was handled on an ad hoc basis.

In addition to the actual IRD documents, the PIs submitted appropriate drawings and sketches of their equipment to identify physical interfacing details. Stress analyses were also submitted to satisfy safety requirements stated in the CV-990 Experimenters' Handbook. These drawings and stress analyses were really adjuncts to the individual IRDs for each of the experiments.

The Mission Implementation Plan (MIP) document, developed from the MSG proposal shown in figure 22, was intended to be a synopsis of the activities planned by all participants to carry out the ASSESS II mission. Its original purpose was to provide a single concise source of information for PIs and upper management regarding general conduct of the overall mission. Questions arose as to whether such a document should be prepared by the Mission Manager or the STS organization which would implement flight operations. For ASSESS II, the NASA Program Manager assigned responsibility for the MIP to JSC. The document summarized the objectives of the mission and responsibilities of the various participating organizations, but did not serve the purpose originally intended.

The Payload Mission Rules were issued by the Mission Manager to spell out the rules for the specific mission. These rules would generally be mission dependent based on the type of payload to be flown. In the case of Spacelab, the payload might consist of pallet only, a combination of pressurized modules plus pallet, or other payload arrangements.

Mission management used the IRD information as the base for several payload requirements documents covering different facets of the mission. Following the plan of figure 22, these were intended to relay to support groups the information necessary to develop operating plans. These were the following:

- Payload Level IV and Launch Site Ground Operations Requirements Document;
- Payload Flight Definition Requirements Document;
- Data Requirements Document;
- Payload Operator Requirements and Preliminary Training Plan.

The Payload Level IV and Launch Site Ground Requirements Document issued by MSFC was really a two-in-one document, and probably should have been split. The requirements to handle Level IV integration and launch site integration were unique in many respects, and were implemented by different organizations, so that even though some requirements may have been the same, two separate documents would seem to have been justified.

The five individual documents listed immediately under the Payload Level IV and Launch Site Ground Requirements Document should have been included in the basic documents just discussed instead of being issued separately, since they were part of the requirements for Level IV Integration and/or launch site payload processing. The first three were drawings and sketches that were transmitted to KSC by letter, but since they constituted important launch site requirements from the payload manager, and never showed up in any other way, they have been identified as separate ASSESS II documents.

Support groups then issued responding documents to the mission requirements in their areas of responsibility. These were the following:

- Level IV Integration Implementation Document;
- Launch Site Integration Implementation Plan (Part B);
- Integrated Summary Crew Activity Plan;
- Detailed Payload Crew Activity Plans;
- Integrated Mission Simulation Plan;
- CV-990 Daily Flight Plans;
- Payload Specialists Training Implementation Document.

The Level IV Integration Implementation Document was the MSFC operating document, to accomplish Level IV integration and testing, while Launch Site Integration Implementation Plan (Part B) was KSC's implementation plan. The KSC Operation and Maintenance Instruction, shown on table 15, was really part of their implementation plan, and could just as well have been included in the basic document.

The balance of the CLASS B documents are generally self-explanatory by the titles. MSFC issued the Payload Specialists training implementation documents. JSC issued the document for the all-up Integrated Mission Simulation Test that occurrred just prior to flight, and an Integrated Summary Crew Activity Plan which for Spacelab will integrate flight crew activities with payload crew operations for the overall flight mission. All of the CV-990 Daily Flight Plans together would be analogous to a single overall mission flight plan issued by JSC for Spacelab.

3.6.2.3 Internal Working Documents (CLASS C)

The CLASS C documents are shown in table 15 for completeness. All of these documents have been discussed previously in the implementation section of this report. They represent essentially internal documentation used by MSFC, KSC, and JSC to handle and track their own operational responsibilities. Only in a few cases, such as in the development of Test Procedures for use during integration, were the PIs significantly impacted by the CLASS C documentation.

3.6.3 Evaluation of Documentation

The documentation used for ASSESS II was basic to the entire mission and has been discussed throughout the implementation section of this report. Evaluation of documentation used during ASSESS II is complicated by several facts which became evident as the mission progressed. Lack of management control resulted in multiple documents, late issues, and changes of title. Considerable effort was expended where not justified, while areas in need of attention were neglected; the P/S training was over documented, IRD records were deficient. But it should be recognized that ASSESS II was a realistic learning experience, not an exercise of proven methods. Accordingly, the following summary observations give perspective to the documentation effort.

1. Insufficient management attention was exercised over documentation identification, content, and schedule of issuance.

2. Baseline documentation plan (figure 22) served to guide information flow, even though little if any overt action was taken to develop the base plan.

3. IRD concept was implemented sufficiently to prove its validity, but not enough to show its full potential.

4. Integrated Payload Description (IPD) of figure 22 was not realized as a single document with feedback to the PIs. Rather, the several requirements documents from the Mission Manager were developed from the IRD data base as elements of an IPD.

Certainly, ASSESS II was somewhat simpler than Spacelab is expected to be, but the basic approach to payload development exercised is believed valid in the larger context, so that the corresponding documentation pattern need not be appreciably expanded.

4. ASSESS II CONCLUSIONS AND RECOMMENDATIONS FOR SPACELAB

4.1 Mission Summary

The ASSESS II mission was a successful simulation of a total Spacelab mission. Management interfaces to be involved in Spacelab were deeply exercised among experimenters and the ESA and NASA organizations. The Mission Manager concept for Spacelab is new, and, even though the early Spacelabs are proceeding under the Mission Manager concept the ASSESS II project was the first significant experience in exercising this concept throughout an entire Spacelab-like mission with active Spacelab organization participants. International aspects of ASSESS II added special reality. The spectrum of activities for experimenters, including experiment development, payload integration, flight operation, data retrieval, and active participation with an operating POCC and MCC was a realistic representation of similar activities to be experienced in Spacelab operations. A Mission Specialist and Payload Specialists were selected and trained, and performed well in flight.

As in any simulation, the exercise was imperfect, with some deviations from Spacelab planned activities. Aircraft system constraints and funding limitations, particularly in the U.S., limited fidelity of the simulation in some areas, and the very tight project schedule, coupled with limited manpower resources, forced some preliminary work to be done in parallel and seriously delayed some activities. Use of an airborne laboratory instead of a space vehicle reduced the cost of the project to a fraction of Spacelab costs so that the economic driver, even though it was significant for ASSESS II, was small compared to Spacelab. The overall resultant "fishbowl" effect of reaction to mistakes or severe problems was minimum. Also, the airborne payload involved a smaller number of experiments than planned for Spacelab 1, although the amount of equipment was comparable in volume. Payload preparation and flight were fully realistic. Safety was mandatory. Mechanical, electrical, and data interfaces all had to be fully addressed. Participation of scientists with intense efforts to obtain meaningful data was complete, and the schedule was held rigid so that events could not be easily shifted. The entire exercise was regarded by all participants as excellent and valuable training for future Spacelab operations.

Following are specific conclusions derived from the ASSESS II mission which are considered pertinent for Spacelab planning along with a synoptic discussion of each conclusion.

4.2 Payload Selection and Funding

4.2.1 Payload Selection

(a) **Compatibility of payload scientific discipline requirements simplifies payload planning and mission implementation.**

For ASSESS II the experiments chosen for the payload established requirements for IR astronomy, solar viewing, upper atmospheric measurements, and earth viewing which included some very specifically identified overflight targets. This immediately led to requirements for both day and night flights. With this mix of experiment objectives, there was no possibility of accommodating every PI's requirements. Flight planning was complicated. Night flights and the astronomy experiments were given priority, resulting in serious compromise of other experiment objectives, particularly those requiring overflights of earth surface targets.

Although it may be necessary to carry interdisciplinary payloads on Spacelab, and some diverse requirements may be easier to accommodate than with an airplane, similar scientific objectives will simplify flight planning and increase efficiency of experiment operations, which will in turn reduce the scope of crew training, and should be expected to yield more usable data for an overall mission.

(b) **Payload complement can be formed by selecting from ongoing experiment development programs or existing instrumentation.**

NASA Office of Applications (OA) avoided use of an Announcement of Opportunity for generating its payload complement for ASSESS II because of limited time available and lack of funding to support new proposals. Instead, in June 1976, OA identified payload candidates among various disciplines that were planned for future Spacelab missions and for which early prototype tests were being conducted using the CV-990. The five OA experiments flown on ASSESS II were selected by this method. In view of planned Spacelab/Shuttle launch rates in the mid 1980s, this selection method could be used with "discipline" Announcements of Opportunity used to secure proposals without regard to a specific mission (e.g., Spacelab 1, etc.). Although ESA used an Announcement of Opportunity, all the experiments they selected were in some stage of development, which also supports the conclusion.

4.2.2 Payload Funding

Conclusions on this topic arise primarily from experience with NASA funded experiments on the ASSESS II program. Spacelab planners should try to avoid these complications which caused considerable difficulty during ASSESS II.

(a) Timely authorization and funding of the payload is mandatory to avoid serious impact on mission definition and resultant compromise of scientific return. Analysis of payload funding schedules is of equal importance to payload analytical integration.

Full understanding and distribution of funds for several U.S. experiments was not accomplished until December 1976, almost nine months after NASA Headquarters approval and only five months before "launch". The GSFC-AEES experiment was not authorized and funded until February 1977, only about three and a half months before flight. This problem reflected throughout the whole chain of participating organizations and delayed payload configuration decisions, interface definition, data processing software, and construction of experiment support hardware. The AEES experiment was in a "crash" schedule mode from authorization to flight with premium time costs, equipment failures not properly addressed, and some loss of scientific data.

(b) Funding deficiencies and multiple funding channels must be avoided to prevent compromising payload elements.

The selection of five experiments comprising the baseline OA payload was made by the NASA HQ OA "discipline" program offices having management cognizance. Funding for hardware was available for all but one experiment, but was not adequate for integration and data analysis. Reprogramming from other funding sources caused delays in getting funds distributed. There was no central control authority established in NASA Headquarters (and, therefore, none at the mission management level) to work these problems. Multiple authorities over funding resulted in on-again-off-again decisions. One experiment was dropped for lack of funding, only to reappear later when reprogramming actions were taken.

(c) Funding allocations should cover all required integration and mission operations support in addition to hardware development and data analysis.

Insufficient effort was made to budget for integration and support activities by experimenters. The analytical integration effort, in particular, was insufficiently supported, with resultant detriment to mission planning, integration, and checkout. Several experimenters were limited by travel fund restrictions to a lower level of personal support than was necessary to do a minimum proper job. One PI was unable to be present for any of the critical preflight integration and testing of his experiment because of lack of funds. Many PIs were unable to attend the second IWG meeting when experiment and mission plans were firming up and an iterative exchange with mission management personnel would surely have prevented many surprises and problems when equipment was delivered for integration.

4.3 Management Relations

(a) Mission Manager concept is sound, but adequate staffing is essential and further development of the concept is necessary to insure efficient coverage of all program aspects.

Implementation of the ASSESS II project under the Mission Manager from MSFC worked very well. There was general feeling that the concept could be implemented at any organization having responsibility for a payload if the Mission Manager had adequate resources in terms of funding and qualified staff to fully organize the payload, identify and track all of the payload interfaces, conduct meaningful analytical integration, identify payload requirements to STS, and plan and staff the POCC during flight operations.

It must be recognized that ASSESS II was not a complete trial of the Mission Manager concept for several reasons: (1) The first appointed Mission Manager could not apply adequate time to the project, and the Assistant Mission Manager was not given sufficient authority or resources to act effectively for the manager in all aspects of the program; (2) the eventual change in Mission Manager introduced a hiatus while he picked up on the project; (3) the Mission Manager's staff was not sufficient to handle all of the assigned responsiblities; and (4) continuity of staff assignments was not maintained, resulting in some learning curve inefficiencies.

Engineering support available to mission management was not adequate to complete or maintain the Investigator Requirements Documents properly. The lack of support also affected the analytical integrations, particularly in the areas of physical, electrical, and data requirements. These areas of the analytical effort were inadequately handled resulting in subsequent problems. Adequate analytical integration support plus continuity of effort to maintain the Investigator Requirements Documents on a current basis should eliminate these difficulties.

The ESA/SPICE Payload Manager served as the single official interface to the MSFC Mission Manager for the European experiments and also managed integration and operation of the ESA portion of the payload in Europe. The ESA Payload Manager took on all European experiment problems and provided strong ESA support to the experimenter to solve them. KSC representatives, in particular, observed that this single interface arrangment for European experiments worked smoothly and efficiently. ESA was able to maintain continuity of managment personnel throughout the project, and their arrangement interfaced well with the NASA Mission Manager concept.

(b) The Mission Steering Group proved an effective forum for solving interface problems and exchanging views and philosophies on the conduct of the mission. ESA suggests that a similar multiorganizational group be used to oversee all joint Spacelab missions.

The Mission Steering Group (MSG) was established for ASSESS II specifically to guide the mission and establish ground rules for the simulation in order to maximize results for Spacelab. As the mission progressed, the MSG, with key representatives from all of the participating organizations, became a forum for addressing basic mission problems.

It is difficult to evaluate the effectiveness of a higher level body such as the MSG used on ASSESS II as it might apply to a single Spacelab mission or a series of missions involving the same organizations. While the MSG was not established as a prototype for Spacelab, some representatives, particularly ESA, felt the MSG forum was their only means to interface with the total project, and to address basic issues which they considered important. Dilution of management at MSFC during the first half of the project period left a void which the MSG tended to fill, and some expressed concern that the MSG was getting involved in implementation decisions rather than in policy. Strong mission management would probably eliminate that problem, but in the case of ASSESS II a tendency to address implementation areas developed before effective mission management was established, and the Mission Manager later felt his decision making prerogative was being usurped by the MSG.

After the mission experince was completed, both ESA Headquarters and ESA/SPICE management personnel strongly endorsed such a "board of directors" type overseeing body for Spacelab projects where their involvment is substantial. The MSFC Mission Manager was just as strongly opposed. NASA Headquarters program level representatives finally agreed with the Mission Manager.

(c) Management should clearly inform all participants early in the mission as to roles and responsiblities.

It is essential that an early, deliberate effort be made by program and mission management to inform all prime participants as to the management structure, the various roles and responsibilities, and the management paths required to obtain optimal results. This is particularly necessary for such complex managment arrangements as existed for ASSESS II and are planned for some Spacelab missions. The STS role and its relationship to other implementing centers was not clearly defined by NASA Headquarters at the outset of ASSESS II. Interviews with several participants late in the ASSESS project revealed that they had only sketchy ideas as to the responsibilities of various organizations and of their relationships with them.

The first IWG meeting was the only meeting that included most of the participants, and an attempt was made there to inform them as to the various roles and responsibilities. However, that was almost a year before flight and some roles and responsibilities were not yet fully established. U.S. Payload Specialist arrangements came about later. The Mission Specialist role and selection were difficult to develop and finally occurred very late. The second IWG meeting at MSFC, five and a half months before flight, was poorly attended which precluded much information exchange. No other such meetings were held. Thus, it is not surprising that some participants (PIs and P/Ss) interviewed during the final weeks were not familiar with some of the key management personnel and their responsibilities.

(d) Participation by PIs throughout the mission planning and implementation phases can enhance overall mission understanding (by both management and user) and thereby improve science return. PIs must recognize their leadership position concerning their experiments.

In ASSESS II, each PI and/or his staff participated directly in IRD activity, IWG meetings, System Level Payload Integration, and the real-time flight operations through the POCC. In addition, access to his equipment was relatively easy during Launch Site Payload Processing if he had such a need. The PIs were pleased with their degree of involvement. The intent of ASSESS II was both direct involvement and major responsibility on the part of the PI. Responsibility for experiment success was in his domain, except for constraints of safety and interference with the flight vehicle or other experiments. This plan for PIs to accept full responsibility for experiments was not fully recognized by all PIs. PI effort to aggressively identify their interface needs in some cases required strong prodding by mission management, and the need for thorough and complete testing during integration was not fully achieved in all cases and led to serious experiment problems in flight.

The degree of his responsiblity for integrated testing, P/S training and operational procedures, and support of all mission operations with a sufficient and effective support team, must be realized and fully sponsored by the PI.

4.4 Pre-flight Planning and Payload Integration

4.4.1 Investigators' Working Group

(a) The IWG can be a satisfactory forum for scientific inputs and a valuable channel for information flow between management and the PIs.

For ASSESS II the IWG concept worked very well. The two independent indoctrination meetings in Europe and the U.S. were excellent. Two other full meetings were called, and although attendance at the second meeting was kept down by the unavailability of travel funds, in general, the IWG had the following beneficial results: discussion of mission plans and objectives, science interchange among PIs, evolution of a cooperative experiment between two PIs, recommendations for selection of Payload Specialists, transfer of information about the flight carrier and interface limitations, and PI contributions to mission planning. With more extensive use of the IWG, all of these functions can be better exercised for Spacelab. While for ASSESS II, one indoctrination IWG meeting plus two full working meetings seemed about right, a much longer preparation period for Spacelab flight probably necessitates more IWG meetings. They should start early in the mission to disseminate mission plans and information about experiment integration requirements. Appropriate additional meetings at regular intervals will permit organized updates of information from the experimenters, continued beneficial interaction among experimenters, as well as planning updates by mission management. A teamwork approach enhances opportunity for greater mission success, and IWG meetings provide the best forum for building a successful team.

(b) The Mission Scientist (and any IWG cochairman or vicechairman) needs to have clearly defined responsibilities, full support by the PIs, and be provided with a management overview.

The Mission Scientist served a key role in planning and execution of science activity, and provided focus of science requirements and science tradeoffs to the Mission Manager. He worked independently with the PIs and with planners for flight operations to present the science case to mission management. This mode of operation was very effective. During flight operations, the NASA and ESA Mission Scientists were very successful in coordinating and managing PI activities.

The Mission Scientist must be carefully selected. He serves dual and somewhat opposing roles. On the one hand he serves the Mission Manager and must be realistic about management constraints, even at the expense of science objectives if warranted. On the other hand, if he is to represent the PIs in their absence, he must have their respect and stand hard in favor of the experimenters in the face of project management resource and schedule pressures. Thus, a Mission Scientist is the bridge between mission implementation actions and the scientific objectives. He must be strong in his own right to insist on and maintain a solid objective position, and to do this he must be kept well informed on a timely basis of the overall project activity. His effectiveness in performing this role will depend upon his own stature as a science manager, and the degree to which all other participants recognize the requirement for his analysis and possible arbitration of science considerations.

4.4.2 Investigator Requirements Document

(a) A single requirements document interfacing with each PI is desirable and feasible. Face-to-face discussions, with the participation of technical experts, are necessary to clarify interfaces. These discussions must start early in the mission and continue to be iterated througout the mission to insure proper information transfer.

The use of the IRDs during ASSESS II was a pre-Spacelab trial of this single interface document concept. The IRD exercise was very good, and while improvements are in order, indications are very strong that the concept · desirable and workable. Several lessons become apparent from this experi- ... ce and are summarized as follows:

1. The single document plan has merit. From a mission management point of view, a single document which addresses all interfaces with the experimenter concentrates managment attention to all his needs in an organized way, and at an appropriately early time to identify lead time requirements before a schedule crisis. From the experimenter's point of view, he grew to recognize that the document truly addressed his needs, and provided him the opportunity to spell out his total requirements early. Even though the IRDs were not maintained current during the entire implementation period, they contained the basic requirements for the entire payload. Eleven such documents were employed to describe all PI and experiment requirements in detail.

2. The organization and wording of the IRD requires careful attention for application to Spacelab. The question and answer format was good, but overall organization of the questions needs very careful study and improvement to eliminate redundancy and to achieve maximum clarity with brevity. It is recognized that no single document can be comprehensive enough to elicit all details of all experiments in a simple predetermined format. However, the IRD must be structured to identify all basic requirements to a workable level of detail, with provision for expanding sections where more information is needed by management team specialists to implement requirements. It was found that careful wording is needed so that management and experimenters can understand each other unambiguously. A significant wording problem was obvious in the ASSESS II IRDs, where the use of engineering jargon confused several PIs.

3. The IRDs must be filled out during face-to-face meetings. It was quickly recognized that face-to-face meetings were necessary to provide an opportunity for discussion of background for the various IRD questions and to discuss interfaces with the vehicle. Without exception, PIs required assistance in aligning their interface requirements to vehicle capabilities. The discussions clarified many points and led to enthusiastic responses by the PIs to supply information. Both in Europe and in the U.S., a two-day meeting was scheduled with each PI. In general, this resulted in overtime sessions and a rush to finish on the second day. A longer first meeting is necessary, especially for a first-time experimenter with a complex experiment.

4. Mission management staff must be well qualified and experienced to attain a satisfactory rapport with experimenters in filling out IRDs. The ASSESS II meetings to fill out the IRDs were successful. Only a small interfacing group (perhaps 3 or 4) is needed to deal with experimenters in filling out IRDs. However, it is absolutely mandatory that experts who fully know the interfacing systems (electrical, mechanical, data, etc.) work with the experimenters in developing this information. Further, it is helpful if the interviewing group has developed some background knowledge on each experiment, and

is generally familiar with the methods of scientific research and the points of view of experimenters. The interview team should not only codify the requirements of an experiment, but the representatives should make suggestions for better usage in situations where the experimenter has not taken optimal advantage of Spacelab facilities.

5. Concentrated effort is required following face-to-face meetings to clarify information and insure completeness. A very large quantity of data was generated during each IRD meeting and most of the information was hand-written. This simple informal recording proved adequate for management use when clearly worded and carefully written. Some hastily written material was difficult to decipher and should have been clarified and cleaned up quickly while the thoughts were still fresh. A small point, which turned out to be a significant problem on some IRDs, was the use of a shade of ink that would not make satisfactory copies.

6. Completed IRDs must be fed back to the experimenters. It is important that IRDs be returned quickly to each PI for his information as to interface plans, and also for his concurrence that the information correctly represents his needs.

7. IRDs must be maintained up-to-date by mission management since they become the basic reference documents for the experiments and drive the whole process of payload preparation, integration, flight planning, and flight operation. It was intended that the ASSESS II IRDs should be the basic source of information about all aspects of the experiments and their interfaces, and that one could refer to the IRDs for all requirements for ground testing, installation, and operation in flight. Because the ASSESS II IRDs were not kept current, their use was limited after the second analytical integration. While the two visits to fill out the IRDs seemed about right, subsequent updated information that was gathered without meetings should have been fed to the IRD format to maintain the documents as complete authoritative sources throughout the flight preparation period.

4.4.3 Analytical Integration

(a) The analytical integration of a Spacelab payload must be accomplished in a timely, complete fashion so that all participants can receive complete payload definition and requirements early enough to plan the payload processing activities.

The analytical integration effort for ASSESS II was well done and timely to the extent it was carried out. However, after the last organized effort extensive work was still required to solidify final physical, electrical, and data interfaces. The feedback to experimenters and others was excellent after initial analytical integration, largely because management presented results directly to the participants and could interact with them. Following the second analytical effort feedback to the experimenters was less effective due to poor meeting attendance, and results had to be relayed by the Mission

Scientist. No further organized exchanges took place between management and experimenters before the payload integration period.

4.4.4 Integration of ESA Payload in Europe

(a) For Spacelab payloads involving ESA experiments, testing, integration, and operation of those experiments under ESA management at a centralized European site would be extremely beneficial.

The ESA sponsored integration, test, and operational activity at ESA/SPICE was extremely beneficial. In most cases, the experimenters needed extensive support to get their equipment assembled and working properly. Individual assistance was supplied and many problems were identified and solved during the ESA/SPICE integration activity. With the support of a NASA safety representative, safety issues were addressed, thus avoiding major difficulty later. Valuable P/S training was accomplished. The ESA integration activity insured that the ESA complement arrived in the U.S. as a tested set of experiments, thus reducing their integration time with the balance of the payload.

4.4.5 System Level Payload Integration

(a) The value of off-line System Level Payload Integration activities (Level IV) is directly related to fidelity of the test facility and completeness of the tests performed.

For ASSESS II, off-line System Level Payload Integration activity (Level IV) was performed in a special ground based integration and checkout area at ARC. It was a minimum cost arrangement, which simulated the system functions quite well, but was not intended to duplicate physical interfaces to any great degree. This first-time integration of the entire payload uncovered many problems — most were solved, although some were passed on to launch site processing. The ability to address all problems in an off-line system simulator is strongly proportional to the investment in simulator equipment to achieve high fidelity to the carrier vehicle. Without exact cabling configuration (both data and power), duplicates of the flight support systems, and exact physical interfaces some problems cannot be identified.

(b) Off-line System Level Payload Integration activities (Level IV) are very effective in crew training.

For ASSESS II, although the ESA P/Ss had participated and trained during the ESA integration activity, the off-line System Level Payload Integration and operation at ARC was the first time all P/Ss had an opportunity to operate experiments as a complete payload. The P/Ss were given basic responsibilities during this phase, side by side with the experimenters, who also participated directly in this phase of integration. This was excellent training for the P/Ss, and it is highly recommended that P/Ss be given this same opportunity and assignment for Spacelab.

4.4.6 Launch Site Payload Processing

(a) For launch site integration, timely detailed technical definition of payload/carrier interfaces is essential.

Most of the ASSESS II launch site integration requirements were delivered to KSC about two weeks before start of Launch Site Payload Processing. As a result, KSC had inadequate lead time to prepare for their work. Interfaces were not totally defined. However, for ASSESS II, the P/Ss and experimenter support groups were utilized essentially full time to accomplish the integration, and alleviated the situation.

(b) Effective launch site payload processing can be performed using a single direct payload manager interface to the KSC payload processing management. A payload test team approach, using the M/S, P/Ss, and PIs when necessary, under the jurisdiction of KSC, to directly support and participate in the KSC launch site processing operations was very successful and is recommended for Spacelab.

For ASSESS II the KSC launch site Manager, utilized the M/S and the P/Ss full time, as well as the ARC support staff representing the launch site support contractor, to carry out integration and testing. The Mission Manager was the single official interface with KSC for the payload, but close liaison was maintained with the ESA Payload Manager and the MSFC Ground Operations Manager, who had handled the Level IV Integration.

Although KSC maintained strict control of the schedule and operation, they were also very receptive to participation by the experimenters. This team approach was very successful for ASSESS II and simplified the launch site integration and testing efforts. While this arrangement worked well for ASSESS II, the STS participants seriously questioned that this procedure can be followed at KSC for Spacelab, for several reasons. First, the support service contractor at KSC will be responsible for carrying out most of the detailed work. Although there appear to be valid arguments in favor of this approach, in the past this practice has forced heavy documentation emanating from payload participants, mainly experimenters, to provide sufficient detail so that personnel not fully familiar with the experiments can carry out the work safely and successfully. It should be recognized that direct participation by experimenters and P/Ss who have lived with the experiment hardware and know it well can substitute for large quantities of such documentation if they are permitted to do so and are available. The second reason put forth by STS participants for limiting the ASSESS II team approach is a valid concern about too many people participating in flight vehicle activity where safety is paramount. Their concern may well limit participation by the experimenter and his immediate staff. However, the P/Ss are perfect candidates for overseeing experiment installation and testing. They are few in number, yet know all the experiments, and very importantly, they will fly so that their consideration for safety will be totally serious, yet should be sufficiently practical to permit them to do their job in flight. Another positive feature in favor of P/S participation is the additional training to be gained with the flight configured payload. The team approach with heavy and responsible use of the P/Ss during launch site payload processing is recommended for Spacelab.

(c) To minimize experiment systems failure, time should be scheduled to conduct experiment functional tests on the integrated vehicle. Failure to perform these tests, at least on priority experiments, implies technical risk that may not be commensurate with mission investment.

There is no fully satisfactory substitute for test of the payload components in the actual flight configuration. While a high-fidelity test device for system level (Level IV) integration does allow very significant debugging of the system interfaces and the payload experiments, there will always be at least minor configuration variations in such a test device from the flight system that can produce serious anomalies in payload operation. In ASSESS II, each experiment was checked out on the aircraft after final flight vehicle integration. A number of problems were found and solved. For Spacelab, the KSC integration is baselined only to insure interface and EMI compatibility. It is recommended that a full operational check of at least priority experiments be included to insure proper data producing capability.

(d) Past experience should be applied to insure that experiment tests are conducted that will indicate possible experiment hardware weaknesses or susceptibilities.

A great deal of experience exists at both NASA and ESA centers for checkout of experiments to be flown in space. The participation of the implementation centers in the design review and test planning phases of the experiments can assist the PI's rate of success through experience transfer. The ground rule now being considered for Spacelab puts prime responsibility upon the PI to insure satisfactory operation of his equipment, while the STS responsibility is limited to safety and interface compatibility. For ASSESS II, at the discretion of the experimenters, experiments were not thoroughly tested in all cases before flight. One prime experiment failed; others had operational problems. A positive approach to marry the knowledge of experienced integration management personnel with the experimenters' responsibility to perform critical experiment tests is recommended.

(e) An all-up Integrated Mission Simulation is valuable and is recommended, at least for the early Spacelab missions. Inclusion of instrument operation to verify operational interfaces during the simulation enhances the probability of experiment success.

A generally effective end-to-end Integrated Mission Simulation was conducted in ASSESS II with the payload flight crew carrying out experiment operation supported by full MCC/POCC participation. Many problems were identified, some with hardware, and some with operations. This level of simulation offers the most realistic possible training for the total operations team (MCC, POCC, and payload crew), and should be included during the final integration period for Spacelab, especially for early missions.

(f) Time should be provided in the launch site processing schedule to allow for some final experiment testing in the launch vehicle and for handling last-minute problems, which are bound to arise. Suitable facilities for handling these problems should be available at the launch site.

Experience with previously launched space systems, as well as the analogous ASSESS experience, has shown that experiment problems will inevitably show up at KSC during integration of the payload into the flight vehicle. Some final experiment testing or calibration with flight system hardware may be required, particularly if problems arise during integration, to assure that acceptable flight data will be acquired. While this could be done in flight, the inherently greater risks would appear to justify onground verification. Facilities for metal work and electronics operations, together with highly trained personnel immediately available to the launch site integration operation to provide support for experiments, are most desirable. Equally important are simple procedures to use these facilities and personnel so that quick fixes can be implemented with minimum disruption of the integration schedule.

4.4.7 Safety

(a) Safety considerations for ASSESS II were effectively applied with a low level of formality, but it was not considered that the level of detail applied to ASSESS II contributed materially to understanding the required level of detail necessary for Spacelab.

Many safety considerations for Spacelab were not required to the same depth for ASSESS II (e.g., outgassing, stress corrosion, and detailed hazard analyses), although design control and review were exercised in all areas of potential hazard to personnel or equipment.

For ASSESS II payload management provided guidance in safety matters to the PI and his team, starting with the initial IRD meetings, to assure timely development of safety-qualified experiments. Early identification and tracking of potential problem areas, on-site consultation, and suggestions for alternate solutions to accommodate science requirements by the responsible management specialist greatly benefits the experimenter and can reduce his documentation effort. The safety specialist's knowledge of each experiment facilitates review and approval of experimenter supplied design documents, and aids in preparation of operational safety plans.

Safety considerations for the aircraft systems and the payload at ARC were handled by the Airworthiness Assurance Office. General safety inspections were handled on a daily basis during integration and ground operations by the Aircraft Inspection Branch, with simple problem sheets which incorporated provision for signoff on the same sheet upon corrective action. Final all-up mission safety approval was issued in writing by the Airworthiness and Flight Review Safety Board, after formal meeting(s) with review of all safety related items and operational procedures. All flight personnel were required to participate in formal safety briefings. The Aircraft Commander was the final safety authority during flight.

4.5 Payload Flight Crew

4.5.1 Mission Specialist

(a) The M/S role in ASSESS II and the management arrangement were very successful and are recommended for Spacelab.

After much controversy and delay, the arrangement for a Scientist Astronaut to serve as Mission Specialist (M/S) for ASSESS II was worked out. The M/S remained administratively under JSC but was assigned functionally to the Mission Manager at MSFC. In addition to his ground based duties, he served on the flights as the alter ego of the Mission Manager. As the mission progressed, it became apparent that he also operated very effectively as leader of the Payload Specialists (P/Ss). He assumed this added role naturally as a result of his experimental background, his training experience, and his personality. The P/Ss were all well satisfied with this arrangement, particularly appreciating his acting as a buffer between them and the PIs during their busy operating times in flight.

(b) The M/S functions for ASSESS II were unique to that position and served a vital need.

On ASSESS II the M/S had the sole responsibility to handle aircraft support systems that interfaced with the experiments. These were the cental data system, the power supply and distribution system, and the specialized instrumentation such as gyrostabilized mirrors and a water vapor overburden radiometer. The overall function was extremely important and necessary, and could not have been handled by the P/Ss.

The M/S was also very effective as the communications coordinator between the payload crew, flight crew, and the POCC. He provided the Mission Scientist in the POCC with a balanced overview of the payload operations, and also handled many specifics in behalf of the P/Ss. This unloaded the P/Ss of the communications burden to a substantial degree which they appreciated because they were completely occupied with their experiment operation tasks. Further, the M/S kept track of the various legs of the flights and assisted the P/Ss in timing of their activities with respect to various flight tracks, and coordinated requests for flight plan changes with the flight and payload crew. As a scientist, he could appreciate what the P/Ss were doing, and frequently could help them in overburdened situations. As a team, the M/S and the P/Ss operated very smoothly.

(c) The M/S should be assigned early in a mission so that sufficient time will be available for training in all aspects of activity for which he is assigned responsiblity.

On ASSESS II the M/S was not selected until December 1976, five and a half months before the simulated spaceflight. This time was insufficient for training on all systems for which he was to be responsible. In particular, it was impossible for him to get more than cursory training on the complex central data system.

4.5.2 Payload Specialists

(a) Participation of the P/Ss (time of selection, training schedule, etc.) should be included as an integral part of the mission planning so that their involvement begins at the optimum time commensurate with their assignments. In particular, P/S involvement should commence at a stage that would allow their inputs to the control and operations aspect of the experiment design.

ASSESS II P/Ss were selected eight months before flight. By the time they got to most of the PI laboratories for training, much of the hardware design was solidified. As in ASSESS I, the P/Ss all made strong observations that their early input to design would have enhanced successful operation of the hardware and obtaining of science data.

(b) Effective verbal communication skills should be an important criterion for P/S selection.

During ASSESS II, it was noted that some P/Ss were significantly less adept at giving and receiving information than others, and tended to communicate less effectively under stress. This problem does not relate particularly to whether or not a P/S is a native speaker of English, but to fundamental communication skills and attitudes which affects the success of making repairs and collecting data. This aspect of competence should be carefully considered in making P/S selections for Spacelab.

(c) Prior to final selection, P/S candidates should be subjected to some type of stress, including timeline activity.

Observations indicated that the ability of P/Ss to operate under stress of multiple activity varied considerably. In Europe, psychological tests were used that clearly eliminated some P/S candidates and raised concerns about others. These concerns were borne out on ASSESS II during the integration and flight periods.

(d) Any PI candidate for P/S must be fully cognizant of the workload time commitment and demonstrate his ability to support both roles.

On ASSESS II, one P/S was also a PI. Some interference was noted when he interrupted his ASSESS II activity to take care of urgent PI management responsiblities. Very careful consideration should be given to any PI who proposes to be a P/S on Spacelab, to assure his genuine willingness to forego his basic PI duties or have them handled by others, and that he thoroughly understands the time required away from his home base for meetings, training, and operational duties associated with the Spacelab payload.

(e) The use of backup P/Ss from the mission management team is feasible, but practicability depends upon the balance of duties required for a specific mission.

For ASSESS II, the NASA Assistant Mission Manager was selected to be backup P/S for U.S. experiments. This plan for a single backup for both NASA P/Ss was adopted particularly to save travel funds, and was acceptable because the individual was considered to be well acquainted with the U.S. experiments. His management duties were severely diluted, but he handled P/S training and generally represented the payload crew to management during the preflight phases in addition to undergoing his own limited training. The question arises as to whether capable candidates will be willing to accept only a backup assignment for Spacelab, with historically a very low probability of flight assignment, unless there is some accompanying responsible assignment (which dilutes both jobs), or some strong liklihood that a backup P/S assignment is a step toward prime assignment on another mission.

(f) Each crew candidate should be subjected to sufficiently realistic functional and environmental simulation of his role early in the training period to permit self-evaluation of his desire to proceed.

The P/Ss were verbally informed about the medical experiment before the ASSESS II mission, but obviously all did not realize the potential physical problems. Some substantial physical difficulties were experienced by one P/S during the 72-hour collection of P/S preflight baseline medical data at ARC. The problem was sufficiently severe that, due to potential loss of medical data and/or degradation of his overall effectiveness, serious consideration was given to replacing him for the flight mission. He was not replaced, and the medical data was collected with no detectable degradation of P/S performance. However, the situation strongly illustrated the need for a better understanding early in the project.

(g) P/S training must be tailored to the individual P/S selected and the complexity and degree of P/S understanding of any given experiment. PIs must devote adequate time and effort to maximize the training effectiveness.

On ASSESS II, P/Ss training was varied. Initial training was scheduled on a time basis per experiment without regard to P/S capability or initial understanding of experiments, but some adjustments were made as training progressed. Discussions with P/Ss after the mission indicated that training, in some cases, had been overdone for some experiments and was inadequate for others. Mission management judgment should be blended with PI and P/S appraisal of need for training time, consistent with the background and capability of each P/S for each experiment and its priority.

(h) NASA should consider special means to provide administrative support for inhouse as well as out-of-house P/Ss in order not to preclude nomination of highly qualified candidates.

For ASSESS II, nominations of one inhouse and one contractor P/S candidate were withdrawn from the NASA portion of the payload. The contractor proposed P/S had no chance of being selected because there was no means to pay his salary or support his travel. The inhouse candidate was withdrawn for lack of administrative support. Consideration of P/S nomination from a NASA center raises the question of devoting travel funds from his organization, if that organization has no basic responsibility for Spacelab operations. The travel fund problem is so severe under the present system that, without some obvious incentive, this area of consideration can exclude qualified candidates. Based on ASSESS II experience, NASA salaried candidates have an advantage over out-of-house nomineees, and even within NASA, unless some special means to provide support is arranged, the best possible P/S candidate may not be nominated.

(i) P/S participation in development of experiment operation procedures contributes significantly to their training and operational understanding, and supports their responsibility as the onboard PI representative.

For ESA experiments, the P/Ss were given the responsibility to develop operational flight procedures for their assigned experiments. This proved to be a very effective method to assure their complete understanding of experiment operation, and caused a very deep interaction with the PI to iterate various modes of operation. The further hands-on operational responsibility assigned to the P/S during Level IV and launch site integrations was an excellent combination to maximize P/S training for flight.

NASA chose to have the PIs maintain responsibility for all procedures generation, with review and iteration with the P/Ss. However, one of the P/Ss was a PI and the other was well acquainted with much of his experiment responsibility at the outset. Although little difference in P/S operational success could be detected between the ESA and NASA approaches, the ESA P/Ss stated that their preparation of operational procedures was of significant benefit in their training.

(j) Flight operations workload planning must allow for a P/S adaptation period, with attendant lower effectiveness for the first several days of the mission.

Even without the effects of zero-g, for ASSESS II the P/Ss readily stated that they required from one to three aircraft flights before they had reached a high degree of effectiveness in experiment operation. The P/S who had many details to consider, but was concerned with only one operational goal, developed operational effectiveness more rapidly than those faced with a multiplicity of operational goals (single vs multiple experiment operations). Even the M/S, with his considerable flight experience, felt that he was not handling his several duties with full efficiency until about the third flight. Increased experiment/system level training can minimize, but not eliminate this initial lower effectiveness.

4.6 Flight/Ground Operations Interactions

(a) Adequate resources and time must be provided for training of POCC personnel, especially PI science teams.

The POCC for ASSESS II was fully manned as planned for Spacelab. Some POCC training occurred for ESA personnel during the ESA integration and operation activity in Europe, but very little operational training took place at ARC before the start of flight operations. Total plans for training at ARC could not be exercised due to minimum schedule time, total launch team workload, and the minimum on site PI support teams. Initial operations were inefficient, but improved with time. Whereas experienced management personnel may man key positions for Spacelab, which eliminates their training needs, most PIs will be untrained. PI participation in flight communications was very poor in many cases during ASSESS II, especially during the early flight period. Leadership of the PI group in the POCC by the Mission Scientist was very good, but some training for that arrangement is recommended.

(b) The TV text uplink is a beneficial mission operations tool. Facsimile capacity for transmission of troubleshooting information is desirable and should be incorporated into the Spacelab concept at an early date.

The TV text uplink and its Polaroid readout in the aircraft proved its utility by being used increasingly as the ASSESS II mission progressed. The ability to send simple messages to P/Ss and the M/S, with a record for reference, was found to be far less interruptive of work than extensive voice communication. Inability of the link to handle facsimile precluded sending wiring diagrams that were needed for troubleshooting. Provision for such transmission to Spacelab would be very beneficial.

(c) Periodic data samples from Spacelab to the POCC during the mission are essential for PI experiment surveillance and to provide for operations instructions to be sent back to the spacecraft.

Data slices were passed to the POCC each day, and ground-based facilities were available through the POCC to determine the effectiveness of experiment operation. This system was highly successful, and is recommended for Spacelab. In ASSESS II, some interface problems occurred between POCC displays and the experiment data record, but with the quick-look information available, in every case a work-around was implemented so that nearly all data were retrieved.

(d) If backup P/Ss are to be used effectively in the POCC, they must be trained on all experiments. Also, on joint missions, Mission Scientists must be familiar with all experiments.

For ASSESS II, the backup P/Ss served as the main POCC communicators. This was an effective arrangement because of their familiarity with the payload experiments and crew. However, because project guidelines prevented cross-training by the P/Ss for both NASA and ESA experiments, they each had limited knowledge of some experiments, which was a disadvantage. This experience emphasizes that for Spacelab communication to be fully effective, both the sender and receiver must be conversant to a reasonable level of detail with all aspects of the payload.

The Mission Scientist must also be conversant with the payload to a considerable level of detail so that he can make decisions on the best use of flight time. It is therefore imperative that he understand the science and operation of all experiments.

4.7 Experiment Hardware Considerations

(a) **Automation of routine tasks is recommended to reduce P/S workload and operating errors; however, manual bypass capibility is also desirable.**

Experiments that contained automation of routine tasks and did not require extensive adjustments or setup of controls by the P/S appeared to have a higher data-take success ratio than those with extensive manual setup and control. However, where possible, provision should be made for manual override of automated systems in the event of a malfunction. Two examples from ASSESS II illustrate these points. The infrared telescope experiment was highly automated with computer control. However, when the computer occasionally malfunctioned, adequate manual operation by the P/S was possible. Conversely, one U.S. experiment was also highly automated with computer control, but not in such a way that the P/S could easily bypass it. When the PI recognized early in the mission that the data were badly degraded, he was unable to give corrective instructions to the P/S because there were no suitable manual control provisions.

(b) **Use of off-the-shelf hardware should be considered where modifications or testing to meet the Spacelab constraints is cost effective.**

The majority of the components that made up the ASSESS II experiments were off-the-shelf items. They seemed to perform as well as specially constructed components. The primary reason for resorting to special construction was the need for a unique functional capability. Reliability, low power consumption, etc., were definitely secondary considerations.

(c) **Payload integration and operations management personnel, as well as the payload flight crew, should have available a complete set of simplified schematics. These should clearly show all interface connections and controls for ready reference during integration and operation when problems occur.**

In the preparatory phase of ASSESS II it was generally accepted that the definition of electrical and control interfaces between the experiment and support systems would be adequate to perform integration and checkout operations. Thus, except for Spacelab rack interfaces with other experiment elements, the PIs provided intraexperiment electrical and control diagrams in various degrees of detail. During Systems Level Payload Integration it was recognized that a greater depth of information could be used to advantage, and other diagrams were developed by management in cooperation with PI representatives. These were of benefit in subsequent integration and checkout activities, and also were made part of the Flight Data File to aid P/S troubleshooting. Even though it is recognized that intraexperiment hardware is a PI responsibility, unless some reasonable inner visibility is immediately available, internal components can cause severe interface problems without a capability to quickly trace the problem to the source.

4.8 Data Handling

(a) Face-to-face interactive discussions between responsible representatives of the experiment and the central data system with a resulting bilateral interface agreement, including verification procedures, are necessary to fully define and establish the data handling interface.

Interface resolution between experiments and the central data system is traditionally a difficult area. Furthermore, experiment interface identification usually comes late in the process of experiment hardware preparation, which compounds the problem because interface limitations may force redesign or compromise of the experiment. All of this dictates that experts from each side of the interface start face-to-face discussions early and continue interaction until firm interfaces are fully defined and agreed to by both parties. Attempts to define these interfaces without extensive discussion and understanding will almost guarantee problems except for the simplest cases.

For ASSESS II, the key data system experts were unfortunately not brought into discussions with experimenters when the IRDs were filled out. Data interfacing turned out to be a severe problem area. For Spacelab, proper early expenditures of resources in this area will almost certainly be cost effective to prevent later severe problems.

(b) Hardware and software interfaces should be standardized wherever possible between the experiment and the central data system, to simplify integration and checkout and enhance operating reliability.

In the CV-990 central data system, analog data are generally received through an analog to digital converter that is sampled by standardized software. Thus, any analog signal that conforms to the limitations of the converter can be quickly and surely added to the data collection system. Limiting digital interfaces to a format and procedure for which the central computer is designed likewise reduces the need for special programming which is costly, prone to error, and generally makes inefficient use of all resources.

(c) Successful software debugging can be accomplished only if enough time is provided with all experiments being stimulated simultaneously in the planned flight configuration.

Although interfaces between individual experiments and the central data system should be well verified by the time the total integration phase commences, interaction between experiment software modules can only be reliably tested in a full system environment, and sufficient time must be allowed to identify and solve total system problems which are almost guaranteed to show up. The ASSESS II schedule did not provide sufficient debugging time with all experiments operating, and consequently some data processing problems occurrred during flight. Software debugging should be expected to continue well into payload integration, and with the real possibility that this type of problem is likely to show up during flight, it is recommended that the uplink be capable of handling data processing computer programs.

4.9 Documentation

(a) Documentation should be carefully planned and scheduled for issuance. Documents should cover only specific needs, titles should be precise and informative, redundancy should be eliminated, material should be carefully grouped so that the number of documents is minimum, and language should be carefully chosen to eliminate or clarify jargon that is unfamiliar to the recipient.

Although ASSESS II documentation was far from a perfect example for Spacelab, it was a realistic learning experience using the new Mission Manager concept of payload management with the actual Spacelab organizations participating in their planned roles. The documentation created and used was nearly all newly developed, and, apart from many shortcomings, substantial progress was made as a pattern for Spacelab. With the objective of placing full responsibility on the PI for experiment success and simplifying his documentation requirements, the Investigator Requirements Document concept was implemented sufficiently to prove its validity, but not enough to show its full potential. Much improvement of that document is needed for Spacelab.

The documentation plan outlined by the ASSESS II Mission Steering Group was generally valid, but insufficient management attention was exercised over document identification, content, and schedule of issuance.

(b) For joint NASA/ESA missions, both sides should have an opportunity to review all basic mission documents. Some form of mission implementation agreement should be developed and jointly agreed to by both parties. This should identify those documents which commit each other's resources or significantly impact mission objectives and should be concurred in by both parties.

During the progress of the ASSESS II mission, ESA management felt they were being committed without recourse to certain lines of action by NASA issued documentation. No formal means was developed during the program for NASA/ESA discussion of such documents before their issue. ESA feels that they must be able to discuss jointly those areas where commitments of manpower are to be made before detailed policies are set by NASA issued documents.

REFERENCES

ASSESS Project Background

1. Mulholland, D. R.; and Neel, C. B.: Airborne-Science Techniques Aid Shuttle Planning. Aeronautics and Astronautics, May 1973, pp. 24-32.

2. Mulholland, D. R.: A Cost-Effective Approach for Flight Experiments: Application of Airborne Science Aircraft Experience to the Shuttle Sortie Lab. Presented at the 24th International Astronautical Congress, Baku, USSR, Oct. 7-13, 1973. Published in Raumfahrtforschung, Band 18, Heft 4, July/Aug. 1974.

3. Mulholland, D. R.; Reller, J. O., Jr.; Neel, C. B.; and Haughney, L. C.: Study of Airborne Science Experiment Management Concepts for Application to Space Shuttle, Volume I, Executive Summary. NASA TM X-62,288, July 1973.

4. Mulholland, D. R.; Reller, J. O., Jr.; Neel, C. B.; and Haughney, L. C.: Study of Airborne Science Experiment Management Concepts for Application to Space Shuttle, Volume II. NASA TM X-62,287, July 1973.

5. Mulholland, D. R.; Reller, J. O., Jr.; Neel, C. B.; and Haughney, L. C.: Study of Airborne Experiment Management Concepts for Application to Space Shuttle, Volume III, Appendixes. NASA TM X-62,289, Aug. 1973.

ASSESS Lear Jet Simulation Missions

6. Mulholland, D. R.; Reller, J. O., Jr.; Neel, C. B.; and Mason, R. H.: Shuttle Sortie Simulation Using a Lear Jet Aircraft, Mission No. 1. NASA TM X-62,283, Dec. 1972.

7. Reller, J. O., Jr.; Neel, C. B.; Mason, R. H.; and Pappas, C. C.: Shuttle Spacelab Simulation Using a Lear Jet Aircraft, Mission No. 2. NASA TM X-62,352, Jan. 1974.

8. Reller, J. O., Jr.; Neel, C. B.; and Mason, R. H.: Shuttle Spacelab Simulation Using a Lear Jet Aircraft, Mission No. 3. NASA TM X-62,410, Nov. 1974.

9. Reller, J. O., Jr.; Mason, R. H.; and Neel, C. B.: Preliminary Report on Lear Jet Shuttle/Spacelab Simulation, Mission No. 4. NASA TM X-62,408, Dec. 1974.

10. Reller, J. O., Jr.; Neel, C. B.; and Mason, R. H.: Spacelab Simulation Using a Lear Jet Aircraft, Mission No. 4. NASA TM X-62,474, Oct. 1975.

Initial CV-990 ASSESS Mission

11. Neel, C. B.; Weaver, L. B.; and Pappas, C. C.: Preliminary Report on CV-990 Shuttle Simulation Mission No. 1. NASA TM X-62,358, April 1974.

First Joint NASA/ESA CV-990 Spacelab Simulation Mission (ASSESS I)

12. NASA/ESA CV-990 Spacelab Simulation, Executive Summary. NASA TM X-62,457 and ESA-SL-75-1, July 1975.

13. Reller, J. O., Jr.; NASA/ESA CV-990 Spacelab Simulation - Final Report. NASA TM X-73,105, Jan. 1976.

14. Reller, J. O., Jr.: Neel, C. B.; and Haughney, L. C.; NASA/ESA CV-990 Spacelab Simulation - Final Report Appendix A - The Experiment Operator. NASA TM X-73,150, July 1976.

15. Reller, J. O., Jr.; Neel, C. B.: and Haughney, L. C.; NASA/ESA CV-990 Spacelab Simulation - Final Report Appendix B - Experiment Development and Performance. NASA TM X-73,205, Dec. 1976.

16. Reller, J. O., Jr.: NASA/ESA Spacelab Simulation - Final Report Appendixes: C - Data Handling Systems - Planning and Implementation; D - Communications; E - Mission Documentation. NASA TM X-73,182, Sept. 1976.

Second Joint NASA/ESA CV-990 Spacelab Simulation Mission (ASSESS II)

17. ASSESS II Spacelab Simulation - Executive Summary. NASA TM-78,444 and ESA-SL-77-1, July 1977.

ABBREVIATIONS AND ACRONYMS

ADDAS	Airborne Digital Data Acquisition System
ARC	Ames Research Center (NASA)
ASO	Airborne Science Office (NASA/Ames - name recently changed to Medium Altitude Missions Branch)
CCTV	Closed Circuit Television (onboard CV-990)
C/O	Checkout
DCS	Data Communications Specialist
DFVLR	Deutsche Forschungs-und Versuchanstalt fur Luft-und Raumfahrt
EKG	Electrocardiogram
EMI	Electromagnetic Interference
ESA	European Space Agency
ESTEC	European Space Research and Technology Center (an ESA facility)
F/T	Functional Test
GFE	Government Furnished Equipment
GHz	Gigahertz
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center (NASA)
HF	High Frequency
I/F	Interface
INS	Inertial Navigation System
IR	Infrared
IRD	Investigator Requirements Document
IWG	Investigators' Working Group
JPL	Jet Propulsion Laboratory (NASA)
JSC	Johnson Space Center (NASA)
KSC	Kennedy Space Center (NASA)
LA	Los Angeles
LaRC	Langley Research Center (NASA)
MCC	Mission Control Center
MIP	Mission Implementation Plan
MHz	Megahertz
MPI	Max Planck Institute (Germany)
M/S	Mission Specialist
MSFC	Marshall Space Flight Center (NASA)
MSG	Mission Steering Group
μm	Micrometer
NASA	National Aeronautics and Space Administration (USA)
OA	Office of Applications (NASA Headquarters)
OSF	Office of Space Flight (NASA Headquarters)
PAP	Payload Activity Planner
PCU	Payload Checkout Unit
PDT	Pacific Daylight Time
PI	Principal Investigator
POCC	Payload Operations Control Center
POD	Payload Operations Director
P/S	Payload Specialist

ABBREVIATIONS AND ACRONYMS CONT.

QA	Quality Assurance
SF	San Francisco
SPICE	Spacelab Payload Integration and Coordination in Europe (an ESA facility)
STS	Space Transportation System
S/W	Software
UHF	Ultra High Frequency
VHF	Very High Frequency

EXPERIMENT DESIGNATORS

AEES	Airborne Electromagnetic Environment Survey (GSFC)
AWS	Airglow Wave Structure (University of Southampton)
CTM	Chromospheric Temperature Measurement (Capodimente Observatory, Lecce University, and Florence University)
IHR	Infrared Heterodyne Radiometer (LaRC)
EMI	EMI Experiment (ESTEC)
IRA	Infrared Astronomy (Paris Observatory, University of Groningen, Max Planck Institute)
LAS	Laser Absorption Spectrometer (JPL)
MED	Medical Experiment (DFVLR)
SAR	Synthetic Aperture Radar (JPL)
MLS	Microwave Limb Sounder (JPL)
LIDAR	LIDAR (DFVLR)

APPENDIX A

Minutes of Mission Steering Group Meetings

MINUTES

NASA/ESA ASSESS II Mission Steering Group Meeting

April 9, 1976

The MSG meeting was held at NASA/MSFC on April 9, 1976.

The NASA Program Manager reviewed the project status outlining the recent NASA Management meetings which led to firm NASA approval of the ASSESS II mission on March 17, 1976. An official NASA invitation to ESA to participate was extended on April 1.

The NASA Program Manager also discussed composition and responsibilities of the Mission Steering Group. The function of the MSG is to establish policy guidelines for conduct of the mission such that the project will produce the most meaningful results for benefit of Shuttle/Spacelab implementation. The MSG will be co-chaired by NASA and ESA.

Membership of the MSG and affiliation is as follows:

NASA Program Manager, Headquarters OA - Co-chairman

ESA Program Manager - Co-chairman

NASA Headquarters Representative, OSF

NASA Headquarters Representative, OSS

NASA Headquarters Representative, OAST

NASA Headquarters Representative, OA

ESA Headquarters Representative, Spacelab

ESA Headquarters Representative, Science

ASSESS II Mission Manager, MSFC

Flight Operations Representative, JSC

Launch Site Operations Representative, KSC

ASSESS II Manager, ARC

Marvex Corporation (Contract Observer)

All members are urged to ensure that their point of view is represented at each meeting since the mission will be implemented in accordance with the guidelines decided upon at each meeting.

Management

A management structure has been generally agreed to for implementation of the ASSESS II mission. Program management at NASA Headquarters will focus in

OA under the Program Manager working closely with representatives from OSF. The Mission Management will be under MSFC supported by ESA. Payload integration and flight operations will be under ARC with participation by KSC and JSC, respectively.

1. Action: Participation plans by KSC and JSC are due in Headquarters OSF by May 15.

2. Action: An overall Mission Plan will be prepared by the Mission Manager (MSFC) by June 15.

3. Action: The Mission Manager (MSFC) will prepare a plan for documentation to carry out the entire mission - due at the next MSG meeting. This plan will be consistent with the ASSESS program objective of minimum necessary documentation.

Payload

Results of a payload meeting in NASA Headquarters on April 7 established that night-time flights will predominate. The ESA proposed night option (ESA experiments 3, 4, 6, 10, 11) were accepted by NASA to assure ESA adequate lead time to proceed with firm contract arrangements for experiment hardware development. Four NASA experiments (31, 198, 500, 439) were identified by NASA as the prime candidates for ASSESS II. These experiments will be complementary to the ESA preference for night flights. Preliminary analysis by ARC indicates that all of the above experiments can be accommodated on the aircraft. However, final selection of the NASA experiments requires some further evaluation of operational requirements to include the possibility of conducting some daytime flights. If daytime flights can be accommodated, ESA will consider adding a Solar Atmospheric Measurement Experiment, and NASA will consider operating an Infrared Heterodyne Radiometer (439) in the solar mode. NASA is also considering the Laser Absorption Spectrometer (502) to complement the IHR. Such decisions are also contingent on the available space aboard the aircraft and the workload on the payload crew.

The ESA Medical Test Experiment will require instrumentation of the confined personnel. While ESA has decided that this will be no problem for the ESA Payload Specialists, further evaluation is required to determine constraints imposed on the U.S. participants and the physical space requirements. Evaluation of the above and the selection of U.S. experiments to round out the payload is continuing.

4. Action: OA working with ARC will complete payload analysis and finalize selection by May 6.

5. Action: ARC will establish preliminary flight tracks by May 13.

6. Action: Mission Manager (MSFC) will determine extent of implementation of the Medical Experiment by May 6.

7. Action: ARC will determine by May 6 if the MSFC proposed experiment which would be operated only during non-flight periods can be accommodated.

Electromagnetic Interference (EMI)

ESA would like to further their studies of EMI which were carried out on the ASSESS I mission. It was agreed that they (ESTEC) will do this.

8. Action: ESA will submit a plan for EMI measurements in the near future.

9. Action: ESA will send to ARC their experiment requirements to conduct the EMI measurements ASAP.

10. Action: ESA will summarize their desired "EMI Guidelines for Experiments" and submit to the Mission Manager ASAP.

Mission Operation

It was decided that ASSESS II will encompass a 10-day constrained period versus the 7-day period for ASSESS I. A major flight is planned each 24 hour period; however, it is recognized that limitations of aircraft support at ARC may result in a down-period if severe aircraft operations problems occur. This possibility supports the need for the MSFC experiment which would load the P/S with meaningful tasks during non-flight periods.

It was agreed that a Mission Operations Control Center (MOCC) and a Payload Operations Control Center (POCC) physically separated from each other will be implemented for the mission.

It is planned to implement round-the-clock voice communication with the aircraft during the mission.

11. Action: ARC will continue to evaluate how full time voice communication can best be done and report at the next MSG meeting.

It was agreed not to attempt to utilize the free time expected to be available from the flight deck crew on Shuttle for payload operations. Since, in the 990 aircraft operation, neither the pilot nor the co-pilot can easily be taken from their stations during flight, as might be done on Shuttle, it was decided that it would complicate the ASSESS II mission beyond reason to substitute and train proxy individuals to evaluate that situation.

Centralized Experiment Controls

Results of the ASSESS I mission showed that Spacelab experiment design will require careful attention to the centralization of experiment controls if the limited flight crew is to have success in managing and operating many complex experiments. MSFC has investigated the possibility of providing some centralized panels so that the P/S can better manage several experiments. It appears that this approach can be implemented if funds can be made available to fabricate the installation and space is available on the aircraft to accommodate the arrangement.

12. Action: MSFC will work with ARC to evaluate the centralized control panel approach and report at the next MSG meeting.

Mission Specialist/Payload Specialists

MSFC presented their considerations for possible approaches to selection of Payload Specialists for Spacelab. It was proposed that the ASSESS II mission would provide an excellent opportunity to exercise and evaluate the Shuttle P/S selection process. ESA wishes to utilize at least one of the P/S that participated in ASSESS I. It was agreed that ESA will use their own judgement to select their P/S and MSFC will pursue their selection process for U.S. Payload Specialists. ESA will select two or four P/S of which one or two will fly plus a Mission Specialist. JSC will select the Mission Specialist subject to approval by ARC to handle the aircraft systems during the mission.

13. Action: JSC will propose a Mission Specialist.

14. Action: MSFC will establish a NASA position for Payload Specialist qualifications.

15. Action: MSFC will present a plan at the next MSG meeting for selection of U.S. Payload Specialists.

16. Action: ESA will select and train four Payload Specialists.

Next Meeting

During the formative stages of the mission, many decisions must be made, and the discussions leading to these decisions are valuable interchanges which in themselves serve to support Shuttle/Spacelab planning. ESA representatives very strongly requested that the next meeting be held at ESA. The proposed dates are May 24-25, 1976.

MINUTES

NASA/ESA ASSESS II Mission Steering Group Meeting

May 25-26, 1976

The meeting was held at the ESA-SPICE office located within the DFVLR Laboratory at Porz-Wahn, Germany.

The ESA Program Manager reviewed the general status of the project from the ESA standpoint. The SPICE organization (Spacelab Payload Integration and Coordination in Europe) is moving rapidly into a fully operational organization to handle their interest in ASSESS II. They will exercise their SPICE organization involvement with ASSESS II to the greatest extent possible for application to Spacelab 1. They will do a full pre-Level III integration of all ESA experiments at SPICE (DFVLR) and accomplish integrated operation and Payload Specialist training prior to delivery to the U.S. The Life Science group at DFVLR is building a full scale Spacelab mockup under the auspices of the Institute for Space Simulation. The ESA Program Manager has requested installation of the ASSESS II simulation system to be put in the same building (perhaps a temporary inflatable building initially) to be connected to the adjacent existing computer facility which they plan to program to handle appropriate experiment stimulation and simulated interfaces.

An ESA experimenters' meeting was held at SPICE on May 20 at which they were updated on ASSESS II plans in some detail. ESA established scheduled actions to the European experimenters at that time.

The NASA Program Manager summarized the programmatic status of ASSESS II in the U.S. He recently briefed the Administrator of NASA on ASSESS II. Of primary interest at that meeting was the extent of training which will be required to fly on Spacelab and whether PIs will be interested in flying versus proxy experiment operators. The NASA Program Manager also summarized a recent briefing to the NASA Administrator for the Office of Space Flight (OSF) to discuss participation in ASSESS II by JSC and KSC.

KSC is very actively pursuing their plan for participation. The Spacelab Project Office representative from KSC elaborated with emphasis on a KSC desire to use ASSESS II to help lead to simplified procedures and documentation to achieve P/L integration at KSC. The following areas were identified for special attention by KSC:

a) Acceptance Data Package for experiments/payload;

b) Responsibility for experiment performance during integration, test, and checkout;

c) Mission independent and mission dependent training;

d) Long period of time between final C/O on ground and activation on orbit;

e) Level IV integration completed before delivery to launch site (no Level IV at KSC);

f) Organized (controlled) storage of crew equipment;

g) Feasibility of simple document for all experiment requirements.

A request was made by some representatives on the Steering Group for KSC to also give attention to direct participation of the Payload Specialists, if not the PI, in the integration process (in addition to experiment responsibility, item b), with a view toward elimination of documentation for detailed proxy integration procedures.

KSC plans to have two or three key personnel at ARC to participate during the ASSESS II integration process and others involved as appropriate to plan for integration activity and establish useful analogs between ASSESS II and Shuttle/Spacelab. They also plan to participate in an upcoming CV-990 integration for an on-going mission to better establish their interaction in ASSESS II. The KSC plan for ASSESS II is in preparation.

The NASA Program Manager reported that JSC announced at the OSF meeting that their plan will be presented soon. No one from OSF or JSC was present at this meeting to provide any details.

Mission Management

The MSFC Assistant Mission Manager reported on the status of ASSESS II mission management at MSFC. A Mission Manager for ASSESS II has been named (he is also Mission Manager for Spacelab 2) along with an assistant. Also, a Mission Scientist and an assistant have been selected at MSFC. Several specific key individuals from the MSFC Spacelab Payload Project Office have been authorized to move out rapidly on analytical integration analysis.

MSFC plans to establish an Investigators Working Group (IWG) made up of all the PIs to enhance maximum experimenter involvement in payload-oriented decision making, including Payload Specialist selection, allocation of flight time to the various experiments, etc. While the Steering Group endorsed this approach, very strong concern was expressed about the formality proposed (meetings of the PIs). The discusison centered around U.S. Payload Specialist nomination and selection which must take place very soon if the Payload Specialists are to be effectively utilized. (ESA plans to select their P/S by June 15.)

The Assistant Mission Manager also reported on the U.S. experimenters meeting held at MSFC on May 14. They were briefed on Spacelab plans and details of the ASSESS II project including plans for the Investigator Working Group and their participation in selection of Payload Specialists.

Documentation

The Assistant Mission Manager presented the MSFC preliminary general plan for interface documentation. The Mission Manager will work with KSC/ARC to generate a "Ground Operations Requirements" document and with JSC/ARC to generate a "Flight Operations Requirements" as a reference document. These will be provided to each experimenter along with the 990 Experimenters Handbook to provide reference material for ASSESS II. In order to provide a data base on each experiment, for planning use by all organizational elements, a standardized fill-in-the-blanks type form entitled, "Investigator Requirements Document" (IRD), will be developed and will be filled out by each investigator. These will be used to generate a (1) Payload Ground Operations Requirements document, (2) Payload Flight Support Requirements document, and (3) Payload Flight Definition document. These few documents are planned at this time to be the basic interface documents. From all of these and other inputs, a generalized overall Mission Operating Plan will be produced by the Mission Manager. There will be other documents to carry out implementation apart from the above interface documents.

Discussion ensued particularly as to objectives and use of the Mission Operating Plan and consistency of ASSESS II documentation development with Spacelab documentation discussions taking place within the Spacelab Operations Working Group. It was the consensus that ASSESS II documentation planning should be pursued independently, but with full recognition of Spacelab planning and adherence to any NASA/ESA policy agreements.

1. Action: MSFC will review NASA/ESA documentation agreements and Spacelab Operations Working Group plans, further refine the ASSESS II documentation plan based on minimum documentation concept, and present status at next meeting.

Payload and Accommodation

The ESA Program Manager and the NASA Assistant Mission Scientist briefly reviewed the ESA and NASA experiments planned for ASSESS II.

The ARC Manager described the preliminary layout planned for the CV-990 and verified that all the experiments can be accommodated within the aircraft constraints of physical space, power, viewing ports, etc. Preliminary considerations were presented of the viewing limitations of the astronomy and other experiment objectives. The high demands of the ESA IR astronomy objectives which must be integrated with other experiment requirements into a complex detailed flight plan emphasized the urgency to move quickly with this phase of analytical integration analysis. MSFC plans to implement an Experiment Accommodations Team as soon as possible to interface with experimenters to address requirements and negotiate flight tracks and timelines.

Centralized Experiment Consoles

The ARC Manager along with the MSFC Assistant Mission Manager reported on considerations to provide Spacelab-type racks to accommodate centralized controls for the experiments so that the limited number of

Payload Specialists can efficiently control and operate multiple experiments. Configurations and layouts were presented. Costs and schedule were discussed. ESA expressed a need for the racks much earlier than the presently proposed availability to avoid repackaging for their pre-integration in Europe.

2. <u>Action</u>: ARC will proceed immediately to provide the centralized control racks with strong effort to compress the delivery schedule.

<u>Integration Philosophy</u>

ESA will accomplish pre-Level III integration of all European experiments at SPICE (DFVLR) and conduct integrated operation tests and P/S training prior to delivery to the U.S. They plan to provide experiment input stimulation/simulation equipment (EIS) and the necessary GSE required to accurately simulate the experiments to the aircraft and central computer interfaces.

No plans presently exist in the U.S. Spacelab Operations for <u>full</u> functional payload checkout of the integrated payload. No off-line GSE has been authorized and schedule limitations during on-line integration at KSC permit only continuity checks and Spacelab compatibility with some time reserved to solve expected EMI problems. Previous airborne science experience has shown that system level interfaces (particularly with the data system) require deep attention after integration to prevent serious data loss. The ASSESS I mission also demonstrated the problem.

Steering Group representatives voiced strong concern about this problem and discussed alternatives to best utilize the ASSESS II mission to further identify and communicate ingredients in this area for Spacelab planning.

3. <u>Action</u>: Perform integrated system tests of the entire payload on the ground after total integration on the aircraft and immediately prior to the constrained flight period using experiment stimulation data. No checkout flights of the experiments will be performed before the constrained mission. Obtain detailed ASSESS project data to identify problem areas and solutions for each experiment.

<u>Selection and Training of Payload Specialists and Mission Specialists</u>

The MSFC Assistant Mission Manager explained their proposed process to have the experimenters nominate candidates for P/S within the guidelines of Spacelab planning. The Investigator Working Group under the chairmanship of the Mission Scientist would then reduce that number by negotiation to make up the prime and backup P/S. All selected P/S will be fully trained. The prime and backup P/S will be designated by the Mission Manager after initiation of the training process. Apart from the ASSESS mission requirements it is also planned to expose the selected P/S to at least some activities similar to those which will probably be required for space flight training to obtain some data on individuals selected by this procedure. Such activities may include zero-g aircraft flights and water tank space activity simulations. Any problems during such activities will not disqualify the selected P/S for participation in ASSESS.

The ESA Program Manager stated that ESA will select four P/S made up of one PI, one from the ESA Space Science group, and two from DFVLR.

The NASA Assistant Mission Manager presented P/S requirements as follows:

- FAA Class III medical status;
- OSF established anthropometric standards;
- Availability for ESA medical experiment;
- Available full time beginning October 1, 1976;
- Participate in S/L oriented environmental familiarization study;
- Report organizationally to the MSFC Mission Manager;
- Discipline expertise as defined by the Investigator's Working Group.

Proposed Payload Specialist pre-mission duties were listed as follows:

- Participate in experiment development as appropriate;
- Assist in development of experiment operating procedures and timeline elements with PIs;
- Observe/participate in selected Level III/II integration;
- Participate in Level III/II experiment hardware checkout and test;
- Participate in selected mission planning activities;
- Participate in simulations;
- Serve as subjects for the medical experiment;
- Support Payload Operations Control Center (Backup P/S).

Flight Phase Payload Specialist duties were proposed as follows:

- Interactively operate experiments;
- Perform required instrument maintenance/repair;
- Communicate with POCC for experiment operations;

- Interact with POCC for real-time mission planning;
- Interact with CV-990 flight crew for changes in integrated flight plan;
- Onboard responsibility for management of P/L operations and accomplishment of P/L objectives;
- One P/S to be selected as "lead P/S."

The Mission Steering Group asked for more details to demonstrate specific plans for deepest possible involvement of the P/S since a basic guideline of the ASSESS program is to demonstrate that direct activity with responsibility by the PI or his closest participating representative can both reduce documentation requirements (cost) and enhance experiment success.

4. Action: Mission Manager to develop details of P/S responsibilities and activities for discussion at next meeting.

Discussion of Mission Specialist selection and duties was deferred because the JSC representative was not at the meeting. Concern was expressed that the project is moving through important phases and decisions without M/S participation.

5. Action: OA Program Manager will work with OSF to reconcile the Mission Specialist issue and to verify a plan to name an M/S and define appropriate functions and tasks.

Medical Experiment

The ESA Program Manager explained the ESA medical experiment to obtain selected medical data on each P/S for 7 days prior to flight, throughout the constrained flight period, and for 4 days post-flight. Data will be obtained on each backup P/S on the ground during the flight period for comparison. Objectives are to gain data relative to Circadian rhythm and workload. The project is highly organized. Excellent and detailed planning has already been done to interact and utilize the ASSESS program to gain specific data.

The Medical Experiment PI from DFVLR has discussed the project with NASA Headquarters, ARC, and JSC, and it was reported that the experiment is now considered to be a joint endeavor between DFVLR, NASA-ARC, AND NASA-JSC.

The NASA Assistant Mission Manager said that all U.S. as well as ESA Payload Specialists will participate in the experiment.

ADDAS Requirements

This subject was deferred until after a proposed joint experimenters meeting where ADDAS familiarization and requirements will be discussed.

Electromagnetic Interference (EMI)

The ESA Program Manager reported on ESTEC's plan to conduct EMI studies. In accordance with an action request from the last meeting, he distributed an ESTEC report spelling out guidelines for hardware design to reduce EMI and establish tolerances for acceptable emissions. Details of the EMI specifications and plans for EMI measurements were presented to the ESA experimenters at their meeting on May 14. Agreements were reached there for ESTEC to serve as advisors and consultants to the ESA experimenters to achieve acceptable EMI levels. ESTEC will visit each European experimenter's laboratory to conduct EMI measurements prior to delivery of instrument packages to SPICE at DFVLR for pre-Level III integration and tests. Also, EMI tests will be included on the partially integrated (ESA experiments only) payload at DFVLR.

U.S. experimenters received a very general summary of the EMI study project at the U.S. experimenters meeting at MSFC on May 14. Details will be presented to them at the joint experimenters meeting to be held on July 12-13. Some discussion ensued about the desirability of ESTEC's direct interaction and assistance to U.S. experimenters prior to delivery of instruments to achieve a maximum effort toward good design for EMI for the entire payload. This was deferred until discussion at the joint experimenters meeting. Much of the hardware for U.S. experiments already exists in aircraft flight configuration and it is questionable that funds are available for any significant redesign.

ESTEC has requested that ARC isolate the power generators on the aircraft and supply power to the payload through a single bus. Also, that the ADDAS system be grounded through a single ground connection. The ARC Manager stated that these will require significant effort, expense, and time in an aircraft schedule already very tight. Some or all of the work might be done during the aircraft modification period scheduled for January 1977.

6. Action: Investigate the possibility of accomplishing the ESTEC requests to modify CV-990 wiring system to reduce EMI levels. - ARC.

Open Actions from Past Meeting (4/9/76)

1. KSC and JSC participation plans due 5/15 are still in process.

2. A draft Mission Plan will be prepared by 6/15 - MSFC.

3. Documentation plan present. Further action item at 5/26 meeting - MSFC.

11. Full time voice communication with aircraft evaluation still in process by ARC.

13. JSC to propose a Mission Specialist - still open.

15. MSFC plan to select P/S - in process.

16. ESA selection of P/S - in process.

All other open actions have been completed.

Next Meeting

Considerations were discussed of having the next Steering Group meeting in conjunction with the joint experimenters meeting to be held at SPICE-DFVLR on July 12-13. It was decided that more time is needed after that meeting occurs to hold a meaningful MSG meeting.

Proposed dates for the next MSG meeting are July 28-29 at NASA-ARC.

MINUTES

NASA/ESA ASSESS II Mission Steering Group Meeting

August 17-18, 1976

The meeting was held at NASA/Ames Research Center
Moffett Field, California

The NASA Program Manager reviewed the project status from the NASA point of view and reported that the selection of U.S. experiments is still not solidified due to funding problems. The communications experiment from GSFC has been removed from the payload. Of the remaining four experiments, another will probably be eliminated, leaving a U.S. complement of three experiments. The funding problem developed because of a) the added experiment costs for redesign of existing equipment to semi-automate in order to reduce the manpower requirement to operate the experiments, and b) the costs to support experimenter's staffs through the ASSESS period. These areas of cost were identified almost a year ago, but the reality of specific cost impact pointed out that this has been an important "lesson learned" from ASSESS for OA because the same ingredients will apply to Spacelab and can be an extremely severe problem especially with a larger Spacelab complement of instruments.

The representative from ESA Headquarters suggested that ESA would be interested in expanding their experiment complement to replace cancellation of U.S. experiments. Subsequent discussion precipitated a decision that it is now too late to add new experiments, but it may be possible to expand the activity on ESA experiments already selected.

1. Action: The NASA Program Manager will interact with OA management by Aug. 27 to reconcile the U.S. experiment support and selection problem.

The ESA Program Manager voiced a mild plea to retain the IR Hetrodyne Radiometer from Langley based on the cooperation that developed at the recent Investigator's Working Group meeting between that experiment and the Solar Physics experiment from Italy.

2. Action: The Mission Manager will notify the ESA Program Manager by Sept. 15 of any additional payload capability that may develop so that ESA can consider expansion of activity for existing ESA experiments.

The ESA Program Manager summarized the ASSESS II status from the ESA standpoint. All contracts with the various experiment groups have been completed. Work on the experiments is progressing on schedule. SPICE representatives plan to visit all the European experiment laboratories within the next month to check progress and iron out any difficulties.

An agreement between ESA and DFVLR to carry out integration of the European experiments at Porz-Wahn, Germany is essentially complete. Only minor considerations remain to be clarified. Drawings are nearly complete for a 9-meter long wooden mockup of the 990 cabin to be used for the integration.

3. Action: The ESA Program Manager will notify the Mission Manager by Oct. 31 of any desired expansion of activity for ESA experiments which may result from action item #2 above.

SCHEDULE

The ASSESS II Assistant Mission Manager discussed the plan for MSFC/ARC to solidify the aircraft layout of experiments immediately after the NASA experiment decision. He expects to arrange for visits to all experimenters during a 3-week period beginning Oct. 1 to update Investigator Requirements Documents (IRDs). This will be followed by an updated analytical integration effort during a 3-week period beginning Nov. 1 leading to a freeze of the integrated payload requirements by Dec. 1. A decision was made to begin the constrained "Spacelab flight" on May 15, 1977. NASA Headquarters representatives expressed concern that the schedule of events leading to the launch date are not sufficiently hard to delineate which decision points are critical to the launch date. For instance, they questioned how much longer the decision on U.S. experiments can be delayed before the launch date is impacted.

4. Action: Mission Manager will develop an overall hard schedule as soon as possible with emphasis on critical paths and identification of critical milestones leading to launch of the constrained mission on May 15, 1977.

EMI MEASUREMENTS

The requests by the ESTEC representatives to modify the 990 electrical system to reduce EMI, and for design modifications of the U.S. experiments to provide single-point grounds has been considered. The NASA Program Manager announced that, nothwithstanding the good work done on ASSESS I to identify design features to reduce EMI and the opportunity to further refine the results on ASSESS II, the funding problem within NASA precludes modifying either the aircraft or the experiments. The ESA Program Manager said it is not feasible for ESA to fund these items. As a result ESTEC will continue their work with the European experiments and will carry out EMI measurements during the integration of those experiments at DFVLR. They would still like to fly the EMI measuring equipment during the flight mission to obtain general data, but they will not conduct detailed tests aboard the aircraft during level II and I integration as earlier planned.

AIRCRAFT SCHEDULE AND EXPERIMENT RACKS

The ARC ASSESS II Manager presented a general schedule of 990 flight activities showing that the flight schedule will accommodate a May 15, 1977 launch date for ASSESS II. He also discussed the schedule for delivery of experiment racks to the European experimenters. Standard racks will be shipped by Sept. 1.

Low-boy racks and the new "Spacelab" racks will be shipped by Nov. 16. Some European experimenters need low-boy racks before that date. The problem cannot be alleviated easily because all of the available low-boy racks are scheduled on a previous mission and cannot be made available until that mission is completed.

5. Action: ARC will immediately provide low-boy rack designs to ESA to permit them to build mock-ups for use until the actual racks can be shipped.

SCHEDULE OF UNCONSTRAINED FLIGHTS

The number of unconstrained flights to be provided during the period following the constrained Spacelab flight simulation was the subject of extensive discussion. During the unconstrained period, the PIs will be allowed to operate their own equipment, and this period will provide the opportunity to insure satisfactory data return for the PI. Naturally, the PIs would like many flights. However, ASSESS I proved conclusively that if the unconstrained flight opportunity is too generous, there is a strong tendency to unload the Payload Specialists during the simulation in favor of the PI getting the desired data when he flies later. The ESA Program Manager preferred a ratio of two to one which would allow four unconstrained flights. Two have been tentatively scheduled. It was agreed by all the the PIs should not reduce their goals during the simulation in favor of later attention by themselves.

6. Action: The Mission Manager will insure that experimenters understand that objectives during the follow-on unconstrained period will be the same as for the simulation period, and that their effort during the unconstrained flights will be for the purpose of refining or obtaining data which was planned for the simulation.

7. Action: The Mission Manager will report to the Program Manager by Sept. 1 the implication and recommendation for the number of unconstrained flights within a maximum limit of four.

PAYLOAD SPECIALIST SELECTION

The ASSESS II Assistant Mission Manager and the ESA Program Manager reviewed progress on Payload Specialist selection. Nominations for P/S were submitted to the IWG during their meeting on July 13. As a result, the U.S. P/S nominations were to be submitted to the Mission Manager by Aug. 1 and the ESA P/S by Aug. 6. DFVLR is doing some medical and psychological tests for ESA. ESA is planning a meeting for Aug. 25 at which time they will decide on four P/S to provide two prime and two backup P/S for the mission.

In the U.S., the funding problem is driving a decision toward only the two P/S with one backup selected from someone already involved in the project who would receive limited training to serve as a P/S if required. This will save travel costs and training costs. The U.S. P/S selection is closely tied to the experiment selection problem and cannot be fully consummated until experiment decisions are made. However, the Mission Manager expects to submit P/S candidates to the Program Manager by Sept. 1.

The ASSESS II procedure for P/S nomination and selection using the IWG for inputs has been an interesting and enlightening process which was considered by the Mission Steering Group to be of immediate importance to Spacelab planners. ESA considered eight nominations, some of which were submitted by DFVLR directly and will be supported by them. In the U.S., 30 nominations have been considered, mainly from JPL who advertised throughout their Center and who are viewing this as a significant first step toward selection of candidates they may wish to fly aboard Shuttle/Spacelab.

8. Action: ARC will prepare an interim ASSESS II report by Oct. 1 covering the selection of Payload Specialists.

PAYLOAD SPECIALIST TRAINING

The ASSESS II Assistant Mission Manager presented the present status of planning for P/S training. A training plan has been drafted, but must be reworked depending upon the final decisions on U.S. experiment and P/S selection. No cross-training of ESA and U.S. P/S is planned except for one session of the U.S. P/S with the ESA Life Science experiment. Partial training will be provided for the one U.S. backup P/S. ESA will fully train all of their four P/S. Those selected for backup will serve in the POCC during the mission.

Some discussion ensued about the procedure to be followed if a P/S gets sick during the mission. Should the P/S be replaced or should he be removed and the remaining P/S attempt to pick up the load perhaps using a preplanned timeline? It was decided not to address the more complicated of the alternatives for this mission, but instead merely replace a sick P/S with the appropriate backup individual.

GROUND OPERATIONS

The Launch Site Operation representative from KSC presented charts showing the schedule of ground activities leading to the May 15, 1977 flight date. Copies of the overall ground operations schedule, the integration and checkout timeline, and the integrated payload checkout configuration are attached. This schedule calls for U.S. experiment Level IV integration beginning March 14 with the ESA/SPICE activity by April 1, 1977 in preparation for integrated payload checkout with the aircraft simulator system. All instruments will be installed in the aircraft beginning April 5. The integrated P/L checkout will represent the use of the Core Segment Simulator at KSC by connecting the P/L to an external power supply and an external ADDAS data system. Each instrument will be excercised as fully as possible using appropriate experimenter provided sensor stimuli. Final checkout will involve use of onboard power and the onboard data system and will be limited mainly to interface P/L compatibility and EMI checks. No flight test checkout of the P/L will be performed commensurate with the Orbiter/Spacelab limitation. KSC expects to obtain detailed checkout procedures from each PI in order to be responsible for P/L checkout. It is planned to use the P/S during the integration and checkout process to operate the experiments, and they will need to be totally available during that period for that purpose.

FLIGHT OPERATIONS

The Flight operation representative from JSC presented a preliminary Flight Planning Integration schedule together with some details of an Integrated Mission Implementation Plan to be issued by JSC. Other documentation and activities leading to the flight period were identified and discussed, including the Crew Activity Plan, Payload Support Plan, and a pre-mission rehearsal to check out communications and interactions between the MOC, POCC, and aircraft.

DOCUMENTATION

The ASSESS II Assistant Mission Manager discussed the general approach to documentation. As a result of an earlier time, he and the ESA Headquarters representative prepared a summary of ASSESS II documentation and its relevance to Spacelab documentation. This is attached. The Launch Site Operation representative from KSC emphasized that, apart from the interface documents, the ASSESS program has prompted action at KSC to reduce internal implementation documentation with commensurate delegation of responsiblity. He said that KSC wants it understood that their requirements for Spacelab are going to be minimal compared to the past.

CREW ASSIGNMENTS

The NASA Program Manager explained that, apart from P/S selection activity, duties and responsibilities particularly for the Mission Specialist are not yet reconciled. The NASA Headquarters representative stated that the Commander/Pilot combination have now been identified to handle interface duties between the Orbiter and Spacelab which leaves the Mission Specialist totally available for Spacelab activities. A lively and extensive discussion followed in an attempt to identify a satisfactory role for the Mission Specialist which led to an impasse between the principal representatives involved. The Chairman deferred the problem to separate negotiation between managements of the affected organizational entities to settle on a solution.

TRAJECTORIES

The ESA Program Manager pointed out that as a result fo the IWG meeting, some PIs changed their viewing objectives and are concerned that they are expected to harden their requirements soon. They want flexibility. The ASSESS II Assistant Mission Manager, the Flight Operations representative for JSC, and the ASSESS II Manager from ARC explained the problems of handling changing requirements. After the IRDs are updated in October, there will still be some flexibility as the mission approaches, but any major change will be difficult to implement. Small deviations can be handled into the flight period if they are justified, but it was strongly emphasized to provide hard requirements during the October period. New trajectories for the combined payload will be presented at the next IWG meeting which will probably be held in early or mid-December after the IRD update and the resultant second phase of analytical integration effort.

USE OF ADDAS DURING SPICE INTEGRATION

ESA has investigated the problem of constructing an ADDAS system for use during the integration of the ESA experiments at DFVLR. The ESA Program Manager explained that while most of the equipment is available at DFVLR, some of the unique U.S. manufactured equipment has been modified for ADDAS which they would have to procure and similarly modify. In addition, they need the software program for the internal ADDAS system. Consequently, he requested that the ADDAS equipment to be used off-line during the integration at ARC be shipped to DFVLR for their use.

9. Action: ARC will determine by Aug. 31 the possibility of sending the ARC-ADDAS hardware together with a software engineer to SPICE at DFVLR.

Following review of previous action items, a meeting date for the next MSG was established for Dec. 7-8 at KSC.

MINUTES
NASA/ESA ASSESS II Mission Steering Group Meeting

December 15, 1976

The meeting was held at NASA/MSFC on December 15, 1976.

Some confusion developed regarding the meeting when the Co-chairman from NASA Headquarters called to explain his inability to attend the meeting, and to request that the MSFC Mission Manager act in his place as Co-chairman. The MSFC Mission Manager was absent, and it was not clear that he would be available to co-chair the meeting. Several alternatives developed which resulted in the representatives from OSF in NASA Headquarters, KSC, and JSC being notified of a possible delay in the meeting. On the morning of December 15, the MSFC Mission Manager arrived and agreed with the ESA Co-chairman to proceed with an official MSG. As a result, official representatives from the above organizations did not attend.

Several summary presentations of material given to the Investigator's Working Group just concluded were shown to the MSG starting with the MSFC Ground Operations Manager who described the ground operations plan for ASSESS II. He discussed the guidelines and assumptions, procedure preparation with scheduled needs of input particularly from the experimenters, GSE, and status of operations documentation. The overall ground operations schedule was discussed in some detail. Whereas ESA had earlier planned to deliver their experiments to Ames on April 1, the ESA Program Manager agreed to advance delivery by two days to March 30. It was also agreed to start the constrained period on the evening of May 16. An earlier consideration to start the constrained activities on Sunday, May 15, was relaxed one day to avoid difficulties and added overtime costs necessary to begin on a Sunday evening.

Some discussion ensued regarding the extent of direct involvement by the PI and his staff during the integration. It was agreed that the PI will have full responsibility for his equipment and will be fully and directly involved during Level IV integration. He will be expected to operate his equipment in accordance with prepared procedures. This will be his last chance to stimulate his experiment to insure fully satisfactory data response before it is "launched."

A guideline was accepted that the experimenter will not go aboard the aircraft during Levels III, II, and I integration except in very special cases where there is concern that the experiment will not operate properly. The Mission Specialist and Payload Specialists will assist in the integration aboard the aircraft in behalf of the experimenter and the installation and checkout will be done according to prepared procedures as if the experiment were being installed aboard Spacelab by the integration contractor at KSC.

The ESA Program Manager presented a summary of pre-integration activities relative to the ESA experiments to be conducted at SPICE in Porz-Wahn, Germany during February and March. He showed a flow of experiments into the simulation system, which is being constructed by DFVLR, along with a schedule of events leading up to a constrained period of operation to be run in their ground facility using the ESA Payload Specialists to operate the experiments with management control in a remote Payload Operations Control Center.

A DFVLR representative showed details of the facilities to be used for the SPICE pre-integration operation including layout of the ESA experiments in a CV-990 mockup, the communication system, and their plans to handle data through a system they are building to very closely resemble the ADDAS system on the CV-990.

The ESA Program Manager invited U.S. observation and participation in the SPICE activity.

The MSFC plan to carry out an off-the-aircraft integration of the complete payload using a separate Payload Checkout Unit was thoroughly discussed. The MSFC Mission Manager described the rationale for conducting the off-line integration. While recognizing the extensive effort on the part of ESA to do a pre-integration of their experiments in Porz-Wahn, he wants to use ASSESS to simulate to the greatest extent reasonably possible a pre-integration test of the entire payload as it will occur at any Level IV integration site and deliver to KSC the payload with zero experiment test requirements. He recognized that there will always be some exception to such an ideal case, and while the aircraft program does present some unique problems that prevent exact reflection of the Spacelab approach, it does allow a very high degree of opportunity to try out the basic approach.

The ESA Program Manager presented in chart form (attached) the ESA analysis of the MSFC proposal. In summary, while he showed a number of reasons for disagreement with the MSFC plan, as outlined in his presentation, he stated that he will accept the MSFC proposal to do off-line pre-integration without using the aircraft as shown on the MSFC schedule if the other participating NASA Centers who were not officially in attendance agree. This was accepted.

The MSFC representatives presented the POCC and data handling concepts for ASSESS II including the physical and organizational arrangements and responsibilities of the various participants.

Since the last meeting, substantial progress has been made regarding the role of the Mission Specialist. The Mission Manager presented the proposal made by the NASA Program Manager for JSC to assign an M/S to functionally report to the Mission Manager at MSFC, for him to act as the alter ego of the Mission Manager during flight, to be the interface between the payload crew and the "STS" flight crew, to be responsible for aircraft-experiment support systems, to be trained as a P/S at the discretion of the Program Manager, and to work directly with the POCC during flight. This proposal has been implemented through NASA Headquarters to JSC and the Mission Manager expressed satisfaction with it. There was general agreement.

The ESA Program Manager invited participation by the M/S in the SPICE activity, and also suggested that the M/S should handle the EMI experiment during flight. The Mission Manager agreed to look into the possibility of the M/S handling that assignment.

MSFC representatives briefly reviewed the flight operations planning that had been presented to the IWG including the agreements reached and the outstanding action item. Seven night flights and two day flights are planned with one possible additional optional flight track. The preliminary timeline plan for the M/S and U.S. P/S for one flight has been delivered to ESA representatives for their use in preparing compatible timelines for the ESA P/S.

Deep concern was expressed regarding the tardiness in obtaining optical path information from the ESA solar experiment. The ESA Program Manager said they are working with the experimenter to solve the problems, but the responsibility must remain with the experimenter. They are helping all they can.

Participants adopted the report of material which had been presented to the IWG.

The ESA P/S training plan was transmitted to MSFC.

A previous action item regarding ESA support for taking the CV-990 with the ASSESS payload to the Paris Air Show is still open. ESA is receptive, but a formal request from NASA is still awaited in order to respond. This action was transmitted to the NASA Program Manager for attention.

The ESA Program Manager announced that an ESA-IWG will be held in conjunction with the SPICE pre-integration, and he suggested that it would be appropriate and timely for the last meeting of the MSG before "launch" to be held at Porz-Wahn at that time. No specific action was taken on his suggestion.

MINUTES

NASA/ESA ASSESS II Mission Steering Group Meeting

March 9, 1977

The Mission Steering Group meeting was held at ESA/SPICE in Porz-Wahn, West Germany.

Since the last Mission Steering Group meeting a new individual was appointed ASSESS II Mission Manager at MSFC. This change became effective January 19, 1977.

The philosophy of Payload Operations Control Center (POCC) staffing was discussed in depth to establish and clarify the guidelines under which the ASSESS II POCC will be handled and the relationship and application of the ASSESS II approach to that being considered for Spacelab. The POCC activity for ASSESS II is essentially a complete reflection of that planned for Spacelab including all of the identified operating positions. However, the discontinuity of aircraft flights presents some anomalies with respect to real-time flight planning and POCC operation.

POCC Mission Scientist Position Staffing

The Mission Manager pointed out that for Spacelab, MSFC plans to have the Mission Scientist sit in a staff position with the Mission Manager as an off-line activity with respect to the on-line POCC operation. In that position he will handle overall science-oriented mission planning. The science position in the POCC will be staffed by the Deputy Mission Scientist to participate in daily real-time execution of the mission.

This concept was relatively new, but ESA expressed concern that while the off-line science planning function might be applicable to Spacelab, for ASSESS II this would place the ESA Mission Scientist in a shared role with the U.S. Deputy Mission Scientist in the POCC. If an off-line mission science activity is to be implemented, it is the desire of ESA to use their prime ESA Mission Scientist to participate in that activity with the prime U.S. Mission Scientist and to appoint an ESA Deputy Mission Scientist to serve in the POCC in conjunction with the U.S. Deputy Mission Scientist. However, ESA expressed concern that science judgements will be compromised in ASSESS II by removing the prime Mission Scientists from the real-time active execution activities in the POCC.

A negotiated settlement of the issue was reached by agreeing to eliminate the off-line science planning function for ASSESS II and concentrate the prime U.S. and ESA Mission Scientists' efforts in the POCC on a shared schedule basis during the most active periods of POCC operation and to use the Deputy U.S. and ESA Mission Scientists during the less critical periods. A specific schedule of participation was established as follows:

		DAY 1	DAY 2
T-8 hours Pre-flight	14-1/2 hrs	U.S.	ESA
T+6-1/2 hrs Flight Period		Mis. Sci.	Mis. Sci.
	9-1/2 hrs	U.S.	ESA
T+9-1/2 hrs Post-flight debriefing and PI data evaluation		Dep. Mis. Sci.	Dep. Mis. Sci.

This schedule of POCC manning by the Mission Scientists was based on a typical day plan, and would repeat throughout the mission period.

The ASSESS II Mission Manager reserved the right to reevaluate this arrangement after the first two days of operation; however, it was agreed that changes to this plan would be discussed with ESA before implementation.

POCC Operations Position Staffing

Detailed discussion also took place regarding POCC staffing of the Operations position. It had been previously agreed that this position will be staffed by the backup Payload Specialists since they have been deeply trained on experiment science and operation and will have established a strong working relationship with the payload flight crews. However, the U.S. philosophy of providing only one backup P/S from the mission management staff to back up the two initially selected U.S. Payload Specialists for operation of the U.S. experiments differs from the ESA approach where two backup Payload Specialists fully trained on the ESA experiments will be available. This imbalance of backup Payload Specialists between ESA and NASA raised the question of guidelines for shared responsibility in the POCC operation position assignments.

It was generally recognized that the U.S. backup P/S had developed a deeper overall interface and understanding of both the ESA experiments and the U.S. experiments through his mission management activities in developing the investigator requirements for all the experiments as opposed to the ESA P/S who have worked only with the ESA experiments. Thus, it was agreed that the U.S. backup P/S will be assigned the key periods of operation in the POCC during the first two days for the initial flights followed by rotation with ESA backup Payload Specialists for flights 3 and 4. Subsequent days will be a repeat of the assignments.

	4 hours Preflight	8 hours Flight Period	4 hours Post Flight
Days 1 and 2	ESA #1	NASA	ESA #2
Day 3	NASA	ESA #1	ESA #2
Day 4	NASA	ESA #2	ESA #1

The Mission Manager also reserved the right of reevaluation of this arrangement after initial operation similar to that stated above for the Mission Scientist assignment.

POCC Activity Planner Position

It was agreed that the POCC Activity Planner position will be manned by NASA throughout. However, an ESA representative will assist the NASA Activity Planner for the purpose of gaining experience in this activity.

Mission Implementation Plan

Approval of the Mission Implementation Plan (MIP) being prepared by JSC has continued to be delayed due to lack of acceptance by the participating organizations. Another recent attempt to reach agreement during a telephone conference was not successful and a new round of rewrite is in progress.

A key point generally accepted during discussion at the MSG meeting is that the present document as written differs substantially from the original intent. The initial understanding was to have a document which would summarize the plan for operations emanating from the Flight Operations Plan, the Ground Operations Plan, and the Flight Support Plan. The ESA Program Manager pointed out that it is inappropriate for ESA to be expected to approve the document since ESA is not involved in the present version.

The NASA Program Manager proposed that statements be included in the document to the effect that arrangements with ESA are covered in the ASSESS II NASA/ESA Letter of Agreement and other existing NASA/ESA documents so that ESA concerns and approval of the document can be dropped. This proposal was accepted thus leaving a continuing need for agreement and approval of the document within NASA.

Documentation

The NASA Program Manager postponed discussion of documentation since most of the documentation is yet to be identified and prepared.

Mission Schedule

The Mission Manager briefly reviewed the mission schedule as attached. He emphasized that some changes have been required to delay integration of the U.S. experiments due to their late availability. Particularly, the EES will be late, specifically due to late authorization by NASA Headquarters. The first two weekends, originally planned for real-time contingency need, are now fully scheduled.

The ESA Operations Manager reviewed the ESA status of their simulation of the pre-Level III activities at SPICE using the ESA portion of the ASSESS II payload. He described the 990 mockup and living quarters used for their simulation including an ADDAS simulator, POCC, Payload Specialist selection, and their flight planning activities. The ESA Operations Manager pointed out that their simulation activities will end on March 13 after which they must change all experiments to operate on U.S. electrical power and check them for satisfactory operation to be followed by packing and shipment beginning March 21. They plan to make delivery of the ESA experiments to Ames by March 30.

ASSESS II Debriefing

It was agreed that the major debriefing meeting for the ASSESS II project will be held at Ames the day following the constrained mission. All significant participants in the mission, including the PIs and Payload Specialists, will be held over for that meeting and will be expected to contribute.

APPENDIX B

Minutes of Investigators' Working Group Meetings

MINUTES

NASA/ESA ASSESS II Investigators' Working Group Meeting

July 12-13, 1976

The Investigator's Working Group (IWG) meeting was held at the ESA/SPICE Office located within the DFVLR Laboratory at Porz-Wahn, Germany.

The meeting was conducted by the NASA ASSESS II Mission Scientist as Chairman of the IWG, with the ESA Mission Scientist as Co-chairman. This was the first opportunity for the ASSESS II investigators to meet together. Functions and responsibilities of the IWG and the Chairman and Co-chairman are shown on the attached chart.

Objectives of the meeting were (1) to obtain first-hand information about details and objectives of each experiment, (2) to gain an appreciation of the mutual requirements and interfacing compromises necessary in mission planning in order for each experimenter to obtain meaningful data, (3) to identify and plan interfaces and data exchange for mutually supporting experiments, (4) to update the experimenters regarding the overall mission planning status with the opportunity for Mission Management to get reactions and suggestions from the experimenters, and (5) to submit nominations by the Principal Investigators for Payload Specialists for the mission. In addition, Mission Management representatives had the opportunity at this meeting to expand and clarify interface information contained in the Investigator Requirements Document (IRD). In fact, some of the IRD's had not previously been received from ESA experimenters. The process of developing an easy-to-complete, yet adequate IRD has been an important learning process, both for Mission Management and for the experimenters as it will apply to Spacelab. Face to face discussions have proven highly efficient and are considered essential to expose the experimenters to the interface alternatives and obtain hard answers from the experimenters to solidify mission planning. Such face to face discussions have also proven highly useful in informing the investigator and his team of the details of mission planning and the characteristics of carrier hardware.

Also in conjunction with the meeting, and as part of an ongoing CV-990 flight project to Iceland, the aircraft was flown to the Cologne/Bonn airport which is adjacent to DFVLR. Arrangements were made for the experimenters to visit the aircraft and observe installed and operating experiments and to discuss their own experiment situation. A special effort was made to acquaint them with the data system (ADDAS) and its interfacing requirements.

The ESA Program Manager welcomed the group and described the ESA/SPICE organizational arrangement as it applies to ASSESS II and Spacelab management in Europe. The NASA Assistant Mission Manager from MSFC discussed the overall ASSESS Program, the particular emphasis of ASSESS II, and the involvement of all the actual Spacelab management elements. It was explained that the IWG, which is intended to be implemented for Spacelab as well as ASSESS II, serves in an advisory capacity to Mission Management. However, it was emphasized that inputs from the investigators individually, as well as the IWG as a whole, will be carefully recognized and strongly supported within the limits of cost and manpower resources. The ESA Program Manager stated that the ESA Mission Scientist will be the ESA representative for all European experiments for ASSESS II, and will be the channel for experiment information and critical decisions.

The Principal Investigators each presented details of the various experiments.

The NASA Assistant Mission Manager introduced the operational planning activity being carried out by Mission Management with a brief explanation of the importance of getting a complete and accurate input from each experimenter through the IRD. He pointed out that the integration analysis effort to consolidate the entire payload requirements is based on the IRD inputs, and that they also serve to formulate the total Mission Plan including both ground and flight operations. The ARC Manager described plans for location of the equipment aobard the aircraft including the central control racks for the various experiments. He explained the constraints imposed by viewing port availability and grouping of experiments to permit operation and control by the Payload Specialists.

MSFC representatives presented details of the flight operation planning, the plan for integration and checkout of the experiments at ARC, and briefly discussed the Mission Control Center (MCC) and the Payload Operations Control Center (POCC) concepts to be implemented at ARC during the mission. The experimenters were informed that there are to be no check flights for the experiments prior to the constrained flight period; instead, experiment flight readiness will be verified by tests to be performed during the ground operations activity.

The NASA Assistant Mission Manager concluded the Mission Management presentation to the IWG on mission planning activity by discussing the crew functions and training. Payload Specialist training will be essentially a full-time activity beginning September 1. Two schedule options are still under consideration leading to starting the constrained mission either on May 15 or June 9, 1977.

An executive session of the IWG was conducted by the Chairman mainly to submit candidates for Payload Specialists. Much discussion ensued regarding P/S qualifications which ranged from capable technician/engineer with expertise in electronics and optics to a scientific background particularly for interpretation of star fields. It was generally agreed that the P/S must have intuition with respect to the data quality. In Europe, the P/S opportunity had been widely advertised. Many applications had been received, and so far, only very coarse screening had been done. The ESA Mission Scientist volunteered a deadline of August 1 for submittal of their candidates. In the U.S., some experimenters were still pondering the question of P/S candidates, but the lack of funding definition to the experimenters had basically prevented submissions. The Chairman established a deadline of August 6 for P/S nominations.

The CV-990 data system specialist from ARC described the capabilities and operation of the ADDAS data system together with the experiment interfacing requirements.

Throughout the meeting there was extensive discussion and suggestions relative to all aspects of the mission. Many requirements were clarified; several new ones were identified. Two experimental groups (one U.S. and one ESA) decided to collaborate on solar measurements. The interchange was very beneficial both for the experimenters and mission planners.

Significant points made regarding the experiments were as follows:

1. Microwave Limb Sounder (JPL)

   a. Needs 4 to 5 hours of integration time.
   b. Has flown on the 990, but is a relatively new instrument. Intend to fly on Spacelab.

2. Synthetic Aperture Radar (JPL)

   a. Has flown on 990, but will require some redesign to simplify control and reduce P/S time.
   b. Present instrument is being developed for sea-satellite in 1978.

3. Imaging Isocon (University of Southampton)

   a. They flew on ASSESS I which was their first flight opportunity and a significant learning experience.
   b. They have improved their data gathering approach and will also improve their equipment.
   c. PI requested provision for a second camera to permit observations from either side of the aircraft.
   d. The IRD from this group had not been received prior to the meeting due to a foul-up in international mail.

4. Life Sciences Experiment (DFVLR)

   a. They will instrument both prime (in-flight) and backup (on-the-ground in the POCC) Payload Specialists.
   b. Expect to get continuous measurements; 3 days pre-flight, 10 days confined flight period, and 3 days post-flight.
   c. 63 minutes per day required in the P/S timeline to obtain and record measurements.
   d. Two freezers required, one on the aircraft and one in the living quarters, to store and freeze 3-hour urine samples.

5. IR Heterodyne Radiometer (Langley)

a. This instrument also aimed toward Spacelab.
b. Upon learning of the ESA solar physics experiment details, there appears to be a strong collaborative opportunity.
c. PI prefers more daytime flights to permit experiment coordination.

6. Airborne Electromagnetic Survey (GSFC)

a. Almost unlimited opportunity to obtain data since very little exists in the emergency bands being covered.
b. Large data rate -- 100 kbs continuous.

7. IR Astronomy (University of Paris)
IR Astronomy (Max Planck Institut)

a. Both groups will use the same telescope from Meudon Observatory that was flown on ASSESS I.
b. Many improvements being made in telescope system. Improved tracking through improved torque control.
c. Improved computerized data handling and control to reduce P/S task load.
d. Planning to install sensors for both experiments on the rear of the telescope with possible split beam arrangement so that easy switching from one experiment to the other may be possible.
e. PI presented new viewing requirements from those earlier discussed as a result of the information presented at the meeting relative to flight track possibilities as integrated with total payload experiment requirements.
f. PI requested water vapor measurements.
g. IRD for this experiment also not received prior to the meeting due to international mail problems.

8. LIDAR (DFVLR)

a. Must not operate the laser below 3 km altitude for safety.
b. PI presented new requirement during the integration and checkout period for time to align the laser. This requires positioning the aircraft relative to a distant target.

9. IR Isotropometer - Solar (Capodimonte Observatory)

   a. Have used instrument for ground-based measurements. Will require redesign for airborne installation.
   b. IRD not yet completed and the experimenter familiar with the hardware details could not attend the meeting. Key questions were posed. He will visit ARC and MSFC in August to discuss I/F and operational problems and complete the IRD.
   c. Need significant interface with the ADDAS to drive their instrument.

In addition to the scientific experiments, several points came up regarding the engineering experiment to measure EMI from ESTEC as follows:

a. Experimenter voiced concern regarding the distance of their equipment rack from the aircraft inverters where measurements are to be made.

b. Requested single-point ground on the ADDAS system.

c. Requested that all experiments be powered from a single inverter to reduce EMI. This is not possible with the existing aircraft system.

d. Requested that the aircraft grounds be terminated at a single point in the forward cargo bay of the aircraft.

e. Requested that NASA experimenters modify their equipment to provide single-point grounding.

ASSESS II INVESTIGATOR'S WORKING GROUP (IWG)

- Scientific and technology advisory group to management.
- Optimization of payload requirements to assure maximum payload return within established mission constraints.
- Recommend Payload Specialists to mission management.
- IWG chaired by NASA Mission Scientist and co-chaired by ESA Mission Scientist.
- IWG composed of one PI for each facility or each experiment not part of a facility.

CHAIRMAN RESPONSIBILITIES:

- Coordinate all PI activities (European and U.S.).
- Establish meeting dates and agenda.
- Act as single point of contact to management.
- Support all investigators in meeting their objectives.
- Act as Co-chairman for Payload Specialist nominations.

CO-CHAIRMAN RESPONSIBILITIES:

- Act as single point of contact to Chairman for European PIs.
- Support European investigators in meeting their objectives.
- Coordinate European PI activities.
- Co-chair IWG meetings for Payload Specialists nominations.

MINUTES

NASA/ESA ASSESS II Investigators' Working Group Meeting

December 13-14, 1976

The Investigators' Working Group (IWG) meeting was held at NASA/MSFC. The previous meeting minutes were discussed and approved. However, the ESA Program Manager noted that the last minutes had not been sent to ESA for perusal before distribution. The Chairman stated that he will send the minutes to them for approval in the future.

The NASA Assistant Mission Manager from MSFC reviewed the project status and reported that the mission is on schedule with a launch date for the constrained flight of May 15, 1977. (This date was later moved to May 16 by general agreement to avoid difficulties and extra overtime costs to start the mission on Sunday evening.) A round of visits to all the investigators was completed in late November to solidify information regarding experiment requirements and interfaces. Each Experimenter Requirements Document (IRD) was fully updated with some exceptions where the experiment design and/or operational considerations had not progressed far enough to complete the information. A final formal session of analytical integration had just been completed at MSFC, the results of which formed the basis for the IWG presentations.

The IWG meeting was broken up into a first day of presentations followed on the second day by several working sessions and a summation meeting of conclusions and actions required.

ARC representatives reviewed the aircraft configuration for the mission. Several changes had been made since the last IWG, but the configuration presented was essentially final reflecting the latest inputs from the IRDs. The optical tracking arrangement for the ESA solar physics experiment is still due and will probably require movement of their racks, but only slightly. They also presented the layout of the living quarters, configuration and contents of each of the "Spacelab" central consoles, and a summary of electrical power requirements. Additional information was requested from some experimenters regarding electrical power as shown on that chart. Experimenters were also requested to submit any special data display requirements to be shown on the closed circuit TV display in the aircraft during flight. This request was made in the IRD, but perhaps was not fully understood.

It was explained that, as opposed to Spacelab, the aircraft experiment support systems are not intended to be unattended. Therefore, some non-confined personnel (ghosts) will fly on the mission to maintain the aircraft electronics, ADDAS system and stabilized mirror system, plus an ASSESS observer. The PI from NASA/Langley requested an additional "ghost" to handle laser maintenance since his experiment has not been funded to improve their laser to Spacelab quality. It was agreed to support this request.

MSFC representatives presented a detailed schedule of ground operations to take place at Ames showing activities for every experiment and for functional checkout of the entire payload. An off-the-aircraft pre-integration (Level IV) of the entire payload to be managed by MSFC was shown, which will employ a special payload checkout unit (PCU). This will be followed by integration of the payload on the aircraft to be carried out under the jurisdiction of KSC (Level III, II, I). The Level IV payload checkout represents off-line payload checkout of the Spacelab payload before it reaches the orbiter. Final agreement for this plan for off-line checkout of the ASSESS II payload had not been reached with ESA, but this was the MSFC plan. A final decision was to be reached at the upcoming Mission Steering Group meeting.

MSFC also presented a number of charts giving the guidelines for ground operations with a request for experiment operations procedures from each experimenter with due dates. They strongly emphasized the need for these procedures since that information is the basis for much of the integration document preparation. In addition, GSE requirements were identified and discussed.

A summary was presented of the integrated payload mission planning including the guidelines used, a summary of experimenter requirements and constraints taken from the IRDs, and some details of each of the proposed flight tracks to accommodate the requirements. The ensuing discussion uncovered some potential problem areas where some instruments would be turned on and off as their periods of opportunity become available in the integrated flight planning for the entire payload. For instance, it was proposed that the JPL-SAR would operate only over specified targets, and timelines would be built around this plan. However, it was pointed out that during previous flight experience with that instrument, it was never turned off during flight which raised questions about its operation. An action was taken to determine the ramifications of this problem with the JPL PI who was not at the meeting. Also, the Langley PI must identify his specific interactive ground stations in the immediate future to permit solidification of flight track patterns. The DFVLR clarified a desire for continuous measurements versus measurements only over specific truth sites.

Although it was recognized that flight tracks may be altered in real time during the mission for a variety of reasons, the constrained flight period will begin with a hard schedule and very specific plans and timelines for each flight. PIs were encouraged to study the details presented at the meeting to assure that their requirements are appropriately accommodated.

A preliminary detailed payload crew activity plan had been prepared for one flight by the Mission Specialist and the U.S. Payload Specialists. It was presented and discussed to show the detailed individual timelines which will be used to guide each individual efficiently through the entire awake period. Specific time allocations were scheduled for all experiment operations including pre aircraft flight warmup and calibration, interactive flight operations of the various instruments, shutdown after landing, and the debriefing period. A similar complete timeline for the entire payload flight crew will be prepared for each flight, and will be used by the POCC as well as the onboard crew as the baseline schedule.

The preliminary sample payload crew activity plan was submitted to the ESA representatives so that the timelines for the ESA Payload Specialists can be developed in a similar manner. The ESA and NASA plans will then be merged into a complete composite plan probably during the pre-integration activity at Porz-Wahn when the total payload flight crew will be together.

The ARC Manager announced that arrangements look very favorable that the U.S. Air Force will support the mission by providing relay of HF communications from the aircraft to the POCC at Ames throughout the flight period. This will simulate voice communications with Spacelab and permit real-time interaction with the payload crew. However, the MSFC Assistant Mission Manager pointed out that all communications with the crew will be shut down about 25 percent of the time to simulate the black-out periods applicable to Spacelab. This has not yet been scheduled but will apply to some of the HF communications during flight as well as data and TV transmission when the aircraft is on the ground--which is considered to be part of the "Spacelab" mission flight period and will be fully constrained.

MSFC presented and discussed the Payload Operations Control Center (POCC) concept and arrangement including guidelines, organizational concept, individual responsibilities, and the proposed physical layout. These plans are yet to be hardened with the JSC arrangement and interaction with the Mission Control Center (MCC), and with Ames who will provide the facilities.

Handling of data during the constrained period was discussed and a typical POCC mission timeline for one day was presented showing how data will be retrieved from the aircraft, the interactive use and scheduling of data terminals to permit PIs to analyze and scan the data output, interactive planning for the next aircraft flight period utilizing inputs from the PIs and the Mission Scientist together with mission management and the professional flight planners, and also how external information such as weather satellite inputs will flow into the system. A schedule of data requirements milestones was presented along with the guidelines and ground rules which will apply to data handling during the constrained period to be properly compatible with this Spacelab flight simulation. A list of problem areas where more information was needed from some experimenters was discussed along with open items yet to be finalized.

During discussion of the various open items and requests from the PIs for more information, the Langley PI observed that since mission management representatives had actually filled out his IRD some time ago during discussion with him, it was difficult for him to remember the details, and he has never received a copy of the completed document. He recommended that a copy of the IRDs be sent to the PIs so they will have a baseline from which to submit further information. It was quickly agreed that this should have been done. MSFC will send a copy of each IRD to the respective PIs as soon as possible.

A variety of action items and decisions, in addition to those shown, developed during the presentations as follows:

1. The LIDAR Experiment (DFVLR) needs space for PI-provided ground equipment and general concern developed about space for the PIs to prepare their experiments at Ames. The ARC Manager will furnish a proposed plan to MSFC to handle this problem.

2. An unresolved problem as to whether a timing signal must be added on one channel of the CP-100 recorder was discussed. This would eliminate a channel to be used for EMI measurements. The ESA Mission Scientist will resolve this problem.

3. ASSESS Mission Management will interface with ground sites in real time during the mission to assure full coordination and realignment if and when schedules may change. PIs can and probably will interact with the sites as required for planning and data interchange. MSFC will solidify and coordinate the real time flight interaction.

4. Some changes were given during the meeting for developing the flight track planning for the analytical integration phase and it was agreed that as a result of the baseline requirements in existence as a result of the IWG meeting and the specific action items on this subject, MSFC will perform one more iteration of flight planning to refine the flight tracks.

5. The ESA Mission Scientist specifically requested that the NASA Mission Scientist attend the ESA pre-integration activity in March in Porz-Wahn and participate in an ESA IWG to be held at that time to fully resolve ESA/US interactive experiment problems.

6. All experiment support equipment except some cryogenics will be assembled for loading prior to the mission flight. There will be no exceptions. However, mission management may decide not to carry all tapes and reels aboard the aircraft during specific flights if the specific flight is weight critical and some data taking impairment would result, but the tapes and reels will be held in bonded storage as if they were on the aircraft.

7. Concerns were expressed that full adherence to requirements of the Medical Experiment may interfere with ability of the flight crew to fully handle other experiments. Specifically, the attachment of electrodes as an interference to get a full measure of rest was cited as an example. The ESA Mission Scientist will work out with the Medical Experiment PI a proposed set of guidelines to be applied to this problem during the mission.

8. In general, prepared food will be made available to the constrained flight crew to eliminate encroachment on their time to attend experiments in order to prepare food.

9. DFVLR has offered through SPICE to have a medical doctor available throughout the mission to work with Ames to assist in any problem which may arise. The ARC Manager will coordinate this offer with the medical office at Ames and notify ESA.

10. Subsequent to the actual meeting, a point came up which indicated that the water vapor meter, to be furnished through Ames as a general mission support item, can be quickly reprogrammed from water vapor measurement to ozone measurement. The NASA Mission Scientist requested that ARC explore this possibility for quick change during flight as it might apply to the solar flights where there is a desire for both measurements.

Following working sessions on the second day of the IWG meeting, conclusions and open items with actions were summarized by the session leaders in the areas of (a) payload configuration - ARC, (b) ground operations - MSFC, (c) mission planning and flight operations - MSFC, and (d) POCC and data handling - MSFC.

APPENDIX C

Experiment Problems During Flight

This appendix lists by experiment and flight the major recognized deviations from expected experiment operation including interfaces with the aircraft and experiment support systems.

LIDAR The LIDAR experiment performed well during the first seven flights excepting flight two when a blown fuse was mistaken for a dead battery. The fuse was blown prior to flight two when the P/S attempted to charge the battery pack while the experiment was turned on. All data from that flight were lost. This circuitry should have been tested during the Mission Simulation Test, since daily battery charging was included in the P/S timeline. However, it was not tested until after the first aircraft flight which resulted in the blown fuse. Unfortunately, the problem was not discovered until preparations for the next flight were fully underway with no time available to solve the problem. During the last two flights, when the laser fired, the experiment frequently did not see any laser light reflected from aerosols in the beam. It was not clear at the close of the mission what caused that problem.

The LIDAR experiment was never fully mated to the central data system. Serious interfacing problems were encountered throughout all phases of payload integration, and the problem identification vacillated between the central data system and the experiment. Just before launch a defective experiment component was identified. Correction was made, but intermittent data transmission persisted during flight. Fortunately, data was recorded on an internal experiment recorder so that no data was lost, but because of the interface difficulty with the central data system, ability to obtain quick-look data during the mission was impaired.

CTM The CTM experiment achieved good results operating in the night-sky-brightness mode, but, because of a serious design deficiency, it did not do well viewing the sun. This basic difficulty was due to the fact that the experiment included no positive means of guiding on the sun.

At the IWG meeting in July 1976 the CTM PI in discussion with the IHR PI (who used the sun as a light source for ozone detection) conceived a plan of mating IHR stablized mirror orientations to the independent CTM stabilized mirror and thus eliminated need for a CTM sun tracking addition to his experiment. Since the IHR experiment did include sun guidance optics, and its mirror could follow the sun, this idea should have, in theory, put CTM on the sun whenever the IHR was on the sun. However, the CTM instrument, which viewed in the far IR, could not "see" the sun from the ground so that, although an attempt was made, the two experiments could not be boresighted prior to flight. Thus, the first attempt by CTM to guide on the sun (flight eight) ended in complete failure. Early in flight nine the stabilized mirror operators attempted a crude mirror boresight by setting both azimuth and elevation to zero, as indicated by benchmarks on the mirror support structures, and comparing values for those parameters as computed by the central data system for both mirrors and displayed on closed circuit TV. There were initial difficulties in implementing this unique fix in real-time, but concentrated effort on the part of the mirror operators and the central data system operator as the flight progressed achieved a satisfactory slaved operation of the CTM mirror through the computer system. The CTM experience demonstrates especially well the importance of careful mission planning and of carrying out proper preflight testing if such problems are to be avoided in flight.

A CTM lock-in amplifier failed early in flight four. The PI was informed via radio link, and, while no spare had been put aboard, management treated the situation as though there had been a spare in stowage and allowed replacement of the amplifier instead of having the P/S attempt repairs.

AWS An earlier single-camera version of the AWS experiment had been flown successfully on the CV-990 during ASSESS I without significant problems. However, during ASSESS II focus and/or sensitivity problems were encountered on every flight for reasons not identified at the end of the mission. The P/S spent considerable time in flight attempting to improve the focus, but he had little usable ground time to troubleshoot the problem during the first five days of the mission, since camera operation required low ambient light levels at night. Finally, prior to flight six he was able to bring both cameras into excellent focus, but an undiagnosed cause defocussed the right viewing camera immediately after takeoff for the next flight, and during the flight the left viewing camera lost IR sensitivity. He was unable to remedy the problem with either camera during that flight. The backup P/S brought aboard after flight six (see section 3.5) was considerably less familiar with the AWS experiment, and no attempt was made to operate the left viewing camera during flight seven. The AWS was not operated during the last two flights, in accordance with flight plans, since these were daytime flights.

LAS The LAS experiment had been flown previously with good success at relatively low altitudes and in an open port configuration on a small aircraft, but it operated at considerably less than expected sensitivity throughout the ASSESS II mission. Calibration mode operation during various integration phases was satisfactory, but no means were included to make a direct check of sensitivity because the experiment relied on forward motion of the aircraft to produce a doppler shift in the laser beams reflected back to the aircraft from the ground. The lack of sensitivity was immediately apparent on the first flight. After the second flight, suspecting that the intermediate frequency lay outside the experiment pass band, the P/S shimmed the laser package so that the transmitted laser beam forward angle was increased by one degree. This angle, which was directly proportional to the doppler shift of the reflected laser beams, was never accurately determined. The PI originally specified that the angle was to be 3.0 ± 0.5 degrees in flight and requested verification, but that request for verification was withdrawn. The shift in laser beam angle produced no dramatic improvement, so the P/S (PI) systematically checked out alignment of elements in the LAS optical package during flights five, six, and seven. Some minor adjustments were made and by the end of flight eight some measurable return was being recorded at or above 31,000 feet. However, the return signal never did become as great as expected.

IHR The IHR experiment was flown on the CV-990 about nine months prior to the ASSESS II mission. It was found then that the laser frequencies were a function of cabin air pressure. The PI, by diligent attention, could keep the frequencies properly adjusted, but it was recognized that the operation would require far too much time for a P/S to maintain adjustments and handle other duties on the ASSESS II mission, so the laser package was redesigned. This redesigned package produced less reference laser power than was desired, and was the only part of the experiment which continued to perform poorly throughout the flight mission. The P/S readjusted parameters controlling the laser power on each flight, but could not increase it.

While all data was somewhat degraded as a result of low laser power, on only two occasions (flights six and eight) did other significant operational problems occur. On flight six the pollutant laser ceased to function for a short period for an unknown reason and had to be restarted, and on flight eight the sun track monitor lost contrast so that sun tracking was degraded. In addition, all data from one flight was lost when an instrument mirror cover was not removed.

IRA (Meudon/Groningen/MPI) The Meudon/Groningen portion of the IRA experiment had been flown on the CV-990 during the ASSESS I mission in 1975. On that mission the P/S was severely overworked to operate the experiment. For ASSESS II, the telescope stabilization system was much improved and system redesign provided more automation. Also, the MPI sensor was added to the Meudon/Groningen system for ASSESS II. MPI had had experience flying similar equipment, but their ASSESS II instrumentation had not been flown before.

Internal experiment control of the telescope and optical alignment difficulties were responsible for most IRA problems. The IRA computer problem was related to software, but was so subtle as to remain partially undiagnosed throughout the mission even though computer manufacturer technicians were called in during the Level IV integration. A dropout problem was encountered during all phases of integration and during flights one, four, five, and seven. The P/S was usually able to bring the computer back up in four to five minutes. On flight four only partial operation was restored, and no recovery was achieved on flights one and seven. On flight five full operation was restored.

An optical problem on the IRA was the most serious. Optical alignment of the telescope was checked in the PCU during Level IV integration, and was found to be satisfactory. However, the collimated source required to check alignment was not designed for use on the aircraft after flight integration and a final optical check could not be made. A large offset signal was apparent on the first flight. Exact source of the problem was not determined, but asymmetry in motion of the secondary mirror seemed likely. The large offset signal had to be subtracted out, and unfortunately it was of much greater magnitude than the small signal of interest. Amplitude of the offset signal at the Groningen detector could be reduced by moving the detector in the plane of the proper telescope focus, but this diminished the IR signal of interest. The MPI detector could not be moved. During flight two, the P/S, on his own initiative, managed to almost eliminate the offset signal, but in doing so, he reduced amplitude of the detected IR from the astronomical targets by a factor of two to three. A judgment was then reached with the PI to compromise in reducing the size of the offset signal only to a point where the signal did not saturate the lock-in amplifier. The P/S spent as long as 15 to 20 minutes during each of the next two flights adjusting the position of the Groningen detector to obtain an optimum combination of offset signal and IR astronomical signals.

AEES The AEES experiment had operational difficulties throughout the mission because of an antenna grounding problem which was not discovered until after the actual Spacelab simulation period when the PI could personally inspect the equipment without violating mission guidelines. The installation drawings did not show that the mounting plate on which the 121.5 MHz antenna was mounted was to be grounded to the frame of the aircraft. As a result, the plate was not grounded, and static electric charges built up on the antenna during flight. The resulting intermittent discharges, sometimes as often as every 20 seconds, produced noise bursts on the 121.5 MHz signal channel. They were also picked up on the adjacent 243 MHz antenna, and interfered with aircraft radio signals. The problem had little serious effect on experiment data return, but was a continuous source of annoyance and lost time to the P/S who tried to identify the problem by looking for interference from other electrical systems. This seemed logical at the time.

A more serious AEES problem was instability of the noise generator used to calibrate all four receivers. Fortunately, the PI had included sufficient spares and instructions so that the P/S was able to keep the instrument in operation.

MLS The MLS operational problems were minor and by themselves produced little loss of data. However, the low level of instrument sensitivity associated with the more automated mode of operation designed for ASSESS II was a serious problem and resulted in very limited data return overall. There apparently was insufficient time and manpower available to thoroughly develop the automated system, and it was not until after the constrained "Spacelab" flight that the PI, using a more complex operational mode, accomplished sensitivity improvement.

SAR The SAR had been operated successfully many times aboard the CV-990. It was taken directly from a previous CV-990 program to the PCU for Level IV integration, and was modified only to the extent of introducing P/S centralized control. This only involved regrouping of experiment components and rewiring. Installation drawings were not complete, and two independent dc power sources were used to supply different parts of the experiment because the two sources were convenient. The power sources were of reversed polarity and bucked each other, which resulted in insufficient voltage to drive the experiment data recorders. Operational checkout after flight vehicle integration was satisfactory, because, unlike the flight conditions, only one recorder was operated at a time using independent power sources. Neither in the PCU, nor after installation in the aircraft was the whole experment operated as it was to be operated in flight with both recorders operating simultaneously.

After the recorder problem surfaced on the first flight, efforts were made to identify the difficulty, but the SAR remained inoperative through flights three and four. Finally, prior to flight five, the experiment was declared a failure by Spacelab standards. Flight mission rules were relaxed and the senior SAR technician went aboard and found the problem. One power supply was bypassed and a cable was added between the Spacelab control rack and experiment racks to feed both recorders from the same dc power source. Mission guidelines were relaxed on two other occassions for SAR, a circuit diagram was uplinked in an attempt to help solve the recorder problem, and, when an integrated circuit in the SAR failed, a replacement was carried aboard.

MEDICAL The medical experiment performed satisfactorily. In two cases discharged batteries were replaced from storage during flight, and a mechanical tape recorder problem was resolved by simply exchanging the bad tape recorder for a spare in stowage. One P/S forgot to turn on his encephalograph for five hours between flights two and three. Subsequently, the P/Ss each received reminders from the M/S just before going to bed.