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LIFE SCIENCES SPACELAB MISSION DEVELOPMENT TEST III

SMD III

Data Management Report

National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
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SMD III

Data Management Report

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TABLE OF CONTENTS

		PAGE NO.
1.0	INTRODUCTION	(1)
1.1	SCOPE	(1)
1.2	OBJECTIVES	(1)
1.3	APPLICABLE DOCUMENTS	(2)
2.0	SUMMARY	(2)
3.0	RESULTS	(4)
3.1	JOHNSON SPACE CENTER	(4)
3.1.1	General	(4)
3.1.2	Discussion	(5)
3.2	AMES RESEARCH CENTER	(6)
3.2.1	General	(6)
3.2.2	Discussion	(7)
3.2.2.1	Data Acquisition	(7)
3.2.2.2	Data Processing	(7)
3.2.2.3	Data Display	(8)
3.2.2.4	Software	(8)
3.2.2.5	Communications System	(8)
3.2.2.6	Slow Scan TV	(9)
4.0	RECOMMENDATIONS	(9)
4.1	JOHNSON SPACE CENTER	(9)
4.2	AMES RESEARCH CENTER	(10)
5.0	DISCUSSION	(11)
5.1	SYSTEM DESCRIPTION	(11)
5.2	SYSTEM DEVELOPMENT	(13)
5.2.1	Onboard Data System (ODS)	(13)
5.2.1.1	Functions	(13)
5.2.1.2	System Description	(14)
5.2.2	Ground Data System (GDS)	(14)
5.2.2.1	Functions	(14)
5.2.2.2	System Description	(17)
5.2.3	Analog Data System	(17)
5.2.3.1	Signal Routing	(17)
5.2.3.2	Analog System Capabilities	(17)
5.2.4	POCC Science Processing System (Science Computer)	(20)
5.2.4.1	Functions	(20)
5.2.4.2	Hardware Description	(20)
5.2.4.3	Operating System Description	(21)
5.2.5	High Speed Data Link	(22)
5.2.6	POCC Slow Scan TV System	(23)
5.2.7	SORC Data System	(24)
5.2.7.1	SORC Voice Communications Link	(26)
5.2.7.2	SORC Real-Time Data Processing	(26)

		PAGE NO.
5.2.7.3	SORC Science Application Software	(29)
5.2.7.4	SORC Slow Scan TV System	(31)
5.2.8	MEDICS Storage and Retrieval System	(32)
5.2.8.1	Functions	(32)
5.2.8.2	System Description	(32)
5.3	OPERATIONS	(33)
5.3.1	Onboard Crew Displays and Operations	(33)
5.3.1.1	Crew Displays	(33)
5.3.1.2	Crew Operations	(33)
5.3.2	Onboard Data Recording and Downlink	(34)
5.3.2.1	Analog Data	(34)
5.3.2.2	Digital Data	(37)
5.3.3	POCC Displays and Operations	(37)
5.3.3.1	Analog Data	(38)
5.3.3.2	Real-Time Digital Data	(38)
5.3.3.3	Science Computer Operation	(42)
5.3.3.4	Data Stripping and Transmittal	(42)
5.3.4	SORC Displays, Processing and Operations	(43)
5.3.5	Slow Scan TV Operations	(51)
5.3.6	Library Archiving and Data Distribution	(53)
5.3.7	Test Status Reporting	(54)
5.3.7.1	JSC	(54)
5.3.7.2	ARC	(56)
6.0	POST TEST ACTIVITIES	(57)
6.1	ONBOARD DATA RETURN AND DISTRIBUTION	(57)
6.2	LOG TAPE DATA RECOVERY	(58)
6.3	POST TEST DATA PROCESSING	(59)

FIGURES

FIGURE NO.		PAGE NO.
5-1	Data System Block Diagram	(12)
5-2	Onboard Data System Block Diagram	(15)
5-3	Onboard Data Flow	(16)
5-4	Ground Data System Block Diagram	(18)
5-5	Analog System Block Diagram	(19)
5-6	Data System Equipment in the Test Control Area	(35)
5-7	Test Control Area in Operational Configuration	(36)
5-8	POCC Floor Layout	(39)
5-9	POCC in Operational Configuration	(40)
5-10	SORC in Operational Configuration	(44)
5-11	SORC Data Products	(50)
5-12	MEDICS Report Forms	(55)

1.0 INTRODUCTION

1.1 SCOPE

This report summarizes the development and operation of the SMD III Data System which included the Onboard Data Systems (ODS), Payload Operations Control Center (POCC)* Data Systesm, Science Operations Remote Center (SORC)** Data Systems, Data Links, Slow Scan TV, Data Library functions, and the MEDICS statusing system.

1.2 OBJECTIVES

The original objective of the data handling systems for the SMD III test was to develop a permanent facility for SMD tests that would functionally simulate all elements of the Shuttle onboard, telemetry, and ground data systems that are involved with Spacelab operations. It was determined rather quickly that this ambitious objective was unattainable because the end-to-end system for payloads was not well defined, funds for a high fidelity permanent facility were not available, and the time to acquire new computer equipment before the SMD III test was too short.

With these considerations in mind, a new objective was formulated to develop data handling systems using existing equipment that would functionally simulate the applicable elements of the Shuttle Data systems. These simulated end-to-end elements included the:

1) Onboard Data Systems
2) Data Downlinks
3) Ground Data Systems
4) POCC Science Processing System
5) POCC-SORC Data LInk
6) SORC Science Processing System
7) Data Storage and Retrieval System

* The POCC was located at the Johnson Space Center in Houston, Texas.

** The SORC was located at the Ames Research Center at Moffett Field, California.

1.3 APPLICABLE DOCUMENTS

The following SMD III unique documents are referenced in this report. Copies may be found in the Space Life Sciences Archival Library in Room 2-203, Bldg. 37, Johnson Space Center, Mail Code JM65, Phone (713)483-2889.

SD-SMD-III-001	Experiment Parameters and Patch Panel Configurations
SD-SMD-III-002	Data Display and Printer Formats, Calibration and Limit Sensing Data
SD-SMD-III-005	Onboard Data System/Ground Data System Design Data
SD-SMD-III-006	Telemetry Downlink Locations
	Science Computer Software System for SMD III

2.0 SUMMARY

The long term objective for the data system was to develop a permanent facility for SMD tests that would simulate all elements of the Shuttle onboard, telemetry, and ground data systems that are involved with Spacelab operations. This objective proved to be unattainable for SMD III because the end-to-end system for payloads was not well defined, funds for a high fidelity permanent facility were not available, and there was not enough lead time to obtain new computer equipment prior to the start of SMD III. It was decided to develop a data system, using available equipment as much as possible, that would functionally simulate the applicable elements of the Shuttle data systems.

The Onboard Data System (ODS) and the Ground Data System (GDS) were developed by the Ford Aerospace Corporation using two Varian 620i computers that were at least ten years old. The air-to-ground link was simulated by a hardwired computer-to-computer interface. Due to the limited core and A-to-D capability of the ODS, it was ground ruled that only a single active experiment would be downlinked at a time. A patch board system was used on board to select experiment inputs, and the downlink configuration from the ODS was changed by a crew keyboard entry to support each experiment. The ODS provided a CRT display of experiment parameters to enable the crew to monitor experiment performance. An onboard analog system, with recording capability, was installed to handle high rate data and to provide a backup to the digital system. The GDS attempted to simulate POCC functions that will be available in Mission Control. It accomplished engineering unit conversion and limit sensing, and provided real-time parameter display on CRT's in the Science Monitoring Area (POCC) and the Test Control Area. The GDS also provided an output to the Science Processing System. The Science Processing System was developed by Technology, Inc., using a PDP-11/40. It was intended to provide a link to the Science Operations Remote Center (SORC) computer at the Ames Research Center (ARC), and to provide graphics parameter display in the POCC. The graphics display capability was not implemented due to development problems, but the ARC link functioned normally throughout the test. The link between the Science Computer and the SORC computer utilized a conditioned telephone line. The SORC computer provided tabular and graphic CRT displays and strip charts for the principal investigators at ARC.

The operation of the Data System was coordinated by the Data Manager under the direction of the Science Manager. The ODS and GDS were operated by Ford Aerospace personnel and the Science computer was operated by Technology, Inc. personnel.

The development and implementation of the Data System was hampered by a shortage of funds, schedule limitations and other difficulties. Even so, it performed well and proved the value of real-time experiment monitoring. The principal investigators were able to monitor the performance of their experiments and offer assistance where needed.

3.0 RESULTS

3.1 JOHNSON SPACE CENTER

3.1.1 General

Prior to and during the test a major concern was that the data subsystems were in series with no redundancy so that a failure anywhere would preclude data from the next link. Additionally, the ODS and GDS used minicomputers at least 10 years old which are no longer actively supported by the manufacturer and with little systems software to aid in writing application software.

Fortunately, these concerns were not necessary since they both worked very well throughout the test with only 20 minutes of data lost in a period between experiment runs. The data lost was Spacelab environmental data and experiment background data and its loss had no impact at all on experiment results.

Aside from one drum hardware failure in the ODS, no hardware failures occurred. Additionally, the software performed all functions required and some new software was added (e.g., display raw voltages, drive auditory alarm, etc.) as the test progressed. Prior to the test, it was decided that the ODS and GDS would be "throw-away" systems because of the age of these systems. Despite their excellent performance in this test, that decision still appears sound because they lack the fidelity required for real payloads.

The POCC Science Processing System (Science Computer) was plagued with developmental problems, e.g., missed delivery, inadequate testing, application software bugs, etc. Once these problems were overcome, the system performed well, completing all the functions established except the graphics display. No hardware failures occurred during the test and no data was lost.

Like the Science Computer, the SORC Science Processing System experienced numerous developmental problems with hardware failures on almost each peripheral during Phase Training, the two-day simulation and SMD III. Despite this, the only failure which impacted the SORC occurred during the second day resulting in the loss of six hours of background data. All lost data was recovered from ODS log tapes after the test. The high speed data link went down only once during the SORC operations.

With respect to the MEDICS storage and retrieval system, it functioned as expected with no hardware problems except a stuck key on one terminal which was readily fixed. Finally, the analog system performed all functions with only minor hardware problems.

3.1.2 Discussion

The total collection of systems put together by teams of contractors using existing eq ipment generally performed well, however, the real question is what was learned from the exercise that can be applied to preparing a data capability for the Shuttle era in life sciences.

Certainly the test showed that all elements (systems) developed are needed for an effective life sciences program. The value of real-time monitoring from the engineering and operational management point of view was never really questioned, as this has been demonstrated in many other NASA programs. Since the capital investment is typically high, the value from the scientist viewpoint can be more readily questioned. Prior to the test, most scientific investigators expressed skepticism that real time local or remote monitoring of the experiments was needed. It seemed apparent that they felt reassured about the quality of their research data by monitoring it during collection. Additionally, the real time summary statistics, ground stripcharts and CRT displays gave them the ability to identify problems in real time. Without this sort of capability, much useless and perhaps misleading scientific information will be collected.

Because of constraints (time, money, etc.) it was decided very early to use limited bandwidth phone lines to get information to the remotely located scientist. This limitation restricted users from tracking some raw data, caused a 3-5 minute delay in seeing the real-time problems, some synchronization problems, and limited TV coverage due to slow scan. While fixes were made to these problems, increasing the bandwidth should be considered with some cost/benefit analyses as the experiment program firms up.

Another area where considerable learning from the test occurred was in interfacing experiments to the onboard data system. Some problems that occurred in interfacing were common grounding, single vs. differential analog inputs; voltage regulation, and scaling for computer input, late delivery, writing software to provide raw voltage displays on the ground; acquiring, controlling, testing, and changing experiments calibration data. Given that we will be interfacing numerous experiments in relatively short periods of time, this area must be streamlined including precise definition of interface options and a life sciences users guide with pictorial representation of options and common errors made in interfacing. Consideration should be given to developing independent low cost optional interface test unit(s) that could be put in core and loaned to experimenters during their experiment development stage.

During the early phase of SMD III program development, a policy was developed that all experiments must have their own display equipment that is independent of the onboard data systems display. The results were a wide variety of digital and analog meters, oscilloscopes, hardcopiers, stripcharts and CRT's with each consuming variable amounts of power. It was clear from the exercise that much remains to be done in selecting and flight qualifying such displays for use as loaned core equipment. Additionally, the use of onboard stripcharts validated the need for this equipment over digital CRT displays because the hardcopy display provides a short range historical record, non-electronic annotation can be made, and scientists within many branches of life sciences are familiar with this tool. Ground based stripcharts, both at JSC and Ames, once again demonstrated their value to the scientific community.

While no serious problems occurred during this test, the amount of worry about computer failures (as well as the cost of standby computer maintenance personnel) strongly suggest that high capital investment is wise to obtain reliable equipment for a permanent facility to be frequently used over the shuttle era. Redundancy of all or portions of the data system is clearly needed and a failure-mode analysis should be part of the implementing contractor's study.

Finally, the systems implemented were only a crude representation of what will actually be available. It was somewhat surprising that several very old minicomputers and several inexpensive new minicomputers could meet the needs of the experiments almost as well as the expensive systems actually planned (e.g., 3 French Flight computers, 4 IBM Flight computers, 4-6 Interdata ground computers, 3-5 large IBM computers, and 1 large CDC computer). The surprise however, disappears when one considers they must meet the needs of all of NASA over a 10 year period.

What level of flight data systems fidelity is needed for Level IV integration? The SMD III does not provide an answer to this question. It provided an extreme lower limit -- in fact, below a minimum since no one would suggest we could use the same systems over an extended time frame. In effect, current unknowns in the program will help define this level, e.g., how much money will be available, what requirements will be placed on such systems, what use can be made of other NASA systems under development, etc. While the SMD III test did not answer all the questions, it proved to be extremely valuable in helping us define where more work, studies, and thought are necessary.

3.2 AMES RESEARCH CENTER

3.2.1 General

The SMD III objectives included the establishment and operation of a "remote ground station" (which became known as the Science

Operations Remote Center - SORC) at Ames Research Center. The detailed planning for the SORC started less than 5 months prior to the SMD III test. It was fortunate that ARC had sufficient resources to provide most of the equipment needed to operate the SORC thus avoiding long procurement cycles. There was, however, a finite limit on what was available and, as a consequence, there was little or no back-up equipment readily available. Several areas were left vulnerable as a result; i.e., no backup computer capability at either the SORC or JSC, only one high speed data link, no backup equipment for CRT displays, etc. The fact that major failures did not occur during the SMDIII test was fortuitous. Major failures certainly would have resulted in real-time data loss to the P.I. As it was, the SORC received, logged, processed and displayed experiment data in real time for the various P.I.'s in the SORC. The capability of the SORC to do that in a routine manner and for the P.I.'s in the SORC to interact with the crew was amply demonstrated throughout the seven day SMD III test.

3.2.2 Discussion

3.2.2.1 Data Acquisition

Data acquisition was in general as planned.
The reliability of the high speed data link was surprisingly high. The reliability of the rest of the data system has to be rated satisfactory to good, i.e., about as expected. The quality of the data was acceptable as would be expected of digital data. Occassional delays of some minutes (5 to 7) were experienced and attributed to computer crashes at JSC and the SORC and switching the SORC computer from off-line processing and software development back to real time data handling. Such delays seemingly had no impact on the experiment nor caused the P.I.'s undue consternation.

3.2.2.2 Data Processing

Data processing was done in real-time whenever an experiment generating data signals was being conducted. At other times the computer was used for off-line data processing and software development. Although the SORC computer and JSC science computer compatibility was established as planned, there was a serious problem in establishing a workable interface between the JSC ground based data system and the JSC science computer. That delay of approximately 3 weeks precluded an end-to-end systems checkout including the real-time data processing software. The consequence was a one week slip in the SMD III test and some software development taking place during the SMD III test.

During the two day simulation not all of the experiments were exercised, but it still became apparent that some of the planned night data processing could not be accomplished, but would have to be done post test. The primary limitation was the time required to transmit the full data stream (as planned) over the 9600 baud line in the time allocated.

3.2.2.3 Data Display

Data Display of the experiment data was accomplished in real-time as planned for the respective experiments. The display formats were established in conjunction with the respective P.I.'s and considered more than satisfactory for providing the P.I. with sufficient information in appropriate form to be truly interactive. The type and number of data display devices in the SORC was adequate for the SMD III test, but as for the computer there was no back-up equipment readily available.

Operationally, the delays in data acquisition cited in 3.2.2.1 above did cause some confusion between what was displayed on the JSC stripchart which was hardwired to the onboard system (certainly an un-real situation for a real mission) and what was being displayed on the stripchart in the SORC from the lagging digital data.

The SMD III test time-line was established to have the experiments run serially and the data system was structured accordingly. Such an arrangement may not be possible for a real mission.

3.2.2.4 Software

The software was divided into "system" software and "applications" software and was developed independently along those lines with well defined interfaces. Each category of software was tested informally with its own test data generator programs. The interfaces were kept simple, to a minimum and well defined. Special software was written as required to verify the output of the system software as it was developed. The application software and system software were merged and tested in a loop mode at ARC to verify all ARC internal interfaces.

Delays were encountered in establishing the ARC/JSC interface and time was inadequate for proper interface testing prior to operational support. A one week schedule slip allowed the methodical checkout of each data format. Numerous programming errors were discovered and corrected within this time and the system was able to support full operations by the end of the week.

Software systems generally evolve with usage. This was particularly true in SMD III; however, with the short time available for end-to-end testing a significant amount of program evolution occurred during normal working hours and excessive shift work for program development and refinement.

3.2.2.5 Communications System

The communications system was generally grouped into two segments, 1) the data links and 2) the voice links.

The 9600 baud high speed data line was routed directly from JSC to the SORC. To preclude potential problems, the attendant SORC 209A data set was positioned in the computer rack. No malfunctions were experienced with the equipment thus allowing the link to be fully utilized. Due to the limitations of the 9600 baud line, selective data compression was necessary, but did not compromise any of the experiments.

The other data links were designed to be used in conjunction with the FTS phone lines with no data compression.

In addition to the data links, the entire voice communications system had to be installed in the SORC. The requirement was to supply an appropriate system which would allow the SORC to communicate with JSC and also the onboard crew. Such a system was established, but only by expending considerable effort after the initial installation and then with unresolved problems that impeded the real-time operations of the SORC.

3.2.2.6 Slow Scan TV

Slow scan TV equipment was supplied to the SORC and JSC by the Nippon Electric Company for use during the SMD III test. The slow scan color TV was the only TV planned for and installed in the SORC. The TV signal from the NEC equipment was transmitted over an FTS telephone line which proved to be reasonably reliable and sufficient for the use intended. Picture quality was excellent. Close-up pictures in support of specific experiments were not required nor obtained. The system could be used to obtain "snapshots" but preferably not as a complete replacement to a full TV stream.

Once in operation, the disc recorder proved a good way to record the slow scan TV pictures in view of the recording quality, the flexibility of operation and the recall capability. However, for post test storage, the images had to be transferred from the disc to magnetic tape.

4.0 <u>RECOMMENDATIONS</u>

4.1 JOHNSON SPACE CENTER

1) Allow adequate time for delivery of critical hardware and software items. A late delivery perhaps does not appear to impact the test, but it telescopes the development schedule so severely that the personnel responsible are under undue strain to attempt to meet milestones. A certain amount of pressure is beneficial to a project, but when it becomes overbearing, productivity and efficiency suffer.

2) The use of DECNET and RSX-11M was very good for quick development of a large quantity of software. These standard, vendor-supplied systems are well documented and relatively free of bugs. It is recommended that future development of such systems fully utilize such commercial software packages.

3) The second day before the seven day simulation one of the P.I.'s requested a significant software change. This change was made, tested and validated before the simulation started. Such a response is characteristic of a payload dedicated operation and singularly uncharacteristic of a control center operation. This supports the concept of a payload specific ground based computer system.

4) In operating a data system such as that for SMD III, or for operational use, a dedicated communications loop is required for data coordination. In SMD III, the Data Manager required closely timed coordination with the real-time computer operator, the data recorder technician, the science computer operator, and the Ames operators, which was extremely difficult using telephones and shared communications loops.

5) Sufficient monitors should be provided such that the Data Manager, who is responsible to Science and to Flight for data operations, has a complete status display of the entire data system, including status of a remote transmission link and how far behind real-time the data is being transmitted.

6) The test suggests that further consideration and study be given to:

   a. Increasing bandwidth capability to Ames.

   b. Simplifying experiment interfaces to the onboard system and providing test units for this task.

   c. Identifying and standardizing experiment onboard display equipment (including stripchart).

   d. Documenting data systems reliability requirements and the fidelity level required for the integration program.

4.2 AMES RESEARCH CENTER

ARC recommendations for all future endeavors and planning, whether additional SMD tests or for a shuttle life sciences dedicated mission, are as follows:

1) Include a SORC in the planning as an effective operational entity.

2) Complete installation and checkout of all data links and communications links prior to any operational use.

3) Data link should have sufficient speed to accommodate pnysiological waveform data.

4) Define and establish better methods for the ground personnel (and particularly the P.I.'s) to determine the experiment progress.

5) Provide backup equipment for critical data system components, i.e., computer main frame, certain data display devices, etc.

6) Allow sufficient time for software development and checkout.

7) Exercise all experiments in end-to-end systems tests and/or simulations prior to test/flights.

8) Provide remote control for onboard TV cameras and a full TV stream for P.I.'s.

9) Provide software for real-time continuous waveform display of experiment data and for summary data displays/ hardcopy for P.I.'s.

10) Computer operational checkpoint capability would be a plus.

5.0 DISCUSSION

5.1 SYSTEM DESCRIPTION

The Spacelab Mission Demonstration III (SMD III) was designed to simulate the systems and concepts involved in a genuine Spacelab flight. Various life sciences experiments typical of those which might constitute a payload on a Spacelab mission were evaluated and selected for the simulated mission. The data requirements of these experiments were considered along with the proposed capabilities of the Spacelab data system and a low cost data system simulator was conceived. Figure 5-1 is a simplified block diagram of the data system developed for SMD III.

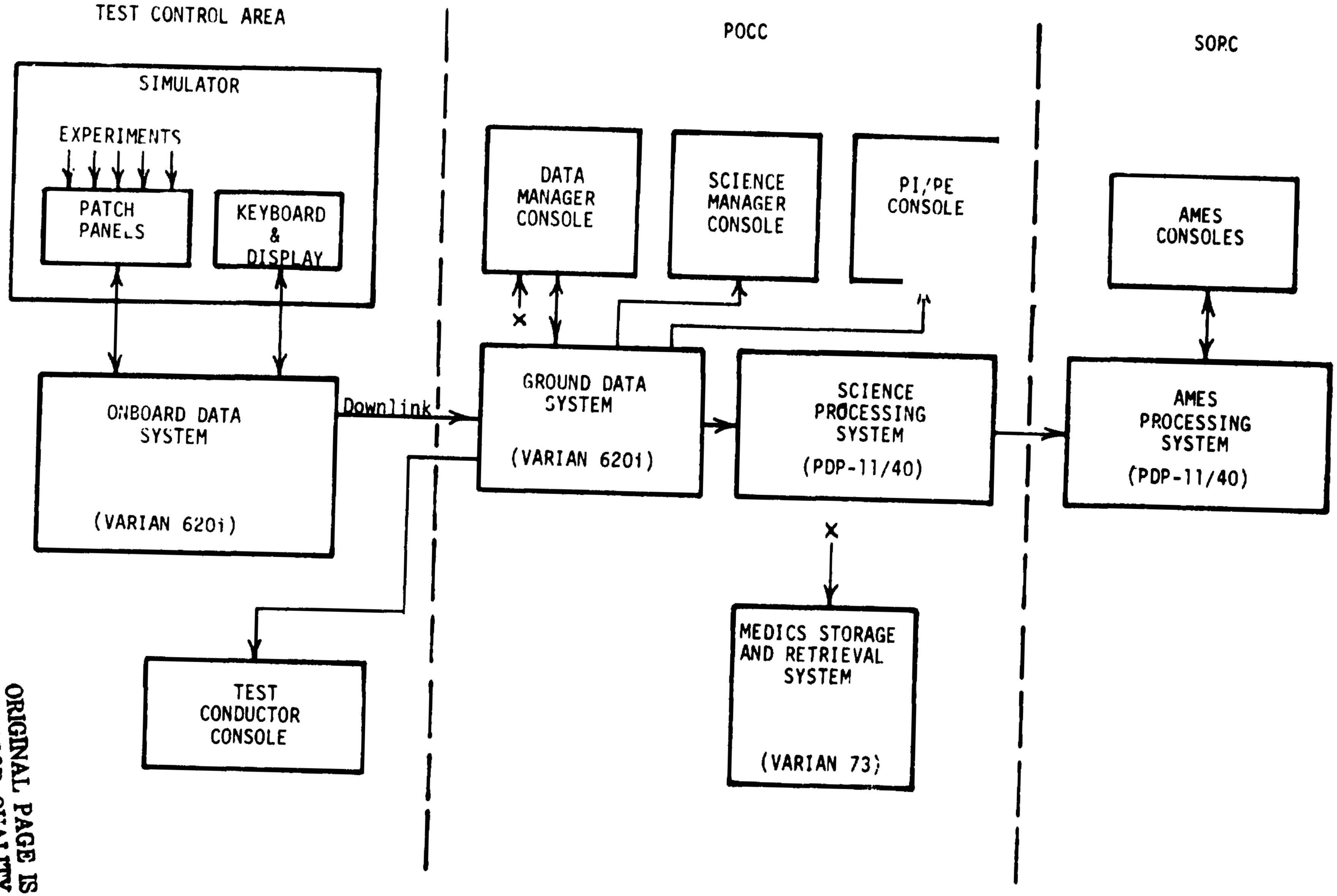

FIGURE 5-1, SMD III DATA SYSTEM BLOCK DIAGRAM

The Onboard Data System was simulated with a single Varian 620i. This system was used to acquire data from the experiments, log it on tape for archival purposes, and send it to the Ground Data System (GDS). The air to ground link was simulated by a hardwired computer to computer interface. The GDS was likewise simulated by a single Varian 620i. The GDS served as the ground telemetry station and the real time display driver of a Payload Operation Control Center (POCC).

Due to the limited core capacity and A-to-D inputs of the ODS, it was ground ruled that only a single active experiment would be downlinked at a time. A patch board system on board was used to select experiment inputs, and the downlink configuration from the ODS was changed to support each experiment.

An onboard analog system, with recording capability, was installed as a backup to the digital system, and to handle high rate data. Due to lack of D-to-A converters for the GDS, the analog system was hardwired to analog displays in the POCC.

The existing MEDICS computer system at JSC was remotely accessed from the POCC and the SORC for data base storage and retrieval of the data library index and test status information. This system was also available to the Flight Surgeons console to provide access to crew medical records.

Data from the GDS was fed to a PDP 11/40, used as the Science Computer in the POCC for temporary data storage and near-real-time processing. Furthermore, the Science Computer was used to drive the real-time data link to the SORC at Ames Research Center.

The SORC data link terminated at another PDP 11/40 computer, which served as the SORC display driver, as well as for scientific processing.

Communication with the SORC from the POCC and test area was also maintained by a slow-scan TV system, and by two voice communication lines.

5.2 SYSTEM DEVELOPMENT

A summary of the development and configuration of each system is as follows:

5.2.1 Onboard Data System (ODS)

5.2.1.1 Functions

1) Simulate a limited Spacelab Remote Acquisition Unit (RAU).

2) Provide real-time onboard parameter display and downlink configuration control via one CRT/keyboard terminal.

3) Log all digital data.

4) Provide engineering units conversion.

5) Interface with the GDS.

5.2.1.2 System Description

The ODS digital section consisted of a vintage Varian 620i minicomputer with 20K core memory, two magnetic tape drives, small drum, paper tape reader, 48 AD channels, CRT display, 3 serial I/O channels, and keyboard (See Figure 5-2). In the real Spacelab this system would consist of three flight French computers in the Spacelab and four flight IBM computers in the orbiter. The complete ODS was placed outside the mockup with only the CRT display and keyboard being onboard for crew interaction.

Because of the limited A-to-D channel capacity of the ODS and the lack of a backup ODS, a patch board system was installed. Onboard all analog signals were routed to a patch panel as shown in Figure 5-3 where they went to the ODS for A-to-D conversion and directly to analog recorders and stripchart recorders in the science monitoring room. Experiments were grouped and the crew inserted the appropriate patch panel before running a specific experiment. In the real Spacelab, sufficient capability has been baselined to handle all channels simultaneously.

With respect to interfacing the specific experiments to the onboard data system, several problems were encountered. One experiment (#66) required a digital sampling rate higher than the available equipment could handle so the ODS was bypassed to display it directly on stripcharts in the science monitoring area. OTR #1 and experiment #75 used microprocessors and the serial interface cards could not be delivered on time and the ODS was bypassed. All other experiments went through the ODS. It should also be noted (Figure 5-3) that all experiments had local displays independent of the ODS. As originally implemented, the ODS was to provide a digital downlink of 4,000 SPS, however, this was not needed and was changed to 2,000 SPS continuous downlink to the GDS. ODS and GDS design is described in SD-SMD-III-005.

5.2.2 Ground Data System (GDS)

5.2.2.1 Functions

1) Interface with the ODS.

2) Provide real-time parameter display and control in the Science Monitoring Room and on the test conductors console.

3) Provide limit sensing.

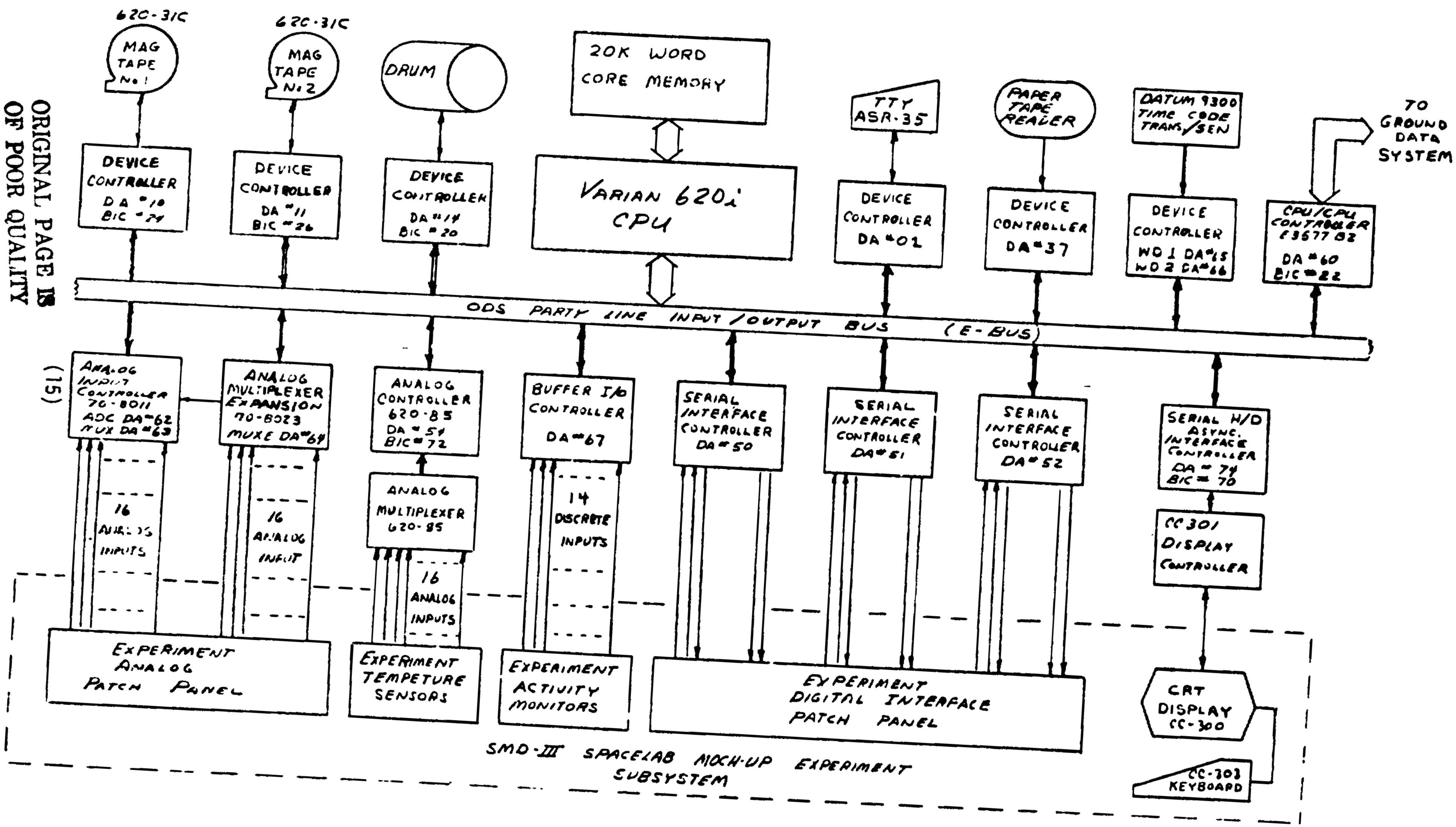

FIGURE 5-2, SMD III ONBOARD DATA SYSTEM BLOCK DIAGRAM

ORIGINAL PAGE IS OF POOR QUALITY

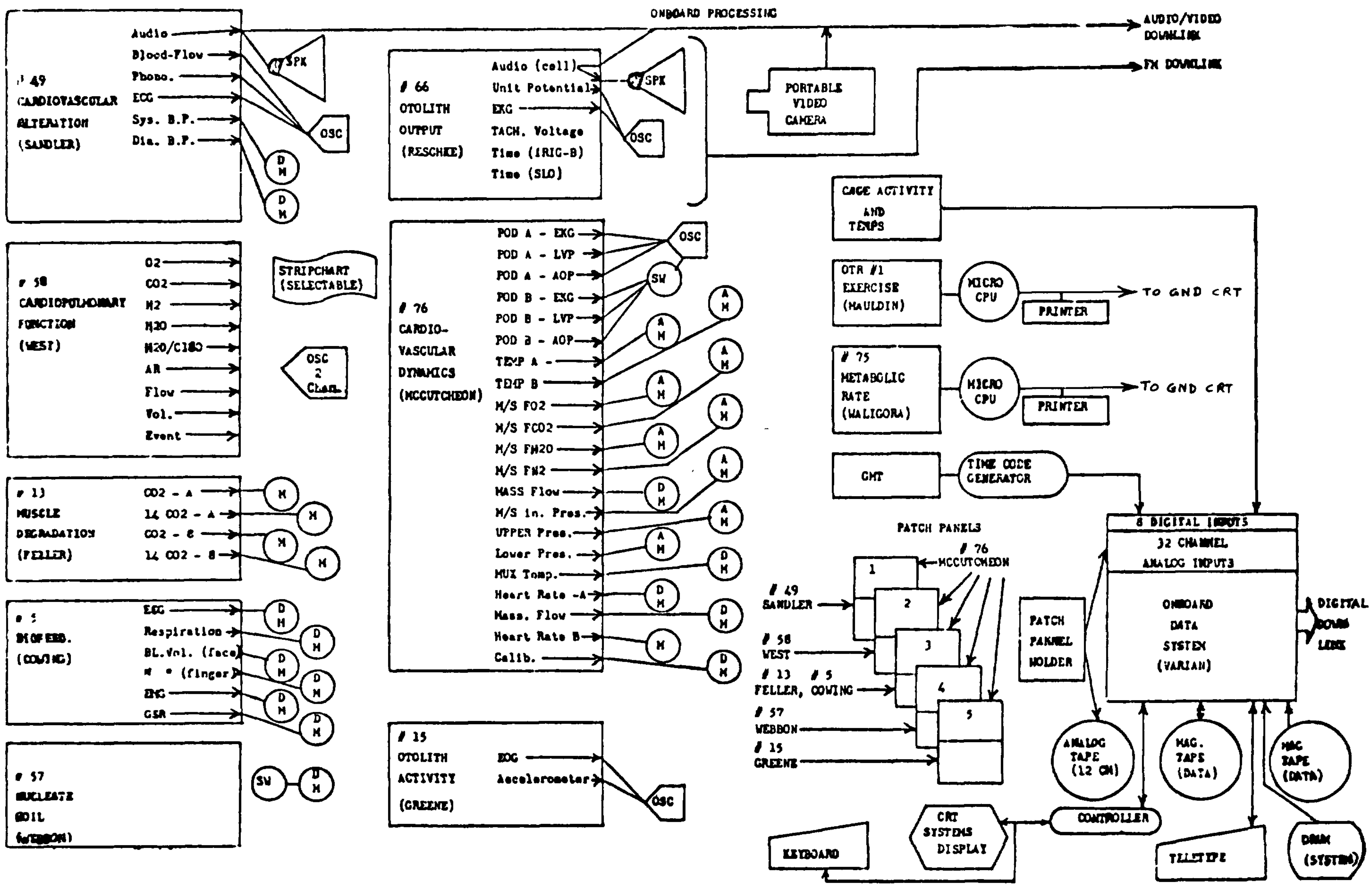

FIGURE 5-3, SMD III ONB_ARD DATA FLOW

4) Provide parameter printouts for any selected experiment.

5) Interface with the Science Processing System.

6) Provide engineering unit conversion.

5.2.2.2 System Description

Like the ODS, the GDS consisted of a vintage Varian 620i with 20K core memory and assorted peripherals (see Figure 5-4). Specific software was written to accomplish the functions specified. Once the test started, an auditory alarm was added to alert the monitors whenever any of the cage temperatures or other selected parameters went out of limits. In effect, the GDS attempted to simulate POCC functions normally provided by IBM 370 computers in Mission Control. The output of GDS was a continuous block of 4,800 words to the Science Processing System.

5.2.3 Analog Data System

5.2.3.1 Signal Routing

Analog signals originating at the various spacelab experiments were distributed throughout the analog data system by means of an analog patch panel located in the Spacelab Core rack. Data from the experiments was routed to interface panels mounted underneath the floor sections, where a mating cable carrie' it to the analog patch panel. The data was passed to various poin.. within the system. Actual routing of signals was controlled by installing different patch boards in the patch panel.

The analog data system is illustrated in block form by Figure 5-5.

Standard procedure was to route the data through a buffer amplifier which was associated with a particular A-to-D converter channel of the onboard Varian computer. Output from the buffer amplifiers was then passed to other equipment within the analog system. This arrangement kept the input impedance to the A-to-D converters constant as different analog system devices were incorporated.

Digital information generated by the experiment was routed to the onboard Varian computer through a similar patch panel arrangement.

5.2.3.2 Analog System Capabilities

As pointed out previously, all analog signals were routed through the analog patch panel and buffered before being sent to other analog devices. Each of the inputs to the 32 buffer amplifiers was physically wired to the input of an A-to-D converter within the onboard Varian computer. The buffers were differential input amplifiers having a closed loop input impedance of four megohms,

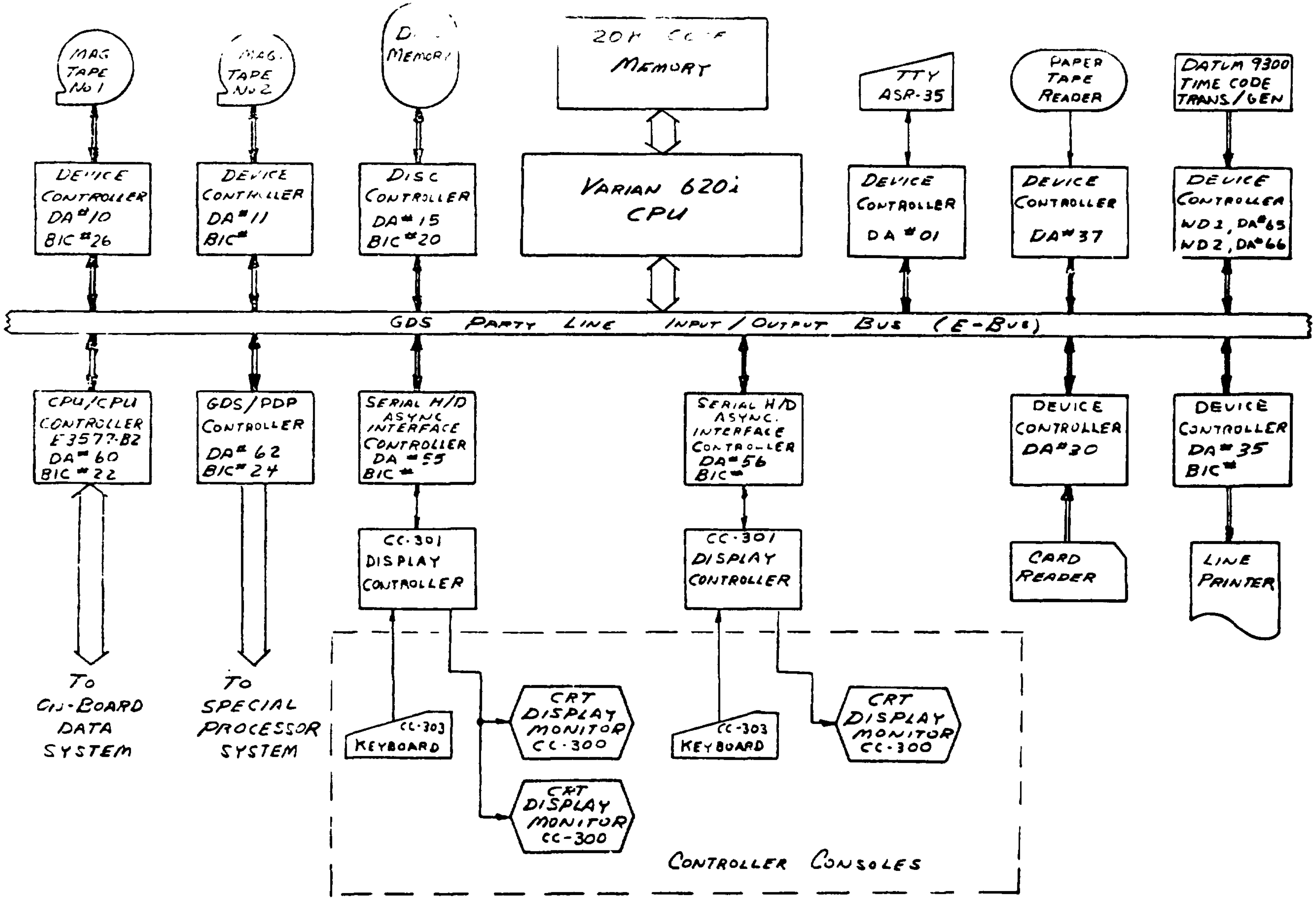

FIGURE 5-4, SMD III GROUND DATA SYSTEM BLOCK DIAGRAM

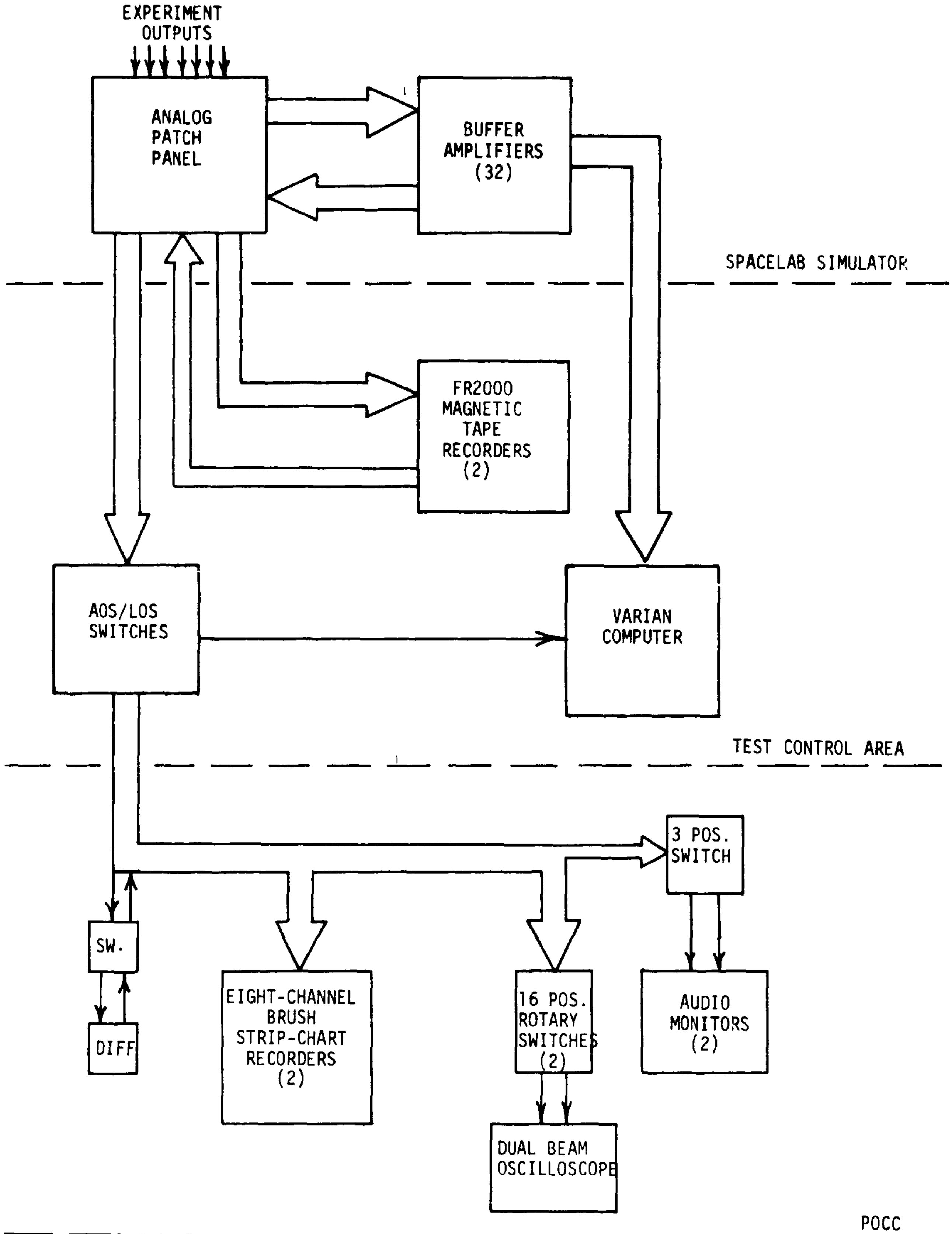

FIGURE 5-5, SMD III ANALOG SYSTEM BLOCK DIAGRAM or 1 meg. when used single ended. Frequency response of the buffer amplifers was DC to 6 Khz.

Two FR 2000 magnetic tape recorders operating at 1 7/8 IPS were used to record analog data from the experiments. IRIG B time code was placed on channel 14 of each recorder.

Two eight channel stripchart recorders (Gould Brush Recorders) were located in the POCC to provide the P.I. with a hardcopy of his analog data. IRIG B Slow code at 10 seconds per frame was placed on marker channel B of each recorder. A switch selectable experimenter supplied analog differentiator could be inserted on channel 5 of recorder #1 or #2 at the discretion of the Data Manager.

Additional means of viewing analog data by the P.I. was provided by way of a Tektronix R556 dual beam oscilloscope mounted in the PI/PE console. Two 16 position rotary switches gave the P.I. the option of placing data appearing on the strip chart recorder on either, or both channels of the oscilloscope. Two experimenter supplied audio monitors were mounted in the PI/PE console. Selection of the monitors was by means of a 3-position rotary switch located under the oscilloscope.

A 6-channel stripchart recorder located on board the spacelab allowed the crew to display and make hard copies of analog data from the experiments.

5.2.4 <u>POCC Science Processing System (Science Computer)</u>

5.2.4.1 Functions

The major functions of the computer were:

1) Demultiplex the downlink buffer.

2) Distribute the demultiplexed data to experiment specific tasks.

3) Perform rudimentary processing.

4) Store the data in experiment specific files.

5) Send data to the Science Operations Remote Center (SORC) at Ames Research Center.

6) Plot selected data values for investigators.

5.2.4.2 Hardware Description

The science computer was a PDP 11/40 with the following features:

1) 112 K memory (16 K DEC core and 96 K semiconductor)

2) Decwriter console printer

3) 2 Tektronix graphics display units

4) LV-11 electrostatic line printer

5) TMB-11 tape drive

6) Floating point instruction set

7) 4 RK05 cartridge disk drives

8) 2 RX-11 flexible disk drives

The interface to the Varian 620i ground system was accomplished using a Digital Equipment Corporation supplied DR-11B parallel digital interface. The cable wiring was performed by Ford Aer[illegible]ce and Communications personnel. The interface to the SORC c[illegible]er at Ames was performed using DECNET, Digital Equipment Cor[illegible]on's network system. The hardware on the science computer [illegible] MDB Systems supplied DU-11 synchronous line adapter. This was interfaced in turn to a Bell 209 9600 modem to the SORC computer at Ames.

5.2.4.3 Operating System Description

The PDP 11/40 science computer was operated under the DEC supplied RSX-11M operating system, version 2.0. This multitasking real time system provided all the executive and supervisory services to run the multiple tasks required to support SMD III in the science computer. The system supported both assembly language (MACRO-11) and FORTRAN programs and provided a consistent I/O structure.

The network portion of the system was supported by DEC's DECNET version 1.1. This software package running under RSX-11M provided the data transfer functions and remote program control functions required to fully support the SORC. Particularly effective was the DECNET concept of multileaved data streams whereby several logical links can be supported over a single physical link. This allowed the applications software to be experiment specific and relatively independent of other programs in the system. DECNET handled all line protocol and maintained statistics on the line and link. DECNET also proved to be valuable as an operating tool, allowing hardcopy communication between the SORC and science computer operators. Typewritten messages, as well as files and examples, could be sent between the two centers via DECNET. This was especially useful for synchronization and query when the voice loops and telephones were all busy.

The interface to the Varian via the DR-11B posed an initial problem in that the DR-11B is not supported as a standard device under RSX-11M. A user written driver had to be developed and incorporated into the operating system to allow convenient and consistent software access to the device. Under version 2.0 of RSX-11M, all device drivers must be developed and loaded at SYSGEN time. This causes considerable problems in debugging a new driver. Under version 3.0 loadable driver support is included. Therefore, the DR-11B driver was developed under version 3.0 and then migrated back to version 2.0 for the operational system. For further design details, refer to the report, Science Computer Software System for SMD III.

5.2.5 High Speed Data Link

The SORC computer was connected to the JSC Science computer by a high speed data link (9600 baud conditioned telephone line from JSC to the SORC through 209A-L1 data sets). The use of the 9600 baud telephone line limited the amount of data that could be sent to the SORC to approximately 400 words per second. That limitation necessitated the formation of various strategies and the writing of appropriate software at both JSC and ARC for getting sufficient data to the SORC during the conduct of an experiment. In addition to the 9600 baud data line, several FTS telephone circuits were utilized for voice coordination and separate transmission of data signals such as X50 audio blood flow.

In the early planning of the SORC and the data system, it was thought that for redundancy two 9600 baud lines may be needed. However, based on the reliability of the first link during the first week of operation, it was decided in the interest of economy to have only one 9600 baud line for the SMD III test. The soundness of that decision was later confirmed by the fact that the high speed data link went down only once during the SORC operations.

5.2.6 POCC Slow Scan TV System

The POCC slow scan TV system was required to transmit color or black and white pictures from the Spacelab to the SORC and to receive black and white pictures from the SORC for display in the POCC.

The system was built around equipment furnished by Nippon Electric Company (NEC) and included the following

1) NEC equipment consisting of a Model DFP-751 Color Freeze-Picture Transmission System, an HPP-7100DC Power Supply, an HPB-6782 Remote Control Console, and appropriate connecting cables.

2) Bell Telephone Data Set 208B

3) A black and white monitor for the live TV feed to the system.

4) A color monitor reflecting the contents of the system memory, i.e., the picture being sent or received.

The POCC slow scan TV system had the capability to both send and receive via a non-conditioned telephone line. Inputs to be sent were taken from a TV feed line from the TV officer's console in the Test Control Area. Any downlink output from the mockup could be switched onto this line, with or without a superimposed digital clock image. The TV console was also connected to the JSC TV control system, allowing the receipt of previously recorded TV, test patterns, and commerical TV.

A feed from the slow scan system back to the TV console allowed incoming pictures to be put on any of the monitors in the Test Control Area or the POCC, or to be routed to JSC TV control. Initial attempts were made to videotape the incoming pictures in the TV control area, with only limited success. It was discovered that the transmission included only a single field, with no interlacing, which was incompatible with a standard video tape recorder (VTR). An interlaced signal could be produced by pre-recording on a disc and replaying the regenerated signal to the VTR, as was done on TV from earlier space missions. There was insufficient need for recording transmissions to the POCC, however, to justify the additional equipment and operators required.

5.2.7 SORC Data System

"The primary purpose of the ARC Science Operations Remote Center is to receive data generated by the respective experiments and to process and display those data in such a manner as to allow real-time evaluations and decisions concerning those experiments." (Excerpt from SORC General Policy). The development of the real-time data system and the complimentary communications system was directed toward the attainment of that capability.

It was recognized very early in the planning of the SORC that the computer system would be a long lead item. At that time, the exact experiment requirements were not known. Consequently, the computer system was designed to have a certain amount of inherent flexibility and the final system (as described below) was reasonably close to that planned for the SORC.

A PDP 1140 computer formed the nucleus of the SORC real-time system. Peripheral equipment required for SORC operations included expanded memory (up to 128K), two RK05 Disc drives, two Kennedy 9000 9 track tape drives, two Omron Video Displays, a VT-11 CRT display, a Versatek Plotter, a custom built digital-to-analog converter (DAC), an eight channel brush stripchart recorder, a teletype and a DQ-11 communication device.

The computer was moved to the SORC in early February. Its basic configuration at that time consisted of 32K of memory, two disc drives, the VT-11 and the Versatek Plotter. Installation of the RSX-11M Version 2 operating system began at that time to allow multiple user access to the machine during software development. The first priority was to expand the memory from 32K to 96K using the DEC Memory Management System and Plessey memory cards. Slow delivery from Plessey impeded progress in this area for approximately one week but, once received, the added memory capability was rapidly installed and checked out. Addition of the two Omron displays from JSC allowed software development to proceed as planned. The installation and check out of the DAC and stripchart recorders completed the hardware configuration necessary for development of the science applications software.

SORC system software development was somewhat hampered by late delivery of the Bell 209 Modem (used for tie-in to the 9600 baud line) and the power racks for the two Kennedy 9000 tape drives. Again, once the hardware was received, it was rapidly installed and checked out without difficulty.

In general, the late delivery on some hardware items did not seriously delay software development. There always existed a sufficient quantity of parallel software development tasks to which the programming manpower could be diverted until hardware items were installed.

During software development, the SCRC computer hardware worked flawlessly. Hardware down time from equipment failure was negligible. During Phase Training, the two-day simulation and SMD III itself, hardware failures on almost each peripheral device occurred at one time or another. The failures were in all cases fixed within six hours of their detection and, only in the case of the tape drive failure, was the entire system forced to be shut down. The most frequently occurring problems were caused by nuisance failures in the stripchart recorder - pens clogging, paper alignment, amplifiers and pen drivers with intermittent failures, etc. Eventually, the original recorder was swapped out with a newer model from the ARC bedrest facility. One Omron display failed at the end of the two day simulation. It was hand carried to the factory for service (replacement of a timing PC board) and returned the same day. The Versatek printer/plotter stopped functioning at one point during the seven day simulation. A service engineer from Versatek disassembled, checked and reassembled the unit. No hardware problems were found; the unit began functioning again and continued to do so throughout the remainder of the simulation.

The only hardware failure which impacted the SORC occurred during the second day of the seven day test when the primary tape drive failed to log the incoming data on tape. The system was shut down while inspection of the tape drive progressed through the night. It was finally ascertained that a cold solder joint in a power regulator was the culprit. After readjusting the bridge balance on the regulator output the tape worked properly for the remainder of the test.

The impact of this failure was a loss of approximately six hours of background data plus the uncertainty of the quality of the data logged on the tape prior to detection of the failure.

The actual hardware configuration used in SMD III was the full realization of the system planned three months earlier. Trade-off studies performed in the planning stage minimized the number of output displays to save costs. The switchable two page display capability of each Omron allowed four output formats to be displayed by the viewer without significant impact on the system software or mass storage resources. The VT-11 found more use than originally planned by displaying the Experiment 76 Pod data during background data collection periods as opposed to only durin_ LBNP runs. In retrospect, an additional numerical display would have been useful, but not necessary, for display of selected experiment specific parameters in experiments 5, 13, 50 and 57. For the most part, however, graphical presentation of the data was adequate for the experimenter's real-time assessment of the data.

5.2.7.1 SORC Voice Communications Link

Initial planning for the SORC included the following voice communications lines:

1) Science monitor; JSC comm loop

2) Air to Ground; JSC comm loop

3) Video link; dedicated FTS line

4) Audio blood flow and data fax; dedicated FTS line

5) Science coordination; non-dedicated FTS line

6) Test coordination; non-dedicated FTS line

7) Data coordination; business line

8) Three each telephone lines with FTS and 9 level capability

In order for the SORC to function properly it was anticipated that three positions within the SORC would require speakers, headsets and push to talk microphones. The final SORC communications system included the above cited lines, but with certain attendant problems. The problems were identified at an early stage, but were never resolved by the ARC Communications Branch or the telephone company leaving the SORC with a sub-standard and deficient system. Problems inherent in the system included, but were not limited to; a) the speaker at each of the three stations was wired to only one comm loop with no capability to switch to the other comm loop, b) the volume of the sound produced by the headsets was too low to be of value except possibly in a quiet room, c) the push-to-talk microphones did not switch out the adjacent speaker in the talk mode, resulting in a serious amount of feed back. Such problems presented operational difficulties within the SORC and maybe to a lesser degree, in the POCC as well.

5.2.7.2 SORC Real-Time Data Processing

The real-time data processing software utilized in the SORC was developed by two contractors, Technology Incorporated and Cybernex. Technology Incorporated was responsible for the overall system specification and all science application, test data generator, display, hardcopy and system status software development. Cybernex was responsible for the overall hardware integration and maintenance, the installation of the operating system (RSX-11M version 2), the data link software (DECNET), hardware drivers and the data logging software.

The interface between the JSC and ARC software was formally controlled by the "JSC Science Computer to ARC Science Operations

Remote Computer Interface Control Document for SMD III". This document specified the format and internal structure of each of 17 possible data record types, their frequency of transmission and the communicating task names (required by DECNET). The basic data link design concept was to accumulate data at JSC in records specific for each type of experimental data then transmit these records via DECNET to corresponding tasks in the ARC computer. DECNET provides for transmission error detection, automatic frame re-transmission and status code logic in both the sending and receiving tasks. The inherent capabilities of DECNET assured error free transmission of the data frames; however, in doing so, the maximum transmission rate on a 9600 baud line was limited to 400 words per second. This constraint prevented the direct transmission of the 2000 word frames generated by the onboard computer, required the use of data compression at JSC and impacted the real-time reconstruction of physiological waveforms as will be discussed below. Development of alternate data transmission protocols compatible with RSX-11M was felt to be too time consuming and too risky in view of the proximity of the fixed schedule milestones before us. DECNET did prove to be highly reliable during operations and once the system and the users became accustomed to its limitations, the decision to use it was vindicated.

Selection of the RSX-11M Version 2 operating system was based on the need for expanded multi-user, multi-task capabilities over RT-11. Some debate occurred on whether or not to wait for Version 3 to be released since some problems were known to exist in Version 2, particularly in the areas of VT-11 displays, tape handling and checkpointing. A history of one month slips by DEC in the release date cast doubt on the credibility of the proposed release date at that time. The decision was made to live with Version 2 and to design the software accordingly. As it turned out, just about the time the Version 2 display problems and the tape handling problems were overcome by software workarounds, Version 3 was released. The decision remained to stay with Version 2, since we were well into the development of system software by that time. System crashes and the inoperability of task checkpointing did cause consternation downstream during final software system integration. Whether or not Version 3 would have avoided these problems is not known; however, it is quite likely that a switchover to Version 3 upon its release would have impacted the software development schedule by one to two weeks.

Utility software developed on the system primarily centered around output devices. The DAC driver was a modified version of the Lab Peripheral System (LPS) driver. It allowed use of the standard A-to-D Fortran calls developed for the LPS and its use was transparent to the calling task. A macro called SCHART was developed to simplify and standardize the interface between the science applications software and the DAC driver. This macro underwent considerable development to decrease its size and improve its speed. Standard macros were developed for utilizing the Omron's and an entire graphics package (GRAFIX) was developed to support the VT-11 CRT displays. The latter was necessary since the RSM-11M Memory Management System which utilizes a virtual memory is incompatible with the fixed core software of the VT-11. Also as part of the utility software, a graphics text editor (VTEDIT) was developed, a much needed improvement over EDI, the DEC text editor. With both editors available on the system simultaneous program development by several users was made possible.

After development of the operating system and the above mentioned utilities, work started on the SMD III peculiar software. The system design was based on an "hourglass" configuration; that is, 17 input paths existed between the 17 record generating tasks at JSC and the 17 corresponding receiver tasks at ARC. All the receiving tasks reported receipt of data to a single controlling executive task which logged the data on tape and enabled processing of the data in one of 12 application tasks.

This concept was utilized to isolate the ARC Computer from the control of the JSC computer at some central point. This was necessary since DECNET, when used in the task-to-task mode, initiates receiver tasks in the downstream computer as required.

In order to maintain local control of the number of tasks running while at the same time allowing the system to be as automated as possible, the receiver tasks, under direct control of the JSC computer, were designed to have minimal impact on the ARC computer. Their functions were to direct the incoming data frame to a pre-allocated portion of a global common, COMBUF; to inform the executive via an event flag that new data had arrived and, upon receipt of processing complete signals from the executive logger and the corresponding science applications program, request the next frame of data from the JSC computer. Note that using this technique no data would be lost at ARC. Delays in ARC logging or processing resulted in "backing-up" the data on the JSC spool since the receiver would not request new data until the current data had been completely processed.

Time and core were saved by using a global common buffer for storage of the incoming data. This buffer and the set of event flags indicating processing status formed the main interface between the "system" software and the "science applications" software. Although informally controlled once it was defined it was strictly adhered to and remained stable throughout the software development process. Early definition of this and the JSC/ARC interface allowed the parallel development of the system and the applications software.

As described below, the applications software was developed completely independent of the system software; this included separate discs, separate working hours for the programmers and separate test data for program testing. It was not until the software integration phase of the project that the programs were played together. This points out the need for simple, clean and well defined interfaces between generic types of software.

Integration of the system and application software went very smoothly on an experiment-to-experiment basis. Total system integration, however, uncovered run time and core allocation problems. A second generation logging executive and independent tape writing task were generated to improve overall run time. The SCHART macro was rewritten to reduce its size and run time. With the new improved programs the system was operational and ready for end-to-end checkout with JSC.

By the time both the JSC and ARC systems were ready for end-to-end tests the SORC was being called upon to support Phase Training. Going directly to live experiment data undercovered problems in the JSC/ARC interface in which it was difficult to identify the source since all the links in the end-to-end data system were involved. Little progress was made until Project management placed a one-week hold on the schedule to allow a checkout of the data system.

The most fruitful checkout was the end-to-end voltage test whereby a known constant voltage was applied to the onboard patch panel pins and sampled according to each possible configuration number. A review of the digital values reaching the SORC quickly identified problems in both the transmitting and receiving software. Most problems involved the miscalculation of array pointers and were readily corrected. A digital tape made from the GDS allowed the test to be replayed until satisfactory results were obtained.

A User Demonstration Test was conducted with each P.I. before the Project schedule was resumed. In this test taped data was played through the Science Computer at JSC and transmitted to the ARC computer where all data processing functions were performed and verified by the P.I. The system was at this point ready to support operations.

5.2.7.3 SORC Science Application Software

The primary objective of the SORC science application software was to provide the P.I.'s with a real-time display of their data in a manner which would facilitate the evaluation of the quality of the data signals being collected and the identification of major trends in the data. In general, this meant the reconstruction of analog waveforms for stripchart displays and the production of summary plots and listings on various output devices.

Seventeen programs were originally identified; one corresponding to each of the possible data formats sent from JSC. Since similar functions were to be performed in each of them (data block receipt, time decoding, decalibration, display outputs, etc.), a skeleton master program, XXXGEN, was written first as a programming standard. Use of global text editing techniques allowed the rapid production of 17 individualized rough cut programs from XXXGEN. Common functions such as time word decoding and strip-chart output displays were identified as Fortran callable macros.

Early versions of the application programs provided their own test data generation code as a debug option in the compilations. This decoupled the programs from the development of system software and allowed an early start on the decommutation, decalibration and display portions of the application programs. As system software became available; namely, DECNET, the executive and the individual receivers, the test data subroutines were broken out of the programs and rewritten as independent programs utilizing DECNET to transmit the test data, thereby exercising the total ARC data flow paths.

The outputs from the application programs are summarized in the Data Products and the SORC Display tables of Para. 5.3.4.

On two of the high data acquisition rate experiments, X76 and X50, the maximum transmission line data rate of 400 sps required the experimenters to choose between greatly degraded waveform reconstruction at a slow sampling rate or "snapshots" of data transmitted in slower-than-real time (i.e., 15 second samples sent over 45 seconds). The P.I.'s opted for the "snapshot" technique. This meant that only 25% of the acquired data would end up at ARC in real-time. The original plan called for transmitting 100% of each day's recorded data during the night for both of these experiments. With a 4 to 1 time expansion it would have taken two hours of transmission for each 30 minutes of data collected.

This technique was tried for the first night of the simulation. Since there was not enough manpower to staff the SORC computer on a 24 hour basis, the makeup data transmission was tried in an unmanned mode. Approximately four to five hours of transmitted data could be collected this way, but invariably a tape switchover, a program abort or an unknown error condition would cause the process to halt. The 24 hour real-time background data would be spooled at JSC so none of it was lost, but by the time the system was restarted in the morning, live data collection was ready to begin and transmission of the makeup data was held off until the following night. At this rate the makeup data soon became several days backlogged and the entire concept was re-evaluated and dropped since the real-time data acquired during the day was sufficient for P.I.'s experiment evaluation. The alternate chosen was to send the makeup data tapes after the mission.

5.2.7.4 SORC Slow Scan TV System

A complete slow scan TV system for the SORC was designed around the equipment supplied by Nippon Electric Company (NEC). In general, the SORC (as was planned) had the capability to receive color pictures through the slow scan system and display those pictures on various color TV monitors; to transmit over the slow scan system black and white pictures; to store selected received and transmitted pictures and on demand retrieve and display any one of the stored pictures on the SORC monitors.

The final slow scan TV system in the SORC included the following:

1) NEC equipment consisting of a model DFP-751 Color Freeze-Picture Transmission System, an HPP-7100 DC Power Supply, an HPB-6782 Remote Control Console and appropriate connecting cables.

2) TV monitors for signals into and out of NEC equipment.

3) TV color monitor for displaying images from the NEC equipment.

4) TV disc recorder - Data Disc model 3106 - which had the capability of storing up to 200 images and playing back two pictures simultaneously (one from a fixed head and one from a moving head).

5) TV color monitors for images from disc recorder.

6) Two black and white TV cameras; one on a tripod with a zoom lens and the other mounted vertically over a lighted table for documents, drawings, graphs, etc.

7) Equipment to send received or stored TV images to Stanford University via a microwave link and to received images from Stanford which could be sent to JSC via the slow scan TV system.

The slow scan TV system was used on a daily basis in conjunction with the preparation for the SMD III test including phase training and the two day simulation. Commencing on April 5, 1977, the TV system was operated continuously throughout the day. During the two day simulation the system in the SORC was operated continuously for nearly 40 hours. During the SMD III test the system was operated continuously throughout the seven day test - approximately 160 hours. Total time that the slow scan TV system was operated in the SORC was estimated at nearly 400 hours.

One major problem that required a considerable effort to overcome was getting the SORC video disc recorder to sync. on the signal from the NEC equipment. JSC had similar problems with their video tape recorder and never did solve the problem. The solution used for the SORC was to feed the sync. pulse from the NEC equipment into two sync. pulse generators which produced adequate sync. pulses for the disc recorder to sync. up. Even so, when the onboard hand held camera was used, the sync. pulse was of such poor quality that it could not be recognized and therefore no recordings could routinely be made of the pictures from the onboard hand held camera.

5.2.8 MEDICS Storage and Retrieval System

5.2.8.1 Functions

1) Provide daily experiment status reports locally.

2) Provide remote experiment status information to Ames.

3) Provide Crew Medical information to Flight Surgeons.

4) Provide access to the Life Sciences Library index for real-time cataloging of data.

5.2.8.2 System Description

This system consisted of a remotely located timeshared minicomputer system (Varian 73) operationally used at JSC for storage and retrieval functions. Terminals were located in the POCC, in the flight medicine office, and at the Ames SORC. The system is forms oriented so that specific forms were developed for SMD III statusing, manually entered, and selectively retrieved at any of the interactive terminals. In Spacelab, this system simulated a management tracking system.

5.3 OPERATIONS

5.3.1 Onboard Crew Displays and Operations

5.3.1.1 Crew Displays

In addition to the individual experiment displays, the data system provided other common usage displays.

The six-channel stripchart recorder was used to display and record real-time analog data. Originally experiment supplied for X58, it became common usage equipment for X13, X50, and X76 as well. Although time was required for setup, and maintenance of the ink-fed stylii presented problems, the crew felt that this type instrument, or other analog device, was required to view analog data and notice trends that would not be apparent on a digital display. One failure occurred on day 4 when ink failed to feed to any of the pens. The unit was passed out and replaced with a spare unit. The failure was traced to a metal shaving shorting the control for the ink feed solenoid.

The onboard ODS terminal contained a CRT display which presented experiment data, updated every one second, in formats corresponding to the experiment configuration as described in SD-SMD-III-002.

In order to satisfy a crew request for an environmental display on board after the system had been configured, a second CRT was added, driven by the GDS, paralleling the environmental display on the Data Manager, Flight Director, and Payload Officer's console, since this display output was already available.

5.3.1.2 Crew Operations

Experiment selection and downlink data configuration were all selectable by the flight crew.

One of nine patch panels was inserted by the crew, depending on the experiment to be run. Patch board selection configured the onboard stripchart recorder, the onboard analog recorders, and the downlink analog system, and selected the parameters available to the ODS for downlink. Parameters and configurations for each patch panel are given in document SD-SMD-III-001. No problems were reported in operation of the patch panel system.

The crewman entered a coded configuration number for each experiment or for standby operation from the onboard terminal keyboard of the ODS. This configuration number configured the ODS downlink, and also caused the ODS to automatically display the selected experiment data on the onboard CRT in accordance with SD-SMD-III-002. The ODS output to the CRT each second was carried on the same half duplex line as the input from the keyboard. This caused some operational difficulties, for if a character was entered in the keyboard when it was not being scanned, the computer might recieve part or none of the character. Attention was required to the CRT feedback while entering commands to verify that each character was recieved properly.

A push button was provided on the data rack to start recorders. Use of this button by the crew signalled the analog recorder operator that the experiment was ready to take data. Use of this system was generally unsatisfactory, in that the crew often overlooked this step during the pressure of the experiment setup.

Other comments by the crew concerned the single experiment capability of the system, and the need for data reduction and storage provisions. The fact that the system could handle only one active experiment at a time proved to be a constraint on scheduling, and occasionally a limitation on crew activity, where a crewman had to wait to perform an experiment while another completed an experiment in progress. The crew also felt that both time and space should be allowed for data reduction and analysis, and that dedicated storage should be provided for data products and supplies.

5.3.2 Onboard Data Recording and Downlink

Although intended to simulate Spacelab/Orbiter systems, the "onboard" recorders were located outside the mockup in the Test Control Area and attended by ground personnel. Figure 5-6 shows the location of the data system equipment in the mockup and the Test Control Area and Figure 5-7 is a photograph of the Test Control Area in operational configuration. For purposes of the simulation, no data was given to the Data Manager or P.I. during Loss of Signal (LOS) periods, and data and tape management functions of the Data Manager with the operators were conducted only during Acquisition of Signal (AOS).

5.3.2.1 Analog Data

One or both of the two 14-track analog data recorders were operated as required for the number of parameters. Track assignments were controlled by the onboard patch panel as described in SD-SMD-III-001. The recorders were only operated during experiments generating analog data. Operating at 3 3/4 IPS, approximately three hours of uninterrupted recording was available. The recorders were operated by the Data Technician (DataTech) position, which was staffed by Northrup Services, Inc. personnel on a 24 hour, three shift basis. The Data Tech also operated voice recorders and performed facility maintenance in support of the Facilities Engineer, but was responsible to the Data Manager for data recorder operation.

Data Recorder #2 exhibited mechanical difficulties during the two day simulation, and some parameters of X76 were lost. (Data was logged on the digital system and recovered.) The recorder was repaired by Ampex, and although problems continued, virtually no data was missed during the seven day test.

In operation of the analog system, it was found that we could not reliably depend on the crew signal for data take start. Close

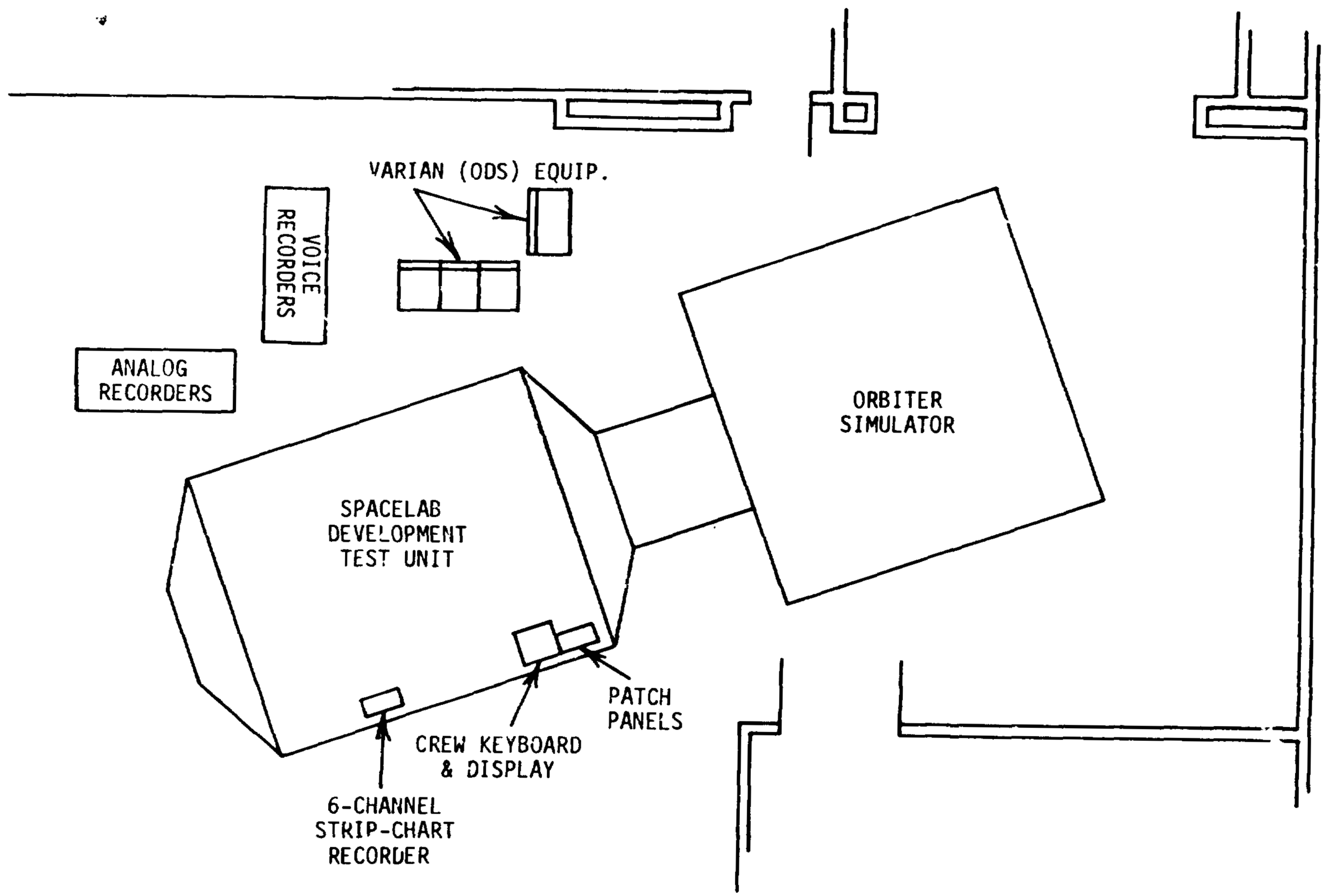

FIGURE 5-6, SMD III DATA SYSTEM EQUIPMENT IN THE TEST CONTROL AREA

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monitoring and anticipation of LOS periods were required by the Data Manager and Data Tech to assure that recorders were running during data output.

Analog downlink was by hardline to the POCC and was interrupted by a switch actuated by the Simulation Supervisor (SIM SUP) during LOS periods. Each of the 16 analog lines to the POCC corresponded to a stripchart recorder channel. Channel assignments were established by the patch panel in accordance with SD-SMD-III-001.

5.3.2.2 Digital Data

The ODS formatted the digital downlink in accordance with SD-SMD-III-006 based on the patch panel installed and the configuration selected by the crew. The downlink was hardwired to the GDS in the POCC. Input from the LOS switch actuated by SIM SUP set a bit in the downlink. The GDS recognized the bit and did not decode the downlink for real-time POCC display during LOS. The downlinked data continued to be transmitted to the Science Computer and to Ames, where it was not displayed during LOS.

Continuous digital tape logging was maintained of all data, placed on the downlink, using dual tape drives with automatic toggle at the end of the tape. Tape changes were required about every 50-55 minutes. This system was operated on a 24-hour, three shift basis by Ford Aerospace personnel, who also monitored the GDS in the POCC.

Only one failure occurred during the test on day 4 when the ODS drum memory, which had exhibited problems earlier, failed to function when a new configuration was called. The program was reloaded to a new location on the drum by the operator and the system was restarted. A total of approximately 20 minutes of background and housekeeping data was lost. If the system had not recovered, a backup technique was available. Prior to the test, a set of tapes was prepared for both the ODS and GDS whereby each experiment configuration could be loaded manually by the operator.

An additional operating problem was the lack of communication between the ODS operator and the Data Manager. The only headset jack of the ODS operator was controlled from an unrelated, remote system console where the operators did not monitor the facilities coordination loop.

5.3.3 <u>POCC Displays and Operations</u>

Operation of the POCC was the responsibility of the Payload Science Manager, who controlled experiment operations, flight crew interfaces, P.I. coordination, and provided the management interface. The Data Manager was responsible to the Payload Science Manager for the functional operation of the POCC, including data acquisition, processing and transmission, data recording, data storage, display configuration, slow-scan TV operation, coordination with TV Controller and with Facilities Engineer, and interfacing with communications and telephone activities.

The Data Manager console position was staffed by Martin Marietta personnel on a two shift, 24 hour basis. Supporting this position were the ODS/GDS Operator, staffed by Ford Aerospace three-shift 24 hours; Science Computer Operator, staffed by Technology Inc., two-shift, 16 hours; and Librarian/MEDICS Operator, staffed by Kentron Hawaii, two-shift, 16 hours.

Figure 5-8 provides a floor layout of the POCC and Figure 5-9 shows the POCC in operational configuration. The GDS and the Science computer are against the far wall, with the line printer to the left. The next row back contains the Data Manager console on the left and the PI/PE console on the right. The back row contains the Science Manager console and the table used by the ARC activities coordinator.

Operation of the POCC was in accordance with AOS/LOS rules, with data, TV, and voice communication from the Spacelab being shut off by the AOS/LOS switch on the SIM SUP console. Digital data continued to be received, processed, and transmitted to ARC, but displays were inhibited.

5.3.3.1 Analog Data

The primary display of analog data was on two 8-channel stripchart recorders, shown between the PI console and the Data Manager console in Figures 5-8 and 5-9. Data outputs on the 16 lines were configured by the patch panel installed by the crew as defined in SD-SMD-III-001. Initial set up of the recorders was by the Data Manager, but the P.I. could set up and operate the recorders at his option. Each recorder had one channel which could be switched to route data through a differentiator prior to display, for an X76 experiment specific requirement. Some confusion arose from use of this switch, since the differentiator had to be switched out for other experiments. In between prime experiment runs, the stripchart recorders continued to run at a slow speed to provide a record of the X76 pod monkeys' physiological parameters. The only mechanical difficulty with the recorders was a bent frame on one recorder which occasionally caused the paper not to track properly.

Closer examination capability of any parameter was provided by a dual beam oscilloscope on the PI console. Either beam could be switched to any of the 16 analog channels.

Audio outputs, cell firing from X66 and doppler blood flow from X50, were routed to the PI console. Normally, the PI used a headset to listen, but the signals could be switched to a speaker. An acoustic coupler was used to transmit the doppler audio to ARC via dialup FTS telephone line.

5.3.3.2 Real-Time Digital Data

The GDS received data downlinked from the ODS, demultiplexed and translated the data, applied engineering unit conversion, and

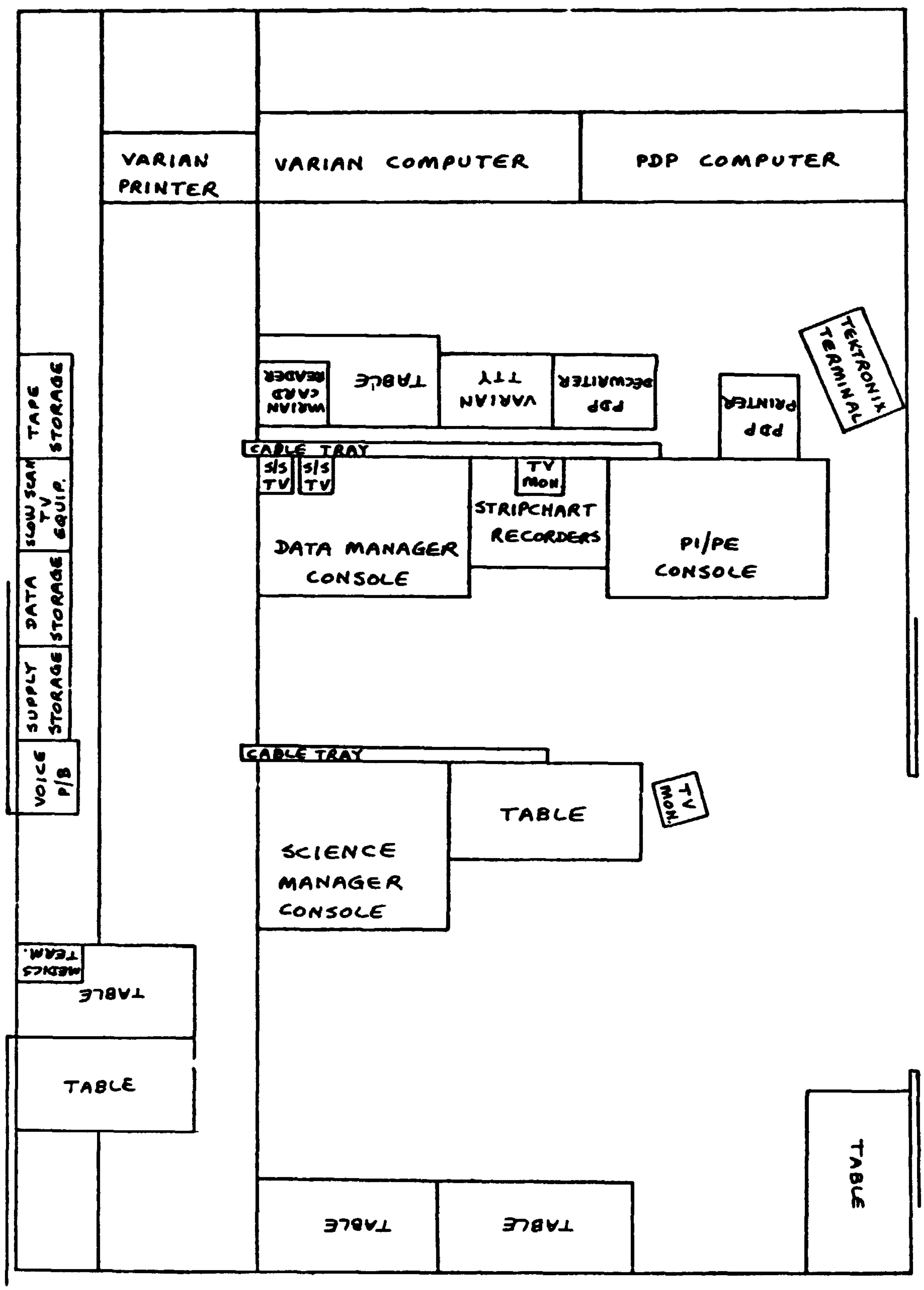

FIGURE 5-8, SMD III POCC FLOOR LAYOUT

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drove the digital displays. Displays were updated once per second, and were controlled by a keyboard on the Data Manager console. Only two display formats could be used at any time, due to hardware availability.

The first display was a fixed configuration and contained ODS/GDS system status information for the use of the Data Manager. Due to the format limitations, this display was also designed to include spacecraft and holding facility environmental and housekeeping data. CRT's containing this display were made available to the Test Director and Payload Officer's console in the Test Control Area, in order that they could monitor tne environment in the Spacelab. A late request by the crew for environmental data, which could not be handled with the ODS, resulted in another CRT carrying this display being installed onboard.

The second display was callable from the Data Manager's Keyboard and was experiment specific. Besides the specific experiment parameters, each format contained "background" data from X76, due to the requirement for continuous monitoring of the pod monkeys. This display was provided on the Data Manager, PI/PE, and Science Manager consoles. During the test, an additional monitor paralleling the console displays was added in the ARC ready room across the hall from the POCC. Formats for the digital displays are shown in document SD-SMD-III-002.

A line printer was also available on call from the Data Manager's Keyboard. The line printer updated once per second with the same parameters available on the CRT displays. Experiment specific formats plus an environmental format were provided as called for by document SD-SMD-III-002. Primary use of the line printer was to record X76 data during active Lower Body Negative Pressure runs and to collect environmental data during the night for personnel monitoring the holding facilities.

Prior to the test, a feature was added to the ODS and GDS software which allowed a display or printout to be called either in engineering units with calibrations applied, or in raw voltages. This feature was used extensively both before and during the test for troubleshooting, sensor calibration, and calibration software checks.

Both the ODS and GDS provided limit sensing on critical environmental and physiological parameters for the holding facilities and the X76 moneky pods, with an asterisk as a visual indication on the CRT displays. Just prior to the test, an audible alarm was added to the GDS with enable/disable capability from the console. This alarm was quite useful, particularly on the night shifts when console operators had other duties. Due to a peculiar set of circumstances, however, an alarm was missed on day 5 of the test. The monkey pod air flow, one of the limit sensed parameters, had to be shut down during an active X76 run due to instrumentation interference by the air flowmeter. The audible alarm, therefore, was disabled during an active X76 run to prevent a continuous alarm signal. This condition existed on day 5 when the Simulation Supervisor generated a simulation problem of a 400 Hz power failure in the Spacelab. Loss of 400 Hz shuts off the air circulation system in one of the animal holding facilities, which generates an alarm. The POCC was supporting the X76 run and a simultaneous X66 run, and the visual indication was not noticed for almost an hour. Even with the audible alarm off, the delay would not have occurred had this been a real problem rather than a simulation. Displays had been furnished to the Payload Officer and the Test Director in order to monitor environmentals, and the Facilities Engineer was monitoring power. These operators were participating in the simulation, however, and did not report the problem.

5.3.3.3 Science Computer Operation

Due to development problems, no processed data was available in the POCC, although the Science Computer could be used to dump downlinked records and hardcopy them for use in troubleshooting. The primary use of the Science Computer, then, was to receive downlink data from the GDS, store, and transmit to ARC, as discussed in the next section.

The Science Computer was limited in the number of display terminals, so the Data Manager did not have any display of the system status. This problem was compounded by the fact that the computer operator did not have access to a communications loop. The only way the Data Manager could tell if the ARC data link was up was by shouting over the consoles to the computer operator. A status display was also needed to tell how near real-time the link was operating, since ARC might be looking at data that was several minutes old. Unless the Data Manager knew this status, coordination with ARC was very difficult.

The lack of a communications loop for the computer operator also meant that coordination with the ARC operator could be done only by FTS telephone. If communications could not be established by phone, coordination had to be relayed through the Data Manager. This became complicated because the ARC operator had to leave his position to get to a communications loop. Additionally, the only loop available for communication with ARC was the Science Coordination loop, which was used primarily for PI coordination.

5.3.3.4 Data Stripping and Transmittal

The task of gathering data from the Varian link and forwarding it to the SORC was handled by the Science Computer in three steps. (1) demultiplexing, (2) spooling, and (3) transmission to ARC. Receipt of the downlink buffer was in a scrambled format so that it required demultiplexing. The demultiplexing was handled on an experiment basis by tasks dedicated to this purpose. These tasks, called spoolers, were called in dynamically based on the configuration number in the downlink buffer. A typical spooler performed the demultiplexing operation and wrote the data in SORC link format to a spool file on the disc. The reason for the intermediate spool file was to preclude data loss due to a link dropout or failure. The final step was to read the data from the spool file and send it to Ames via the link.

Certain experiments (X50, X76A, X76B) had data rates exceeding the 9600 BPS link capability. For these experiments, only a portion of the data was transmitted real-time to maintain a reasonable flow of information to the P.I.

The entire data stream from 76A, 76B, and 50 were recorded on tape in real-time. It was planned to send these tapes to the SORC overnight. This plan was abandoned when it became apparent that manning ARC was required, as well as at JSC.

One operational problem occurred when the 76A and 76B experiments were run back-to-back. The 11/40 was severely limited in disc space and had but a single tape drive. Therefore, the disc and tape had to be reconfigured between 76A and 76B. This required about two minutes which were not always readily available. In a Shuttle era operation, this sort of limitation would not occur.

5.3.4 SORC Displays, Processing and Operations

Operation of the SORC was the responsibility of the SORC Director with the support of a SORC Science Chief and a SORC Operations Chief. They were assisted by PI's, PE's, technicians, and others as required. Figure 5-10 is a photograph of the SORC in operational configuration.

In concert with the general operational policy of the SORC, every attempt was made to process and display the experiment data sent to the SORC in a timely manner, i.e., real-time, so that appropriate displays could be presented for the respective P.I. A listing of the SORC real-time data displays is given below by experiment number.

Experiment		Data Displayed	Type of Display	Display Device
X5	a	Heart Rate	Stripchart	Brush
	b	Respiration Rate	"	"
	c	EMG	"	"
	d	Blood Volume (Finger)	"	"
	e	Blood Volume (Face)	"	"
	f	GSR	"	"
	g	Heart Rate	CRT plot-5 sec. ave.	VT-11
	h	Respiration Rate	"	"
	i	GSR	"	"
	j	Blood Volume (Finger)	"	"

Experiment		Data Displayed	Type of Display	Display Device
X13	a	CO_2 Rat A	CRT plot-1 min. ave.	VT-11
	b	$14\ CO_2$ Rat A	"	"
	c	CO_2 Rat B	"	"
	d	$14\ CO_2$ Rat B	"	"
X15	a	EOG	Stripchart	Brush
	b	Acceleration	"	"
X50	a	Audio Blood Flow	Stripchart	Brush
	b	ECG	"	"
	c	Blood Flow	"	"
	d	Echocardiogram	TV of onboard recd.	Slow Scan TV
	e	Systolic Blood Press.	CRT plot 1 min. ave.	VT-11
	f	Diastolic Blood Press.	"	"
	g	Average Blood Flow	"	"
	h	Heart Rate	"	"
X57	a	Heater Current A	Stripchart	Brush
	b	Heater Current B	"	"
	c	Heater Current C	"	"
	d	Heater Voltage A	"	"
	e	Heater Voltage B	"	"
	f	Heater Voltage C	"	"
	g	Liquid Temp. Top	"	"
	h	Liquid Temp. Bottom	"	"
	i	Liquid Temp. Mid.	CRT plot 1 min. ave.	VT-11
	j	Heating Plate Temp. A	"	"
	k	Heating Plate Temp. B	"	"
	l	Heating Plate Temp. C	"	"
X58	a	O_2	Stripchart	Brush
	b	Switched Gas	"	"
	c	CO_2	"	"
	d	Argon	"	"
	e	Flow	"	"
	f	Volume	"	"
X76 A&B	a	ECG	Stripchart	Brush
	b	Heart Rate	"	"
	c	AOP	"	"
	d	LVP	"	"
	e	LVP Expanded	"	"
	f	DP/DT	"	"
	g	Differential Pressure	"	"
	h	Mean LVP	CRT plot 1 min. ave.	VT-11
	i	Mean AOP	"	"
	j	Heart Rate	"	"
	k	Pod Differential Pressure	"	"

Experiment	Data Displayed	Type of Display	Display Device
X76-background			
a	Heart Rate A 1 min. ave.	α/Numeric	Omron
b	AOP A "	"	"
c	LVP A "	"	"
d	Temp A "	"	"
e	Flow A "	"	"
f	Heart Rate B "	"	"
g	AOP B "	"	"
h	LVP B "	"	"
i	Temp B "	"	"
j	Flow B "	"	"
k	Ambient Press	"	"
l	Ambient Temp	"	"
m	Upper Pod Temp A	"	"
n	Upper Pod Temp B	"	"
o	Lower Pod Temp A	"	"
p	Food/Water A	"	"
q	Food/Water B	"	"
r	Fractional O_2	"	"
s	Fractional CO_2	"	"
t	Fractional H_2O	"	"
u	Fractional N_2	"	"
v	O_2 Production	"	"
w	CO_2 Production	"	"
x	Respiratory Quotient	"	"

Experiment	Data Displayed	Type of Display		Display Device
OTR 14/15				
a	Prim Sys in Temp	α/Numeric	1&10 min ave	Omron
b	Prim Cage in Temp	"	"	"
c	Rodent Sys in Temp	"	"	"
d	Rodent Cage in Temp	"	"	"
e	Rodent Cage Out Temp.	"	"	"
f	Activity Cage - 10 min.	"	"	"
g	Activity Cage	"	"	"
h	Activity Cage	"	"	"
i	Activity Cage	"	"	"
j	Activity Cage	"	"	"
k	Activity Cage	"	"	"
l	Water Consumption	"	"	"

Experiment	Data Displayed	Type of Data		Display Device
OTR 16/17				
a	Prim Sys In Temp	α/Numeric-1&10 min ave		Omron
b	Prim Cage In Temp	"	"	"
c	Prim Sys Out Temp	"	"	"
d	Rodent Sys In Temp	"	"	"
e	Rodent Cage In Temp	"	"	"
f	Rodent Sys Out Temp	"	"	"
g	Metabolic Sys In Temp	"	"	"
h	Activity Cage - 10 min.	"	"	"
i	"	"	"	"
j	"	"	"	"
k	"	"	"	"
l	"	"	"	"
m	"	"	"	"

During the conduct of each experiment the data was passed from the JSC Science computer to the SORC using predetermined data formats. Number "crunching" was necessary for the high data rate experiments, but in all cases the P.I.'s received sufficient data to assess in real-time their respective experiment.

Original planning called for the SORC to be manned 24 hours per test day. At night the non-real time data transfer and data processing was to take place. During the two day simulation the SORC was manned 24 hours per day. Based on that experience, it became apparent that plans to process all non-real time data each night were overly optimistic. The data transfer rate was the limiting factor. Therefore, the non-real time data was not sent to the SORC at night, but was collected on magnetic tape for processing after the SMD III test was completed. The housekeeping data and X76 background data was sent to the SORC and stored on tape for processing and display early each morning.

All data received over the high speed data line was digital including data to be displayed on the stripchart. In that case the digital signal was converted to an analog signal as would be done in a real mission versus the non-real situation that prevailed at JSC where the stripchart recorder was hardwired to the spacelab mockup.

The SORC operations were pretty much as planned other than for the elimination of the night time data processing. The SORC was not on a shifting basis; i.e., the SORC was operational at 0530 to 0600 hours each day until after the status meeting each night (2000 to 2200 hours) and staffed throughout that time by the same people. The only exception was the computer operators - the semblance of a shifting pattern was established, but not enforced by the SORC director nor adhered to by the personnel involved. For the most part they would stay beyond the end of their shift for as long as needed.

The P.I.'s were notified when their experiment would be conducted and they would be in the SORC approximately 1/2 hour ahead of the scheduled time. As it turned out, the conduct of the individual experiments frequently ran behind the CAP. That resulted in the P.I.'s experiencing long waits or going back to their labs until called again. The predictability of the experiment start times left something to be desired and frequently even the status of experiments in progress could not be ascertained with any certainty by either SORC or JSC operations people. Thus, several occasions arose where the experiment was started without the P.I.'s being in the SORC.

A finite amount of time was required to change the onboard configuration from one experiment to another. Similarly, the ground based computer systems needed a finite amount of time also. Instances arose during the first few days of the SMD-III test, where neither JSC nor the SORC had sufficient time and subsequent data processing in the SORC would run behind by several minutes, gradually catching up as the experiment progressed. The catching up process was experiment dependent and required a considerable time for say X76 whenever the data processing started out "behind" the conduct of the experiment.

The data system was in operation 24 hours per test day. The computers at the JSC and the SORC would from time to time crash, which would cause the data processing to lag the experiment forcing a catch mode also. Seldom was there sufficient time to troubleshoot and document the cause for a computer crash, but on the other hand, down times were usually short. On only one occasion could the cause of a system crash be traced to a high-speed data link dropout.

In addition to the real-time experiment data received, processed and displayed for the P.I.'s, there were data products produced for the P.I.'s. Some of the data products were produced immediately after the end of the applicable experiment run. Examples are hard copies of the graphics plots and printouts of certain experiment data all done on the Versatek printer/plotter. Some data such as the BSHF activity measurements and average temperatures were supplied on the teletype once per hour throughout the day. Some data requiring additional processing was processed again at the earliest opportunity consistent with receiving real-time experiment data. All data received by the SORC was logged on magnetic tape as a master data file.

During the X76 experiment with its high speed data rates, the stripchart tracings were not continuous throughout the experiment run. That was due to the time required to periodically receive and process the "housekeeping" and experiment 76 background data interspersed with the experiment data being received, processed and displayed. Although the stripchart records (for all experiments) had a generated time code channel as a part of the record, some additional post SMD III data processing was to be accomplished to produce a continuous stripchart recording for post test analysis.

Finally, as per planning for data processing, certain data products such as magnetic tapes for the various P.I.'s were to be produced after the completion of the SMD III test.

All deliverable data products produced by the SORC for the various P.I.'s are cited in the table of Figure 5-11.

EXPERIMENT	SORC DATA PRODUCTS						
	DIGITAL MAGNETIC TAPE	STRIPCHART	HARD COPY PLOT	RAW DATA PRINTOUT	PROCESSED DATA PRINTOUT	TELETYPE	SLOW SCAN TV RECORD
5	X	X					
13	X		X	X			X
15	X	X		X			X
50	X	X	X				X
57	X	X	X	X			
58	X	X					
76 ACTV	X	X	X				X
76 BKGD	X			X			
OTR 14/15	X		X		X	X	
OTR 16/17	X		X		X		

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FIGURE 5-11, SMD III SORC DATA PRODUCTS

5.3.5 Slow Scan TV Operations

The mode of operation in the SORC was to check out the system when powered up by sending to and receiving from JSC color test patterns. If the test patterns received at both ends were normal then the system was judged to be operating satisfactorily and the system would be placed in the "sequence" mode transmitting pictures from JSC to the SORC. Throughout the day as events of special interest were encountered, "one shot" operation would be used and specific pictures selected by personnel at JSC would be sent to the SORC. Frequently, JSC would request that pictures of the processed data displayed in the SORC be transmitted to JSC for which the "one shot" mode would be used. After each special event the system would be reconfigured back to the "sequence" mode cited above.

Primary utilization of the slow scan TV system was by the SORC personnel and principal investigators (P.I.'s) of the various experiments. In the sequence mode, for instance, those in the SORC could have a general knowledge (albeit, not detailed) of the onboard activities and experiments that were being conducted. The system was also used routinely for sending specialized pictures such as for the X50 echocardiograms, close ups of some of the experiments during phase training and close ups of the surgical work bench and the work being done at that station.

Soon after the installation of the slow scan TV system in the SORC it became apparent that it would be used on a daily basis, not because of preference for the slow scan, but because it was the only TV planned for and available in the SORC. Those in the SORC became somewhat dependent upon the TV system to provide some information concerning the onboard activities - information which was to be obtained from no other source. In that regard the system proved its usefulness in that the minimally sufficient information obtained from the slow scan TV helped the SORC operate in its expected mode.

The slow scan TV system in "sequence" mode provides a new picture every 150 seconds. To the casual observer that might seem sufficient. However, to the operations people who follow the onboard activities very closely for control and coordination purposes and the P.I.'s who have specific experiment protocols which are being followed by the onboard crew, the slow scan TV was not adequate to follow the activities associated with many of the experiments. The motion that is observed by viewing a full TV stream in and of itself imparts a certain amount of information to the viewer that is totally lacking in the slow scan system.

Even so, slow scan TV coverage would be sufficient for some of the relatively inactive or passive experiments and in cases such as X50 where the P.I. planned to utilize the "snap shot" capability of the slow scan TV to get a quick look at some of the onboard analog data.

The effectiveness of the slow scan TV in providing useful scientific information is questionable at best. This is evidenced by the fact that out of a potential of 200 addresses available on the disc recorder only 30 were utilized for experiments other than X50 (which planned to use it for echocardiograms) and most of those were of the general experiment set up. In all fairness, however, the lack of interest in preserving pictures was probably due to the inability to remotely control the camera(s) and/or to get close ups of the experiment or experiment subject.

Effectiveness of the system was not compromised by maintenance problems. In the checkout and early equipment usage stages, some problems were encountered with the NEC equipment in the SORC. An NEC representative checked out and repaired the equipment which operated maintenance-free thereafter. One problem that required a considerable effort to overcome was to get the disc recorder to synch up on the signal from the NEC equipment.

Drop outs were relatively infrequent and could be traced to the telephone line and the link was re-established with little or no consequential delay. Noise on the line would show up in the pictures as lines through the picture, but were never any source of concern or the cause of information loss. The most severe operational test had to be the SMD III test when only one short drop out occurred in seven days of continuous operation.

5.3.6 Library Archiving and Data Distribution

Based on the successful experience of Spacelab Mission Simulation II, a branch of the Space Life Sciences Archival Library was established at the POCC for the duration of the test. This branch was staffed by Kentron Hawaii personnel from the library on a two-shift, 16 hour basis. The first shift came on at 2 p.m. local, after the day's experiment activity had started. The librarian collected data generated so far by the Data Manager, checked it into the library, and cataloged it for input to the computerized library index. As data was generated during the day, each piece, whether tape, printout, or stripchart, was logged in and cataloged. The work sheets of cataloged data were then input into the library index using one of the MEDICS terminals in the POCC. Input was completed by the second shift, which began at 10 p.m. local. This assured that all data was accounted for and the index was current.

Checkout of data was handled by the librarian whenever data was needed by the P.I. or others for analysis. The librarian could also draw on the resources of the library for background and past program data and documentation, if needed.

By checking all data into the library, as generated, the problems found in past programs of missing and lost data are circumvented. Even though much of the data from this test was given to the P.I.'s on permanent loan, the library maintains a record of its existence and the responsible party for its location.

5.3.7 Test Status Reporting

5.3.7.1 JSC

A new data base, called SMD3, was generated in the MEDICS data storage and retrieval system. Three forms were used to enter data, the ACCOMP for completed experiments, the MALF for problem tracking, and the TV for television scenes recorded. Examples of completed forms as retrieved from the data base are shown in Figure 5-12. An additional form for crew health status was planned, but the medical officer decided it was not necessary.

The Experiment Activities Planning Officer was responsible for completion of the ACCOMP handwritten worksheet after each experiment run, with inputs from the Principal Investigator. The MALF worksheets were prepared by the Payloads Officer for system problems, and by the Assistant Payload Science Manager for experiments. TV inputs were taken from the log maintained by the TV Officer.

The Data Librarian collected the worksheets every evening after crew "lights-out" and entered them into the data base, thus assuring that all the day's accomplishments were entered. The Data Librarian and Data Manager then prepared a daily status report which was distributed to all operating positions in the POCC and Test Control Area prior to the next day's activities. Canned retrieval routines, called MACRO's, were developed which facilitated retrieval of cumulative test results to date in a tabular format. An access code was also established for ARC so that they might retrieve the status data for the SORC via telephone.

No operating problems were encountered with the system, and only one work-around was required. This occurred when scheduled maintenance in Building 30, where the MEDICS computer was located, required a shutdown of air conditioning for a day and the computer could not be used.

FORM NAME: AO CMP #1	
DATE:18MAY77	
TIME:1430	
LOG NO:0047	
EXP:	[illegible]
PROCEDURE:	[illegible]
SUBJECT:	[illegible]
OPERATOR:	[illegible]
RUN NO:	[illegible]
RESULTS:	GOOD DATA
PROBLEMS:	NONE EVIDENT
COMMENTS:	EXPERIMENT RUN DURING LOS. ARC SUP- REPORTS ABOVE RESULTS FROM DATA CH- [illegible] AFTER AOS

FORM NAME: MALF #1	
DATE:19MAY77	
TIME:0239	
LOG NO:0020	
EXP:	[illegible]26
STATUS:	NEW
LOCATION:	SPACELAB
TYPE:	SCIENCE
TITLE:	LOW H2O READING
DESCRIPTION:	H2O READING 0.0040 FOR SOME TIME. V- ERIFY H2O SWITCH IN "OPERATE".
ACTION:	VERIFY SWITCH POS. DURING EVE. STAT- US. PSP INADVERTENTLY LEFT IN "CAL.- " POSITION. SWITCHED TO "OPERATE." - PROBLEM CORRECTED.
ASSIGNEE:	
RESPONSE:	
COMMENTS:	

FORM NAME: TV #1	
DATE:18MAY77	
TIME:0454	
LOG NO:0047	
START:	0454
STOP:	0522
CAMERA:	[illegible]
[illegible]:	[illegible]
[illegible]:	
SLOW SCAN:	[illegible]
ACTIVITY:	[illegible]
COMMENTS:	

FIGURE 5-12, SMD III MEDICS REPORT FORMS

5.3.7.2 ARC

The SORC borrowed a TYMSHARE 1030 terminal from another organization at the ARC and was assigned an access code to the MEDICS computer prior to the two day simulation. The SORC had no direct input into the MEDICS computer. The data dump from the MEDICS computer was acquired in the SORC early each morning and scanned for content. The data consisted of a listing of the SMD III Accomplishments to date, a Malfunction listing and a TV listing. Each morning the SORC Director and the SORC Science Chief would review and identify verbally to the POCC Data Manager the TV sequences that should be retained and later made available to the P.I.'s. Otherwise the MEDICS information was used very little.

6.0 POST TEST ACTIVITIES

6.1 ONBOARD DATA RETURN AND DISTRIBUTION

During the conduct of the experiments on SMD III a number of hard copy data products were produced in the Spacelab mockup. These included stripchart recordings, marked-up test procedures, printer tapes, and exposed film.

As each data product was completed it was placed in a duffel bag on the mid-deck which the crew had set aside for the purpose. At the end of the mission the Data Manager went aboard and removed the duffel bag prior to crew egress. The Data Manager and SLSAL library personnel inventoried the contents and each data item was logged into the MEDICS system. The individual data items were then checked out to the PI's or placed in the Space Life Sciences Archival Library (SLSAL) as appropriate.

The crew indicated post-mission that the duffel bag was an unsatisfactory arrangement and suggested that a locker be provided on future missions to house data supplies and completed data products. The use of this locker should be clearly specified in the flight procedures.

6.2 LOG TAPE DATA RECOVERY

It was recognized from the beginning that a problem existed in recovering data from the ODS log tapes, since they were in a seven track format from the Varian computer/tape drive, and the processing would be done on a PDP 11/40 computer, which uses a nine track format. During pre-test development, format conversion was done on the MEDICS computer for a number of tapes. This required carrying the tapes to another facility, however, and tied up a computer which was in active use for other tasks.

Just prior to the test, software was written for the GDS computer which allowed the GDS to read the log tape and put the data on the link to the Science Computer. The Science Computer than could transmit to ARC and/or generate a nine track tape.

After the test, ARC determined that they were missing approximately 18 hours of Experiment 76 physiological background data, mostly in the 48 hour pre test control period. Since playing this data to ARC at real time rate would be very time consuming, Ford Aerospace modified the GDS software to allow reading the log tape at four times the recorded speed. The data was then recovered and nine track tapes were made and shipped to ARC.

6.3 POST TEST DATA PROCESSING

The complete set of JSC analog tapes and the JSC Science Computer digital tapes were shipped to ARC post mission. These, in conjunction with the digital log tapes created at ARC, constituted the basis for all post-test data processing. The JSC Science computer tapes were of two types; the experiments 50 and 76 high rate data recorded during a run and the balance of the SMD III data recorded as daily files.

The data for each experiment were stripped from the ARC master data tapes to generate the individual Experiment Data Records (EDR) delivered to the Principal Investigators. The JSC daily files tapes were used as a backup source to fill in any data gaps in the ARC tapes. The JSC Experiment 50 and Experiment 76 data tapes were used as the prime source of high rate data for portions of the Experiments 50 and 76 EDR's.

Once the EDR tapes were created and minor modifications were made to the applications software the data for each experiment were replayed to generate final data products consisting of stripcharts, listings and plots.