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SPACELAB/ORBITER SAIL
REQUIREMENTS ANALYSIS

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SPACE SHUTTLE ENGINEERING AND OPERATIONS SUPPORT

AVIONICS SYSTEM ENGINEERING

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PREPARED BY: P. A. Broome
R. J. Neubaur
R. T. Welsh

TASK MANAGER: P. A. Broome for
G. L. Hornback
Senior Group Engineer
488-5660 Ext. 315

APPROVED BY: C. S. Sitler
C. S. Sitler
Technical Manager
488-5660 Ext. 258

APPROVED BY: C. V. Wolfers
C. V. Wolfers
Deputy Project Manager
488-5660 Ext. 260

APPROVED BY: R. F. Pannett
R. F. Pannett
Project Manager
488-5660 Ext. 258

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CORPORATION

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1.0 EXECUTIVE SUMMARY

This design note presents the results of a McDonnell Douglas Technical Services Company (MDTSCO) study which define the Shuttle Avionics Integration Laboratory (SAIL) requirements for supporting the Spacelab/Orbiter avionics verification process. The principal topics addressed in this design note are a Spacelab avionics hardware assessment, Test Operations Center/ Electronic Systems Test Laboratory (TOC/ESTL) data processing requirements definition, SAIL (Building 16) payload accommodations study, and projected funding and test scheduling.

The information presented herein evolves from the "Spacelab/Orbiter Interface Test Analysis" study conducted by MDTSCO. This study concluded that the Spacelab/Orbiter Computer Systems, the PCM Data Link, and the High Rate Digital Data System hardware/software relationships were of such a complex nature that early avionics interface verification would be required. It also concluded that the SAIL is a prime candidate test location to accomplish this early avionics verification.

It is felt that the requirements delineated in this report provide a technically sound baseline for the conduct of Spacelab/Orbiter avionics interface verification in the SAIL.

Further expansion of this study depends on the resolution of issues involving the commitment of Spacelab to the SAIL, the firm definition of Software requirements, and the role of SAIL in the overall Spacelab verification process.

3.0 DISCUSSION

A meeting was held at Marshall Space Flight Center (MSFC) to discuss the Spacelab/Orbiter avionics interfaces. The purpose of the meeting was to assess the degree of concern for each of the Spacelab/Orbiter avionic subsystem interfaces and also to identify those subsystems that would preferably require early verification testing.

Those interfaces that would require early subsystem verification testing are documented in the McDonnell Douglas study entitled, "Spacelab/Orbiter Avionics Interface Test Analysis" (1.3-DN-C0612-001). This study also identified the Shuttle Avionics Integration Laboratory (SAIL) located at the Johnson Space Center (JSC) as a prime candidate test location for early Spacelab/Orbiter avionics interface testing. The suitability of the SAIL for performing the interface compatibility tests was described in a McDonnell Douglas study, "Preliminary Spacelab/SAIL Implementation Planning" (1.3-TM-C0612-006).

The analysis and planning documents described above made it obvious that additional studies would be required to establish a set of detailed Spacelab/SAIL implementation requirements. The results of these studies are presented in subsequent sections of this document. These sections address Spacelab avionics hardware assessment, data processing requirements, physical accommodation in SAIL, and projected funding and test scheduling.

3.1 SPACELAB AVIONICS HARDWARE ASSESSMENT

The Spacelab avionics hardware requirements for SAIL usage are presented in the ensuing subsections. These subsections identify the major Spacelab avionics interfaces as defined in the Shuttle Vehicle/Spacelab Avionics Interface Control Document, ICD-2-05301.

Each subsection presents a brief description of the avionics interface, a statement on the verification and hardware requirements and the rationale for the hardware requirements. The tables associated with each subsection delineate the interface verification requirements based on the preliminary Spacelab Interface Verification Plan, JSC-07700-14-PIV-03, prepared by MSFC; and the Spacelab hardware required to perform the verification. Additionally, a functional block diagram depicting the Orbiter/Spacelab interface is presented.

One of the requirements in the SAIL is that avionics hardware should be flight qualified or flight qualifiable. This requirement applies to Spacelab avionics hardware.

3.1.1 Orbiter/Spacelab EPDS Interface

3.1.1.1 Interface Description

The Spacelab has no internal source of electrical power. The Orbiter supplies the necessary electrical power to the Spacelab subsystem equipments and experiment equipments. Primary power will be provided by the Orbiter fuel cells (#3 prime, #2 backup) and emergency power will be supplied by the Orbiter main buses. There are two locations where electrical power will be available to the Spacelab loads. These are the Orbiter Aft Flight Deck (AFD)

3.1.1.1 Interface Description (Continued)

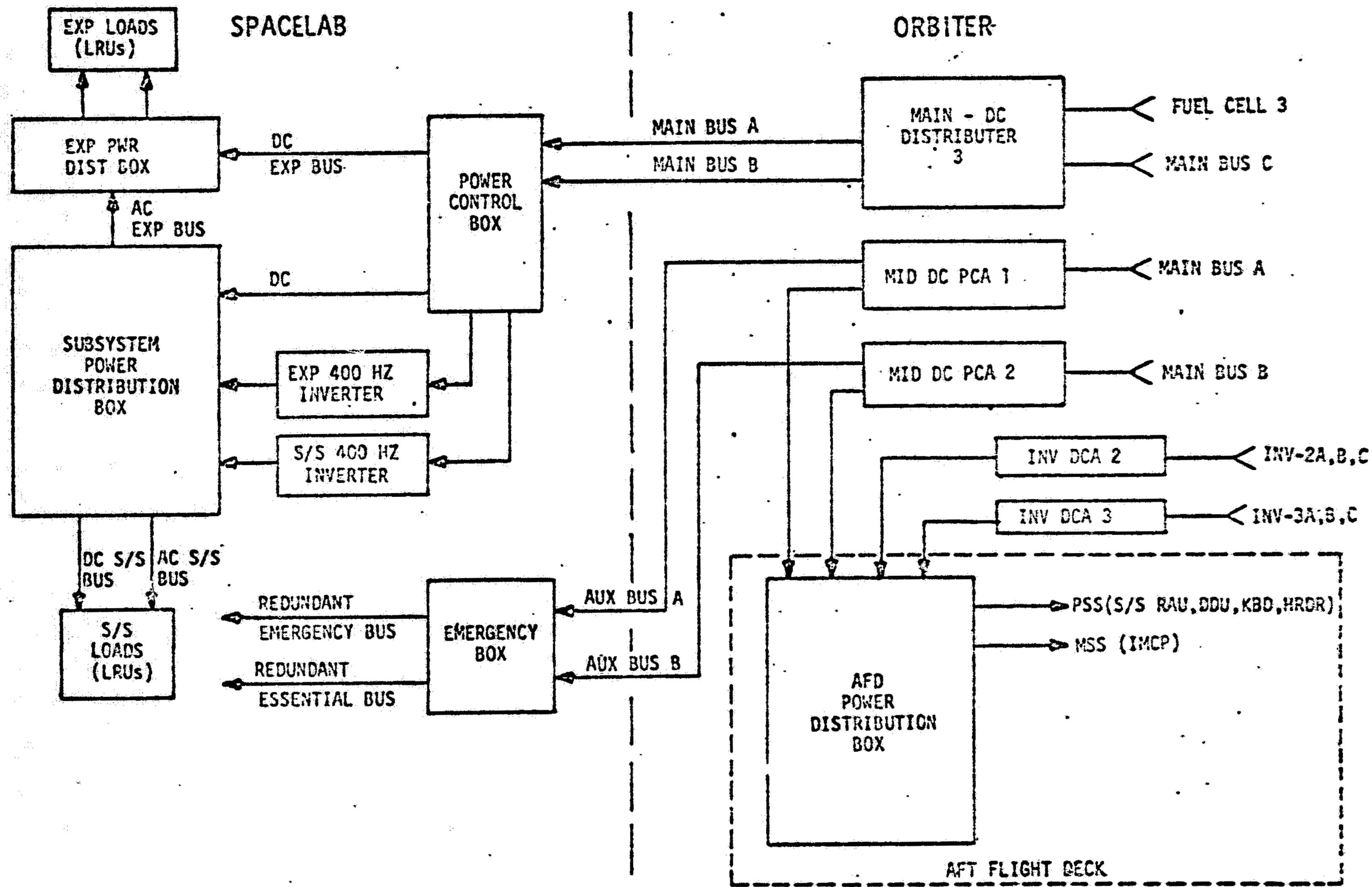
where AC&DC power is supplied for Spacelab installed equipments and the cargo bay where only DC power is provided to the Spacelab Electrical Power and Distribution System (EPDS).

The Orbiter buses which supply electrical power to the Spacelab will be referenced to the structure within the Orbiter. Within the Spacelab, the primary power feeders and their returns are isolated from structure. A functional block diagram of the Orbiter/Spacelab EPDS interface is shown in Figure 3.1-1.

3.1.1.2 Requirements - Verification and Hardware

The Spacelab verification requirements that will determine if the Orbiter electrical power system and the Spacelab EPDS are compatible in a flight configuration are listed in Table 3.1-1.

Table 3.1-1 also lists the Spacelab avionics hardware that will be required, in the SAIL, to perform the Orbiter/Spacelab EPDS compatibility tests. Note that the EPDS Monitor and Control Panel (MCP) and the Experiment Switching Panels (ESP) are not required in the SAIL. The MCP is a redundant panel, utilized in the module configuration, for direct access to EPDS functions. The essential monitor and control functions relating to the EPDS can be accomplished by the Integrated Monitor and Control Panel (IMCP) located in the AFD. The ESP is an extension of the Experiment Power Distribution Box (EPDB) and their utilization is mission dependent. The EPDB satisfies the SAIL requirements to provide experiment power distribution.



ELECTRICAL POWER DISTRIBUTION SYSTEM INTERFACE
FIGURE 3.1-1

ORBITER/SPACELAB EPDS INTERFACE

SOURCE DOCUMENT	VERIFICATION REQUIREMENT	SPACELAB HARDWARE	PART NO.	SAIL	
				QUAN.	STATUS
MSFC PIV-03 SEC 3.11	a. VERIFY THAT THE PAYLOAD IS CAPABLE OF ACCEPTING POWER AS SPECIFIED IN ICD-2-05301	1. INVERTER, 400HZ	06-110-00	2	REQ'D
		2. EPDS MONITOR AND CONTROL PANEL	06-120-00	-	NOT REQ'D
JSC 07700-14 -PIV-01 TABLE 3-1	b. VERIFY SIMULTANEOUS USE OF MORE THAN ONE ELECTRICAL POWER FEEDER	3. EXPERIMENT SWITCHING PANEL(S)	06-130-00	-	NOT REQ'D
		4. POWER CONTROL BOX	06-140-00	1	REQ'D
	c. VERIFY THAT THE PAYLOAD GROUNDING IS IN COMPLIANCE WITH ICD-2-05301	5. SUBSYSTEM POWER DISTRIBUTION BOX	06-150-01	1	REQ'D
		6. EXPERIMENT POWER DISTRIBUTION BOX	06-150-02	1	REQ'D
		7. AFD POWER DISTRIBUTION BOX	06-150-03	1	REQ'D
		8. EMERGENCY BOX	06-210-00	1	REQ'D
		9. INTEGRATED MONITOR AND CONTROL PANEL (IMCP-R7)	00-420-00	1	REQ'D
		10. ASSOCIATED FLT TYPE WIRE HARNESS	UNKNOWN	SET	REQ'D

TABLE 3.1-1

3.1.1.3 Rationale

The SAIL requires the Spacelab avionics hardware, identified in Table 3.1-1 to verify the capability of the Spacelab to accept and distribute Orbiter supplied electrical power and determine the adequacy of the power returns. The test activities for this verification process include:

(a) The dynamic interaction between the Orbiter and Spacelab electrical power distribution systems

(b) Proper hardware response to power on stimuli including monitoring data for visual and PCM readout

(c) Specified input voltage margins including AC&DC bus characteristics

(d) Specified output load capabilities including bus characteristics

(e) The prime bus power and emergency bus power switchover capability

(f) The isolation of the Spacelab power return lines

3.1.2 Orbiter MDM/Spacelab S/S-EXP I/O's, RAAB And C&W Interface

3.1.2.1 Interface Description

The Orbiter/Spacelab computer interface consists of a bidirectional link for command, guidance, navigation and control data transfer between the Orbiter MDM and the Spacelab Subsystem (S/S) and Experiment (EXP) Input Output Units (I/O's). This bidirectional link consists of dual redundant MDM serial input output channels connected to independent couplers in the Spacelab I/O's. Each channel consists of four hardwire connections: one digital line for bidirectional half duplex data transfers up to 10 KBPS and three discrete lines for data transmission direction, command and data word gating.

3.1.2.1 Interface Description (Continued)

The Orbiter/Spacelab computer interface also includes a MDM output to the Spacelab Remote Amplifier and Advisory Box (RAAB) for activation of the Spacelab Command and Data Management System (CDMS). This link consists of three hardwire connections: one line for system activation (DOL), one line for system monitoring discretes (DIL) and one line for system monitoring analog (AID).

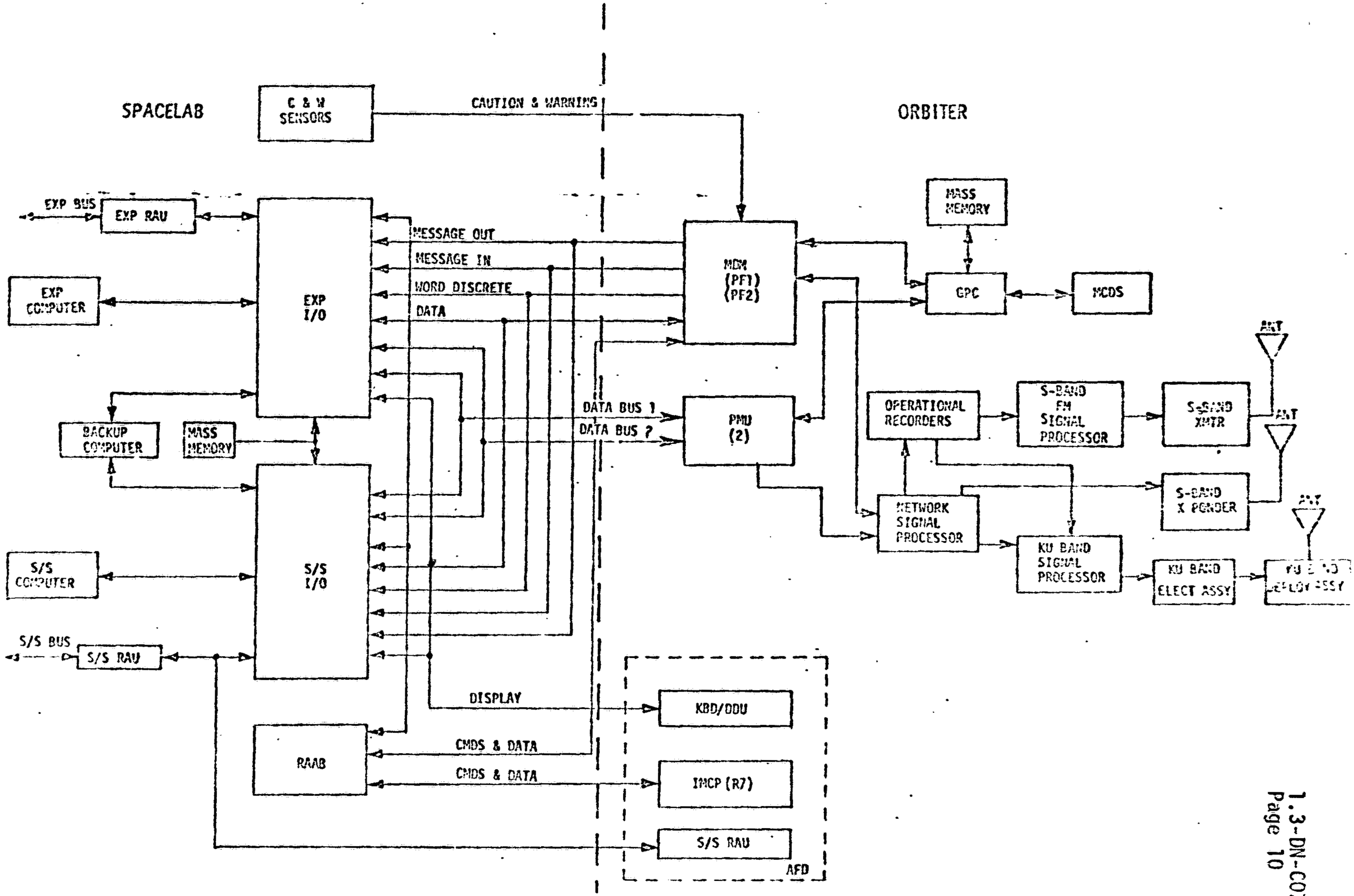
The third Orbiter/Spacelab computer interface consists of hardwire inputs from the Spacelab C&W and emergency sensors. These signals are discrete inputs from emergency sensors and discrete and analog inputs from caution and warning sensors.

A functional block diagram of the Orbiter MDM/Spacelab I/O's, RAAB and C&W Interface is shown in Figure 3.1-2.

3.1.2.2 Requirements - Verification and Hardware

The Spacelab verification requirements that will determine if the Orbiter/Spacelab computer systems are compatible in a flight configuration are listed in Table 3.1-2.

Table 3.1-2 also lists the Spacelab avionics hardware that will be required in SAIL to perform the Orbiter/Spacelab compatibility tests. Stimuli will be provided for the Spacelab C&W system by SAIL elements similar to those provided for the Orbiter C&W system.



S/S-EXP I/O's, RAAB AND C & W INTERFACE
FIGURE 3.1-2

ORBITER MDM/SPACELAB S/S - EXP I/O's, RAAB AND C&W INTERFACE

SOURCE DOCUMENT	VERIFICATION REQUIREMENT	SPACELAB HARDWARE	PART NO.	SAIL QUAN.	SAIL STATUS
MSFC PIV-03 SEC 3.12	a. VERIFY THE CAPABILITY OF THE PAYLOAD TO ACCEPT DISCRETE SAFING COMMANDS FROM THE MDM	1. INPUT OUTPUT (I/O) UNIT	07-110-00	2	REQ'D
		2. REMOTE ACQUISITION UNIT (RAU)-S/S	07-120-01	8	REQ'D
JSC 07700-14-PIV-01 TABLE 3-1	b. VERIFY THE CAPABILITY OF THE PAYLOAD TO ACCEPT GN&C STATE VECTOR AND ATTITUDE INFORMATION FROM THE ORBITER	3. RAU-EXP	07-120-02	TBD	REQ'D
		4. RAU/DDU INTERCONNECT STATION	07-131-01	TBD	REQ'D
	c. VERIFY THE CAPABILITY OF THE PAYLOAD TO PROVIDE ATTITUDE REFERENCE SENSOR DATA FROM A PAYLOAD MOUNTED SENSOR	5. MASS MEMORY INTERCONNECT STATION NO. 1	07-132-01	1	REQ'D
	d. VERIFY THE CAPABILITY OF THE PAYLOAD TO PROVIDE CAUTION AND WARNING DATA, IN THE FORM OF DISCRETE DIGITAL AND ANALOG INPUTS, TO THE MDM	6. MASS MEMORY INTERCONNECT STATION NO. 2	07-132-02	1	REQ'D
		7. DATA BUS COUPLER	01-139-01	2	REQ'D
	e. VERIFY THAT THE PAYLOAD AND PAYLOAD INTERFACES CAN BE TESTED AND CHECKED OUT BY THE PERFORMANCE MONITORING FUNCTIONS OF THE GPC	8. COMPUTER	07-210-00	3	REQ'D
		9. DATA DISPLAY UNIT (DDU)	07-310-00	1	REQ'D
		10. KEYBOARD	07-320-00	1	REQ'D
	f. VERIFY THAT THE PAYLOAD CAN RECEIVE SERIAL-DIGITAL OUTPUTS FROM THE MDM	11. MASS MEMORY UNIT	07-510-00	1	REQ'D
	g. VERIFY THAT THE PAYLOAD CAN SUPPLY SERIAL-DIGITAL INPUTS TO THE MDM	12. REMOTE AMPLIFIER & ADVISORY BOX (RAAB)	00-410-00	1	REQ'D
	h. VERIFY THAT THE PAYLOAD CAN RECEIVE DISCRETE OUTPUT SIGNALS FROM THE MDM	13. C & W SENSORS	UNKNOWN	-	NOT REQ'D
	i. VERIFY THAT THE PAYLOAD CAN SUPPLY HIGH AND LOW LEVEL DISCRETE AND ANALOG SIGNALS TO THE MDM	14. INTEGRATED MONITOR & CONTROL PANEL (IMCP R7)	00-420-00	1	REQ'D
		15. ASSOCIATED FLT TYPE WIRE HARNESS	UNKNOWN	SET	REQ'D
	j. VERIFY THAT THE PAYLOAD CAN PROVIDE ANALOG AND DISCRETE CAUTION AND WARNING SIGNALS TO THE ORBITER C&W SUBSYSTEM				

TABLE 3.1-2

3.1.2.3 Rationale

The SAIL requires the Spacelab avionics hardware, identified in Table 3.1-2, to verify that the (1) Orbiter MDM/Spacelab S/S - EXP I/O's, (2) Orbiter MDM/Spacelab RAAB and (3) Orbiter MDM/Spacelab C&W system are compatible.

3.1.2.3.1 The Orbiter MDM/Spacelab S/S - EXP I/O test activity will verify the capability to communicate between the Orbiter GPC and the Spacelab S/S - EXP computers via the MDM's and I/O units. The test activity for this verification process includes:

(a) The dynamic interaction, between the two computer systems, to command and data transfers
(b) The dynamic response to state vector updates
(c) The dynamic interaction to payload pointing sensor data
(d) The redundancy management capabilities as they relate to primary and secondary I/O and PMU coupler switchover
(e) The capability to load and verify Spacelab computers in the hardware control mode
(f) The performance monitoring capability between the Orbiter GPC and the Spacelab computers

3.1.2.3.2 The Orbiter MDM/Spacelab RAAB test activity will verify the capability to activate/deactivate the Spacelab subsystems. The test activity for this verification process includes:

(a) The dynamic response of the subsystem equipments to the activation/deactivation sequential commands including talkback data
(b) The dynamic response of the experiment equipments to the activation/deactivation sequential commands including talkback data
(c) The capability to perform the rapid reconfiguration functions

3.1.2.3.3 The Orbiter MDM/Spacelab C&W test activity will verify the capability to receive and process backup C&W sensor data. The test activity for this verification process includes:

(a) The accuracy of the C&W sensor data through the system

(b) The dynamic response of the Orbiter GPC to the C&W sensor data

3.1.3 Orbiter PMU/Spacelab S/S - EXP I/O Interface

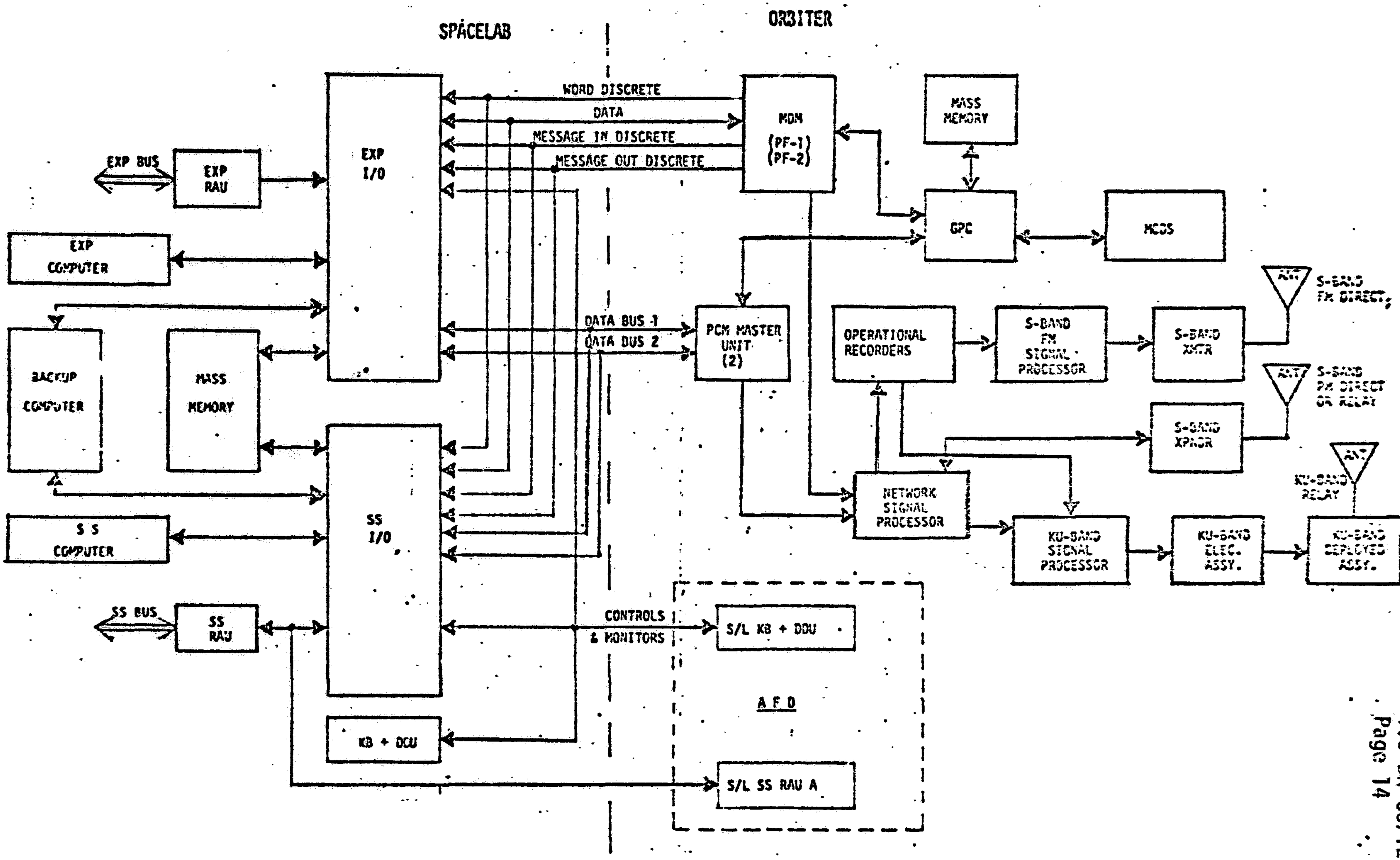
3.1.3.1 Interface Description

The PMU - I/O interface provides the downlink data path from the Spacelab to ground based receiving stations.

The Orbiter will provide for the acquisition of data from the two Spacelab I/O units via two redundant PMU data buses. A data bus is connected to each of two PCM Master Units (PMU's) with only one data bus active at a given time. Selection of the active PMU will be accomplished manually by the Orbiter while the selection of the redundant Spacelab I/O unit couplers will be accomplished remotely by the Orbiter or manually by the Spacelab. The redundant data buses are connected to the Spacelab S/S - EXP I/O unit couplers with identical data bus couplers.

The Spacelab, when normally activated shall respond to the PMU fetch commands with response data words via the selected PCM data bus.

A functional block diagram of the Orbiter PMU/Spacelab I/O Interface is shown in Figure 3.1-3.



INPUT/OUTPUT INTERFACE
FIGURE 3.1-3

3.1.3.2 Requirements - Verification and Hardware

The Spacelab verification requirement that will determine if the Orbiter/Spacelab PCM data bus will operate as a digital data transmission system in a flight configuration is listed in Table 3.1-3.

Table 3.1-3 also lists the Spacelab avionics hardware that will be required in the SAIL to perform the Orbiter/Spacelab PCM data bus compatibility test.

3.1.3.3 Rationale

The SAIL requires the Spacelab avionics hardware, identified in Table 3.1-3, to verify the capability of the Spacelab to receive fetch commands and transmit computer memory data across the data bus and the capability to detect signal errors and provide correct responses. The test activities for this verification process include:

(a) The dynamic response to fetch commands including cycle time
(b) A demonstration of data acquisition synchronization
(c) A demonstration of the PMU - I/O coupler switchover capability
(d) The appropriate handling of and recovery from noise bursts
(e) A demonstration of the performance monitoring and redundancy management capabilities

3.1.4 Orbiter MTU/Spacelab RAAB Interface

ORBITER PMU/SPACELAB S/S EXP I/O INTERFACE

SOURCE DOCUMENT	VERIFICATION REQUIREMENT	SPACELAB HARDWARE	PART NO.	SAIL QUAN.	SAIL STATUS
MSFC PIV-03 SECT 3.13 JSC 07700-14 -PIV-01 TABLE 3-1	a. VERIFY PAYLOAD CAPABILITY TO PROVIDE DIGITAL ENGINEERING DATA TO THE ORBITER PMU	1. I/O UNIT	07-110-00	2	REQ'D
		2. RAU-S/S	07-120-01	8	REQ'D
		3. RAU-EXP	07-120-02	TBD	REQ'D
		4. RAU/DDU INTERCONNECT STATION	07-131-01	TBD	REQ'D
		5. MASS MEMORY INTERCONNECT STATION NO. 1	07-132-01	1	REQ'D
		6. MASS MEMORY INTERCONNECT STATION NO. 2	07-132-02	1	REQ'D
		7. DATA BUS COUPLER	07-139-01	2	REQ'D
		8. COMPUTER	07-210-00	3	REQ'D
		9. DATA DISPLAY UNIT	07-310-00	1	REQ'D
		10. KEYBOARD	07-320-00	1	REQ'D
		11. MASS MEMORY UNIT	07-510-00	1	REQ'D
		12. ASSOCIATED FLT TYPE WIRE HARNESS	UNKNOWN	SET	REQ'D

TABLE 3.1-3

3.1.4.1 Interface Description

The Orbiter Master Timing Unit (MTU) provides the pulse duration modulation time code signal (GMT) and the square wave clock signal to the Spacelab. Greenwich mean time (GMT) and a 1024 KHZ clock signal is transmitted across the interface, via separated shielded hardlines, to the Remote Amplifier and Advisory Box (RAAB) for distribution to the Spacelab using equipments. There are three other clock signals, 4608 KHZ, 1 KHZ and 100 HZ that are available at the Orbiter interface for Spacelab mission unique experiment usage. These three clock signals will not be verified in the SAIL.

A functional block diagram of the Orbiter MTU/Spacelab RAAB Interface is shown in Figure 3.1-4.

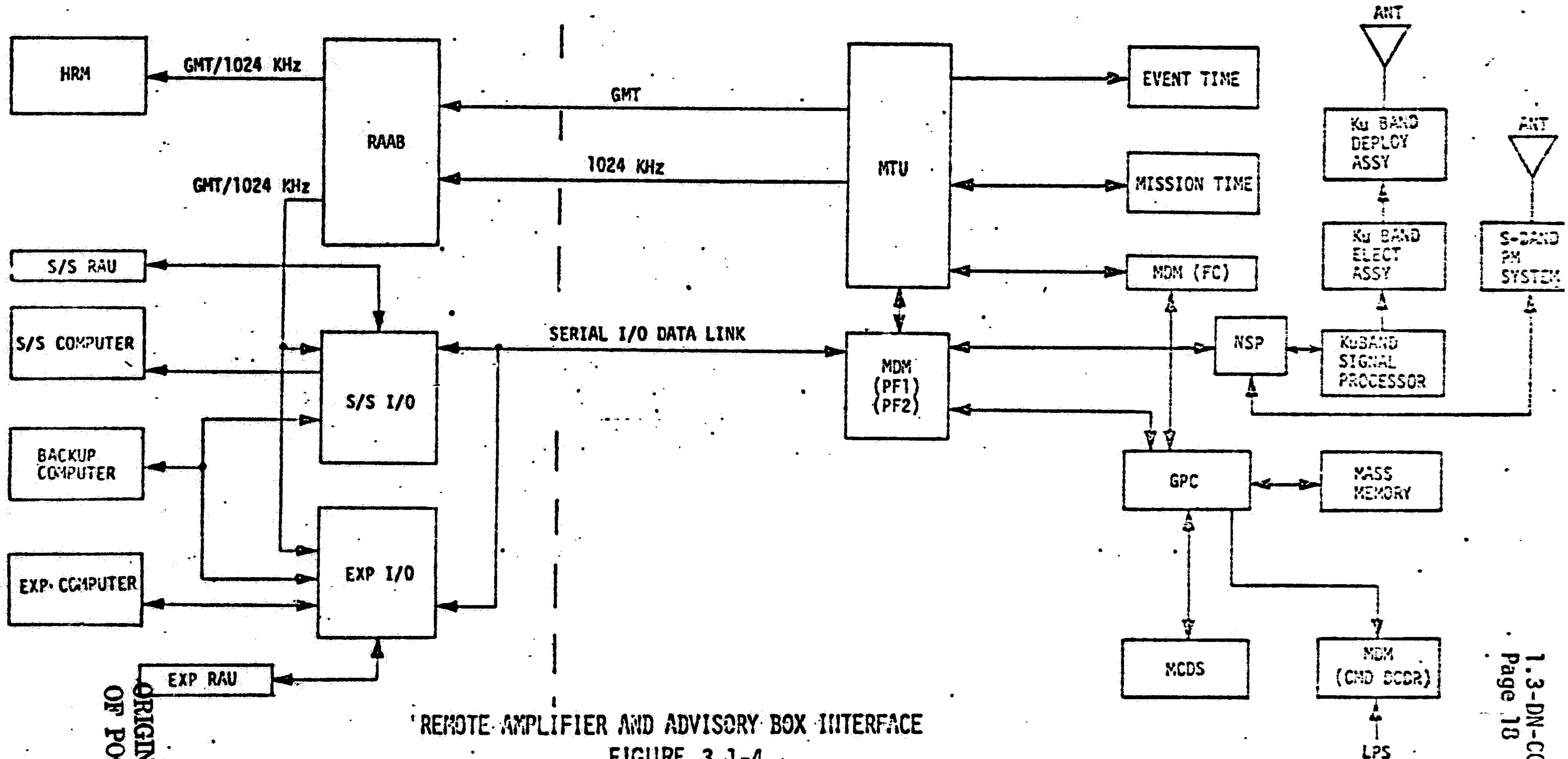
3.1.4.2 Requirements - Verification and Hardware

The Spacelab verification requirements that will determine if the Orbiter MTU/Spacelab RAAB are compatible in a flight configuration are listed in Table 3.1-4.

Table 3.1-4 also lists the Spacelab avionics hardware that will be required in the SAIL to perform the MTU/RAAB compatibility test.

3.1.4.3 Rationale

The SAIL requires the Spacelab avionics hardware, identified in Table 3.1-4, to verify the capability of the RAAB to process MTU GMT and clock signals and distribute same to the S/S - EXP computers via the I/O's, the high rate multiplexer, and the experiments via remote acquisition units.



REMOTE AMPLIFIER AND ADVISORY BOX INTERFACE
FIGURE 3.1-4

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ORBITER MTU/SPACELAB RAAB INTERFACE

SOURCE DOCUMENT	VERIFICATION REQUIREMENT	SPACELAB HARDWARE	PART NO.	SAIL QUAN.	SAIL STATUS
MSFC PIV-03 SEC 3.14	a. VERIFY THE CAPABILITY OF THE PAYLOAD TO ACCEPT GMT FROM THE ORBITER MASTER TIMING UNIT	1. I/O UNIT	07-110-00	2	REQ'D
		2. RAU-S/S	07-120-01	8	REQ'D
JSC 07700-14 -PIV-01 TABLE 3-1	b. VERIFY THE CAPABILITY OF THE PAYLOAD TO ACCEPT TIMING SYNCHRONIZATION FREQUENCIES AS SPECIFIED IN ICD-2-05301	3. RAU-EXP	07-120-02	TBD	REQ'D
		4. RAU/DDU INTERCONNECT STATION	07-131-01	TBD	REQ'D
		5. RAAB	00-410-00	1	REQ'D
		6. COMPUTER	07-210-00	3	REQ'D
		7. HIGH RATE MULTIPLEXER	07-140-00	1	REQ'D
		8. ASSOCIATED FLT TYPE WIRE HARNESS	UNKNOWN	SET	REQ'D

TABLE 3.1-4

3.1.5 Orbiter Ku Signal Processor - Payload Recorder/Spacelab High Rate Multiplexer Interface

3.1.5.1 Interface Description

The Orbiter KuBand Signal Processor (KuSP) and payload recorder interface directly with the Spacelab High Rate Multiplexer (HRM). The KuSP receives three digital inputs and one clock input from the Spacelab HRM via four hardwire paths. An analog input, via hardwire, to the KuSP is provided for Spacelab mission unique data.

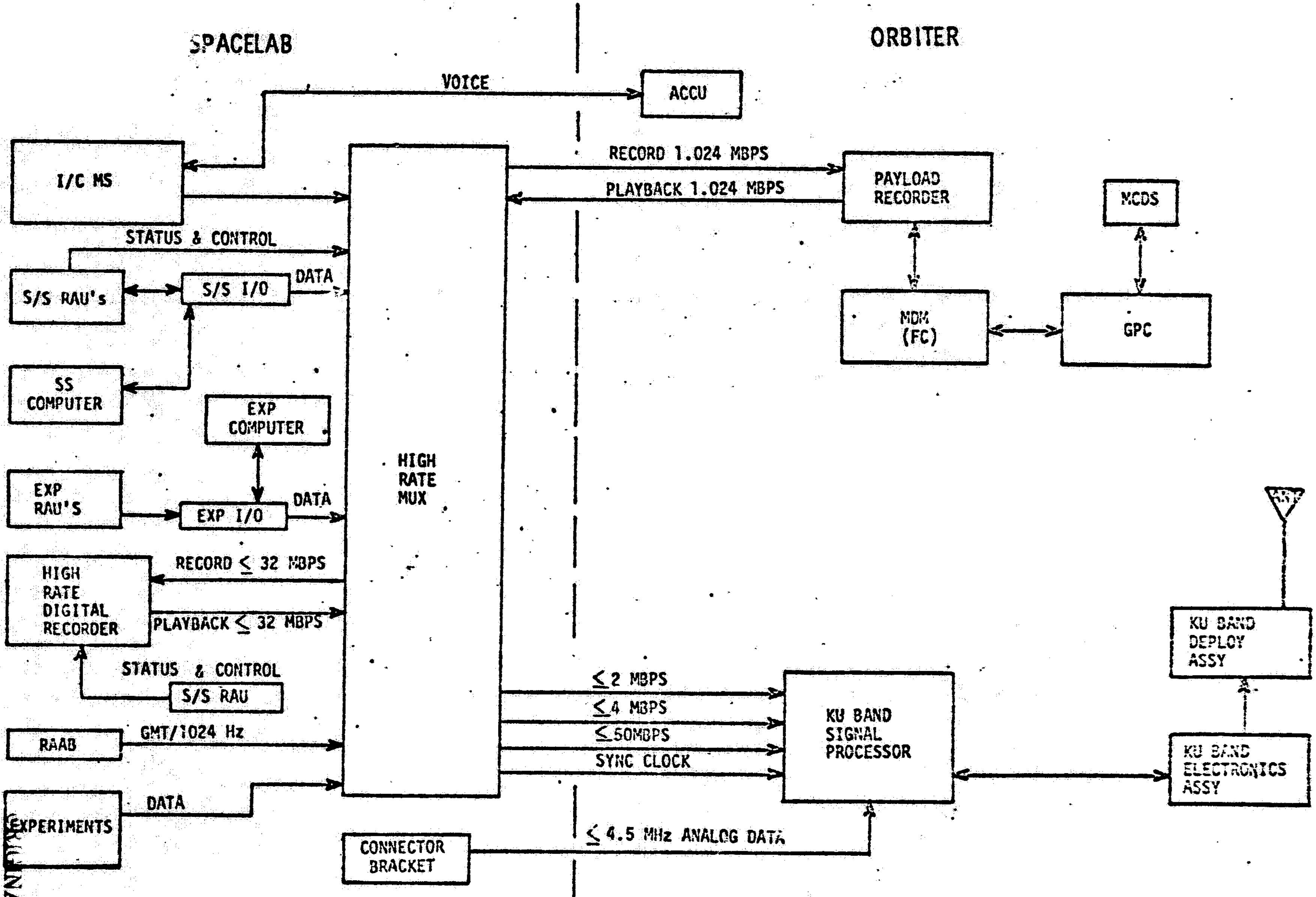
The payload recorder will record and playback, via a hardwire path, bi phase serial data from/to the Spacelab HRM.

A functional block diagram of the Orbiter KuSP - Payload Recorder/ Spacelab HRM Interface is shown in Figure 3.1-5.

3.1.5.2 Requirements - Verification and Hardware

The Spacelab verification requirements that will determine if the Orbiter/Spacelab high rate digital data system is operationally compatible in a flight configuration are listed in Table 3.1-5.

Table 3.1-5 also lists the Spacelab avionics hardware that will be required in the SAIL to perform the Orbiter/Spacelab high rate digital data system compatibility test.



HIGH RATE MULTIPLEXER INTERFACE
FIGURE 3.1-5

ORBITER KU BAND SIGNAL PROCESSOR - PAYLOAD RECORDER/SPACELAB HIGH RATE MULTIPLEXER INTERFACE

SOURCE DOCUMENT	VERIFICATION REQUIREMENT	SPACELAB HARDWARE	PART NO.	SAIL QUAN.	SAIL STATUS
MSFC PIV-03 SEC. 3.15	a. VERIFY THE CAPABILITY OF THE PAYLOAD TO PROVIDE DATA AS SPECIFIED IN ICD-2-05301	1. I/O UNIT	07-110-00	2	REQ'D
		2. RAU-S/S	07-120-01	8	REQ'D
JSC 07700-14 -PIV-01 TABLE 3-1	b. VERIFY PAYLOAD ABILITY TO PROVIDE DIGITAL DATA AT A RATE UP TO 1024 KBPS TO THE MISSION STATION PCM RECORDER	3. RAU-EXP	07-120-02	TBD	REQ'D
		4. RAU/DDU INTERCONNECT STATION	07-131-01	TBD	REQ'D
		5. COMPUTER	07-210-00	2	REQ'D
		6. HIGH RATE MULTIPLEXER (HRM)	07-140-00	1	REQ'D
		7. HIGH RATE DIGITAL RECORDER			REQ'D
		TRANSPORT	07-520-01	1	
		ELECTRONICS	07-520-02	1	
		8. RAAB	00-410-00	1	REQ'D
		9. EXPERIMENTS	UNKNOWN	-	NOT REQ'D
		10. ASSOCIATED FLT TYPE WIRE HARNESS	UNKNOWN	SET	REQ'D

TABLE 3.1-5

3.1.5.3 Rationale

The SAIL requires the Spacelab avionics hardware, identified in Table 3.1-5, to verify the capability of the HRM to: (1) Multiplex and transfer digital data to the KuSP, (2) Interleave the High Rate Digital Recorder (HRDR) playback data into the data stream and (3) Transfer data to and multiplex data from the payload recorder. The test activities for this verification process include:

(a) The dynamic response of HRM to mode commands

(b) A demonstration of the voice digitizing capability of the HRM

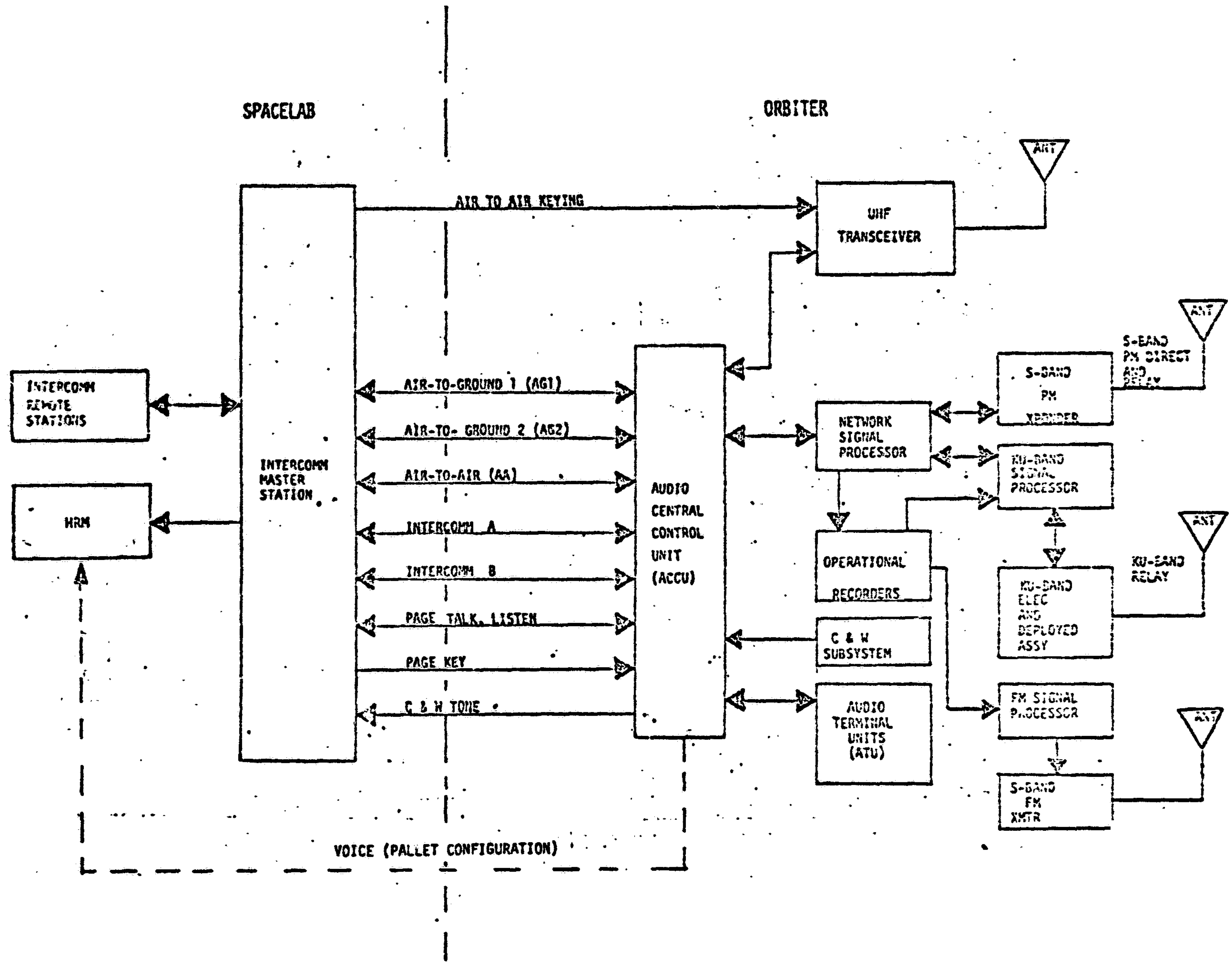
3.1.6 Orbiter ACCU/Spacelab I/C MS Interface

3.1.6.1 Interface Description

The Spacelab Intercom Master Station (I/C MS) interfaces directly with the Orbiter Audio Central Control Unit (ACCU), via hardware connections, in the Spacelab module configuration. Access of the three Spacelab simultaneous voice loops to any of the Orbiter two-way (talk/listen) audio channels is controlled within the Orbiter. A separate hardwire key line is provided from the Spacelab to the Orbiter EVA/ATC transceiver. A page channel is also provided and is superimposed on all internal channels of the Spacelab intercom equipment.

In the pallet only configuration, an audio hardwire line is provided from the Orbiter ACCU to the Spacelab HRM for voice annotation.

A functional diagram of the Orbiter ACCU/Spacelab I/CMs is shown in Figure 3.1-6.



INTERCOMM MASTER STATION INTERFACE
FIGURE 3.1-6

3.1.6.2 Requirements - Verification and Hardware

The Spacelab verification requirements that will determine if the Orbiter/Spacelab audio system is operationally compatible in a flight configuration are listed in Table 3.1-6.

Table 3.1-6 also lists the Spacelab avionics hardware that will be required in the SAIL to perform the Orbiter/Spacelab audio system compatibility test. The Intercom remote station is an extension of the Intercom master station and therefore is not required in the SAIL.

3.1.6.3 Rationale

The SAIL requires the Spacelab avionics hardware, identified in Table 3.1-6, to verify the capability of the Spacelab I/C MS to receive and transmit signal to and from the Orbiter ACCU and the EVA/ATC transceiver. The test activities for this verification process include:

(a) The dynamic response to I/C MS switching functions

(b) Adjacent channel interactions

(c) Word intelligibility of single and simultaneous voice loop transmissions

(d) Evaluation of signal characteristics

3.1.7 Orbiter/Spacelab C&W Interface

3.1.7.1 Interface Description

The Orbiter has the capability to monitor input signals from the Spacelab and provide intelligence to the crew via Spacelab C&W System. Spacelab caution inputs are defined as actual or impending anomalous conditions

ORBITER ACCU/SPACELAB I/C MS INTERFACE

SOURCE DOCUMENT	VERIFICATION REQUIREMENT	SPACELAB HARDWARE	PART NO.	SAIL QUAN.	SAIL STATUS
MSFC PIV-03 SEC 3.16	a. VERIFY THE CAPABILITY OF S/L TO INPUT FROM AND OUTPUT TO THE AUDIO DISTRIBUTION SYSTEM	1. INTERCOMM MASTER STATION	07-610-00	1	REQ'D
		2. INTERCOMM REMOTE STATION	07-620-00	-	NOT REQ'D
JSC -07700-14 -PIV-01 TABLE 3-1	b. VERIFY OPERATION OF S/L DISPLAYS AND CONTROLS FOR INSTRUMENTATION, COMMUNICATION, AND OTHER NECESSARY FUNCTIONS BETWEEN THE S/L AND THE PAYLOAD STATION	3. ASSOCIATED FLT TYPE WIRE HARNESS	UNKNOWN	SET	REQ'D

TABLE 3.1-6

3.1.7.1 Interface Description (Continued)

which in combination with another failure constitute a system configuration that could be hazardous to the Orbiter or crew and require action or procedural change for corrective measures. A Spacelab warning input is an actual or impending anomalous condition which, in itself, is hazardous to the Orbiter or crew and requires immediate crew action.

Emergency inputs are defined as a crew hazard requiring immediate instructive crew action. Emergency inputs consist of Fire/Smoke and Rapid Cabin Depressurization.

The caution and warning sensors are connected to the Orbiter MDM and the warning sensors are connected to the MDM and the Orbiter Caution and Warning Electronic Unit (CWEU). In addition each Spacelab sensor has a connection to the RAU which allows an intelligence instruction by the computer system.

Spacelab fire/smoke detectors are located in the right and left avionics racks and in the module cabin. Two redundant detectors at each of the three locations are hardwired to the Orbiter R-7 panel, through six individual inhibit switches.

The Orbiter CWEU provides a switch closure for the master alarm light on the S/L C&W/FSS Panel.

Siren, Klaxon and C&W tones are generated by the Orbiter CWEU and ACCU and sounded through S/L speaker on the C&W/FSS panel.

3.1.7.1 Interface Description (Continued)

Spacelab safing commands to C&W inputs will be issued thru the MDM to the Spacelab effectors and emergency safing commands will be issued by switch closure on the IMCP.

A functional block diagram of the Orbiter/Spacelab C&W Interface is shown in Figure 3.1-7.

3.1.7.2 Requirements - Verification and Hardware

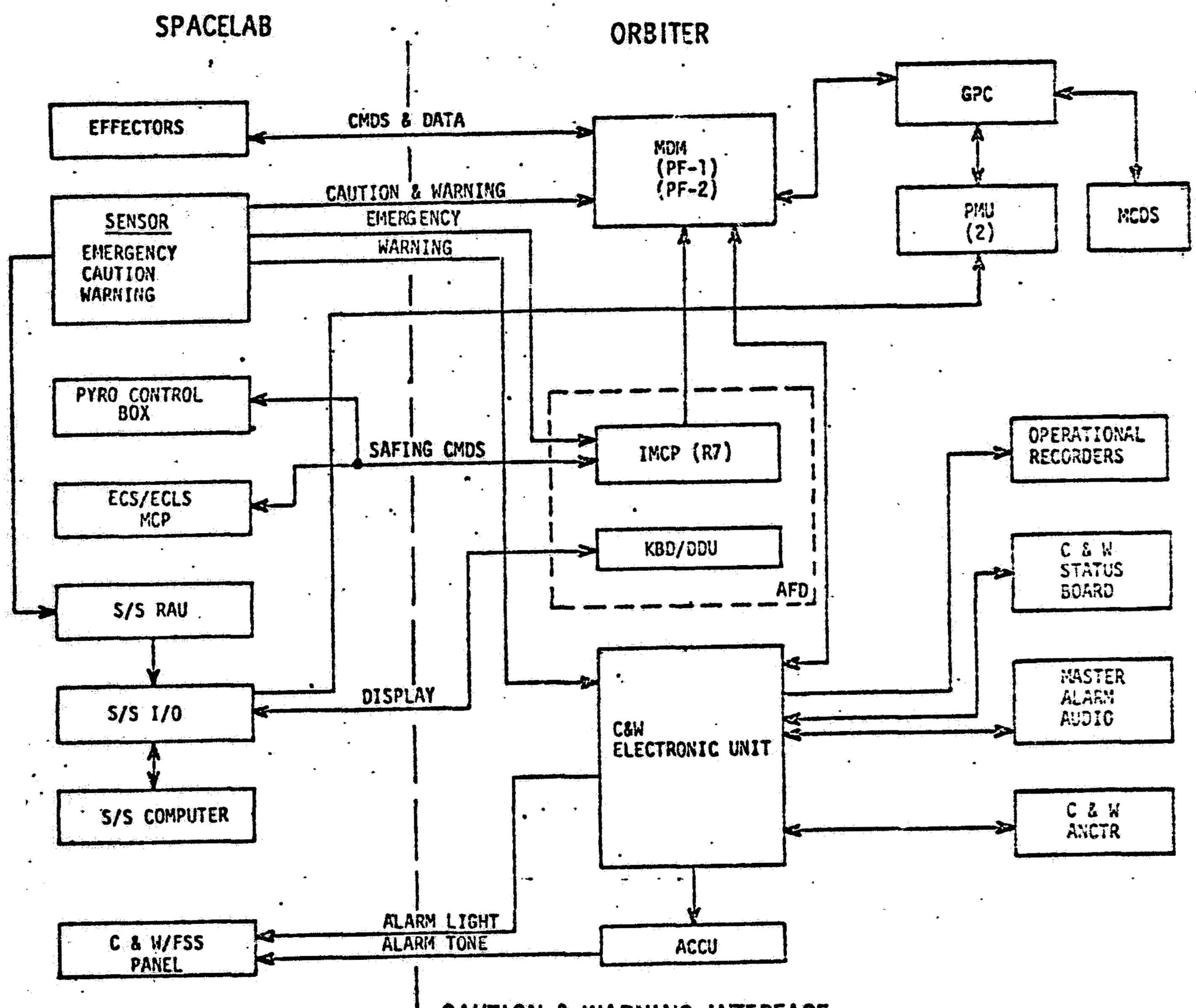
The Spacelab verification requirements that will determine if the Orbiter/Spacelab C&W systems are operationally compatible in a flight configuration are listed in Table 3.1-7.

Table 3.1-7 also lists the Spacelab avionics hardware that will be required in the SAIL to perform the Orbiter/Spacelab C&W systems compatibility test. Note that the C&W sensors are not required in the SAIL. The C&W sensor stimuli will be simulated by SAIL elements.

3.1.7.3 Rationale

The SAIL requires the Spacelab avionics hardware, identified in Table 3.1-7, to verify the capability of the Spacelab to provide analog and discrete event C&W information to the Orbiter C&W subsystem and to accept discrete safing commands from the AFD R7 panel. Functions that will be verified during this test activity include:

(a) Dynamic response of the C&W analog and discrete event information
(b) Data acquisition via the Orbiter PMU
(c) Evaluation of signal characteristics
(d) Adjacent signal path interaction



CAUTION & WARNING INTERFACE
FIGURE 3.1-7

ORBITER/SPACELAB C&W INTERFACE

SOURCE DOCUMENT	VERIFICATION REQUIREMENT	SPACELAB HARDWARE	PART NO.	SAIL QUAN.	SAIL STATUS
MSFC PIV-03 SEC 3.18	a. VERIFY THE CAPABILITY OF THE S/L TO PROVIDE ANALOG AND DISCRETE EVENT C&W INFORMATION TO THE ORBITER C&W SUBSYSTEM	1. I/O UNIT	07-110-00	1	REQ'D
		2. RAU-S/S	07-120-01	8	REQ'D
JSC -07700-14 -PIV-01 TABLE 3-1	b. VERIFY THE CAPABILITY OF THE S/L TO ACCEPT DISCRETE SAFING COMMANDS FROM THE ORBITER AFD R-7 PANEL	3. RAU/DDU INTERCONNECT STATION	07-131-01	TBD	REQ'D
		4. COMPUTER	07-210-00	1	REQ'D
		5. C & W SENSORS	UNKNOWN	-	NOT REQ'D
	c. VERIFY OPERATION OF S/L DISPLAYS AND CONTROLS FOR INSTRUMENTATION, COMMUNICATION, AND OTHER NECESSARY FUNCTIONS BETWEEN THE S/L AND THE PAYLOAD STATION	6. PYRO CONTROL BOX	08-410-01	TBD	TBD
		7. ECS/ECLS MONITOR & CONTROL PANEL	UNKNOWN	TBD	TBD
		8. C & W/FSS PANEL	00-430-00	TBD	TBD
		9. INTEGRATED MONITOR & CONTROL PANEL (R7)	00-420-00	1	REQ'D
		10. DATA DISPLAY UNIT	07-310-00	1	REQ'D
		11. DATA BUS COUPLER	07-139-01	2	REQ'D
		12. KEYBOARD	07-320-00	1	REQ'D
		13. ASSOCIATED FLT TYPE WIRE HARNESS	UNKNOWN	SET	REQ'D

TABLE 3.1-7

3.1.8 Orbiter/Spacelab CCTV Interface

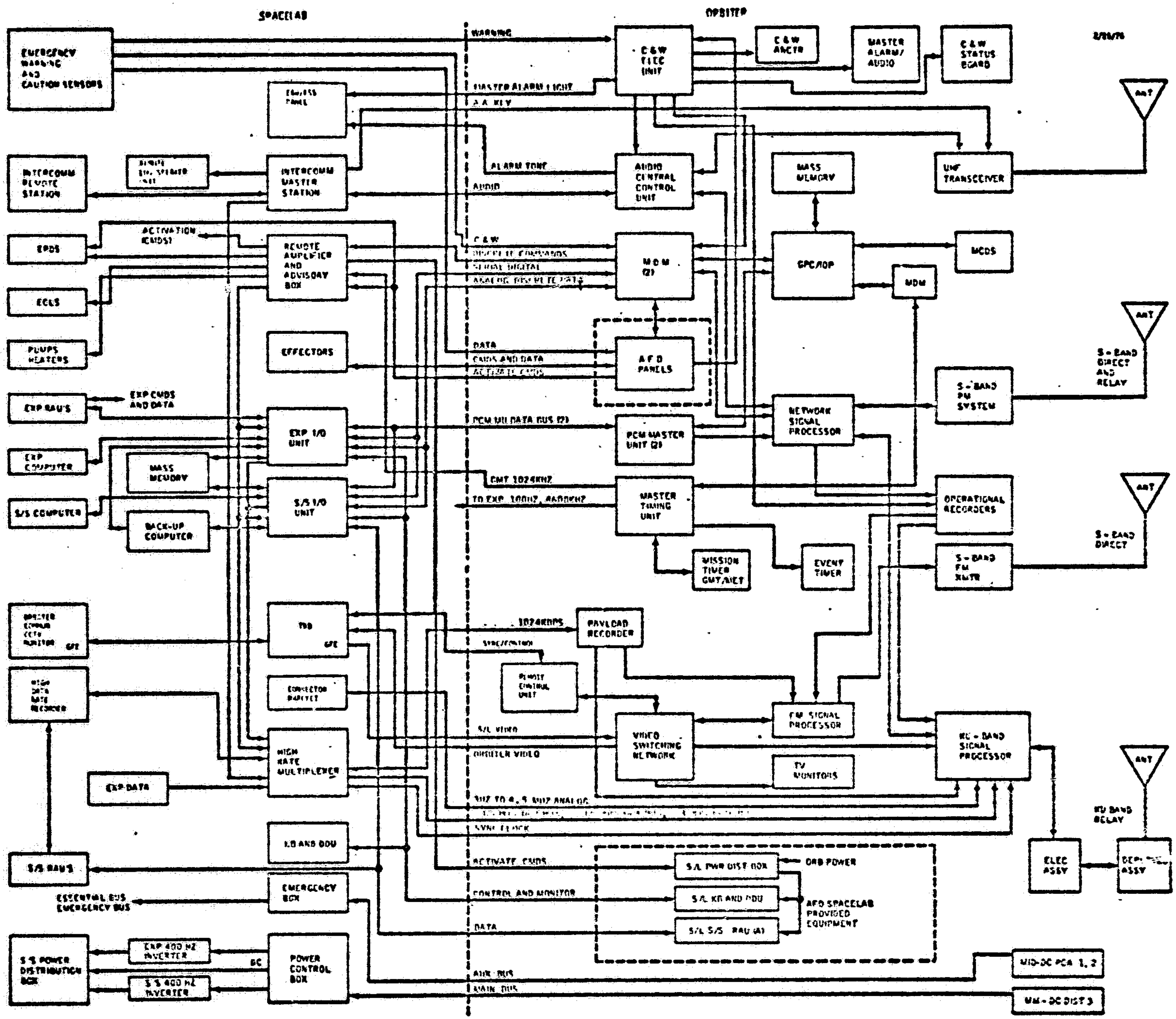
3.1.8.1 The Spacelab Closed Circuit Television (CCTV) subsystem avionics hardware requirements are not included in this report. Present planning indicates that CCTV hardware will be supplied as GFE.

3.2 TOC/ESTL DATA PROCESSING REQUIREMENTS

The Test Operation Center (TOC) and the Electronic Systems Test Laboratory (ESTL) realtime data processing needed to support Spacelab testing in SAIL are presented in this section. These processing requirements were determined by analyzing the integrated Spacelab/Orbiter avionics system and interfaces depicted in Figure 3.2-1.

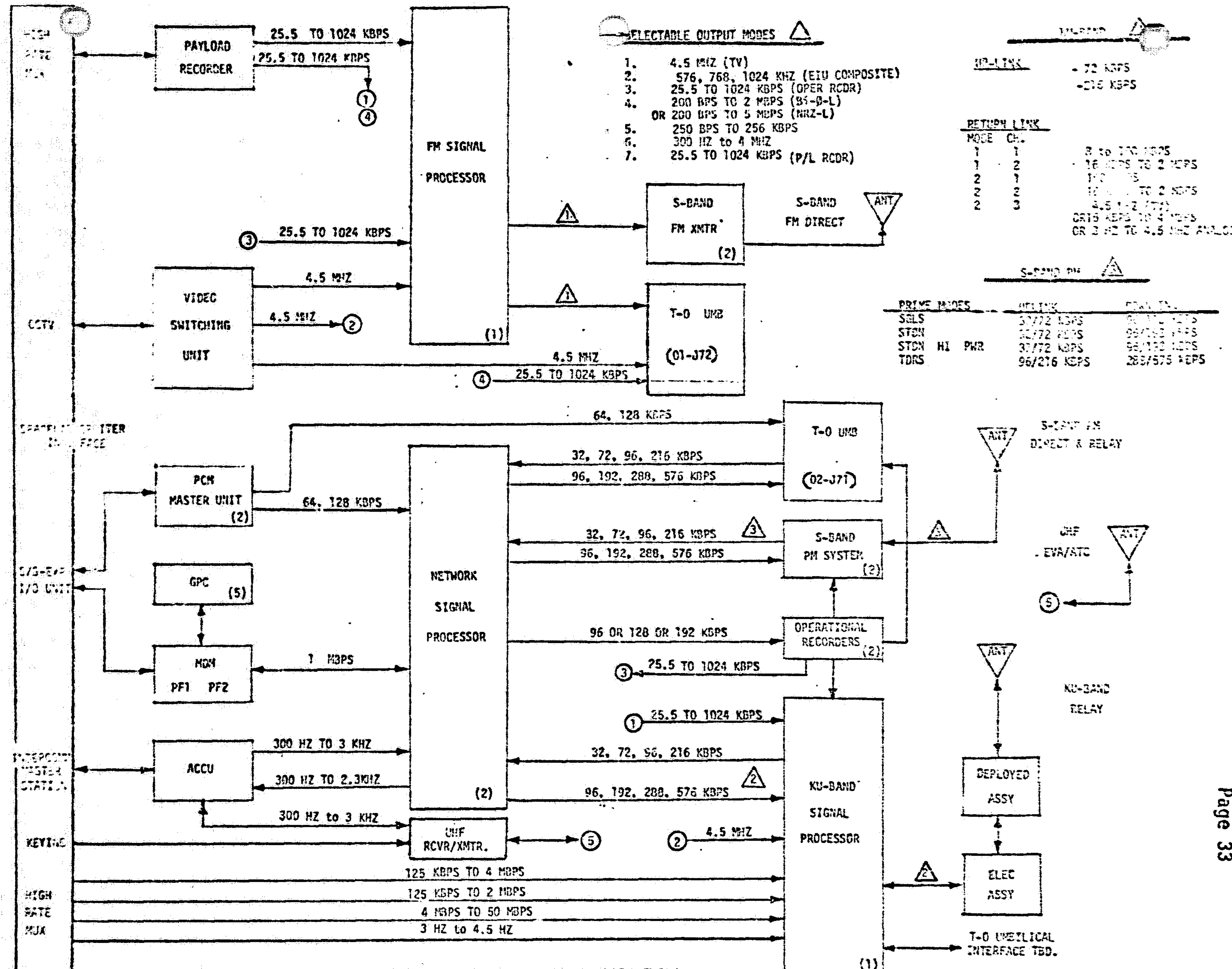
As shown in Figure 3.2-1, the Spacelab does not have an independent data transmission system for ground communication. The Spacelab transmits data and receives commands via Orbiter communication links. A functional diagram has been developed to show the Spacelab/Orbiter data flow and it is presented in Figure 3.2-2. As shown in this figure, Spacelab data can be routed via the Orbiter Ku-Band, S-Band (FM or PM), UHF, or T-0 umbilical paths. Each of these data paths will be discussed in subsequent paragraphs.

A basic ground rule used to determine TOC and/or ESTL Spacelab data processing requirements is that TOC is not utilized to verify the different Communication and Tracking (C&T) Subsystem data paths but rather to gather data to demonstrate integrated avionics system performance. In cases where several uplink/downlink data rates and/or paths



SPACELAB/ORBITER AVIONICS INTERFACE

FIGURE 3.2.1



SPACELAB/ ORBITER FUNCTIONAL DATA FLOW

FIGURE 3.2-2

3.2 TOC/ESTL DATA PROCESSING REQUIREMENTS (Continued)

are available, one total data rate that contains all of the required information has been selected as a data processing requirement for TOC. Since current planning does not envision incorporation of receivers in TOC, data exchange will be between TOC and the Orbite[illegible]ssors rather than the Orbiter transmitter/receivers. This da[illegible] will normally be via the T-0 umbilical interface.

The data rate limits stated are as presently listed in the individual LRU specifications. The operational data rates may be some other value within those specification rate ranges when the system design is firmed up.

ESTL is utilized to demonstrate satisfactory performance of the Orbiter C&T Subsystem. The C&T Subsystem in SAIL is interfaced with the ground network stations and Tracking Data Relay Satellite (TDRS) simulation in ESTL via roof top antennas on Building 16 and 44. All data paths and operational modes that contain Spacelab data are considered applicable for processing via ESTL.

3.2.1 Network Signal Processor (NSP)

There are four different rates for downlink data from the NSP and four rates for uplink. The downlink rates are 96, 192, 288, and 576 KBPS. The uplink rates are 32, 72, 96 and 216 KBPS. The 192 KBPS downlink data rate provides all of the information required to be decommutated, displayed and recorded in TOC. The requirement for command/control from TOC can be satisfied by generating data at a rate of 72 KBPS. All of the NSP data rates are considered applicable to the ESTL.

3.2.2 FM Signal Processor (FMSP)

There are seven selectable output operating modes for downlinking data from the FMSP via the S-Band FM Direct link or by the T-O Umbilical path. These modes are as follows:

(1) 4.5 MHZ (T.V.)

(2) 576, 768 and 1024 KHZ (EIU OUTPUTS)

(3) 25.5 KBPS to 1024 KBPS (OPERATIONAL RECORDER)

(4) 200 BPS to 2 MBPS (Bi-Ø-L) OR
200 BPS to 5 MBPS (NRZ-L)

(5) 250 BPS to 256 KBPS (DOD P/L)

(6) 300 HZ to 4 MHZ (NASA P/L)

(7) 25.5 KBPS to 1024 KBPS (PL RECORDER)

The data from modes 1 and 3 provide all the information required from the Spacelab to be decommutated, displayed and recorded in TOC. The S-Band FM direct link does not have an uplink capability. All of the FMSP output modes are considered applicable for ESTL support.

3.2.3 Ku-Band Signal Processor (KUSP)

There are two modes of operation for downlinking data from the KUSP. Mode 1 is a 2 data channel operation with channel one having an output of 8 to 100 MBPS and channel two with an output of 16 KBPS to 2 MBPS which are combined to form a single signal for transmission.

Mode 2 operates in one of two selectable configurations, normal 3 channel configuration and narrowband bent pipe dual channel configuration. In the normal 3 channel configuration the transmitted signal is comprised of

3.2.3 Ku-Band Signal Processor (KUSP) (Continued)

mode 2 channel 3 data which is either 4.5 MHZ television or 4.5 MHZ analog or 16 KBPS to 2 MBPS digital data, mode 2 channel 1 (192 KBPS data) and mode 2 channel 2 (16 KBPS to 2 MBPS) data modulated to form a composite output signal.

In the narrowband bent-pipe dual channel configuration the narrowband bent-pipe data is combined with the baseband 4.5 MHZ wideband data for FM modulation of the carrier.

Processing of the following KUSP Spacelab downlink data rates, (8 to 100 MBPS), (16 KBPS to 2 MBPS), (4.5 MHZ TV) and (16 KBPS to 4 MBPS), are required to be decommutated, displayed and recorded in TOC. The requirement for command and control from TOC can be satisfied by use of the 72 KBPS NSP uplink data path. All of the KUSP data rates are considered applicable to the ESTL.

The Ku-Band signal processor/T-0 umbilical interface is not defined at this time, but is expected to be implemented in a manner similar to the S-Band/T-0 umbilical interface.

3.2.4 UHF Transceiver

ESTL will be utilized to verify the audio communication link between the Spacelab and an EVA crewman via the Orbiter UHF Transceiver.

3.2.5 Payload Recorder

Frequency response of 1.9 KHZ to 2 MHZ analog and 25.5 KBPS to 1024 KBPS digital are recorded and dumped from this 14 channel recorder. Spacelab has a requirement to record and process the 25.5 to 1024 KBPS digital data rate in TOC.

3.2.6 Summary

The Spacelab data processing requirements applicable to TOC and ESTL are summarized in Tables 3.2-1, 3.2-2, 3.2-3, and 3.2-4. It is emphasized that these requirements are based on the assumption that a full complement of Spacelab avionics hardware, as shown in Figure 3.2-1, will be tested in SAIL. If the scope of Spacelab testing is reduced, it could substantially reduce the TOC and ESTL data processing requirements. For example, if the Spacelab High Rate Multiplexer is not tested in SAIL, then the Ku Band data is not required. The processing requirements presented in this report should be considered as worst case and should be reassessed when the Spacelab/SAIL test program is better defined.

3.3 SAIL PAYLOAD ACCOMMODATION STUDY

Simply stated, the problem is to evaluate several methods of bringing payloads into the SAIL and in some cases handling them after they are in the building. Several basic questions which must be answered become apparent when the problem statement is logically expanded. They are: (1) how is the payload handled outside the building, (2) how is the payload brought into the building, (3) how is the payload handled (lifted, moved, placed) inside the building, (4) what size payloads may be accommodated, and (5) are there approaches other than introducing payloads into the SAIL, to accomplish payload to Orbiter avionics verification?

Two basic conditions (ground rules) are assumed prior to performing the individual evaluations of each payload installation option. They are: (1) the assumption that proper payload support rails are installed in the SAIL, and (2) "staging" or preliminary operational verification of

TOC SPACELAB DATA PROCESSING REQUIREMENTS

FTS SIGNALS VIA T-0 UMB	CMD	DECOM	DISPLAY	RECORD COMPR DATA	RECORD RAW DATA
FM SIGNAL PROCESSOR					
MODE 1 4.5 MHZ (T.V.)			X		
MODE 2* 576, 768, 1024 KHZ (EIU COMPOSITE)					
MODE 3 25.5 to 1024 KBPS (OPER RCDR)					XX
MODE 4 200 BPS to 2 MBPS (BI-Ø-1) OR 200 BPS to 5 MBPS (NRZ-L)					
MODE 5** 250 BPS to 256 KBPS (DOD P/L)					
MODE 6** 300 HZ to 4 MHZ (NASA P/L)					
MODE 7 25.5 to 1024 KBPS (P/L RCDR)					
* NOT A SPACELAB FUNCTION					
** NOT PRESENTLY UTILIZED BY SPACELAB					
NETWORK SIGNAL PROCESSOR					
DOWNLINK					
96 KBPS					
192 KBPS		X	X		X
288 KBPS					
576 KBPS					
UPLINK					
32 KBPS					
72 KBPS	XX		XX	XX	
96 KBPS					
216 KBPS					

TABLE 3.2-1

X = SPACELAB REQUIREMENT

XX = SPACELAB REQUIREMENT ALREADY IN TOC BASELINE

TOC SPACELAB DATA PROCESSING REQUIREMENTS (CONTINUED)

FTS SIGNALS VIA T-0 UMB	CMD	DECOM	DISPLAY	RECORD	
				COMPR DATA	RAW DATA
KU-SIGNAL PROCESSOR					
UPLINK 72 KBPS (SPECIAL MODE) 216 KBPS (NOMINAL CHANNELS 1 AND 2)	X			X	
DOWNLINK					
MODE 1 CH 1 8 to 100 MBPS		X	X		X
1 CH 2 16 KBPS to 2 MBPS		X	X		X
2 CH 1* 192 KBPS (COMSEC)					
2 CH 2 16 KBPS to 2 MBPS					XX
2 CH 3 (a) 4.5 MHZ (TV)		X	X		X
OR					
(b) 16 KBPS to 4 MBPS					XX
OR					
(c) 3 HZ to 4.5 MHZ (ANALOG)					
* NOT UTILIZED BY SPACELAB					
NOTE: KUSP/T-0 FUNCTIONS ARE NOT DEFINED AT THIS TIME					
PAYLOAD RECORDER					
25.5 to 1024 KBPS 1.9 KHZ to 2 MHZ		X			X

TABLE 3.2-2

X = SPACELAB REQUIREMENT

XX = SPACELAB REQUIREMENT ALREADY IN TOC BASELINE

ESTL SPACELAB DATA PROCESSING REQUIREMENTS

FTS SIGNALS	ESTL RF/HARDLINE		
	CMD	DECOM	RECORD
NETWORK SIGNAL PROCESSOR			
DOWNLINK 96 KBPS		X	X
192 KBPS		X	X
288 KBPS		X	X
576 KBPS		X	X
UPLINK 32 KBPS	X		X
72 KBPS	X		X
96 KBPS	X		X
216 KBPS	X		X
FM SIGNAL PROCESSOR			
DOWNLINK MODE			
1 4.5 MHZ (TV)			X
2* 576, 768, 1024 KHZ (EIU COMPOSITE)			
3 25.5 to 1024 KBPS (OPER RCDR)		X	X
4 200 BPS to 2 MBPS (BI-Ø-L P/L)		X	X
OR 200 BPS to 5 MBPS (NRZ-L P/L)		X	X
5** 250 BPS to 256 KBPS (DOD P/L)			
6** 300 HZ 6o 4 MHZ (P/L)			
7 25.5 to 1024 KBPS (P/L RCDR)		X	X
* NOT A SPACELAB FUNCTION			
** NOT PRESENTLY UTILIZED BY SPACELAB			

TABLE 3.2-3

X = SPACELAB REQUIREMENT

ESTL SPACELAB DATA PROCESSING REQUIREMENTS (CONTINUED)

FTS SIGNALS	ESTL RF/HARDLINE		
	CMD	DECOM	RECORD
KU-SIGNAL PROCESSOR			
UPLINK 72 KBPS (SPECIAL MODE) 216 KBPS (NOMINAL CHANNELS 1 AND 2)	X		X
DOWNLINK			
MODE 1 CH 1 8 to 100 MBPS		X	X
1 CH 2 16 KBPS to 2 MBPS		X	X
2 CH 1* 192 KBPS (COMSEC)			
2 CH 2 16 KBPS to 2 MBPS		X	X
2 CH 3 (a) 4.5 MHZ (TV)		X	X
OR			
(b) 16 KBPS to 4 MBPS		X	X
OR			
(c) 3 HZ to 4.5 MHZ (ANALOG)			
* NOT UTILIZED BY SPACELAB			
NOTE: KUSP/T-O FUNCTIONS ARE NOT DEFINED AT THIS TIME			
UHF TRANSCEIVER			

3.3 SAIL PAYLOAD ACCOMMODATION STUDY (Continued)

the payload has been performed outside the SAIL area. These facilities and activities, at present, are not part of a firm implementation plan. However, the above assumptions are made to establish standard conditions during process of evaluating each payload installation option.

Please see Figure 3.3-1 which illustrates the various areas of payload entrance options under discussion. These areas are discussed in greater detail in the material to follow.

Please see Table 3.3-1. The left-hand column of Table 3.3-1 gives the "Significant Accommodation Criteria" against which all installation options are compared. Each optional method of bringing a payload into the SAIL is given as a column heading on Table 3.3-1. The matrix is developed by evaluating each installation area against each significant accommodation criteria. The result of each evaluation is given in the appropriate box in the matrix.

The sources of information used in the study are drawings of the SAIL physical layout, measurements of physical components of the SAIL and on-site observation of the SAIL facility.

3.3.1 Requirements

Option VI is judged to be the preferred method for verifying payload avionics because: with proper planning the aft avionics room need not be moved; alteration of Building 16 structure is not required; fidelity of flight-type payload to Orbiter interface cabling can be preserved; the existing SAIL crane will be utilized as is; scarce SAIL floor space is augmented; and means are provided for off-line checkout and storage.

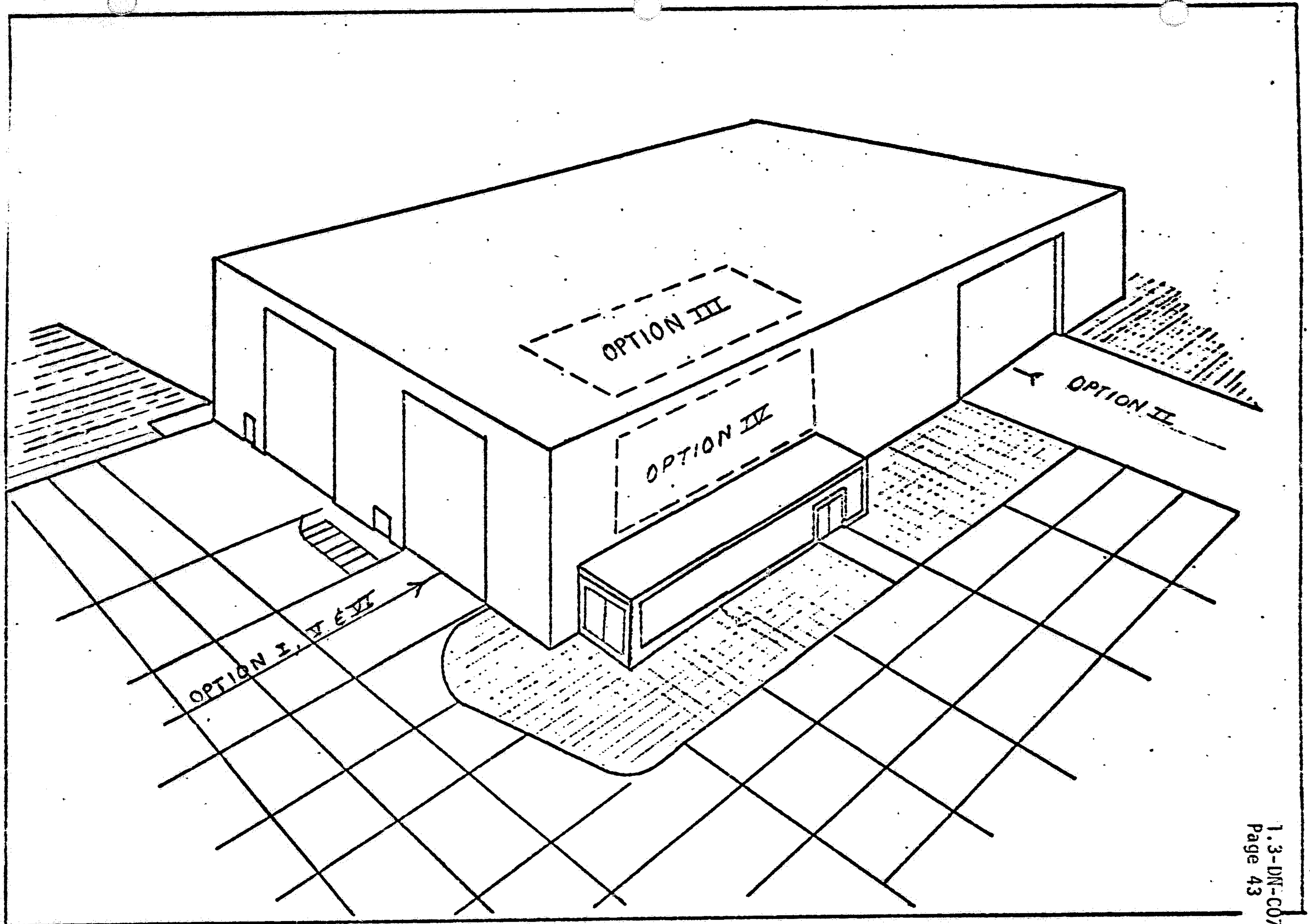


FIGURE 3.3-1

SAIL PAYLOAD ACCOMMODATION OPTION AREAS

INSTALLATION OPTIONS COMPARISON

SIGNIFICANT ACCOMMODATION CRITERIA	OPTION I ENTRANCE THROUGH NORTH DOOR (AFT AVIONICS ROOM REMOVED)	OPTION II ENTRANCE THROUGH WEST DOOR	OPTION III ENTRANCE THROUGH ROOF OVER PAYLOAD BAY AREA	OPTION IV ENTRANCE THROUGH WEST WALL OF BUILDING	OPTION V ENTRANCE THROUGH NORTH DOOR (AFT AVIONICS ROOM RAISED)	OPTION VI ENTRANCE THROUGH NORTH DOOR WITH SAIL UNIQUE PALLETS
1. WHAT ACCOMMODATION CONSTRAINTS EXIST INTERNAL TO SAIL?	LENGTH OF PAYLOAD IS RESTRICTED TO APPROXIMATELY 20 FEET - IMPOSED BY DOOR TO SUPPORT RAIL DISTANCE LIMITATION	DISTANCE BETWEEN CRANE HOOK AND RAISED FLOOR IN MMES AREA IS APPROXIMATELY ONLY 8 FEET. PAYLOAD DEPTH THUS RESTRICTED.	NONE	NONE	CONCEPT IS TOTALLY IMPRACTICAL DUE TO MECHANICAL INTERFERENCES WITH BUILDING INTERNAL STRUCTURE AND PAYLOAD SUPPORT RAILS - PRECLUDES ANY DISCUSSION OF INTERNAL CONSTRAINTS.	NOT APPLICABLE
2. IS ALTERATION OF BUILDING 15 STRUCTURE REQUIRED?	NO	NO	YES. AREA OF ROOF OVER PAYLOAD BAY REQUIRES EXTENSIVE ALTERATION - BOTH TO BUILDING STRUCTURE AND INTERIOR. ROOF CRANE AND TRANSFER AREA ON ROOF REQUIRED.	YES. WALL OVER HYDRAULICS ROOM MUST BE CUT OPEN. INTERIOR SAIL CRANE TRACK MUST BE CUT OR REMOVED.	NO	NO
3. IS TRANSPORTATION DEVICE REQUIRED TO MOVE PAYLOAD INTO BUILDING?	YES	YES	NO	NO	YES. SEE CRITERIA 1 FOR CONSTRAINT COMMENTS.	YES
4. IS PORTABLE CRANE REQUIRED FOR LIFTING PAYLOAD ONTO TRANSPORTER?	YES	YES	NO	NO	YES. SEE CRITERIA 1 FOR CONSTRAINT COMMENTS.	YES
5. MAY EXISTING SAIL CRANE BE USED TO PLACE PAYLOAD ON SUPPORT RAILS?	YES	NO	NO	NO	YES.. SEE CRITERIA 1 FOR CONSTRAINT COMMENTS.	YES
6. IS REMOVAL OF AFT AVIONICS ROOM REQUIRED?	YES	NO	NO	NO	NO	NO
7. WHICH OF THE FOLLOWING PAYLOAD CATEGORIES MAY ENTER SAIL AREA? CAT. A:S/L PALLET (15'W x 10'L x 7'H) CAT. B:S/L SHORT CORE MODULE (15'D x 14'L) CAT. C:S/L LONG CORE MODULE (15'D x 23'L) CAT. D:IUS (ENGINES + P/L) (10'D x 15'L + P/L) CAT. E:SAIL UNIQUE PALLET (15'W x 6'L x 5'H)	ALL PAYLOAD CATEGORIES MAY ENTER SAIL AREA. PAYLOAD CATEGORIES A, B, D, AND E MAY BE INSTALLED IN PAYLOAD BAY. SEE CRITERIA 1 FOR CONSTRAINT COMMENTS.	ALL PAYLOAD CATEGORIES MAY ENTER SAIL AREA. ONLY PAYLOAD CATEGORY E MAY BE INSATLLED IN PAYLOAD BAY.	PAYLOAD CATEGORIES A, B, C, DISASSEMBLED D AND E MAY ENTER SAIL AREA AND BE INSTALLED IN PAYLOAD BAY	PERMISSABLE HEIGHT OF WALL OPENING RESTRICTS ENTRY OF PAYLOADS TO CATEGORIES A AND E. THEY MAY BE INSTALLED IN PAYLOAD BAY.	PAYLOAD CATEGORIES NOT APPLICABLE DUE TO IMPRACTICAL CONCEPT.	CATEGORIZATION OF PAYLOADS NOT APPLICABLE. CONCEPT OF OPTION VI NOT RELATED TO DIMENSIONS IN GIVEN CATEGORIES.

TABLE 3.3-1

3.3.1 Requirements (Continued)

Option VI, the SAIL unique pallet is established as the standard method of verifying payload avionics in SAIL. A detailed definition of the SAIL unique pallet will be submitted at a later date. An output to the SAIL physical layout baseline will be implemented to insure that an entrance path is available or easily arranged for the installation of the SAIL unique pallets.

The existing baseline requirement for movability of the aft avionics room (Option I) will be maintained. The rationale for this requirement is that program cost restrictions may preclude the availability of breadboard or prototype payload systems and experiments. In that case, prototype or flight-type payloads will be included as a SAIL payload accommodation if the need arises.

3.4 PROJECTED FUNDING AND TEST SCHEDULE

The following three Charts 3.4.1, 3.4.2, and 3.4.3 illustrate assumed conditions and requirements necessary to conduct Spacelab interface verification testing in the SAIL. They also present cost of operations based on the assumptions and detailed hardware and data processing requirements. The purpose of this information is to provide a more complete view of the verification activity as it proceeds into the active checkout phase. Figure 3.4-1 delineates the present SAIL/Spacelab test schedule.

SAIL SPACELAB SUPPORT ITEMS

ASSUMPTIONS

1. SAIL HAS FUNDED, ON-GOING SHUTTLE SUPPORT ACTIVITY FOR HARDWARE CHANGES, SOFTWARE CHANGES, AMD MISSION SUPPORT DURING FIRST SHIFT.
2. SPACELAB TESTING IS PERFORMED NOMINALLY ON SECOND SHIFT, FIVE DAYS A WEEK.
3. SAIL VEHICLE DYNAMIC SIMULATOR SUPPORT IS NOT REQUIRED FOR SPACELAB TESTING.
4. SPACELAB TEST REQUIREMENTS ARE SUPPLIED BY SPACELAB PROJECT.
5. SPACELAB HARDWARE, SOFTWARE, AND ASSOCIATED GSE ARE PROVIDED, OPERATED, AND MAINTAINED BY SPACELAB PROJECT.
6. COST DOES NOT INCLUDE KSC PERSONNEL FOR LPS INTERFACE TESTING, IF REQUIRED.
7. SPACELAB TEST DATA ANALYSES AND REPORTS ARE PROVIDED BY SPACELAB PROJECT.
8. SPACELAB INVOLVEMENT IN SAIL IS SCHEDULED FOR SIX MONTHS.
9. SPACELAB TESTS ARE BASED ON PIV-03 REQUIREMENTS DATED NOVEMBER 1976.
10. NASA CIVIL SERVICE IS FUNDED SEPARATELY.
11. POP AND C OF F SUBMITTALS FOR SPACELAB-UNIQUE SAIL UPGRADING HAVE BEEN APPROVED.
12. COST ESTIMATE IS BASED ON 30K/MAN YEAR.

CHART 3.4-1

SAIL SPACELAB TEST OPERATIONS COSTS*

O FLIGHT SYSTEM PERSONNEL			
	o SYSTEM ENGINEERS	10	
	o TECHNICIANS	10	
	o TEST OPERATIONS	10	
	o APPLICATIONS AND FLIGHT SOFTWARE	5	
	o SUPERVISION	3	
		38	
O TOC PERSONNEL			
	o TEST OPERATIONS	10	
	o SOFTWARE ENGINEERING	3	
	o SUPPORT ENGINEERING	1	
	o MAINTENANCE	2	
	o PLANNING & CONFIGURATION	2	
	o LOGISTICS, S/W LIBRARY	2	
		20	
O TOTAL PERSONNEL			58
O SIX MONTHS COST AT $30K/MAN YEAR			870K

* BASED ON ASSUMPTIONS

CHART 3.4-2

SAIL SPACELAB TEST SUPPORT REQUIREMENTS

O DETAILED REQUIREMENTS, DESIGN DEVELOPMENT

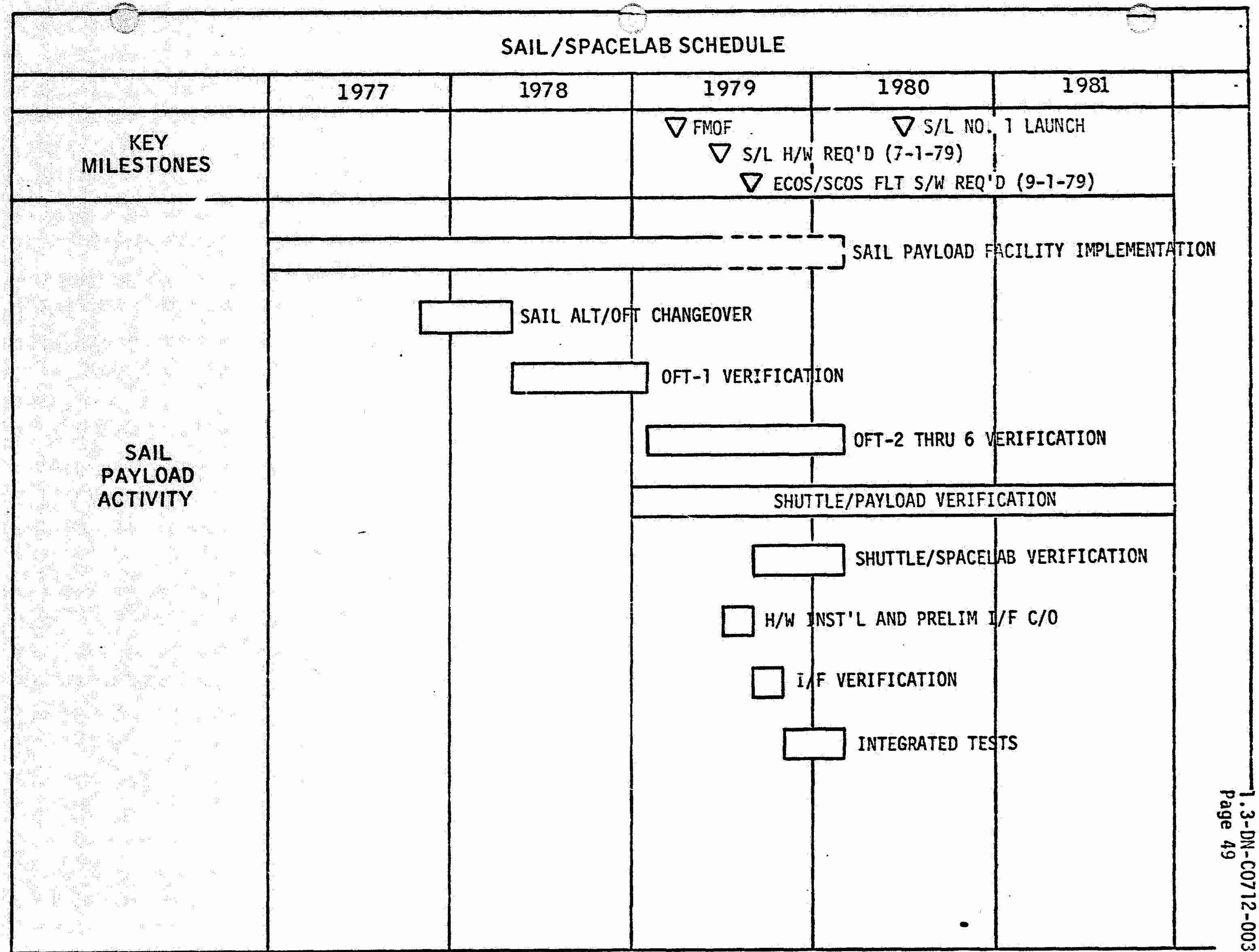
- o INTERFACE DEVELOPMENT, CABLES, J-BOXES, ATTENUATORS, SIGNAL CONDITIONING
- o DATA ACQUISITION AND DATA DECOMMUTATION EQUIPMENT
- o DATA COMMANDS/CONTROL/FAULT INSERTION INTERFACES
- o DATA RECORDING/COMPRESSION/FORMATTING CAPABILITY
- o DATA PROCESSING/CONTROL/DISPLAY EQUIPMENT
- o EXECUTIVE AND SYSTEM SOFTWARE DEVELOPMENT

O COMPLETE DATA INTERFACE/PROCESSING CAPABILITY

- o FLIGHT SYSTEM/SPACELAB/FACILITY CABLE SET
- o COMPLETE TEST OPERATION DISPLAY AND CONTROL SYSTEM
- o INSTALL, CHECKOUT AND INTEGRATE FACILITY/SPACELAB INTERFACES
- o TEST PLAN DEVELOPMENT
- o OPERATIONS SUPPORT

PRESENT GUIDELINES	FY78	FY79	FY80
	500K	900K	200K

CHART 3.4-3



SAIL/SPACELAB SCHEDULE
1977
1978
1979
1980
1981
KEY MILESTONES
FMOF
S/L NO. 1 LAUNCH
S/L H/W REQ'D (7-1-79)
ECOS/SCOS FLT S/W REQ'D (9-1-79)
SAIL PAYLOAD ACTIVITY
SAIL PAYLOAD FACILITY IMPLEMENTATION
SAIL ALT/OFT CHANGEOVER
OFT-1 VERIFICATION
OFT-2 THRU 6 VERIFICATION
SHUTTLE/PAYLOAD VERIFICATION
SHUTTLE/SPACELAB VERIFICATION
H/W INST'L AND PRELIM I/F C/O
I/F VERIFICATION
INTEGRATED TESTS

FIGURE 3.4-1

4.0 FUTURE PLANS, PROBLEMS AND ISSUES

The next MDTSCO task, following the release of this document, will be to develop a SAIL/Spacelab Implementation Plan. This implementation plan will contain verification requirements, test configuration, interface definitions and test schedules.

Before this implementation plan can be prepared, a resolution of issues and problems must be accomplished. An important issue to be firmly resolved is the commitment of the Spacelab to the SAIL for early verification tests. An equally important issue to be resolved is the allocation of Spacelab hardware and supporting EGSE for SAIL/Spacelab verification testing. Problems that require resolution are the definition of the Spacelab software requirements and the role of SAIL in the Spacelab verification process. The test and applications programs of the Spacelab software must be formulated and the availability evaluated for applicability to SAIL for specific verification test activity. SAIL's role in the overall Spacelab verification process will have to be established to determine the most meaningful, cost effective test activity. Present discussions relegate the SAIL to a subsystem level of test activity which does not utilize the full capability of the SAIL.

5.0 CONCLUSIONS

This report presents material in a condensed but complete form gathered over eight months of study. Essentially, all firm sources of information available, applicable to Spacelab/Orbiter avionics interface verification, have been expended. An analysis of the Spacelab/Orbiter interface was conducted to determine the magnitude of the avionics interface. Of the subsystems that comprise the total Spacelab/Orbiter interface the 1) Orbiter MDM/Spacelab S/S-EXP I/O's, RAAB and C&W interface, 2) Orbiter PMU/Spacelab I/O interface and 3) Orbiter KuBand Signal Processor/Spacelab High Rate Multiplexer interface were determined to be the most complex relative to the hardware/software functions involved in the verification of the interface. It was further determined that the complete verification of the interface would require extended test activity. These determinations concluded that early Spacelab/Orbiter avionics interface verification testing should be performed and that the SAIL is a prime test location to accomplish this test activity.

It is felt that the SAIL requirements, presented in this report, constitute a technically sound baseline for the conduct of the Spacelab/Orbiter avionics interface verification in the SAIL. It is realized that the less complex subsystems that form the total avionics interface do not require SAIL-type verification, but the requirements are included for completeness.

Further expansion of this study is possible by assessing the European Space Agency's (ESA) Spacelab test program and evaluating the Software test and applications programs when this information is made available. However, the prime mover for more detailed further studies will be the resolution of issues and problems affecting Spacelab/SAIL verification activity. This activity is predicated on program directives delineating which facility, among several choices, will be used for Spacelab/Orbiter avionics interface verification, and type and quantity of Spacelab avionics available. It is concluded that future detailed studies are dependent on program definition of the SAIL role in the Spacelab/Orbiter avionic interface verification process.

6.0 REFERENCES

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3. ICD-2-05301 Revision A December 16, 1976 — Interface Control Document - Shuttle Vehicle/Spacelab Avionics Interfaces

4. ESA SLP/2104 Review Issue PDR-B 1976 — Spacelab Payload Accommodations Handbook

5. Spacelab PDR-B Volume III Book 6 PDR-B 1976 — Spacelab Avionics

6. Spacelab PDR-B Appendix Book A17 PDR-B 1976 — Measurement Requirement Analysis

7. JSC 07700 VOLUME XIV Revision D — Space Shuttle System Payload Accommodations

8. MC 476-0137 Revision D — Processor, Network Signal Specification

9. MC 478-0106 Revision D — Equipment, S-Band Network Specification

10. MC 409-0025 Revision A — Integrated Communication and Radar Equipment, KuBand Specification

7.0 LIST OF ACRONYMS AND ABBREVIATIONS

AA	AIR-TO-AIR
AC	ALTERNATING CURRENT
ACCU	AUDIO CENTRAL CONTROL UNIT
ADL	AVIONICS DEVELOPMENT LABORATORY - R. I. SPACE DIV.
AFD	AFT FLIGHT DECK
AG	AIR-TO-GROUND
AGC	AUTOMATIC GAIN CONTROL
AID	ANALOG INPUT DIFFERENTIAL
ALT	APPROACH AND LANDING TEST
ANCTR	ANNUNCIATOR
ANT	ANTENNA
ASED	AVIONICS SYSTEMS ENGINEERING DIVISION - JSC
ASSY	ASSEMBLY
ATC	AIR TRAFFIC CONTROL
ATE	AUTOMATIC TEST EQUIPMENT
ATU	AUDIO TERMINAL UNIT
AUX	AUXILIARY
BER	BIT ERROR RATE
BSR	BITE STATUS REGISTER
C&T	COMMUNICATION & TRACKING
C&W	CAUTION AND WARNING
CCTV	CLOSED CIRCUIT TELEVISION
CDMS	COMMAND AND DATA MANAGEMENT SYSTEM
CITE	CARGO INTEGRATION TEST EQUIPMENT
CMD	COMMAND

7.0 LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

C/O	CHECKOUT
C OF F	COST OF FACILITY
COMPR	COMPRESSED
COMSEC	COMMUNICATION SECURITY
CRT	CATHODE RAY TUBE
CWEU	CAUTION AND WARNING ELECTRONIC UNIT
DC	DIRECT CURRENT
DCDR	DECODER
DDU	DATA DISPLAY UNIT
DIL	DISCRETE INPUT LOW
DIST	DISTRIBUTION
DOD	DEPARTMENT OF DEFENSE
DOL	DISCRETE OUTPUT LOW
ECLS	ENVIRONMENTAL CONTROL AND LIFE SUPPORT
ECOS	EXPERIMENT COMPUTER OPERATING SOFTWARE
ECS	ENVIRONMENTAL CONTROL SYSTEM
EG	CODE FOR CONTROL SYSTEMS DEVELOPMENT DIVISION - JSC
EGSE	ELECTRICAL GROUND SUPPORT EQUIPMENT
EIU	ENGINE INTERFACE UNIT
ELEC	ELECTRIC - ELECTRONIC
EPDB	EXPERIMENT POWER DISTRIBUTION BOX
EPDS	ELECTRICAL POWER DISTRIBUTION SUBSYSTEM
ESA	EUROPEAN SPACE AGENCY
ESP	EXPERIMENT SWITCHING PANELS
ESTL	ELECTRONIC SYSTEMS TEST LABORATORY - JSC

7.0 LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

EVA	EXTRAVEHICULAR ACTIVITY
EXP	EXPERIMENT
FC	FLIGHT CRITICAL
FM	FREQUENCY MODULATION
FMOF	FIRST MANNED ORBITAL FLIGHT
FMSP	FREQUENCY MODULATION SIGNAL PROCESSOR
FSS	FIRE SUPPRESSION SYSTEM
FY	FISCAL YEAR
GFE	GOVERNMENT FURNISHED EQUIPMENT
GMT	GREENWICH MEAN TIME
GPC	GENERAL PURPOSE COMPUTER
HRDR	HIGH RATE DIGITAL RECORDER
HRM	HIGH RATE MULTIPLEXER
H/W	HARDWARE
HZ	HERTZ
I/C	INTERCOMM
ICD	INTERFACE CONTROL DOCUMENT
I/CMS	INTERCOMM MASTER STATION
I/F	INTERFACE
IMCP	INTEGRATED MONITORING & CONTROL PANEL
INV	INVERTER
I/O	INPUT - OUTPUT
IOP	INPUT OUTPUT PROCESSOR

7.0 LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

JSC	JOHNSON SPACE CENTER
KB	KEYBOARD
KBD	KEYBOARD
KBPS	KILOBITS PER SECOND
KHZ	KILO HERTZ
KSC	KENNEDY SPACE CENTER
KUSP	KuBAND SIGNAL PROCESSOR
LPS	LAUNCH PROCESSING SYSTEM
LRU	LINE REPLACEABLE UNIT
MAX	MAXIMUM
MBPS	MEGABITS PER SECOND
MCDS	MULTIFUNCTION CRT. DISPLAY SYSTEM
MCP	MONITOR AND CONTROL PANEL
MDM	MULTIPLEXER/DEMULTIPLEXER
MDTSCO	McDONNELL DOUGLAS TECHNICAL SERVICES COMPANY
MET	MISSION ELAPSED TIME
MHZ	MEGAHERTZ
MMES	MARSHALL MATED ELEMENTS SYSTEM
MS	MASTER STATION
MSFC	MARSHALL SPACE FLIGHT CENTER
MSS	MISSION SPECIALIST STATION
MTU	MASTER TIMING UNIT

7.0 LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

NASA	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NRZ-L	NON RETURN TO ZERO - BI-0 LEVEL
NSP	NETWORK SIGNAL PROCESSOR
OFT	OPERATIONAL FLIGHT TEST
OIA	ORBITER INTERFACE ADAPTER
OPER	OPERATIONAL
ORB	ORBITER
PCA	POWER CONTROL ASSEMBLY
PCM	PULSE CODE MODULATION
PDR	PRELIMINARY DESIGN REVIEW
PF	PAYLOAD FORWARD
PIV	PAYLOAD INTERFACE VERIFICATION
P/L	PAYLOAD
PM	PULSE MODULATION
PMU	PCM MASTER UNIT
POP	PROGRAM OPERATING PLAN
PSS	PAYLOAD SPECIALIST STATION
PWR	POWER
RAAB	REMOTE AMPLIFIER AND ADVISORY BOX
RAU	REMOTE ACQUISITION UNIT
RCDR	RECORDER
RCVR	RECEIVER
RF	RADIO FREQUENCY

7.0 LIST OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

SAIL	SHUTTLE AVIONICS INTEGRATION LABORATORY - JSC
SCF	SATELLITE CONTROL FACILITY
SCOS	SUBSYSTEM COMPUTER OPERATING SOFTWARE
SDL	SOFTWARE DEVELOPMENT LABORATORY - JSC
SGLS	SPACE/GROUND LINK SYSTEM
S/L	SPACELAB
S/S	SUBSYSTEM
STDN	SPACE TRACKING & DATA NETWORK
S/W	SOFTWARE
TBD	TO BE DETERMINED
TDRS	TRACKING & DATA RELAY SATELLITE
T/L	TALK/LISTEN
T-0	TIME ZERO
TOC	TEST OPERATIONS CENTER
T/R	TRANSCEIVER
TV	TELEVISION
UHF	ULTRA HIGH FREQUENCY
UMB	UMBILICAL
VSU	VIDEO SWITCHING UNIT
XMTR	TRANSMITTER
XPONDER	TRANSPONDER