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A DEFINITION OF STS ACCOMMODATIONS FOR
ATTACHED PAYLOADS

FOR REFERENCE

F. L. Echols and P. A. Broome

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FOR
ATTACHED PAYLOADS

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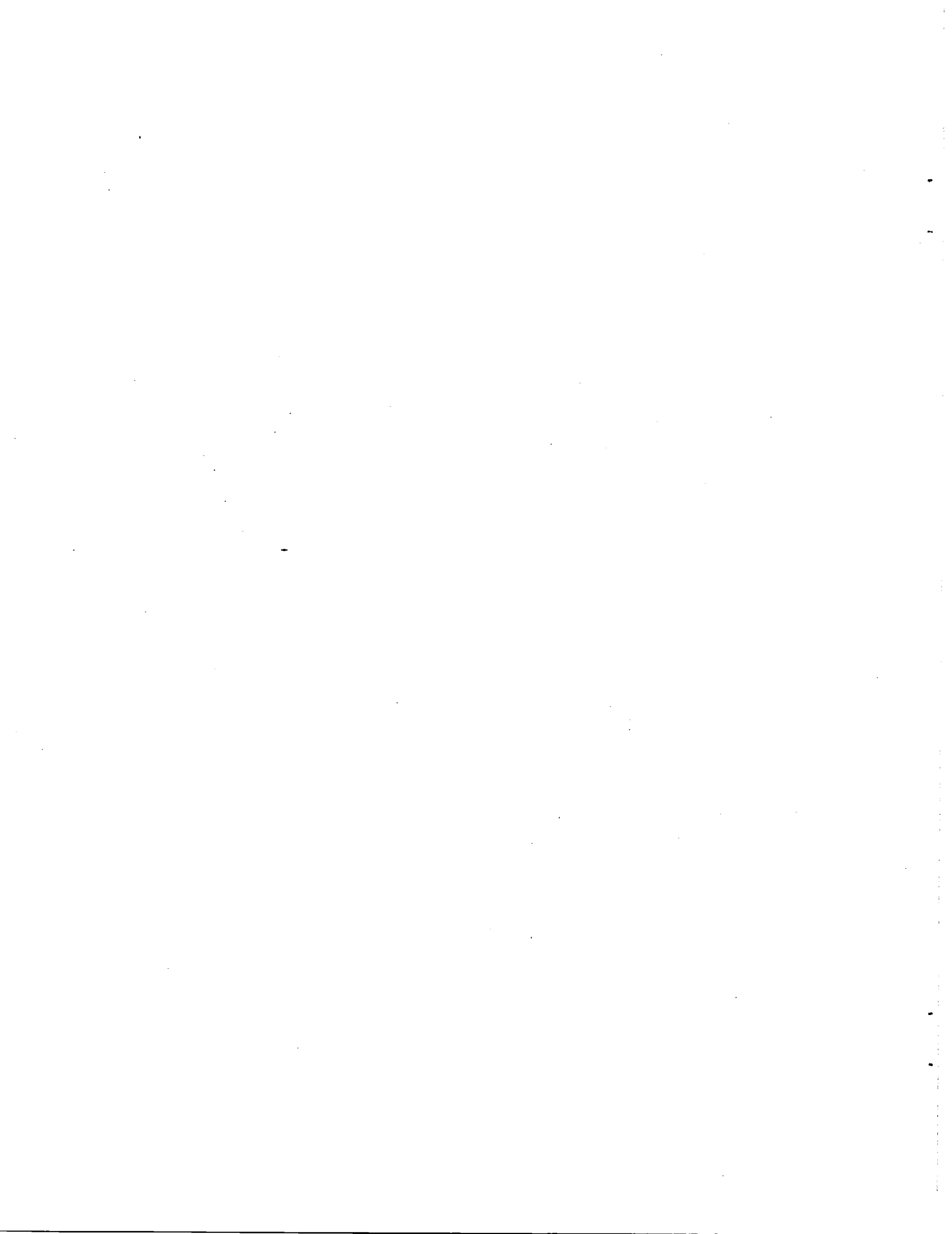


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1.0 INTRODUCTION

1.1 PURPOSE

This report is an input to a Phase A study conducted by the Space Technology Experiment Pallet (STEP) Project Office located at Langley Research Center, Hampton, Virginia. It directly supports the Phase A task of defining a set of carrier avionics for supporting large space structure experiments to be conducted from the Space Shuttle Orbiter (SSO). Specifically it defines the "Baseline" SSO interface pertinent to the STEP proposition.

1.2 SCOPE

This report addresses the flight operations capabilities and considerations and the carrier avionics systems capabilities and provisions that are available to a mixed cargo user of the Space Transportation System (STS). It does not address other aspects of the total STS capabilities and provisions, such as Ground Support Equipment (GSE) and post mission data analysis. The Space Shuttle Transportation System (STS) as referred to herein consists of the Space Shuttle Orbiter (SSO) vehicle, the Mission Control Center (MCC) at the Johnson Space Center (JSC) in Houston, Texas, the Payload Operations Control Center (POCC) at JSC, the Shuttle Ground Processing Facilities at the Kennedy Space Center in Florida, the Tracking and Data Relay Satellite System (TDRSS), and the post-mission telemetry data handling facilities at the Goddard Space Flight Center in Greenbelt, MD. The STS also includes the Spacelab Pallet System managed by the Marshall Space Flight Center at Huntsville, Alabama.

The Spacelab Pallet System consists of U-shaped pallets and associated subsystems designed to expose captive experiments to the hard vacuum of space. Two standard avionics configurations are available from inventory: The "MDM Pallet" and the "Igloo Pallet". More detailed information on the capabilities of these carriers can be obtained from the sources given

in the "Applicable Documents" Appendix of this report.

The most cost-effective way to use the STS is to fly as a quarter-section standard mixed cargo user. Under this guideline the user "rents" only one-fourth of the orbiter cargo bay and shares the total cost of the flight with up to three other users. To further reduce costs, the user should minimize the use of the "non-standard services". Non-standard services are in general any extra cabling and mission unique alterations to the Orbiter which must be installed and then removed after the flight.

Section 2 of this report outlines the operations aspects of the STS and Section 3 covers the on-board interface characteristics and accommodations. Section 4 contains the Safety requirements which users should take into account in the initial phases of planning. Table 3-1 provides a guide as to which services are standard and which are optional.

1.3 GROUND RULES AND ASSUMPTIONS

In the development of the concept of the STEP Pallet System (hereafter called Experiment Carrier or Carrier) certain groundrules and assumptions were established:

- a. The experiment carrier will be a pallet-only configuration and will occupy a single section of the STS cargo bay.
- b. The carrier will be expandable to occupy two sections of the cargo bay.
- c. The carrier will be mixed-cargo compatible with up to three deployable payloads.
- d. The carrier/experiment configuration will impose no constraints on orbit parameters except a minimum altitude determined by atmospheric drag.

- e. Control of carrier/experiment functions will be by crew involvement.
- f. The carrier/experiment will be compatible with Remote Manipulator System (RMS) but will not use it except in an emergency or contingency situation.

2.0 FLIGHT OPERATIONS CAPABILITIES AND CONSIDERATIONS

This section provides the prospective payload user with a basic understanding of the Space Shuttle System. The Space Shuttle System is comprised of three major elements; an expendable External Tank (ET), Two recoverable Solid Rocket Boosters (SRB's) and a reusable Space Shuttle Orbiter(SSO). This section will primarily address the operational capabilities and considerations of the SSO.

2.1 CREW COMPLEMENT DEFINITION

Johnson Space Center (JSC) has established a basic crew complement for all STS missions for one and two-shift on-orbit operations.

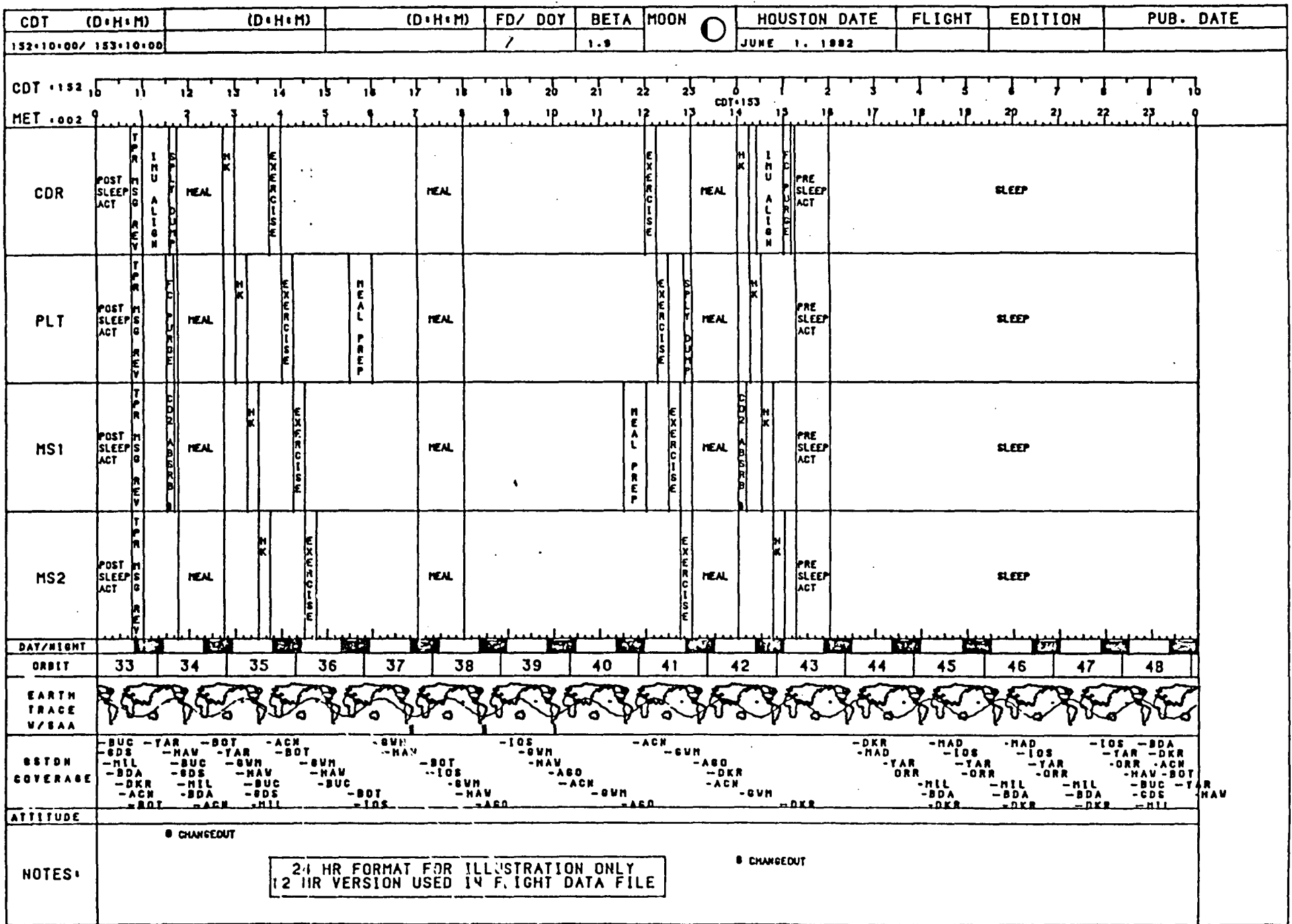
2.1.1 One-Shift Operation

The basic crew complement for one-shift on-orbit operations is four persons. This complement consists of a Commander, Pilot and two Mission Specialists. A typical crew day is sixteen hours awake period and eight hours sleep period as illustrated in Figure 2-1. Figure 2-1 identifies some of the generic crew activities necessary to maintain crew/orbiter health and does not address payload activity.

2.1.2 Two-Shift Operation

The crew complement for two-shift on-orbit operations is nominally six persons. This complement consists of a Commander, Pilot, two Mission Specialists and two Payload Specialists.

In some cases the crew complement for a two-shift operation will be five persons. In those cases, it is presumed that there would be only one Payload Specialist.



2-2

Figure 2-1 One-Shift Operations(On-Orbit)

Current planning is to divide the six member crew into two teams with each team on duty twelve hours and off duty for twelve hours as illustrated in Figure 2-2.

The criteria used in determining one-shift on-orbit operations is based on user requirements and cargo manifest. Current planning is to operate on a one-shift basis for mixed cargo missions that consists of deployable and/or sortie type payloads. Currently, all four crew persons are used for deployment procedures.

For dedicated missions, such as Spacelab 1, a two-shift on-orbit operation is planned. This presents a problem with the team concept since it is necessary to put the Commander and Pilot on different teams since both are required to support launch and entry/landing mission phases. Because it is next to impossible to transition from one-shift to two-shift operations at the start of a mission, the teams start two-shift training approximately one week prior to launch culminating in total crew complement availability to support the launch phase. The second shift sleep period will be modified before entry day in order to provide a full crew complement for the landing phase of the mission.

2.2 MISSION DURATION DETERMINATION

The criteria used to determine mission duration are based on User requirements. The prospective User, after establishing a concept of a payload based on the capabilities and limitations of the STS, submits a request for flight assignment to NASA Headquarters. This request initiates three separate planning activities. These are the preparation of a Launch Service Agreement (LSA), a Payload Integration Plan (PIP), and a Flight Assignment Process (FAP). The LSA and PIP are joint STS and User activities that deal with contractual agreements and payload integration processes. The FAP is an internal STS activity that assesses the User's payload/mission requirements and determines a proper mix of compatible payloads. This activity establishes a

preliminary cargo manifest and is reflected in the STS Flight Assignment Manifest (FAM). The latest FAM (November 1982) is shown in Table 2-1 and reflects current mission duration planning.

The normal Orbiter mission duration is baselined at seven days but missions of less than seven can be provided if User requirements so dictate. In addition, mission durations of up to thirty days can be provided. Use of this extended mission capability would require the addition of mission extension kits which are payload weight chargeable. The duration of the extended mission capability is dependent on crew size, propulsion and non-propulsive consumables and Orbiter maintenance.

In addition to cargo mix and mission durations, the FAM also provides pertinent data, such as crew size, relative to each scheduled mission.

2.3 MIXED CARGO MISSIONS

The majority of the manifested cargo in forthcoming missions consists of multiple deployable payloads mixed with a sortie type payload(s).

The current STS operational philosophy is to launch the deployables as early in the mission as practical in the event of an early contingency landing. If a failure does occur in the early phases of the mission, every effort will be made to launch the deployables before deorbit and landing preps. In the case of sortie payloads, every effort will be made to secure the experiment to a safe configuration for landing. Jettison of the experiment will be done as a last resort. An example of a typical mixed cargo mission is STS-7 which consists of two deployable payloads (PAM-D carriers) and two attached payloads (OSTA-2 and SPAS-01). Figure 2-3 illustrates the preliminary on-orbit operations for the STS-7 mission.

Typically, the PAM-D deploy sequence requires about 2-1/4 hours to complete with all four crew members involved in the operations. Approximately 3-1/2

Table 2-1 Flight Assignment Manifest

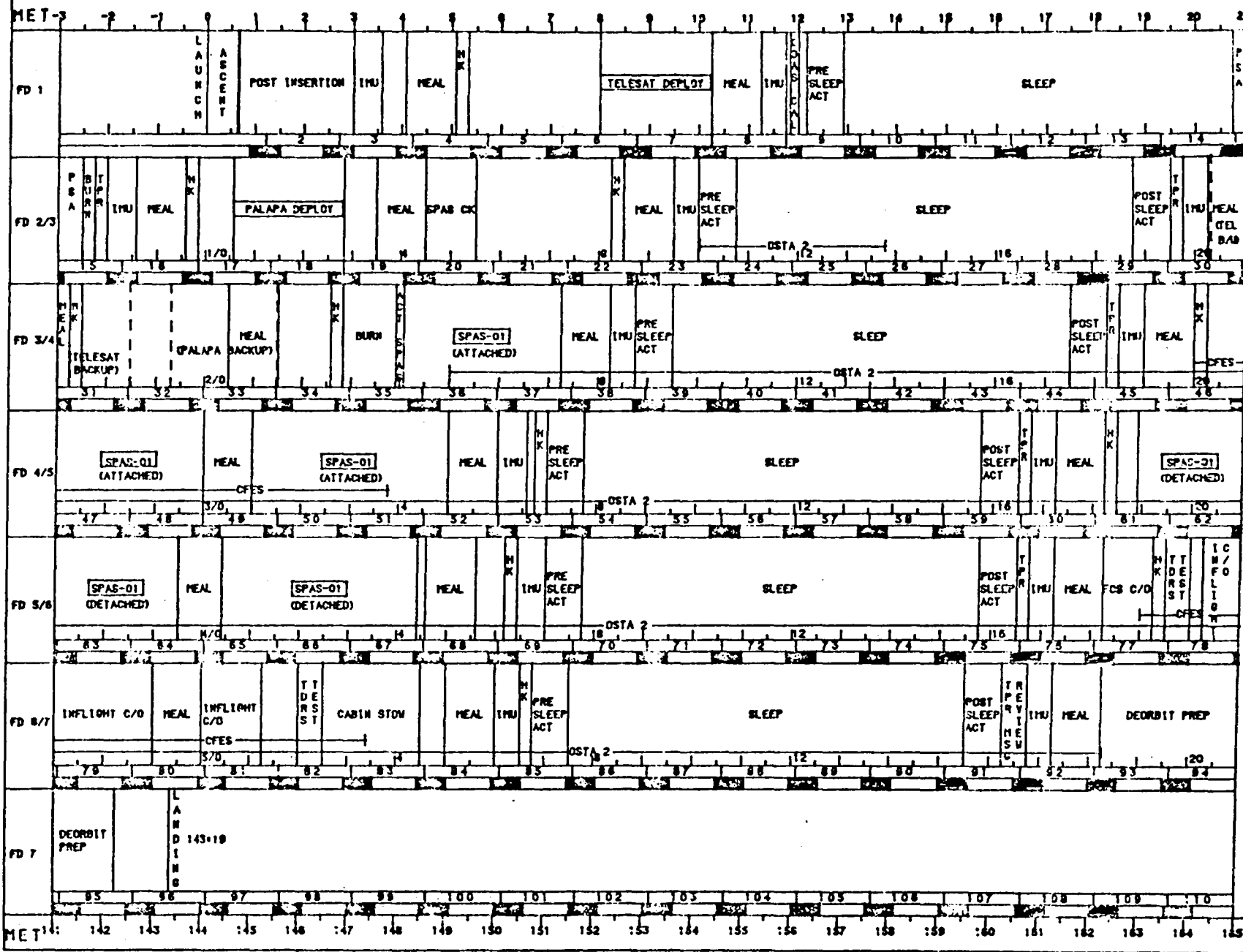
Flight, STS-	Payload	Carrier	Launch date	OY-	Mission duration, days	Launch site	Crew size	Inclination, deg	Altitude, n. mi.	Remarks	11-82
6	TDRS-A	IUS-2 stage	01-24-83	099	5	KSC	4	28.5	150	Mid-deck payloads: PLR, NOSL, CFES, RME	
7	SPAS-01 OSTA-2 TELESAT-F PALAPA-B1	Unique structure MPRESS SSUS-D SSUS-D	04-20-83	099	6	KSC	4	28.5	160	Mid-deck payloads: CFES, MLR	
8	INSAT 1-B TDRS-B	SSUS-D IUS-2 stage	06-29-83	099	4	KSC	4	28.5	150	Mid-deck payloads: CFES	
9	Spacelab 1	Spacelab LM+1 SL Pallet	09-30-83	102	9	KSC	6	57.0	135		
10	DOD 84-1		11-03-83	099		KSC					
11	LFC-1 PDRS PALAPA B-2	MPRESS PFTA SSUS-D	01-31-84	099	7	KSC	4	28.5	160	Mid-deck payloads: ACES, CFES, IEF	
12	MEA-1 TDRS-C	MPRESS IUS-2 stage	03-18-84	103	5	KSC	4	28.5	150	Mid-deck payloads: ARC, ADSF	
13	LDEF-1 SMN Repair	FSS	04-13-84	099	5	KSC	4	28.5	285		
14	OAST-1 TELESAT-1 SYNCOM IV-1 PL OPPTY	MPRESS, SSUS-D Unique stage	05-08-84	103	7	KSC	4	28.5	160	Mid-deck payloads: EML	
15	REFLIGHT OPP		06-04-84	102		KSC					
16	SPARTAN-1 TELSTAR 3-C ARABSAT-A SYNCOM IV-2	MPRESS SSUS-D SSUS-D	07-01-84	099	7	KSC	4	28.5	160	Mid-deck payloads: IEF, CFES	
17	ERBS OSTA-3 PL OPP	Unique structure Pallet	07-28-84	103	7	KSC	4	57.0	183	Mid-deck payloads: ACES, ARC	
18	SBS-D TDRS-D	SSUS-D IUS-2 stage	08-23-84	099	3	KSC	4	28.5	150		
19	Spacelab 3	Spacelab LM+MPRESS	09-15-84	102	7	KSC	6	57.0	200		
20	OSTA-4 TELESAT-H PL OPP	MPRESS SSUS-D	10-11-84	103	7	KSC	4	28.5	160		
21	Spacelab 2	Igloo+3 SL Pallets+ unique structure	11-03-84	099	7	KSC	6	50.0	202		
22	DOD 85-1		12-04-84	103		KSC					
23	DOD 85-2		01-05-85	099		KSC					
24	EOS-1 SYNCOM IV-3 PL OPP	Special structure Unique stage	01-30-85	103	7	KSC	4	28.5	160		
25	Space Telescope LDEF-1 Retrieval	FSS	02-26-85	099	3	KSC	4	28.5	320		
26	SBS-E MEXSAT-A PL OPP	SSUS-D SSUS-D	04-18-85	104	7	KSC	4	28.5	160		
27	OAST-2 RCA-H ESTAR-C TELSTAR 3-D	Pallet SSUS-D SSUS-D SSUS-D	05-14-85	099	7	KSC	4	28.5	160		

Table 2-1 Flight Assignment Manifest(Cont'd)

Flight, STS-	Payload	Carrier	Launch date	OV-	Mission duration, days	Launch site	Crew size	Inclination, deg	Altitude, n. mi.	Remarks	11-82
28	Spacelab D-1	Spacelab LM+special structure	06-11-85	104	7	KSC	6	57.0	175		
29	AUSSAT-1 DOD SYNCOM IV-4 PL OPP	SSUS-D SSUS-D Unique structure	07-09-85	099	7	KSC	4	28.5	160		
30	DOD 85-3		08-03-85	104		KSC					
31	EOS-2 SPACENET-C RCA-M SYNCOM IV-5	Special structure SSUS-D SSUS-D Unique stage	09-01-85	099	7	KSC	4	28.5	160		
32	AMERSAT-A MEKSAT-B PALAPA B-3 WESTAR VII	SSUS-D SSUS-D SSUS-D SSUS-D	09-28-85	102	4	KSC	4	28.5	160		
1V	DOD 86-1V		10-15-85	103		YAFB					
33	MPS-1 CRRES SPARTAN-2 AUSSAT-2	PALLET Special structure MPSS SSUS-D	10-24-85	104	7	KSC	4	28.5	160		
34	OSS-4 GSTAR-D USAT-1 DOD	Igloo+2 SL Pallets SSUS-D SSUS-D SSUS-D	11-22-85	099	7	KSC	5	28.5	160		
35	Spacelab 4 (Life Science)	Spacelab LM	12-17-85	102	7	KSC	6	28.5	160		
36	OSTA-5 STC DBS-A SPACENET-D DOD	MPSS SSUS-D SSUS-D SSUS-D	02-08-86	099	7	KSC	4	28.5	160		
37	DOD 86-1		02-15-86	104		KSC					
2V	DOD 86-2V		03-01-86	103		YAFB					
38	OSS-5 INTELSAT VI-1	Igloo+2 SL Pallets Special stage	03-25-86	102	7	KSC	5	28.5	160		
39	ISPM	CENTAUR	05-23-86	099	2	KSC	4	28.5	100-285		
40	GALILEO	CENTAUR	05-30-86	104	2	KSC	4	28.5	100-220		
41	RCA-K DBS LUX-A DOD RCA DBS-1	SSUS-D SSUS-D SSUS-D Special stage	07-02-86	102	7	KSC	4	28.5	160		
42	DOD 86-2		07-10-86	099		KSC					
3V	LANDSAT Retrieval PL OPP		08-01-86	103	7	YAFB	4	98.2	313		
43	STC DBS-B DOD INTELSAT VI-2	SSUS-D SSUS-D Special stage	08-12-86	104	7	KSC	4	28.5	160		
44	DOD 86-3		08-21-86	102		KSC					
45	AMERSAT-B UNISAT-A WESTAR VIII DOD	SSUS-D SSUS-D SSUS-D SSUS-D	09-23-86	099	7	KSC	4	28.5	160		
46	STC DBS-C DOD INTELSAT VI-3	SSUS-D SSUS-D Special stage	10-04-86	104	7	KSC	4	28.5	160		
47	OSS-6 IRIS USAT-2 DOD	Igloo + 2 pallets Unique Stage SSUS-D SSUS-D	11-07-86	102	7	KSC	5	28.5	160		
48	DOD 87-1		11-20-86	099		KSC					

Table 2-1 Flight Assignment Manifest(Concluded)

Flight, STS-	Payload	Carrier	Launch date	OY-	Mission duration, days	Launch site	Crew size	Inclination, deg	Altitude, n. mi.	Remarks	11-82
49	OSTA-6 STC DBS-D UNISAT-B RCA DBS-2	MPESS SSUS-D SSUS-D Special stage	12-04-86	104	7	KSC	4	28.5	160		
50	AMERSAT-C DOD INTELSAT VI-4	SSUS-D SSUS-D Special stage	01-09-87	102	7	KSC	4	28.5	160		
51	OSS-7 TELESAT-J DOD ARABSAT-8	Igloo+2 SL Pallets SSUS-D SSUS-D SSUS-D	01-21-87	099	7	KSC	5	28.5	160		
4V	DOD 87-1V		01-29-87	103		VAFB					
52	MPS-2 STC DBS-E UNISAT-C SATCOL-A	Pallet SSUS-D SSUS-D SSUS-D	02-10-87	104	7	KSC	4	28.5	160		
53	DOD 87-2		03-04-87	102		KSC					
54	Spacelab D-4	Igloo+2 SL Pallets + 2 SL Pallets	03-21-87	099	7	KSC	6	57.0	200		
55	OSTA-8 SPARTAN-3 ELRECA DOD RCA DBS-3	MPESS MPESS Pallet SSUS-D Special stage	04-11-87	104	7	KSC	4	28.5	160		
56	Spacelab 6	Spacelab SM+2 SL Pallets	05-01-87	102	7	KSC	6	57.0	200		
57	DOD LDEF-2	SSUS-D	05-19-87	099	3	KSC	4	28.5	240		
5Y	OSTA-7 PL OPP	Pallet	05-28-87	103	7	VAFB	4	99.0	160		
58	RCA-1 STC DBS-F INTELSAT VI-5	SSUS-D SSUS-D Special stage	06-06-87	104	3	KSC	4	28.5	160		
59	OSS-3 SATCOL-B DOD	Igloo+2 SL Pallets SSUS-D SSUS-D	06-27-87	102	7	KSC	5	28.5	160		
60	ROSAT PL OPP	Unique Stage	07-24-87	099	3	KSC	4	57.0	256		
61	Spacelab 8	Spacelab LM+1 SL Pallet	08-04-87	104	7	KSC	6	57.0	160		
62	DOD 87-3		08-22-87	102		KSC					
6V	DOD 87-2V		09-01-87	103		VAFB					
63	OAST-3 ELVE DOD ELRECA	MPESS SSUS-D Pallet Retrieval	09-20-87	099	7	KSC	4	28.5	160		



2-3

Figure 2-3 STS-7 Mission Timeline(Overview)

to 4 hours of tracking is required prior to the start of the deploy sequence to determine an accurate state vector. The amount of time required to deploy a PAM plus the time required to maintain Orbiter/crew health dictates that only one deployable can be launched per mission day.

During a deploy sequence, the remaining cargo elements are normally in a quiescent mode using only those resources necessary to monitor/maintain the health/thermal condition of the element.

Post-deployment resource requirements for each PAM-D is currently allocated 500 watts average power for a 24-hour time period.

Generally, on-orbit missions operations for sortie payloads will not commence until after all deployables are launched.

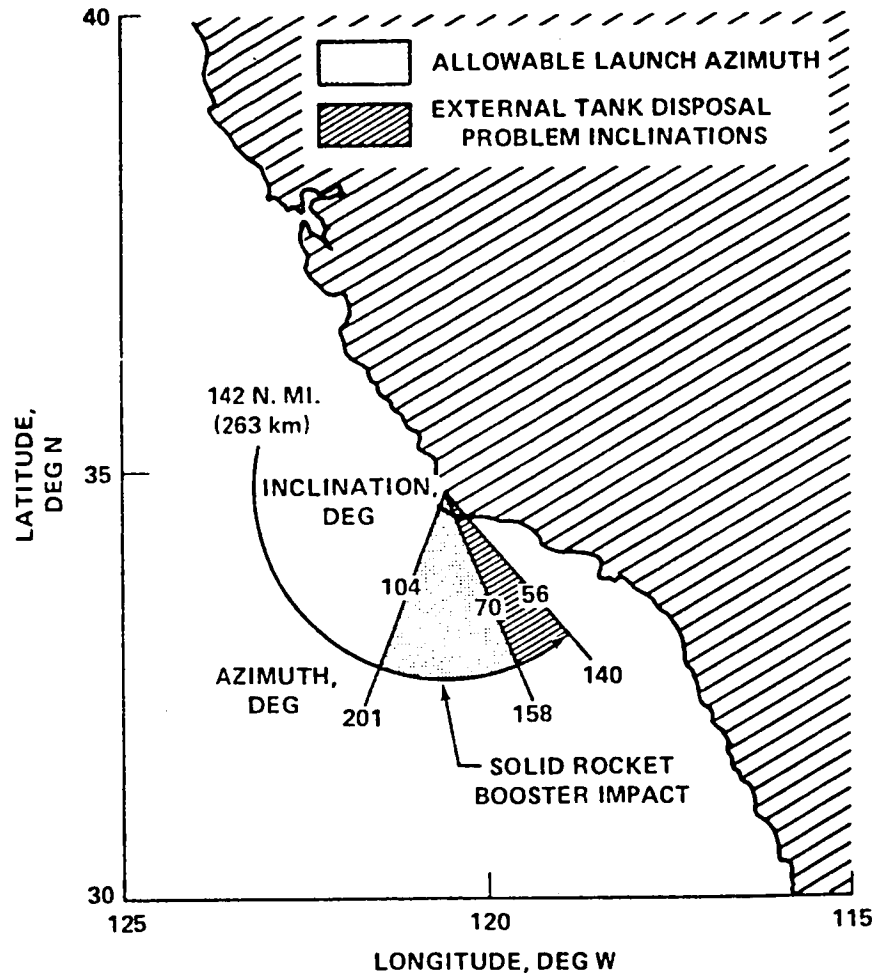
The Orbiter cargo bay services are divided into four equal sections for standard mixed cargo flights. The sortie carrier occupies one section, but multiple sections are available on an optional basis.

2.4 ON-ORBIT OPERATIONS

STS operational flights will be launched from Kennedy Space Center (KSC) in Florida and from Vandenberg Launch Site (VLS) at Vandenberg Air Force Base (VAFB) in California. Launches from VLS are currently scheduled to begin in 1985.

Orbiter inclination angles of 28.5° to 57° can be obtained for circular and elliptical orbits when launched from KSC. Higher orbital inclinations, 56° to 104° , can be obtained from VLS. Figure 2-4 depicts the azimuth and inclination limits from both launch sites.

VANDENBERG AIR FORCE BASE



KENNEDY SPACE CENTER

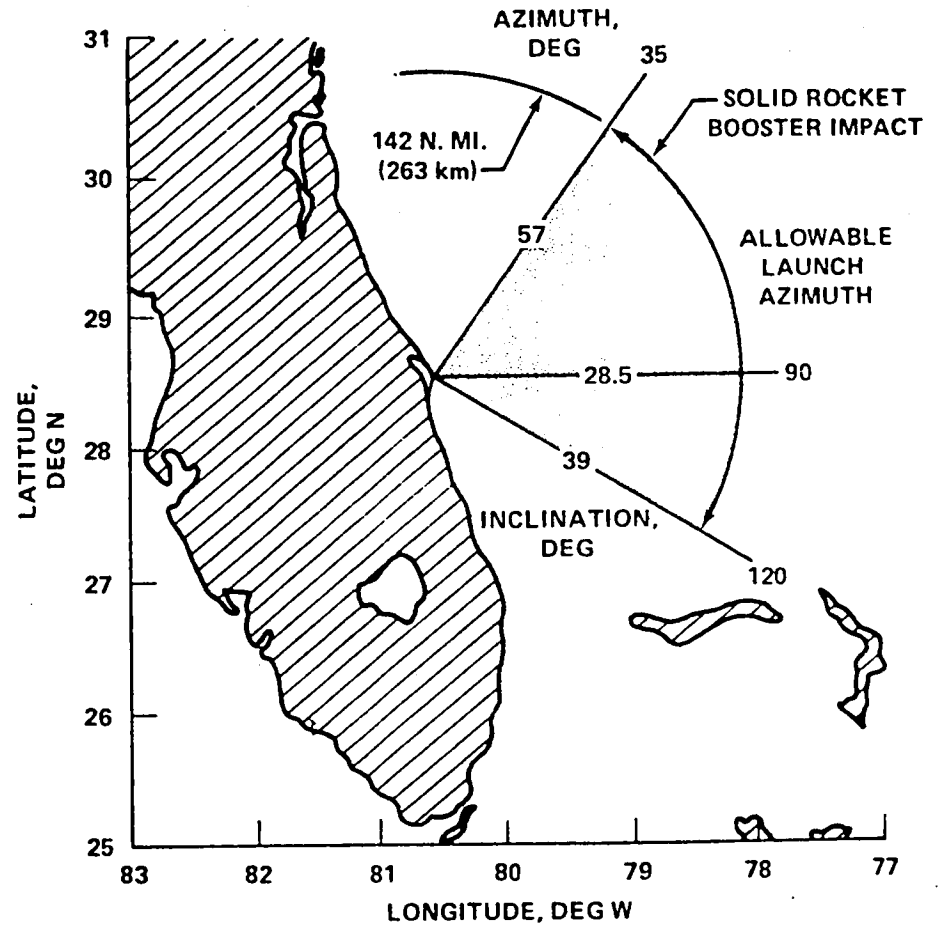


Figure 2-4 Launch Azimuth and Inclination Limits from VAFB and KSC

The Shuttle cargo weight capability decreases rather rapidly as the inclination angle increases. Specifics are contained in Volume XIV of the Space Shuttle System Payload Accommodations, JSC-07700.

2.4.1 Allowable Mass

The design goal of the Space Shuttle System is to provide a capability of launching with a total cargo weight of 65,000 pounds. For mixed cargo flights, this equates to about 16,000 pounds lift-off weight per cargo section.

Conversely the SSO is baselined at a total landing weight of 32,000 pounds (8,000 pounds per cargo section). The Flight Manifest Office at JSC assesses each manifested cargo configuration to determine mass property constraints.

2.4.2 Thermal Control

A payload heat exchanger, within the SSO, is available for the transfer of heat from the payload bay to the Active Thermal Control System (ATCS). The total heat rejection capability of the ATCS is 21,500 BTU's/hr while on-orbit. The ATCS is generally utilized for high heat generating avionics components such as those planned for the experiment carrier.

In addition, 1193 BTU's/hr is available for equipment mounted in the Aft Flight Deck (AFD). This cooling capacity may be increased to a maximum of 2560 BTU/hr avg (3413 BTU/hr peak for 15 min) but will reduce the cooling capability of the payload bay.

Passive thermal control components, such as thermal blankets, special reflective paints and, where applicable, electric heat strips should be used by experimenters to the maximum extent possible. This minimizes complex coolant loop interfaces between the experiment carrier and experiment.

2.4.3 Orbital Attitudes

The currently preferred orbital attitude for the sortie carrier is payload bay up, nose forward (+ZLV/NF). This attitude minimizes requirements for attitude control thruster use, and maximizes the high-rate (Ku-Band) communications coverage. (See Table 2-4 Page 2-32).

The duration of an attitude hold is dependent on many factors. Principal among these are the Beta angle (angle of the sun to the orbital plane), Orbiter attitude, Orbiter/Payload heat rejection profile, and stored water available for heat rejection use. (See Table 2-2).

If the allowable hold time is exceeded, then a preferred attitude must be assumed to allow water accumulation (from fuel cell operation), and/or thermal conditioning. The passive thermal conditioning attitude requires a roll about the x-axis, the x axis within ± 20 degrees of normal to the sun vector, with a rate of from 2-5 revolutions per hour. Gravity gradient holds experience thermal constraints only for beta angles of less than 60 degrees.

Prior to re-entry, time may be required to allow pre-conditioning of the Orbiter insulation tiles.

2.4.4 On-Orbit Maneuvers

Two systems are used for on-orbit maneuvering: Orbital Maneuvering System (OMS), used for final orbit insertion, and major orbital changes - Reaction Control System (RCS), used for minor orbit adjustments and attitude control. The RCS has two modes, Primary (PRCS) and Vernier (VRCS).

During OMS maneuvers, any experimental deployable must be retracted and stowed. Stowing requirements for PRCS and VRCS firings depend on the ability of the payload to withstand the imposed accelerations. (See Table 2-3).

TABLE 2-2. - HOLDING TIMES VS. ORIENTATION AND BETA ANGLE

BETA _ 60°

Cargo Bay Orientation	Hold Time (hrs) Without Radiator Kit	Hold Time (hrs) With Radiator Kit
Deep Space (non 3-axis-inertial)	± 160	± 60
Deep Space, Stellar (3-axis-inertial)	33 to ± 160	33 to ± 160
Direct Earth	17 to ± 160	27 to ± 160
Direct Solar (3-axis-inertial)	21 to ± 160	50 to ± 160

TABLE 2-2 HOLDING TIMES VS. ORIENTATION AND BETA ANGLE (Concluded)

BETA 60°

Cargo Bay Orientation	Hold Time (hrs) Without Radiator Kit	Hold Time (hrs) With Radiator Kit
Deep Space (non 3-axis-inertial)	6*	6*
Deep space, Stellar (3-axis-inertial)	33 to ±160	33 to ±160
Direct Earth	6* (18 to ±160 accumulative)	6* (30 to ±160 accumulative)
Direct Solar (3-axis-inertial)	12 to 86	16 to ±160

*The Orbiter is designed for repeated cycles of a maximum 6-hours attitude hold with no attitude constraints, followed by 3 hours thermal conditioning. For analysis purposes, thermal conditioning shall be assumed to be barbecue of the Orbiter at 2 to 5 RPH about the X-axis with the orientation of the X-axis within +20° of the perpendicular to the sun vector. Upon reaching the accumulative times shown (in parentheses), the Orbiter must be placed in a preferred attitude to allow fuel cell generated water accumulation before repeating the 6-hour hold cycles, also to be defined in applicable payload-unique ICD's.

TABLE 2-3. - ORBITER PER AXIS PRIMARY RCS/VRCS ACCELERATION LEVELS

Acceleration	Command	Maximum Hi-Mode	Nominal Mode	Time Average
<u>TRANSLATION (ft/sec²)</u>				
32 K lbs Payload	+X	0.55*	0.27	0.29
	-X	N/A	-0.28	-0.27
	+Y	N/A	0.28	0.12
	-Y	N/A	-0.28	-0.15
	+Z	1.26**	0.42	0.43
	-Z	-0.94*	-0.55	-0.50
65 K lbs Payload	+X	0.46*	0.23	0.24
	-X	N/A	-0.23	-0.22
	+Y	N/A	0.23	0.10
	-Y	N/A	-0.23	-0.12
	+Z	1.05**	0.35	0.35
	-Z	-0.80	-0.46	-0.42
<u>ROTATION (deg/sec²)</u>				
32 K lbs Payload	+Roll	N/A	1.09	0.80
	-Roll	N/A	-1.09	-0.89
	+Pitch	N/A	1.29	1.16
	-Pitch	N/A	-0.86	-0.81
	+Yaw	N/A	0.72	0.70
	-Yaw	N/A	-0.72	-0.62
65 K lbs Payload	+Roll	N/A	1.03	0.75
	-Roll	N/A	-1.03	-0.84
	+Pitch	N/A	1.18	1.06
	-Pitch	N/A	-0.79	-0.74
	+Yaw	N/A	0.66	0.64
	-Yaw	N/A	-0.66	-0.57

*Hi-mode acceleration in +X and -Z occurs only during OPS 1 (insertion) and OPS 3 (de-orbit) phases with TRANS DAP (Transition, digital autopilot).

**Hi-mode acceleration in +Z occurs only during OPS 2 (on-orbit) phase with on-orbit DAP (digital autopilot).

TABLE 2-3. - ORBITER PER AXIS VERNIER RCS ACCELERATION LEVELS (Concluded)

Payload	Rotation Command	Per Axis Rotational Acceleration deg/sec ²	Translational Crosscouple Acceleration, feet/second ²		
			X	Y	Z
32 K lbs	+Pitch	0.0209	-0.0003	0.0	-0.0056
	-Pitch	-0.0163	0.0	0.0	-0.0077
	+Roll	0.0209	-0.0001	0.0027	-0.0067
	-Roll	-0.0209	-0.0001	-0.0027	-0.0067
	+Yaw	0.0175	-0.0001	-0.0011	-0.0029
	-Yaw	-0.0175	-0.0001	-0.0011	-0.0029
	65 K lbs	+Pitch	0.0191	-0.0002	0.0
-Pitch		-0.0149	0.0	0.0	-0.0064
+Roll		0.0196	-0.0001	0.0023	-0.0056
-Roll		-0.0196	-0.0001	-0.0023	-0.0056
+Yaw		0.0160	-0.0001	-0.0009	-0.0024
-Yaw		-0.0160	-0.0001	-0.0009	-0.0024

2.4.5 Payload Envelope

Payload accommodations are provided in two general areas of the Orbiter: the cargo bay and the aft flight deck in the cabin (Figures 2-5 and 2-6). The dimensions and envelope of the bay are illustrated, together with the structural and payload coordinate systems. The Orbiter stations are included for reference.

The cargo bay is enclosed by doors that open to expose the entire length and full width of the cargo bay. The usable envelope is limited by items of supporting subsystems in the cargo bay that are charged to the payload volume.

The payload clearance envelope in the Orbiter cargo bay measures 15 by 60 feet (4.6 by 18.3 meters). This volume is the maximum allowable payload dynamic envelope, including payload deflections. In addition, a nominal 3-inch (7.6 centimeter) clearance between the payload envelope and the Orbiter structure is provided to prevent Orbiter deflection interference between the Orbiter and the payload envelope.

The payload space on the aft flight deck is intended primarily for control panels and storage.

2.5 SSO/TDRSS COMMUNICATIONS

The Tracking and Data Relay Satellite System (TDRSS) will be the primary communications link between the Space Shuttle Orbiter (SSO) and the ground during the STS Operational era. The TDRSS consists of two active communications satellites in a geosynchronous orbit 130° apart. TDRS East is located at 41° west longitude and TDRS West is located at 171° west longitude (see Figure 2-7). A single TDRSS ground terminal is located at White Sands, New Mexico. The TDRSS has the potential for near real-time global coverage for most users - up to 85%, depending on altitude and attitude. Figure 2-8 depicts the potential geometric coverage by the TDRS. The figure also shows a

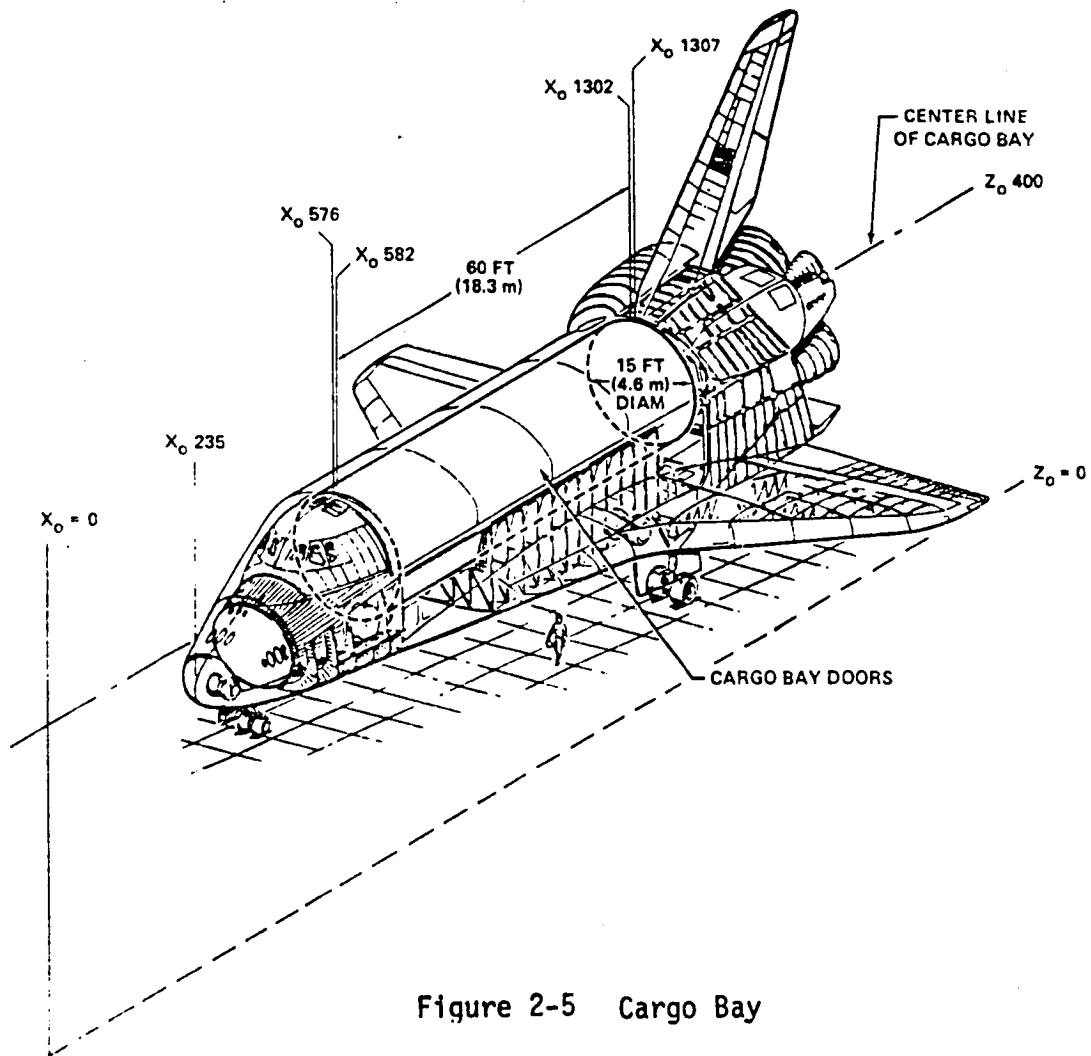


Figure 2-5 Cargo Bay

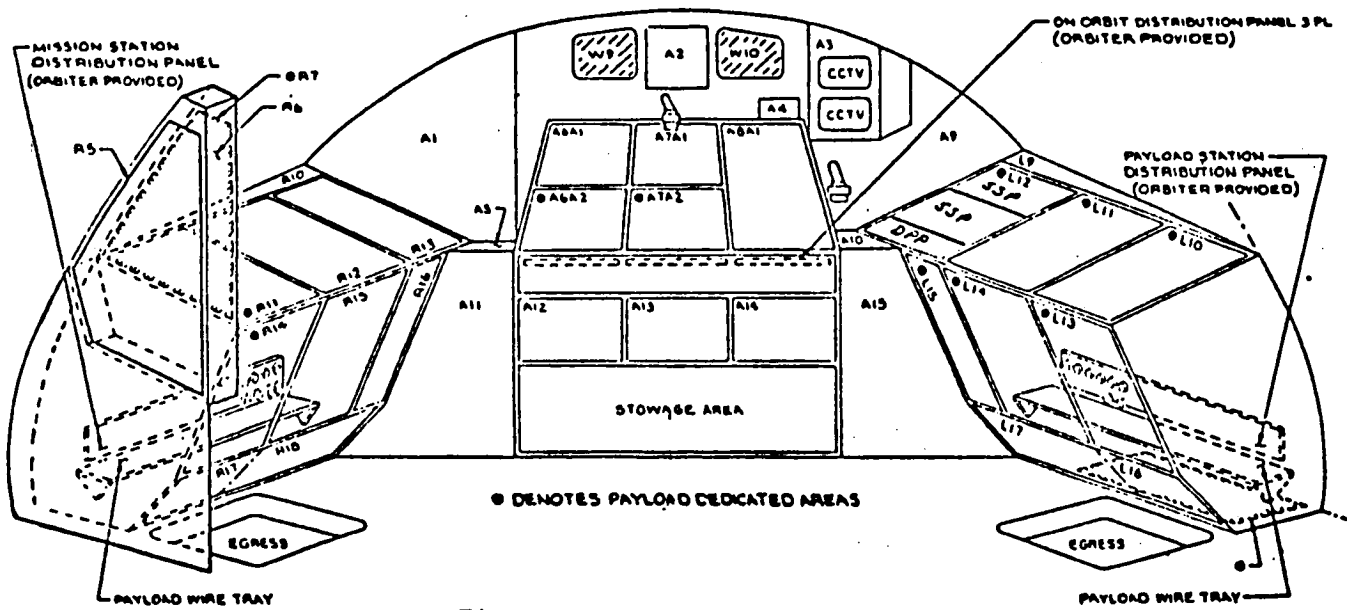
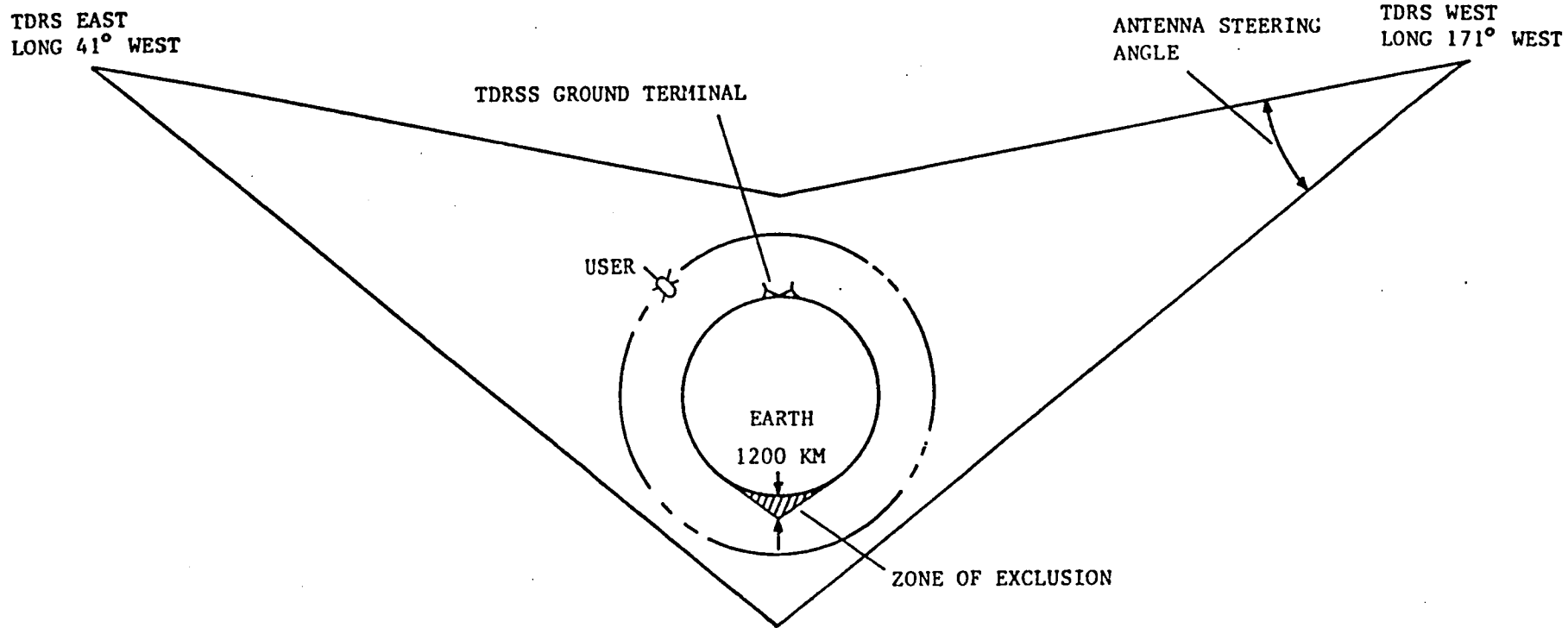


Figure 2-6 Aft Flight Deck



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Figure 2-7 Tracking and Data Relay Satellite System

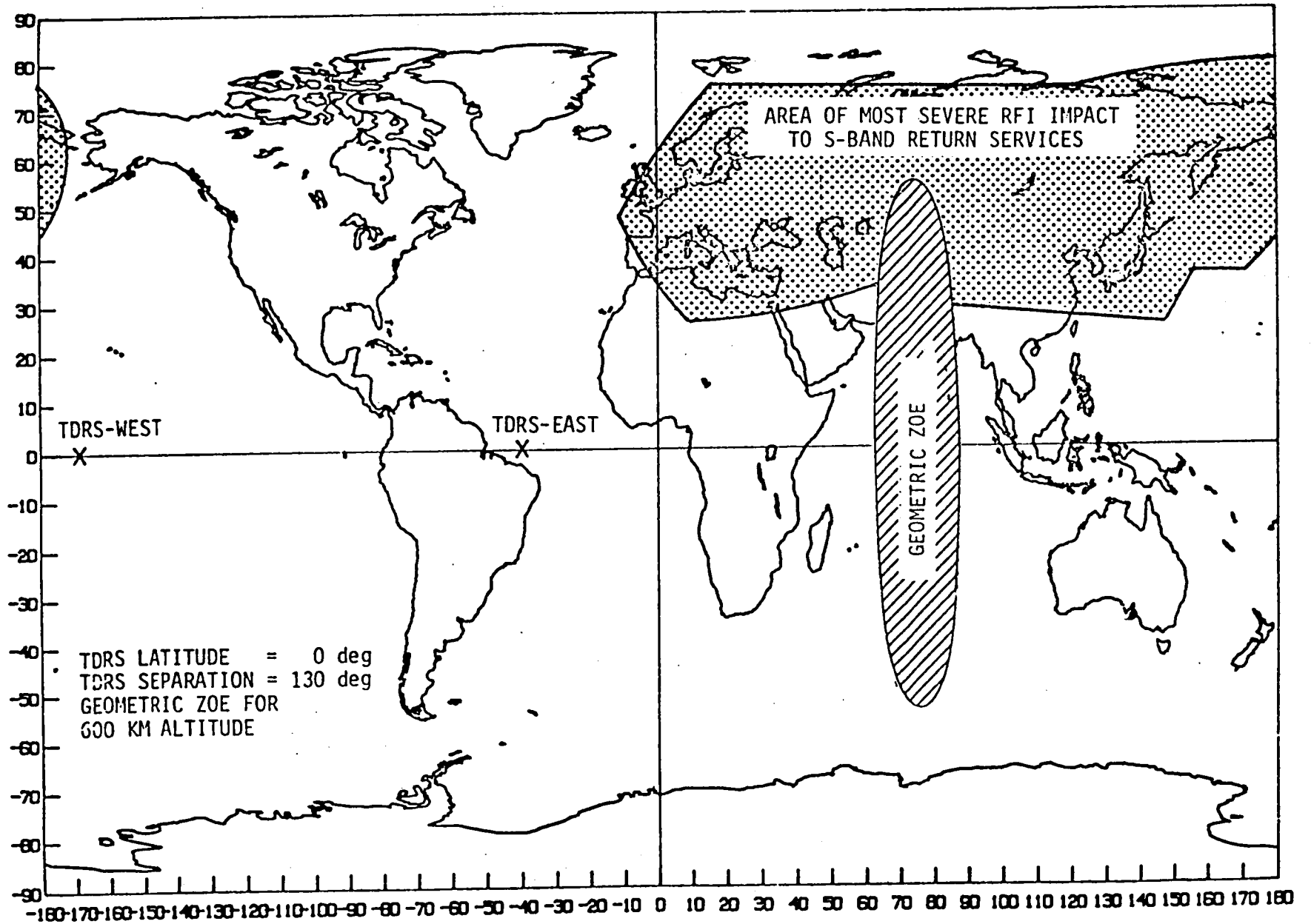


Figure 2-8 TDRSS Zone of Exclusion

Zone of Exclusion (ZOE) area and a high RFI area that impacts S-Band return services. Details of these areas can be found in the TDRSS Users Guide, STDN No. 101.2.

The RF interface between the SSO and the TDRS consists of a Ku Band forward (up) link and return (down) link and an S-Band forward and return link. However, these communication links are possible only if a TDRS is unoccluded by earth and within the operating region of an antenna. Each antenna has restricted operating regions due to hardware limits, signal strength and Orbiter blockage.

2.5.1 Ku-Band Antenna System

The obscuration zone for the Orbiter Ku-Band antenna is shown in Figure 2-9. This zone is incorporated in the antenna software, as a set of polynomials, which prohibits the antenna from transmitting into the area blocked by the Orbiter, which includes the antenna gimbal axis fixed to the deployment boom. The fixed axis antenna gimbal does not rotate more than 360° and so whenever the signal crosses the dashed line, indicated in Figure 2-9, the gimbal "wraps around" 360° to maintain pointing.

The operating region of the Ku-Band antenna includes a five-degree clearance from the envelope of the Orbiter body structure. Figure 2-10 depicts deployed Ku-Band antenna assembly and Figure 2-11 defines the antenna coordinate system.

2.5.2 S-Band Antenna System

The S-Band PM Antenna System is comprised of four quad antennas which provide omnidirectional coverage in the roll plane and 140° beam width in the pitch plane. Figure 2-12 shows the general location of the S-Band PM antennas. The S-Band FM and S-Band PI antennas are shown for reference only.

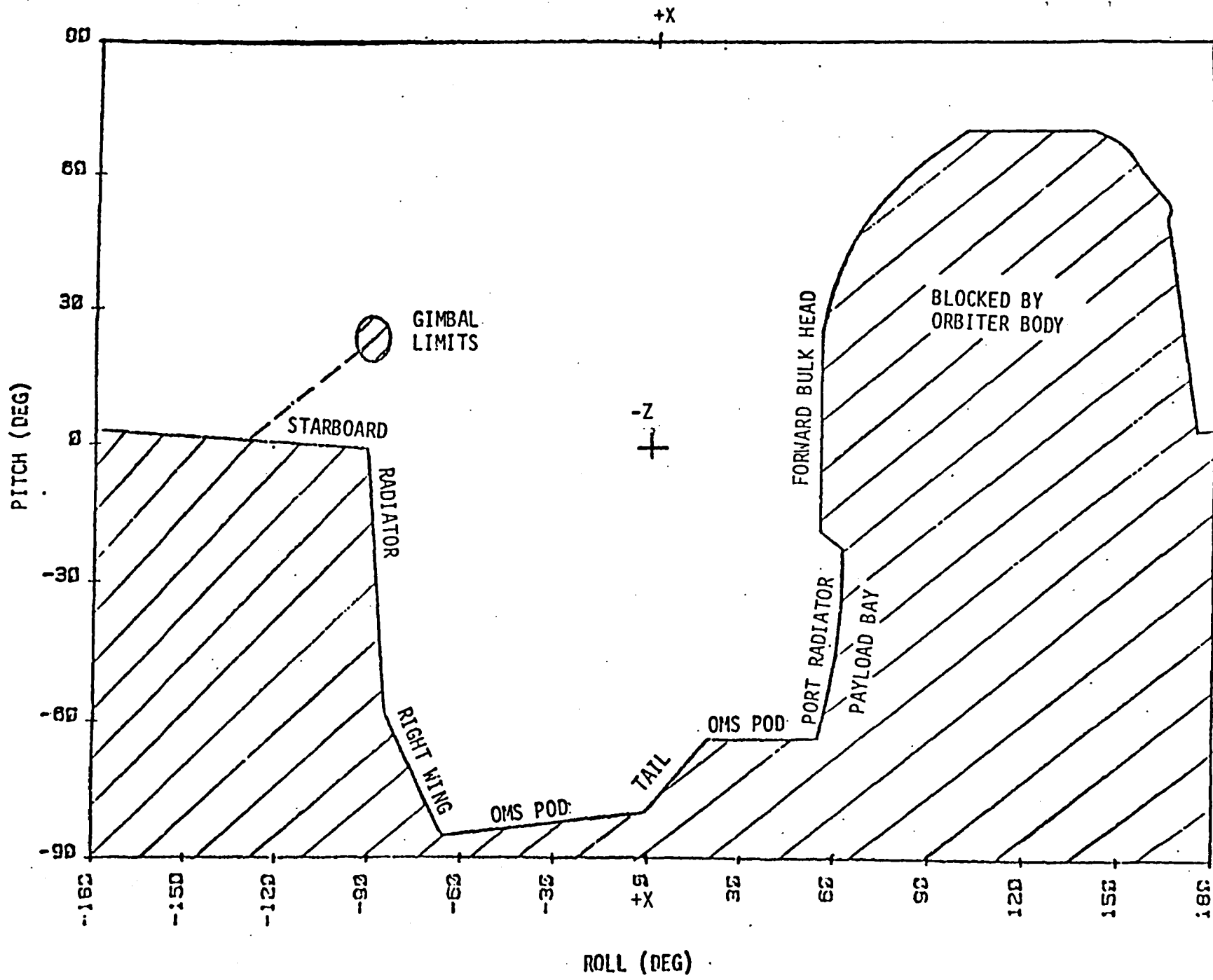


Figure 2-9 Ku-Band Antenna Obscuration Zone

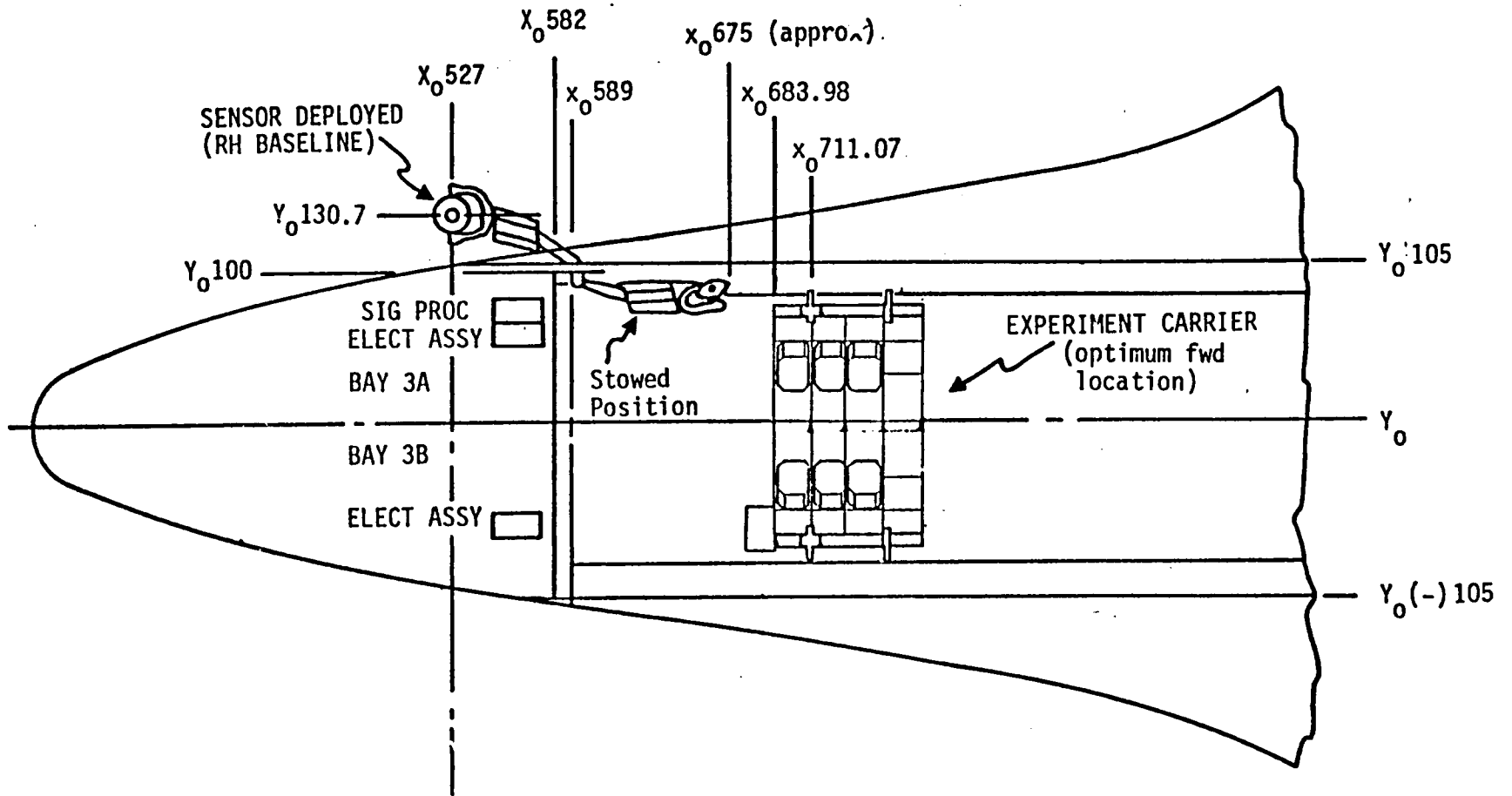


Figure 2-10 Ku-Band Antenna Location

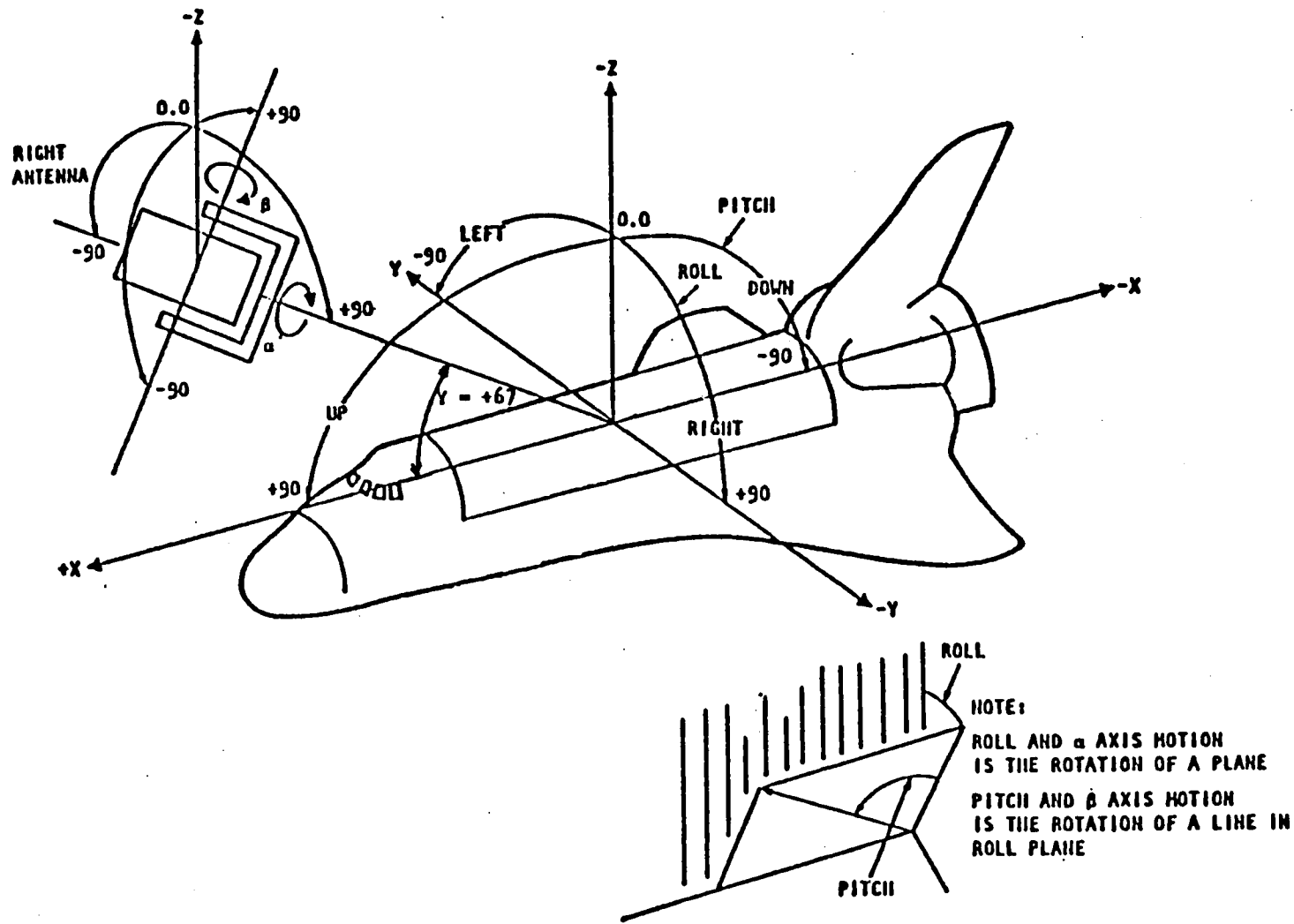


Figure 2-11 Ku-Band Antenna Coordinate System

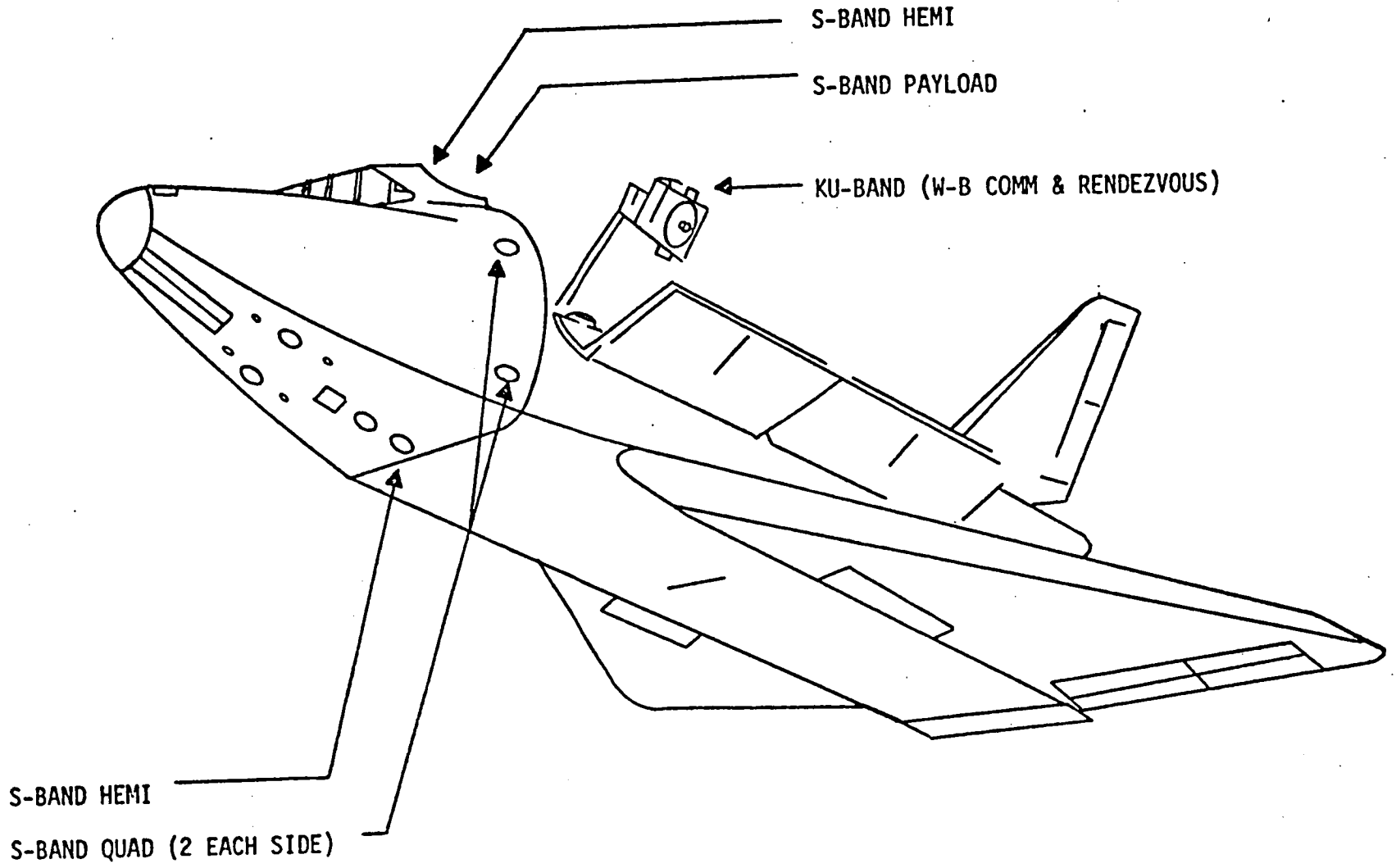


Figure 2-12 Antenna Locations

The S-Band PM Antenna system currently operates in two frequency sets:

1. 2106.4 MHz (Fwd link) and 2287.5 MHz (Return link)
2. 2041.9 MHz (Fwd link) and 2217.5 MHz (Return link)

Currently frequency set 1 is the primary S-Band link and set 2 is the back-up. Figure 2-13 provides an overview of the total SSO/TDRSS communications link.

2.5.3 Communications Limitations

An analysis of the Orbiter Local Vertical Local Horizontal (LVLH) attitude has been conducted, by JSC, to determine the worst-case/best-case attitudes for SSO/TDRS communications. Four attitudes were evaluated resulting in the heads-down nose-forward (-ZLV) attitude providing the worst-case communications while a heads-up nose-forward providing the best coverage. The assumptions used in analyzing LVLH attitudes for both Ku-Band and S-Band communications with the TDRS are:

1. Orbiter altitude is 270 N. Mi.
2. Orbit inclination angle is 28.5° .
3. TDRS locations are at 41° W and 171° W longitude.
4. An overhead time of three minutes per pass is used to account for Ku-Band lock-on delays.
5. No delay time for S-Band acquisition.
6. S-Band frequency of 2287.5 MHz, which provides the smallest field of view based on 4dB criteria, is the only frequency analyzed.

In the heads-down nose-forward (-ZLV) attitude, the average communication per revolution was approximately 27 minutes for the Ku-Band system. The S-Band system average communication was approximately 16 minutes per revolution. These average communication times are based on a ten hour attitude hold condition which equates to just under seven revolutions. Figure 2-14 is a plot of

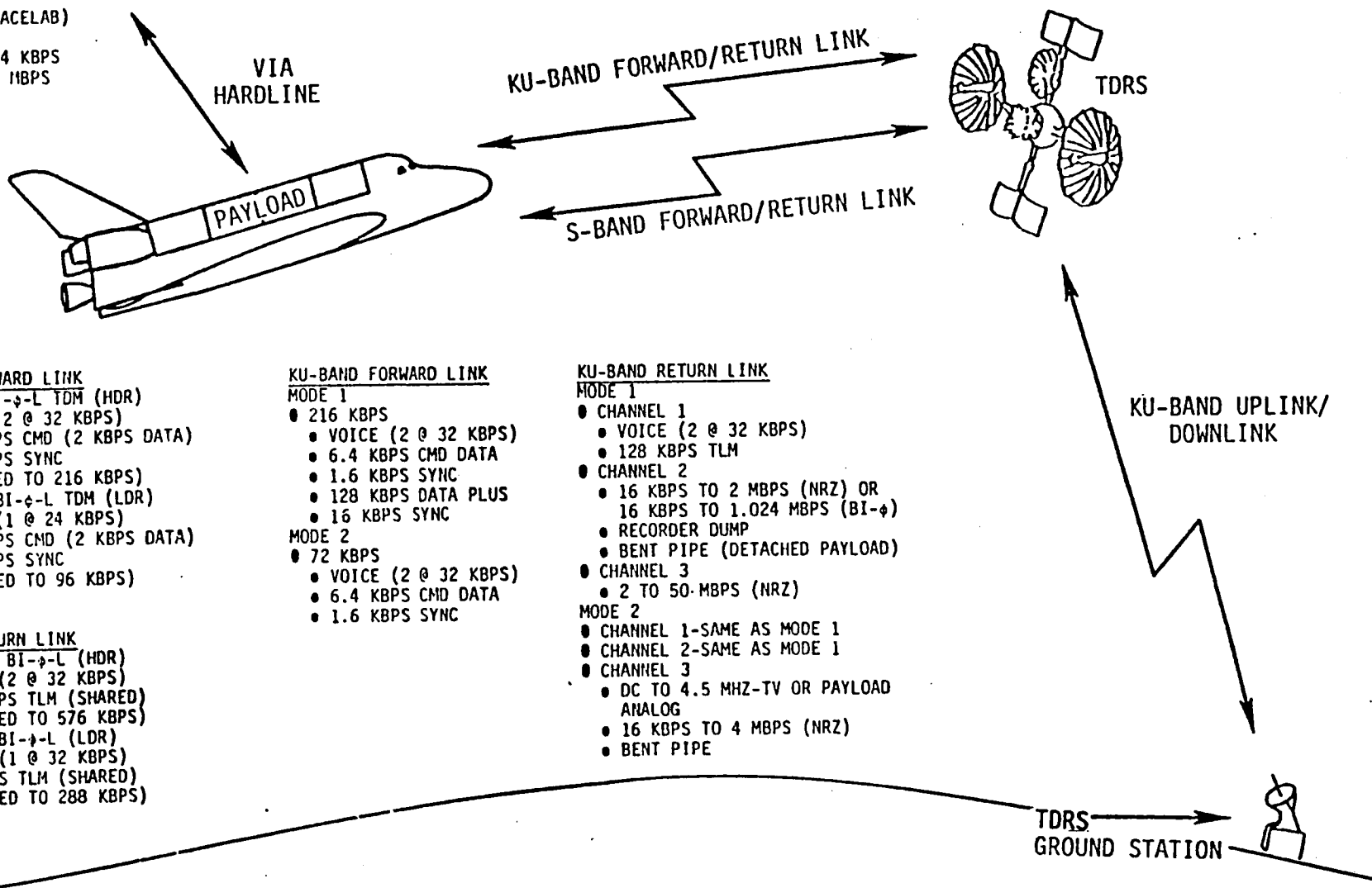
ATTACHED PAYLOADS

FORWARD

- VOICE (SPACELAB)
- CMDS
 - MDM COMPATIBLE
 - PSP < 2 KBPS DATA
 - 128 KBPS CHANNEL

RETURN

- VOICE (SPACELAB)
- TLM
 - PDI < 64 KBPS
 - WB < 50 MBPS
 - TV



S-BAND FORWARD LINK

- 72KBPS BI-φ-L TDM (HDR)
 - VOICE (2 @ 32 KBPS)
 - 6.4 KBPS CMD (2 KBPS DATA)
 - 1.6 KBPS SYNC (ENCODED TO 216 KBPS)
- 32 KBPS BI-φ-L TDM (LDR)
 - VOICE (1 @ 24 KBPS)
 - 6.4 KBPS CMD (2 KBPS DATA)
 - 1.6 KBPS SYNC (ENCODED TO 96 KBPS)

S-BAND RETURN LINK

- 192 KBPS BI-φ-L (HDR)
 - VOICE (2 @ 32 KBPS)
 - 128 KBPS TLM (SHARED) (ENCODED TO 576 KBPS)
- 96 KBPS BI-φ-L (LDR)
 - VOICE (1 @ 32 KBPS)
 - 64 KBPS TLM (SHARED) (ENCODED TO 288 KBPS)

KU-BAND FORWARD LINK

- MODE 1
- 216 KBPS
 - VOICE (2 @ 32 KBPS)
 - 6.4 KBPS CMD DATA
 - 1.6 KBPS SYNC
 - 128 KBPS DATA PLUS
 - 16 KBPS SYNC
- MODE 2
- 72 KBPS
 - VOICE (2 @ 32 KBPS)
 - 6.4 KBPS CMD DATA
 - 1.6 KBPS SYNC

KU-BAND RETURN LINK

- MODE 1
- CHANNEL 1
 - VOICE (2 @ 32 KBPS)
 - 128 KBPS TLM
 - CHANNEL 2
 - 16 KBPS TO 2 MBPS (NRZ) OR 16 KBPS TO 1.024 MBPS (BI-φ)
 - RECORDER DUMP
 - BENT PIPE (DETACHED PAYLOAD)
 - CHANNEL 3
 - 2 TO 50 MBPS (NRZ)
- MODE 2
- CHANNEL 1-SAME AS MODE 1
 - CHANNEL 2-SAME AS MODE 1
 - CHANNEL 3
 - DC TO 4.5 MHZ-TV OR PAYLOAD ANALOG
 - 16 KBPS TO 4 MBPS (NRZ)
 - BENT PIPE

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Figure 2-13 SSO/TDRSS Communications Link

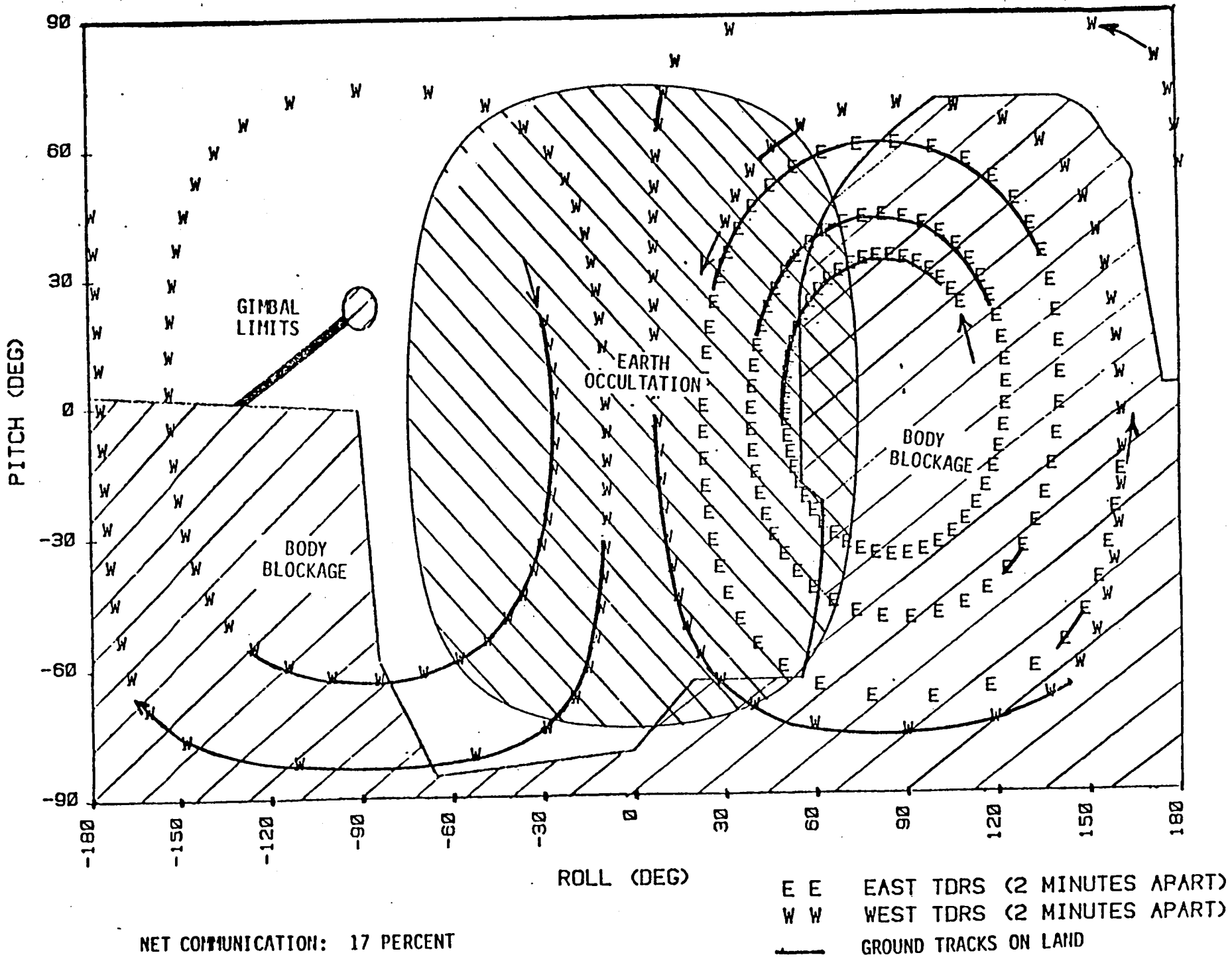


Figure 2-14 Ku-Band Antenna/TDRSS Communication for a -ZLV Attitude

the Ku-Band/TDRS coverage in the -ZLV attitude. Approximately three revolutions are shown to maintain clarity. Figure 2-15 is the gain plot of the S-Band/TDRS coverage at 2287.5 MHz.

In the heads-up nose-forward (+ZLV) attitude, the average communication time increased to approximately 72 minutes per revolution for the Ku-Band and approximately 44 minutes for the S-Band coverage.

Noteworthy to point out is that the Ku-Band coverage will be further impacted if the payload/experiment extends beyond the payload envelope. Two other attitudes were analyzed:

1. +XLV Payload bay forward (BF)
2. -XLV Payload bay back (BB)

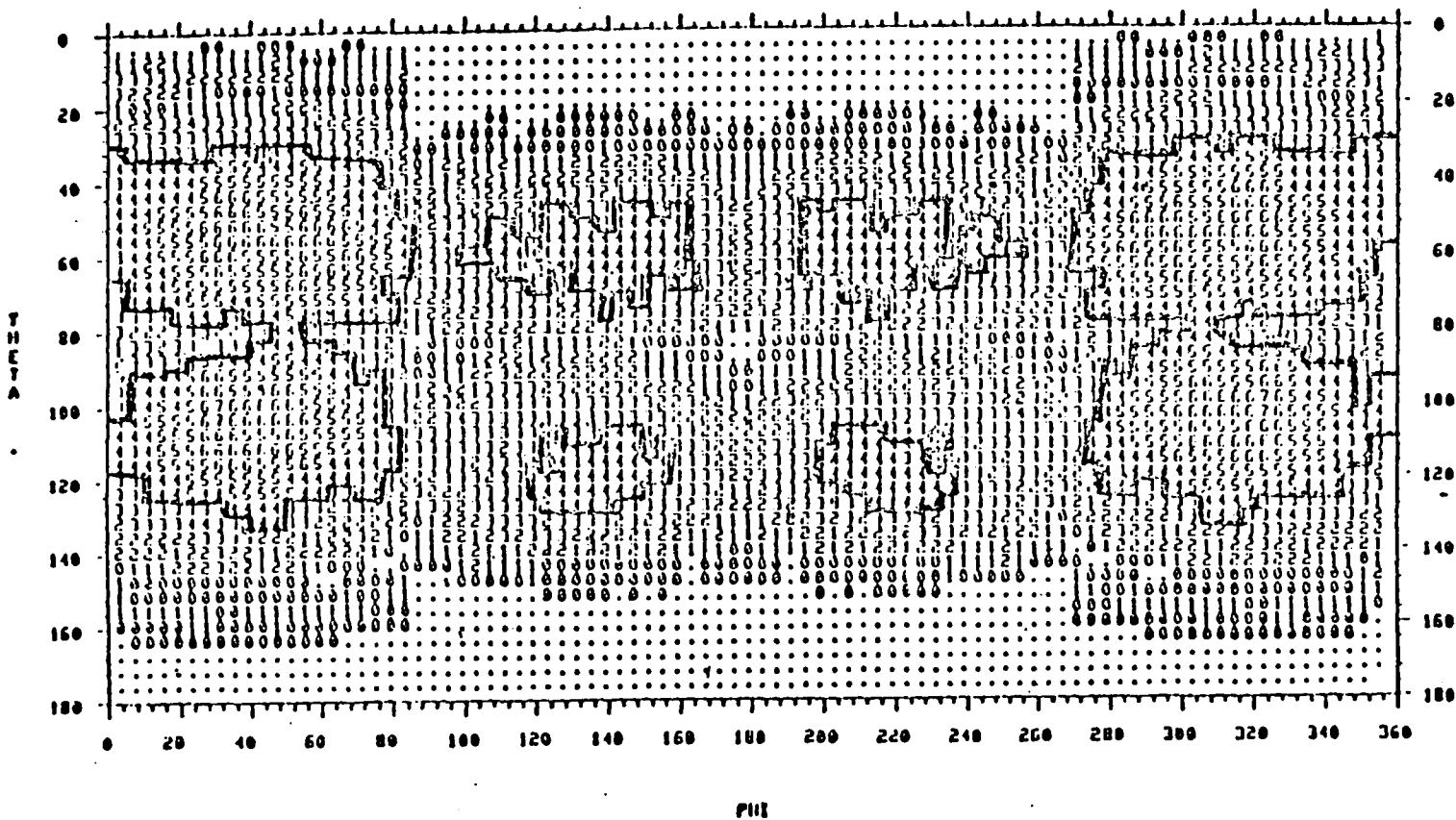
The results of these analysis plus the heads-up/heads-down attitudes are tabulated in Table 2-4.

These analyses represent only four basic attitudes at a given altitude and inclination angle and are not associated with a specific mission.

Analysis/evaluations of specific mission profiles can be accommodated by the Mission Planning and Analysis Division/FM at JSC.

GAIN PLOT

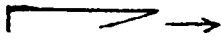
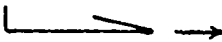
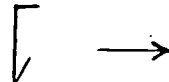

SWITCH BEAM ANTENNA , COMPOSITE GAIN
FREQUENCY = 2287.5 MHz
THETA INCREMENT = 4 DEG.
PHI INCREMENT = 4 DEG.
INVERTS INDICATE GAIN IN DB
INDICATE GAIN LESS THAN 0 DB



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Figure 2-15 S-Band Downlink(2287.5 MHz)Coverage

Table 2-4 Cumulative Percentages for 10 Hour Attitude Hold

ATTITUDE ANTENNA	-ZLV/NF 				+ZLV/NF 				+XLV/BF 				-XLV/BB 			
	COM	BLK	OCC	OV	COM	BLK	OCC	OV	COM	BLK	OCC	OVHD	COM	BLK	OCC	OVHD
S-BAND DOWNLINK (2287.5 MHZ)	17	77	6	0	48	46	6	0	31	63	6	0	49	46	6	0
KU-BAND	31	55	6	9	81	10	6	4	50	37	6	8	79	11	6	5

COM - COMMUNICATION
 BLK - BODY BLOCKAGE
 OCC - EARTH OCCULTATION
 OV - FOR KU-BAND, OVERHEAD OF 3 MIN/PASS FOR LOCK-ON.
 NO OVERHEAD FOR S-BAND.

3.0 PAYLOAD ACCOMMODATIONS FOR MIXED CARGO USERS

This section outlines the electrical resources available to payloads at the Orbiter/cargo bay interface. In addition, the technical basis for sharing the Orbiter payload accommodations among multiple users in the cargo bay will be specified. The criteria set forth herein are aimed at providing equitable shares of the Shuttle resources among users, while maintaining reasonable flexibility in the manifesting of Shuttle flights. This section is not applicable to dedicated flights or to Spacelab flights.

For mixed-user flights, standard accommodations for the cargo bay and Aft Flight Deck (AFD) will be divided into four sections. Each section provides one-fourth of the total capacity for each standard accommodation. Users may be allocated one or more sections to support their requirements.

Resources exceeding, both in amount and kind, those defined as standard accommodations may be negotiated and are referred to as non-standard services. Both classes of services will be outlined in this section.

Two carrier avionics systems exist for interfacing pallet borne experiments to the SSO. One is integral to the Spacelab Igloo pallet system and the other is referred to as the MDM pallet system. The Igloo system is completely described in the Spacelab Payload Accommodations Handbook. The MDM system is derived from Orbital Flight Test (OFT) hardware and is described in the Spacelab Pallet System (SPS) Accommodations Handbook. Neither set of avionics appears to be useful for STEP purposes and will not be discussed further. This section will deal strictly with the Orbiter interface.

3.1 ALLOCATION OF RESOURCES FOR STANDARD ACCOMMODATIONS

The following resources will be offered as standard with each payload section.

3.1.1 Wiring and Harnesses

The Standard Mixed Cargo Harness (SMCH) in the cargo bay provides the following to each of four payload sections:

- a. Main DC power cable.
- b. Control and signal wiring to Aft Flight Deck (AFD).
- c. GPC data bus (2).
- d. Direct connection to an Orbiter MDM.
- e. Control and signal wiring to GSE via T-0 umbilical.

Distribution to four payload sections in the bay is effected by four functionally identical cable sets (Figure 3-1). The length of these cables is such that at least two sets can reach any Standard Interface Panel (SIP). The SIP is located on the port and/or starboard sides of the cargo bay and provides the interface between the SMCH and the cargo element. The relationship of the SIP to the cargo elements is shown in Figure 3-2. One SIP on the port and starboard side will be provided as a standard service. GPC data bus provisions are shown in Figure 3-3.

The standard AFD harness permits connection of the control and signal wiring from the cargo bay to the Orbiter's avionics services and to display and control panels on the AFD (Figure 3-4). This harness provides access to all standard avionics services for each user with some provisions for additional avionics services. It also provides both powered and unpowered switch functions and electromechanical status indicators from the standard switch panel. Cables contained in the standard AFD harness for the standard switch panel may be used for a user-furnished panel at L-10 or L-11 in lieu of the standard switch panel. Figure 3-4 also depicts the wire count of the cables

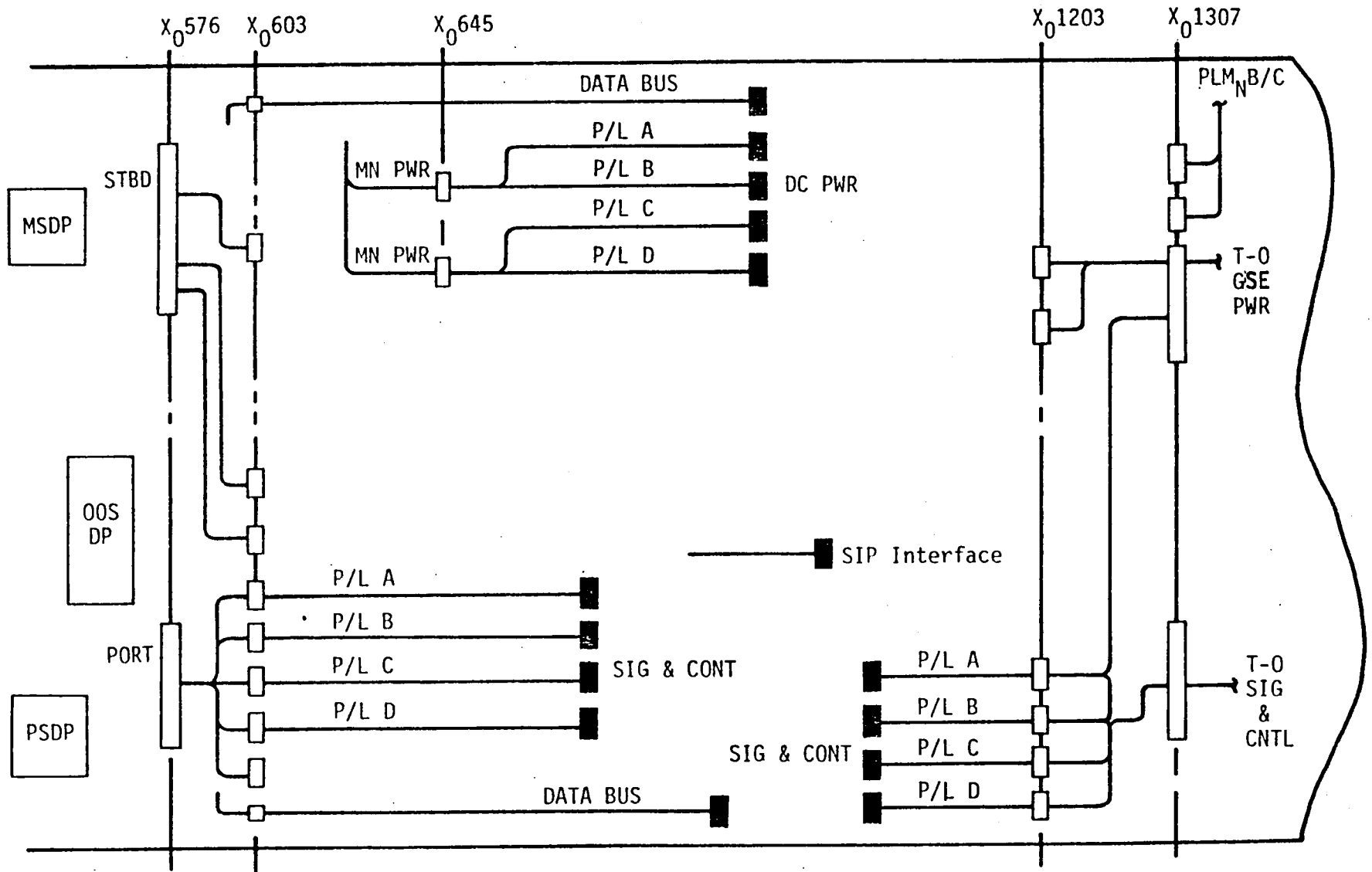


Figure 3-1 Payload Bay SMCH

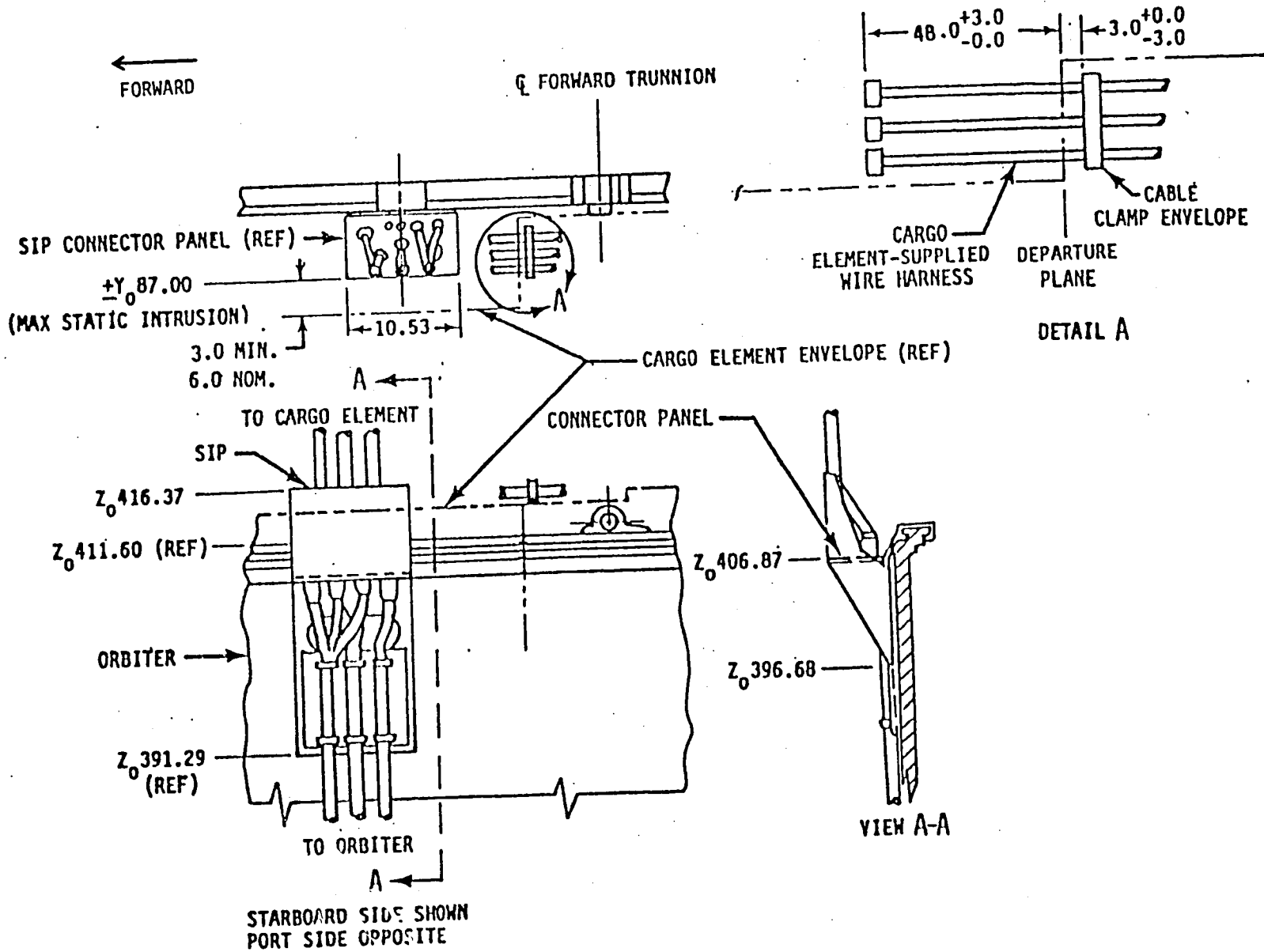


Figure 3-2(1 of 3) SIP Locations

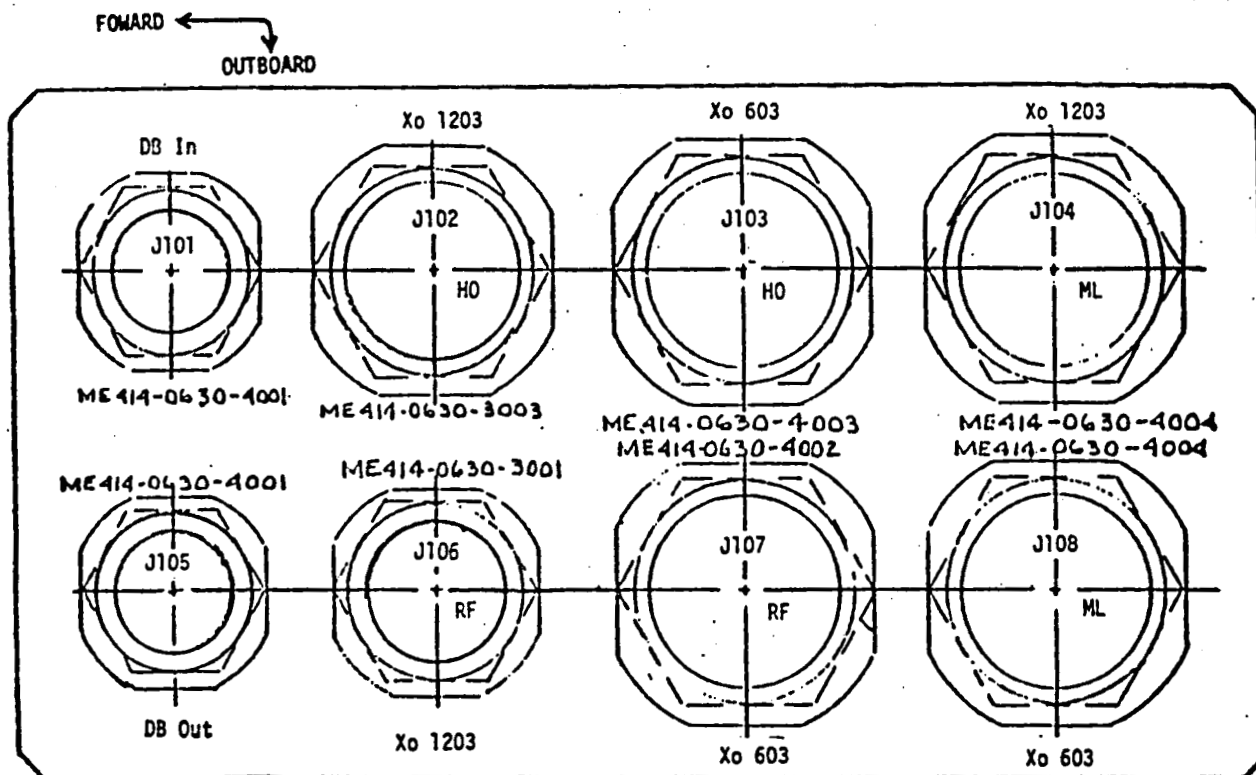


Figure 3-2(2 of 3) SMCH/SIP Port Connector Panel
(Top View with Adaptor Connectors)

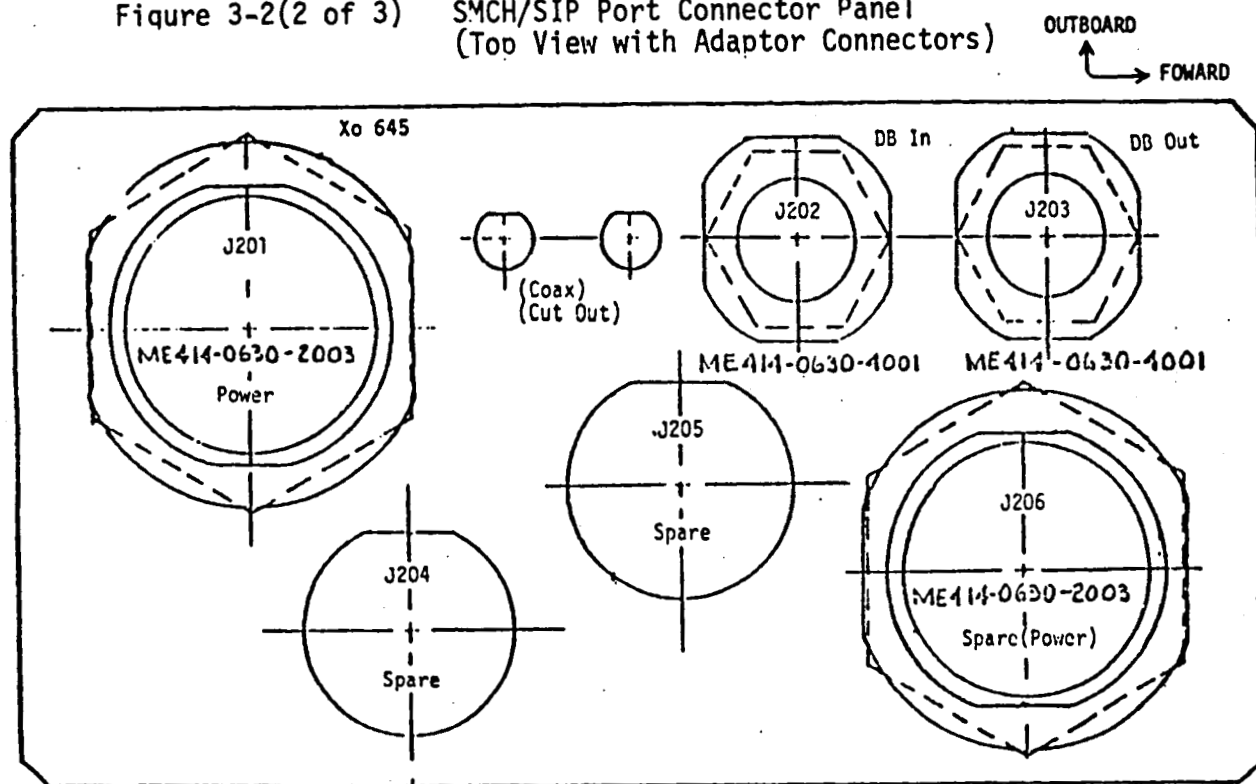
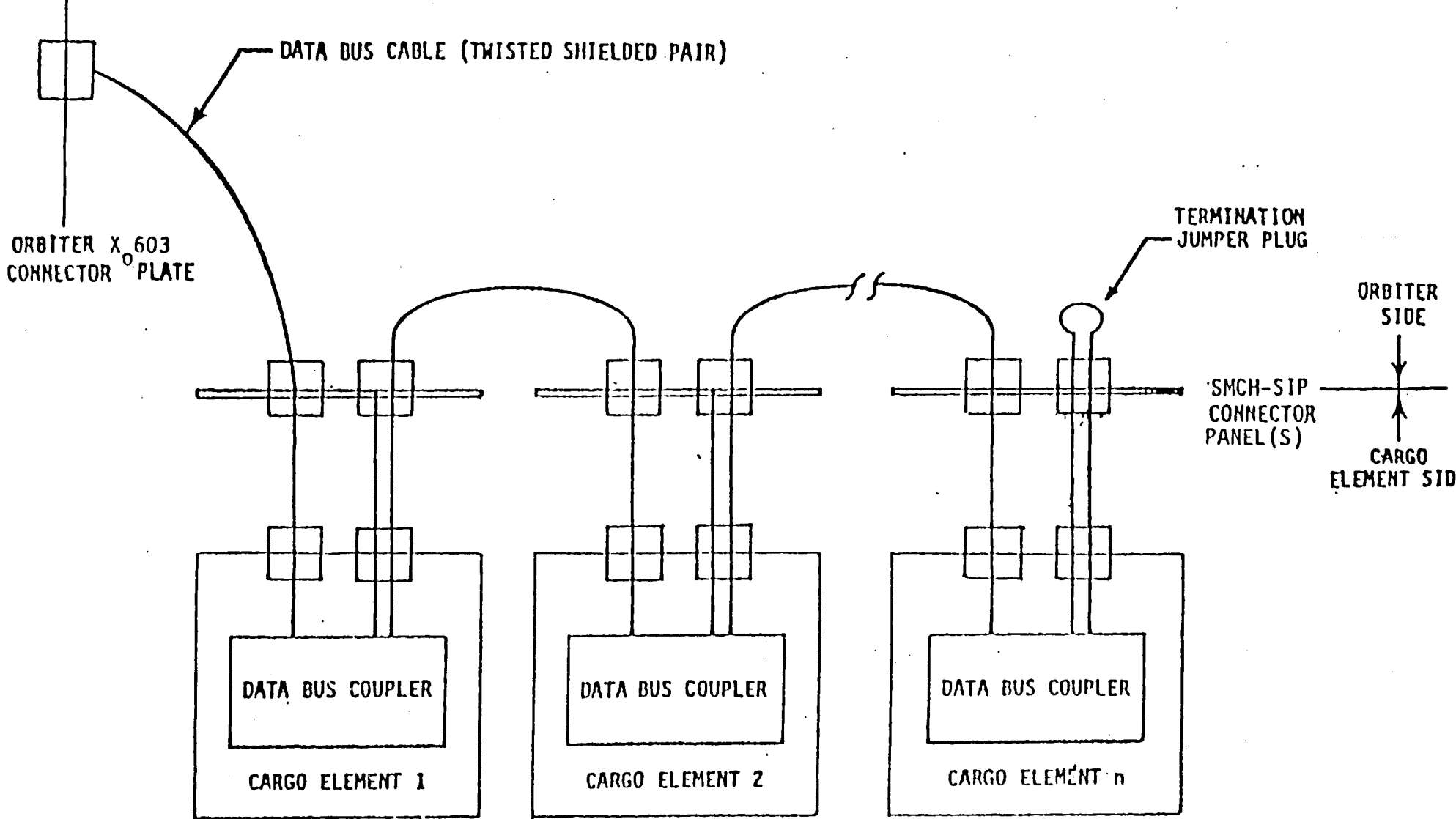


Figure 3-2(3 of 3) SMCH/SIP Starboard Connector Panel
(Bottom View with Adaptor Connectors)



3-6

Figure 3-3 Cargo Element Data Bus Cable Configuration, General Schematic

3-7

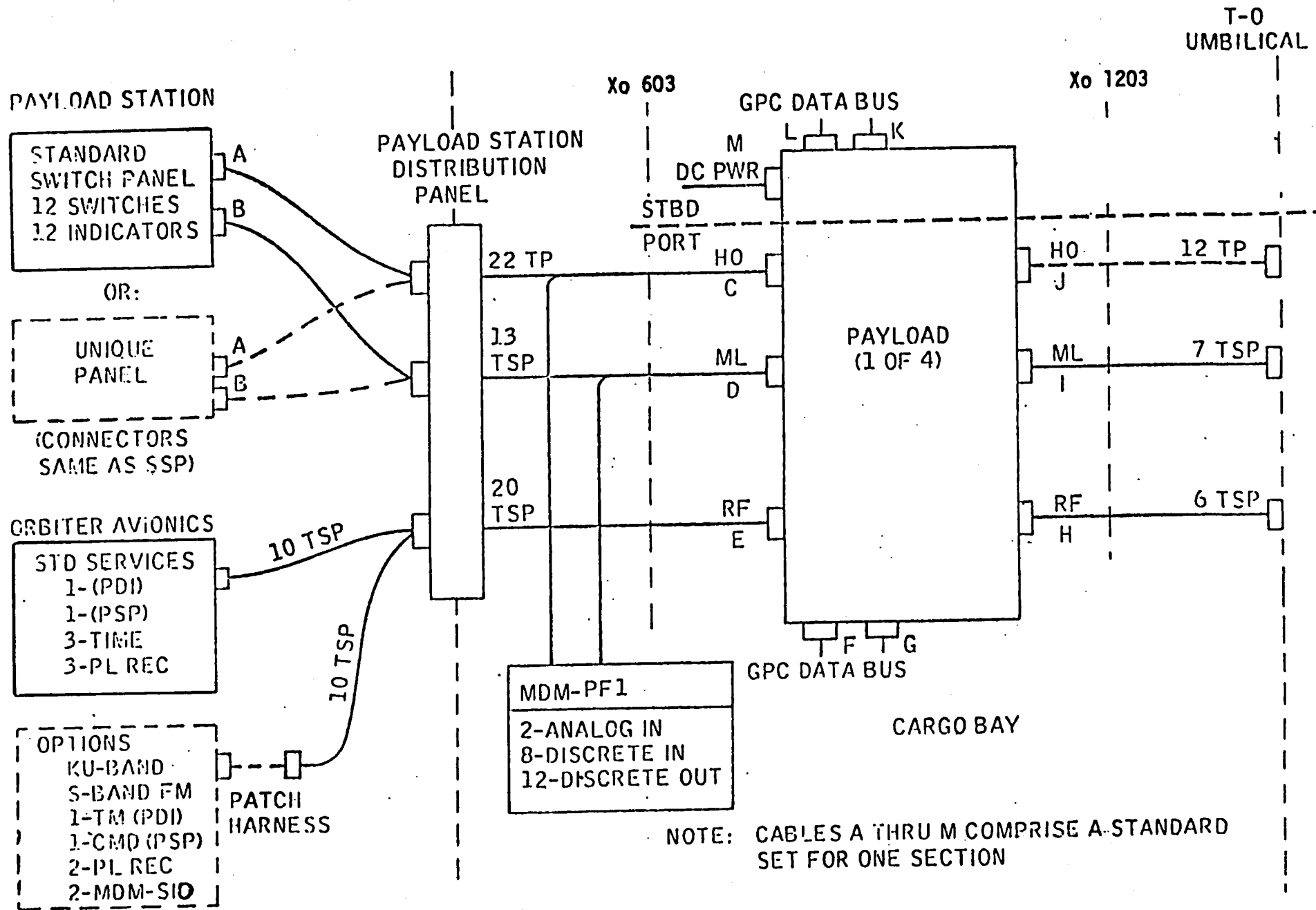


Figure 3-4 SMCH Description-One Section Set

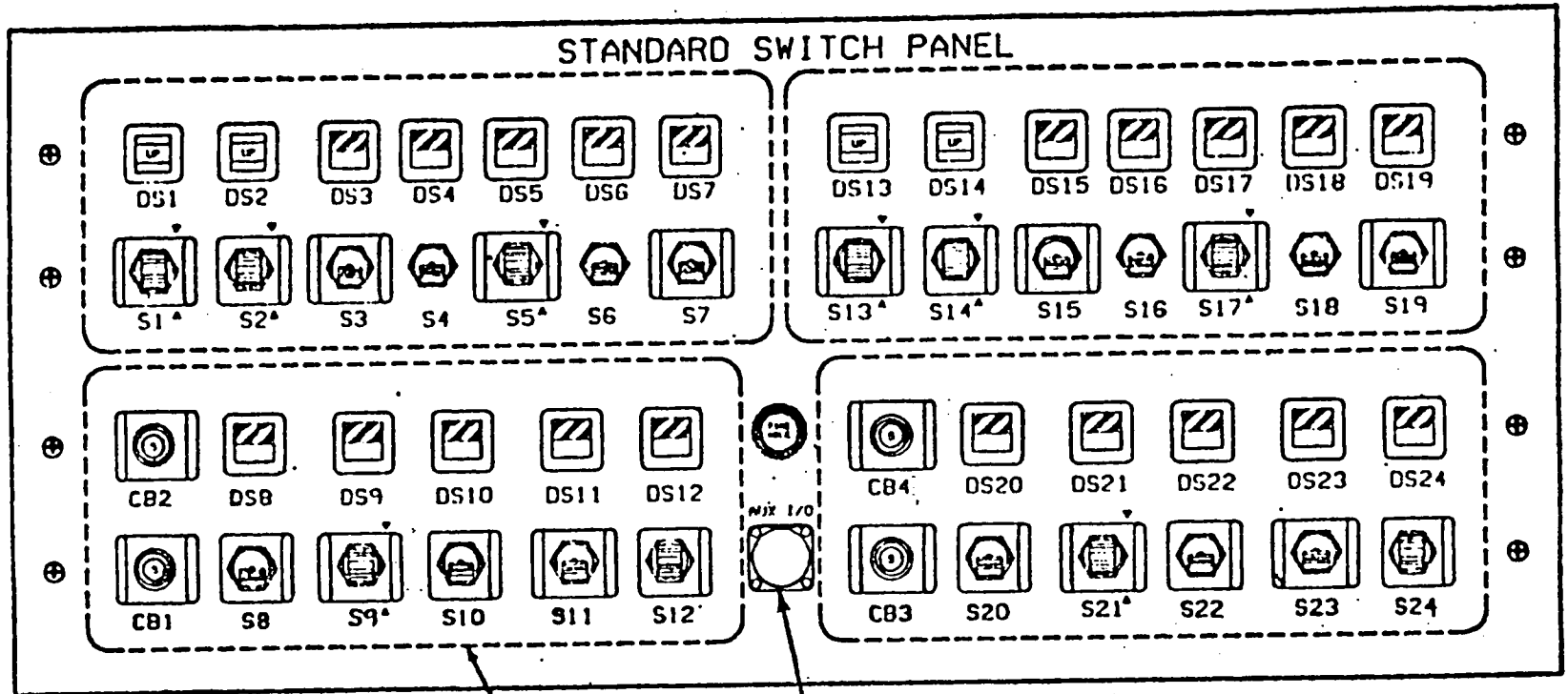
which comprise a section set.

Connector types and pin assignments for the standard mixed cargo harnesses, the standard AFD harness, and the T-0 umbilical harness are given in Section 13.0, Electrical Wiring Interface of ICD 2-19001.

3.1.2 AFD Control and Display Panels

One-half of a standard switch panel (SSP) provides twelve switches, twelve talkbacks, and one 5 Amp circuit breaker for each section (Figure 3-5). The standard switch panel also provides a DC power output connector for each section protected by a 5.0 Amp circuit breaker. Details of the panel devices and their connection to the standard AFD harness are in ICD 2-19001 Section 13.0. Experiment users are urged to use these switches to the greatest extent possible for direct hardwire control of experiments. AFD panel space is available for those users that provide their own unique switch panel for experiment control. The panel space is identified as L10 and L11, in Figure 2-6, with one fourth of the total space allocated for each quarter section user.

The STS has available, as an optional service, a Deployment/Pointing Panel (DPP) that provides arm and fire functions for pyrotechnic devices for user jettison systems. See figure 2-6 for panel location. The jettison panel provides ARM and FIRE functions to as many as eight output circuits, selected individually by a rotary selector switch. Non-standard cabling on the AFD is required to connect this panel to the standard bay harness. Two output circuits can be allocated to each section. The STS also provides a Video recording capability using the SSO Closed Circuit Television (CCTV) system. Currently the video recorder is located in panel space R-11 and is scheduled to fly on all STS missions. Utilization of this accommodation will be on a time-shared basis.



MARKING OF FOUR OVERLAYS TO BE DONE BY JSC PER INDIVIDUAL CARGO ELEMENT REQUIREMENTS (OVERLAY WILL COVER COMPONENT DESIGNATORS)

J14 (NBOE8-98SN) ①

NOTES:

① CONFORMS TO NASA SPECIFICATION 40M39569

Figure 3-5 Payload Standard Switch Panel

In addition to the SSP, each section is allocated one-half the volume of either the L-10 or L-11 console at the payload station (Figure 2-6).

3.1.3 Standard Avionics Accommodations

The following avionics accommodations are standard for each section for mixed-user flights. Figure 3-6 is a functional diagram of the SSO avionics systems for payloads.

3.1.3.1 Power/Energy

For ascent, on-orbit, and descent operations, each section will be allocated 12.5 KWH of electrical energy per day. During ascent and descent phases, DC power will be provided to each section from the Orbiter main DC bus at an average power level of 250 watts and with peak levels of 375 watts for no more than 2 minutes/mission phase.

During on-orbit operations, DC power will be provided to each section from the Orbiter main DC bus up to an average power level of 1.75 KW with peak current levels of 100 Amps for no more than 15 minutes in any 3-hour period of operation. Receipt by a payload section of higher average power levels (up to 100 Amps) is possible on a time-shared basis, but requires specific mission planning considerations which must be included in the PIP negotiations. Use of Orbiter power requires that the payload user provide fusing and crew controlled power disconnect capability, both in the cargo bay and in the AFD. User fusing for main DC power in the bay shall be limited to no more than 100 Amps per section.

3.1.3.2 Payload Data Interleaver (PDI)

The PDI is capable of receiving four simultaneous data streams. Each section will be allocated one input data terminal. PDI bit rates referenced in this paragraph include maximum bit rate (including payload oscillator excursions) and PDI overhead. PDI overhead (in bits per second) is calculated by multi-

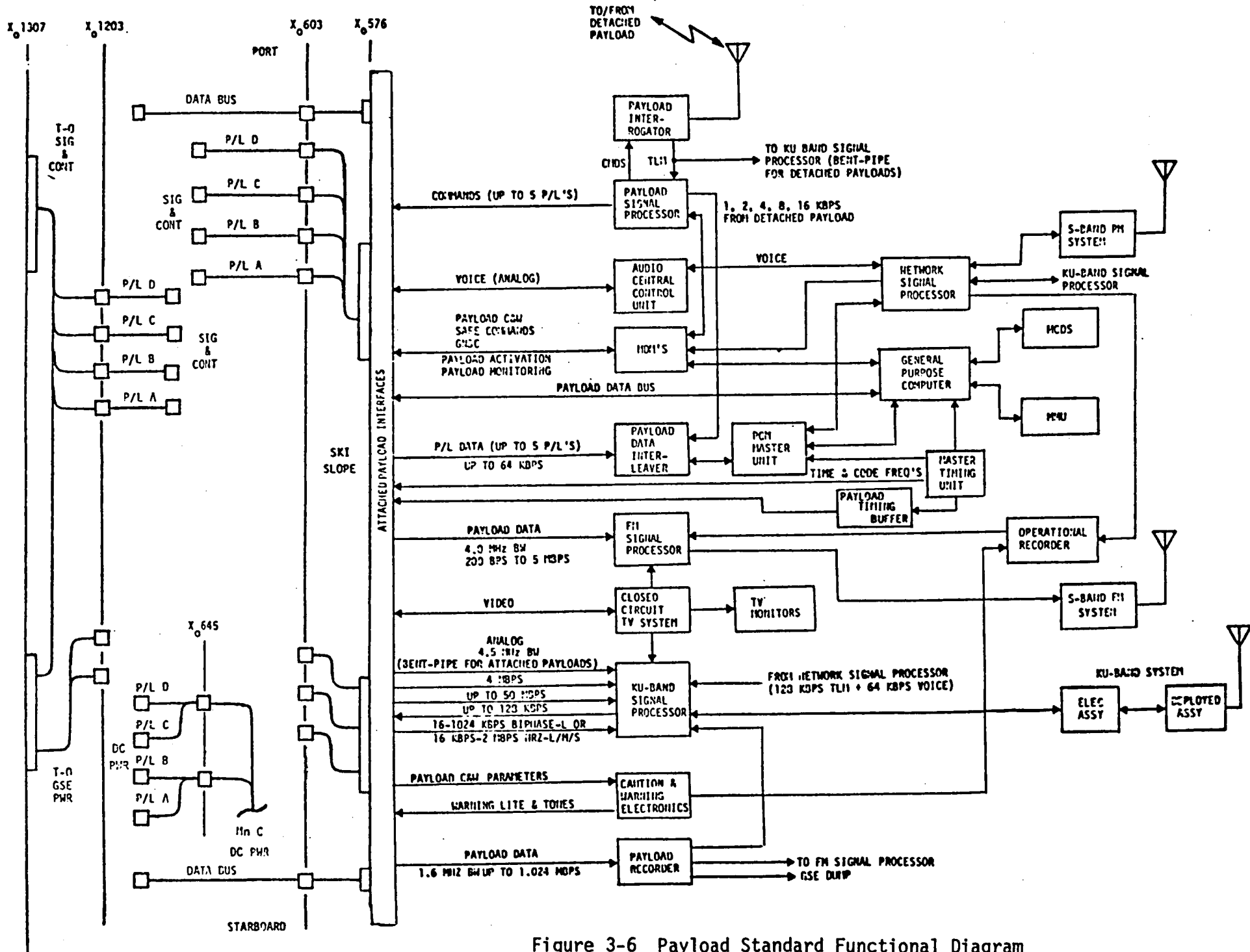


Figure 3-6 Payload Standard Functional Diagram

plying the payload minor frame rate in frames per second times 48. Payload downlink usage (via PDI) are constrained to multiples of 800 bits per second. During ascent, downlink telemetry will be limited to 1.6 Kbps/section. On-orbit, sortie payload downlink will nominally be limited to a 8 Kbps/ section with the use of the S-band PM system except during checkout and development of deployable payloads. During on-orbit operations, a payload section may downlink data at a maximum rate of 34.4 Kbps on a time-shared basis, for up to 20 minutes for predeployment and post retrieval checks. During these periods, other sections will be allowed to downlink a maximum of 1.6 Kbps each. Payload-originated GPC downlink data may be substituted for PDI downlink data on-orbit not to exceed 800 BPS per section.

When the Ku-band is operating on-orbit, a payload section may downlink data at a maximum rate of 68.8 Kbps on a time-shared basis, for up to 20 minutes for predeployment checks, with other sections allocated 1.6 Kbps each.

Payloads should plan to use those data rates consistent with the use of the S-band PM system, as the Ku-band system may be procedurally constrained from operation during on-orbit operations.

3.1.3.3 Payload Recorder

The Orbiter payload recorder provides both an analog and digital recording service to payload users. There are three parallel recording channels, one analog and two digital, allocated for each section. In its standard configuration, the payload recorder will be operated during ascent (10 minutes), descent (10 minutes) and payload deployments at a tape speed of 7.5 inches per second. Each section is allowed to specify ten minutes of recording on-orbit for deployment operations. Data may be recorded for any payload when the recorder is operating.

The recorder does not provide a time base, and any other user requirements must be provided in the user data stream. The maximum total running time of

the payload recorder will be sixty-four minutes.

3.1.3.4 Timing

Each payload section will be provided as standard two GMT and one MET (mission elapsed time) time code outputs in IRIG-B/modified code formats whenever the Orbiter is powered up. Signal characteristics are identified in ICD 2-19001, Section 8.0.

3.1.3.5 Multiplexer/Demultiplexer (MDM)

The following set of MDM functions is furnished to each section via the standard cargo bay harness:

- 8 - Discrete input, low level
- 8 - Discrete output, low level
- 2 - Analog input, differential
- 4 - Discrete outputs, high level

These I/O functions are exercised through the Orbiter GPC software defined in paragraph 3.1.3.8 below.

3.1.3.6 Payload Signal Processor (PSP)

The payload signal processor provides command data to attached payloads. Each section will be allocated one output. Each output is provided redundantly over separate wires from PSPs 1 and 2. The uplink is to be time shared on-orbit. Each section will be assigned a unique command address and the PSP will output commands only to payloads located in the designated section.

3.1.3.7 Payload Interrogator (PI)

Use of the payload interrogator will be time shared on-orbit. For payload

deployment, the use of the PI will be dedicated to the active payload for the deployment sequence. Payload selection will be accomplished by switching frequencies. The PI/PSP are capable of forwarding a maximum of 16 Kbps of telemetry data to the PDI and 2 Kbps of command data to the payload, subject to the limitations of Paragraph 3.1.3.2.

3.1.3.8 Software

The Orbiter General Purpose Computer can receive payload inputs from:

- a. The Orbiter payload MDM's (Paragraph 3.1.3.5).
- b. PI or PDI via PCMMU (Paragraph 3.1.3.2).
- c. Data bus terminal units (Paragraph 3.1.3.9).
- d. Orbiter uplink.
- e. MCDS (Orbiter CRT and keyboard) and output to:
 1. Orbiter payload MDM's (Paragraph 3.1.3.5).
 2. Data bus terminal units (Paragraph 3.1.3.9).
 3. Downlist via operational instrumentation link.
 4. Payload signal processor/payload interrogator.
 5. MCDS.

Onboard processing provided as a standard service for each section includes:

- a. 40 on-board initiated single commands.
- b. 40 analog or discrete parameters acquired.
- c. For acquired data:
 1. Crew display.
 2. Scaling, limit sensing.
 3. Conversion to engineering units.
 4. Downlist via PCMMU MDM - acquired parameters (See Section 3.1.3.2).

Data will be re-assembled on the ground and made available to the user in the PDI input form, provided the data can be downlinked at the PDI input rate

(Paragraph 3.1.3.2). When the PDI input rate does not match the downlink rate, the data are provided in a restructured format.

3.1.3.9 GPC Data Bus

Each payload section will be provided standard accommodation connections to the Orbiter GPC payload data buses. These connections are provided redundantly, one on the port side and one on the starboard of the cargo bay, and are not operated simultaneously. The interface between the payloads and the GPC data bus will be made through a payload-provided data bus coupler (Rockwell Specification Number MC 409-0020), Multiplex Interface Adapter (Rockwell Specification Number MC 615-0010), and Data Bus Isolation Amp (Rockwell Specification Number MC409-0019), as required.

3.1.4 Cooling

Cooling capability for the aft flight deck and cargo bay is provided per the following:

3.1.4.1 Aft Flight Deck (AFD)

During the on-orbit phase, each section shall be allocated 640 Btu/hr continuous cooling at either AFD panel of L-10 or L-11, based on an air flow rate of 101 pounds per hour.

During prelaunch, ascent, descent, and postlanding, each section will be limited to a maximum of 300 Btu/hr.

Use of the AFD cooling provisions will require the user to provide an inlet to outlet ΔP of TBD inches of water on his equipment.

3.1.4.2 Prelaunch/Postlanding Purge

Prior to closure of the Orbiter cargo bay doors, the cargo bay atmosphere will be controlled by the rotating service structure air conditioning system. Nominal temperature during this period will be $70^{\circ}\text{F} \pm 5^{\circ}\text{F}$. Following cargo bay door closure, a flow of conditioned gas (air and GN_2) will be provided in the cargo bay. The inlet temperature of this gas will be controlled at $65^{\circ}\text{F} \pm 5^{\circ}\text{F}$.

3.2 OTHER ACCOMMODATIONS OVER AND ABOVE THE STANDARD

Unique payload requirements not met by standard accommodations may be satisfied by other accommodations. The basic groundrule for standard accommodations is that they all be divisible by four, and equally accessible to each of four payload sections. However, many of the Orbiter accommodations are not divisible by four and cannot be provided to every section on each flight. Table 3-1 is a listing of both standard and non-standard SSO services. For mixed flight users, the availability of these accommodations is subject to conditional agreement with the STS in their Payload Integration Plan. The following constraints are conditions for agreement to providing these services.

- a. The user must demonstrate a requirement for the accommodation, i.e., he is not reasonably able to meet his objectives using standard accommodations.
- b. The time-sharing of these accommodations is subject to conditional agreements. The final STS commitment will be made at the Cargo Integration Review.
- c. User funding of unique integration hardware or software to provide these accommodations will be required.

TABLE 3-1. - PAYLOAD ACCOMMODATION STANDARD AND NON-STANDARD SERVICES MATRIX.

Services	Standard	Non-Standard
Main DC Power	X	
Aux DC Power		X
AC Power		X
Standard Switching Panel	X	
L-10 or L-11 Console	X	
CCTV Monitor/Video Recorder		X
Safing Switch Function		X
Orbiter CWEA		X
Jettison Panel		X
Manual Pointing Control		X
Payload Retention System		X
PDI	X	
PSP	X	
PI	X	
Payload Recorder	X	
Ku-Band		X
S-Band PM	X	
S-Band FM		X
Timing		
o GMT	X	
o MET	X	
o Frequency Reference		X
MDM		
o Discrete & Analog	X	
o Serial I/O		X
GPC Data Bus	X	
On-Board Processing S/W	X	
Cooling		
o AFD Air Cooling	X	
o Payload Heat Exchanger		X

3.2.1 Wiring and Harnesses

In addition to the standard cargo bay harness, each cargo section may utilize the following non-standard cable accommodations in the cargo bay.

- a. 3 COAX to AFD.
- b. 1 direct input to Orbiter CWEA.
- c. 1 hardwired safing switch function.
- d. Aux DC bus A power.
- e. Aux DC bus B power.
- f. AC2 Orbiter power.
- g. AC3 Orbiter power.

Utilization of the above services requires non-standard cabling in the cargo bay. Since these services are not partitioned into user-dedicated connectors, each cargo mix may require a non-standard integrated harness, the cost of which must be pro-rated among all users of the non-standard accommodation (Figure 3-7). In addition, a unique SIP may be required with the cost shared by users.

Certain other Orbiter avionics accommodations are accessible in the cargo bay by provision of non-standard cabling, but are not divisible for mixed cargo users. Utilization of these accommodations is subject to the conditions defined in Paragraph 3.2. They are:

- a. Closed circuit television inputs and outputs.
- b. Aft bulkhead power sources.
- c. 12 gage DC power cables to GSE via T-0 umbilical.
- d. 50 OHM Coax to GSE via T-0.

The aft flight deck standard harness may be supplemented or replaced by user-defined harnesses in order to connect user-furnished panels or other equipment within the limits of the wiring allocations of Figure 3-4. Additional

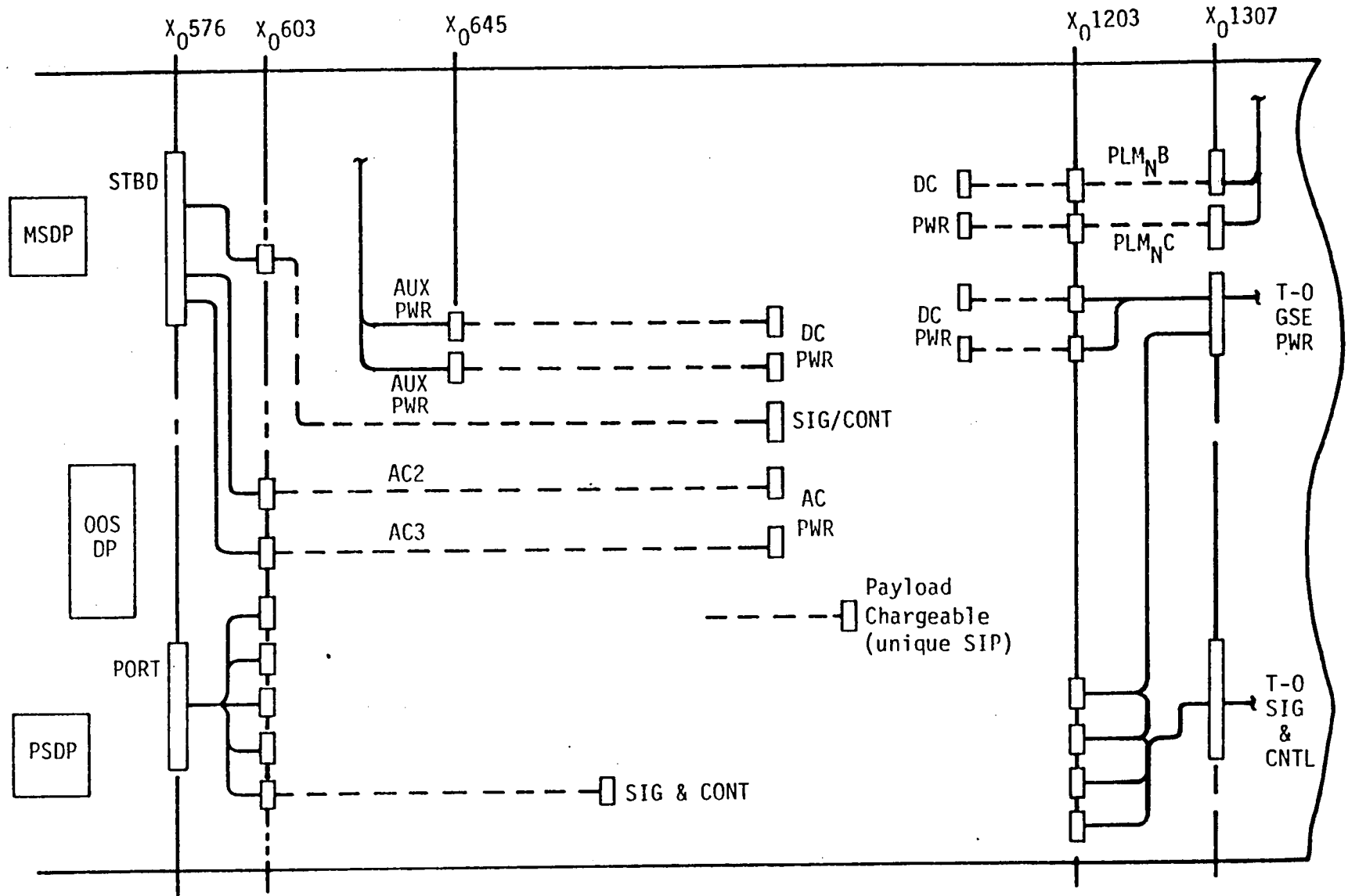


Figure 3-7 Payload Bay Non-Standard Cablinn

space required must be from the users allocation.

The AFD standard harness provides means for patching certain non-standard avionics services (Ku-band, S-band - FM, MDM serial input-output, etc.). Such patching will be in the form of a unique integrated harness.

3.2.2 Power/Energy

Orbiter power can be provided to each section as a non-standard accommodation as follows:

a. Ascent/Entry - Normal operations

Auxiliary DC power in bay	-	400 Watts average, 25 Amps peak for 2 seconds	} Ref: PIRN SD-254A
Auxiliary DC power in AFD	-	200 Watts average 25 Amps peak for 2 seconds	
AC power in bay and/or AFD (Entry Phase Only)	-	350 VA average, 420 VA peak for 2 minutes/phase	

Combined power for each section from main DC, Aux DC and AC buses in AFD shall not exceed 88 watts average, 105 watts peak for no more than 2 minutes/phase.

Combined power for each section from all main DC, Aux DC and AC buses in the Bay and AFD shall not exceed 250 watts average, 375 watts peak for no more than 2 minutes/flight phase.

b. On-orbit - Normal operations

- Auxiliary DC power in bay - 400 Watts average,
25 Amps peak for
2 seconds
- Auxiliary DC power in AFD - 200 Watts average,
25 Amps peak for
2 seconds
- AC power in bay and/or AFD - 690 VA average, 1000
VA peak for
2 minutes/3 hours

Ref: PIRN
SD-254A

Combined power for each section from main DC, Aux DC and AC buses in AFD shall not exceed 188 watts average and no more than 250 watts for two minutes during any three-hour period.

Combined power for each section from all main DC, Aux DC and AC buses in the AFD and Bay shall not exceed 1.75 KW average, 3 KW peak for no more than 15 minutes in any three-hour period.

c. All Phases - Emergency Operations*

- Main DC power - None
- AC Power - None
- Auxiliary DC Power - 50 Watts maximum average

*Loss of 1 or 2 fuel cells, loss of a freon loop or loss of cabin pressure.

During normal operations, additional AC can be provided to a payload section for short-term operations on a time-shared basis, and must be included in the PIP negotiations. Additional AC and DC utility power outlets are available in the AFD and mid-deck cabin areas for payloads as a non-standard service and require PIP negotiations for their use. Use of Orbiter power requires that the payload user provide fusing and crew controlled power disconnect capability in the cargo bay and in the AFD. Voltage characteristics are

specified in ICD 2-19001, Section 7.

3.2.3 Avionics Services

3.2.3.1 Ku-Band System

The Orbiter Ku-band system direct input is available only on a time-shared basis to a payload. Since only a single input to the Ku-band is available, the user or users may be required to provide a signal switching function in order to allow other payloads access to the Ku-band. For mixed user flights, where some payloads are incompatible with Ku-band operation, those payloads will be deployed prior to its use.

3.2.3.2 S-Band FM system

The Orbiter S-band FM system is available only on a time-shared basis to a payload. Each user must fund unique AFD cabling required for access to the S-band FM system. Since only a single input to the S-band FM is available, the user may be required to provide a signal switching function in order to allow another payload access to the S-band.

3.2.3.3 MDM Serial I/O Channels

Two Orbiter MDM serial I/O channels are available through user-funded special Payload Station Distribution Panel (PSDP) wiring. Users with a load factor equal to or greater than 3/8 are entitled to one I/O serial channel. Users with a load factor less than 3/8 may gain use of a serial I/O channel per the conditions of Paragraph 3.2.

3.2.3.4 GPC Software

Commands and onboard CRT data display, in excess of those defined in Paragraph 3.1.3.8, are non-standard. The basic capability to store command sequences in

the GPC and initiate them via PSP or MDM is provided.

When an MDM serial channel is selected as an option, a standard set of GPC software is included. During the on-orbit flight phase, this includes a standard communication convention, GN&C data in the standard format and limited command and onboard CRT display.

If the section user provides a data bus terminal unit which meets the Orbiter data bus interface requirements, the GPC can support it with one serial I/O channel as well as command and onboard CRT display. Support services are the same as for the Orbiter MDM. If a section user provides a second terminal unit, it must be for redundancy purposes only. Characteristics of the GPC software are defined in ICD-2-19001, Section 9. In addition, special data processing in the GPC to user specifications may be negotiated.

3.2.3.5 AFD Control and Display Panels

Non-standard control and display panels furnished by the STS are manual pointing control and a panel-mounted CCTV monitor and a jettison panel.

The manual pointing control unit provides analog and discrete outputs for control of a pointing system or other crew operated device. Wiring to this control unit requires a non-standard wiring harness. The control unit is capable of outputting to the Orbiter GPC via a MDM, or to a user device.

The panel-mounted CCTV monitor is designed for mounting in panel R-11 (See Figure 2-6) in the AFD. It receives input video from the Orbiter CCTV system. Wiring to this monitor is furnished with the system.

For mixed-cargo users, the above accommodations can be made on a time-shared basis.

The jettison panel provides ARM and FIRE functions to as many as eight output circuits, selected individually by a rotary selector switch. Non-standard cabling on the AFD is required to connect this panel to the standard cargo bay harness. Two output circuits can be allocated to each section.

3.2.4 Cooling

3.2.4.1 Payload Heat Exchanger

The payload heat exchanger has two coolant passages available for total payload utilization. Users with a load factor equal to or greater than $3/8$ are allocated use of one passage as standard accommodation. Users with a load factor equal to or greater than $7/8$ are allocated both coolant passages and/or double the cooling capacity of a single allocation. Users with a load factor of less than $3/8$ may gain access to the payload heat exchanger provided he complies with the provisions of Paragraph 3.1.2.

The single passage allocated cooling capacity available on orbit is 14,500 Btu/hr or 10,750 Btu/hr with and without radiator kits, respectively.

Interconnecting plumbing between the heat exchanger and the payload will be user furnished, and the user is responsible for fluid circulation. There is no routing path for this plumbing except through the payload envelope.

3.2.4.2 Prelaunch/Postlanding Spigot Cooling

Ground-supplied conditioned gas (air and GN₂) can be provided directly to a user through the Orbiter spigot system. User provided ducting is required from spigot to payload. This accommodation is provided on a shared basis with gas conditions and flow negotiated with the individual user. Gas condition and flow capability is defined in ICD-2-19001.

3.2.5 AFD Panel Space

Additional panel and mounting space is available in the AFD as shown in Figure 2-6. No standard cable or cooling accommodations are available at these locations.

3.2.6 Payload Retention System

Operation of Orbiter deployable retention fittings, or operation of user-supplied devices through the Orbiter retention system electrical subsystem, requires provision of a patch harness in the Orbiter. The harness will connect up to five selected sets of three electrical receptacles on the cargo bay longerons or at keel fitting locations to selector switch positions at Orbiter panel A6 (orbit station). Five selector switch positions are provided. The retention system electrical power is 115 VAC 3 phase with each phase fused at 3 amps.

4.0 SAFETY CONSIDERATIONS

The NASA has established a set of safety requirements that are applicable to all cargo elements that plan to use the STS. These requirements are defined in NASA document NHB 1700.7A, Safety Policy and Requirements for payloads using the STS. Among these requirements is one that is directly applicable to large space structure experiments: (Section 202, page 2-4)

"Deployment/extension preventing payload bay door closure.

If during planned payload operations an element of the payload or any payload support equipment violates the payload bay door envelope, the hazard of preventing door closure must be controlled by independent primary and backup methods, and this combination must be two failure tolerant."

The SSO/experiment carrier can provide the following capabilities in support of contingency or emergency conditions. It is presumed that 400 Hz drive motors will be used for deploy/stow sequences.

- a. An AC power source that by-passes the power distribution box and is controlled by crew command. This power source is either AC #2 or AC #3, depending on which source is used for normal operations.
- b. An AC power source provided by the payload retention system. This source can be connected dual redundant and is also crew controlled.
- c. Crew Extra Vehicular Activity (EVA). The experiment must be EVA compatible and an EVA-safe corridor must be provided through the cargo elements volume.

In addition, a jettison capability is required. A universal jettisonable mounting base will be provided by the experiment carrier when candidate

experiments are identified. This jettison capability will include pyro activated cable cutters and clamp rings.

The SSO Remote Manipulator System (RMS) will be used to control the jettisoned experiment to preclude damage to the SSO. Experimenters will be required to incorporate a GFE supplied grapple fixture on their experiments to be compatible with the RMS.

5.0 KSC GROUND PROCESSING

This section provides the prospective payload user with an overview of the primary accommodations provided by the Kennedy Space Center (KSC) for pre- and postflight processing. A detailed description of the management roles of the KSC organizations, the launch site host role, payload processing guidelines and the launch site planning process is contained in the Launch Site Accommodations Handbook for STS Payloads, K-STSM-14.1. Shuttle launches will also be possible from the Vandenburg Air Force Base (VAFB) beginning in late 1985. VAFB accommodations are beyond the scope of this document, but are described in the K-STSM-14.1 Handbook.

The facility accommodations available to the user as identified herein provide support to all elements of the mission manifest and to other missions being processed simultaneously. The user must remain cognizant during his design development of the necessity to share these facilities. Especially in cases where the facilities will be required for days as opposed to hours, or when required during major integrated tests, the designer should coordinate his requirements closely with KSC. An example of such a case would be GSE interfaces to the facility. These are required for long periods of cargo testing by all elements of the mission, by the spacecraft, upper stages, and experiment pallets.

5.1 OVERVIEW

Figure 5-1 shows a pictorial map of the launch facilities at the Eastern Test Range (ETR). The ETR is comprised of the NASA Kennedy Space Center, located on the west side of the Banana River, and the Cape Canaveral Air Force Station (CCAFS) on the east side. Payloads to be carried by expendable launch vehicles are processed on the CCAFS side and launched at the Delta, Centaur, and Titan complexes. Department of Defense (DoD) payloads to be carried by the Shuttle are also processed on the CCAFS side at the Shuttle Payload Integration Facility (SPIF). These payloads are transported directly from the

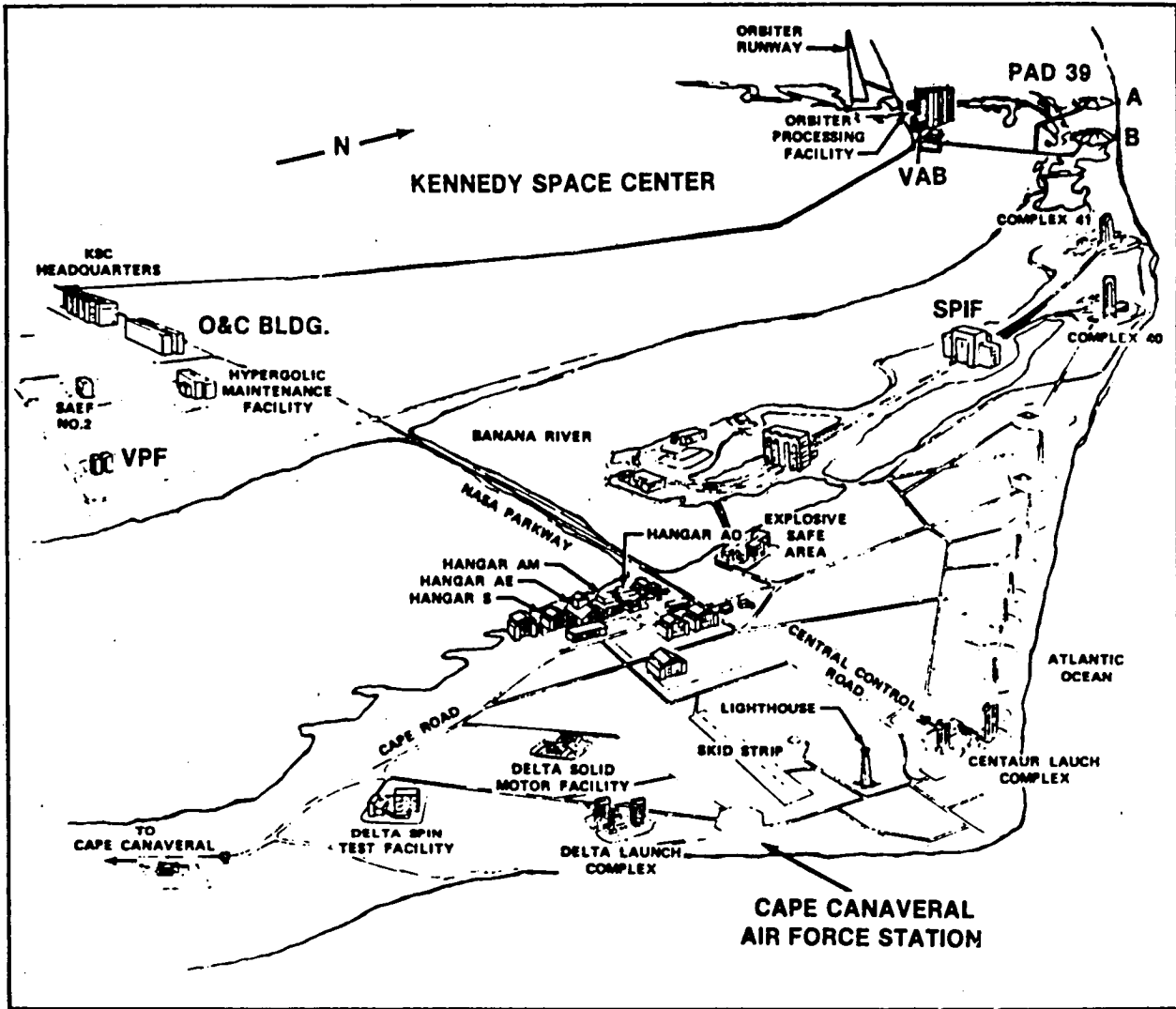


FIGURE 5-1. EASTERN TEST RANGE

SPIF to Launch Complex 39 for vertical installation into the Shuttle cargo bay.

Non-DoD payloads for the Shuttle are processed on the KSC side of the ETR. These payloads fall into two main categories, deployable and attached, and most use the Standard Mixed Cargo Harness (SMCH) for economical reasons. Figure 5-2 shows the overall ground flow of the payloads as they are readied for launch. In order to obtain the shortest shuttle turnaround, simulated Orbiter-to-cargo interface verification is conducted prior to installation in the Orbiter. This is done in the SPIF for DoD cargos and in the Operations & Checkout (O&C) Building or Vertical Processing Facility (VPF) for non-DoD payloads.

Deployable payloads are transported to the VPF usually after they have been mated with their orbital transfer stages. The Payload Assist Module (PAM) is used to illustrate this flow in Figure 5-2, although the Inertial Upper Stage (IUS) and eventually the Centaur are other carriers processed in the VPF.

Attached payloads are received into the O&C Building for processing. Provisions are available in this building for payload component storage, initial checkout, and integration with the carrier. Examples of SMCH carriers for attached payloads include the Spacelab Pallet System (SPS) and the NASA Multi-Purpose Experiment Support Structure (MPRESS). More detail is provided on the O&C Building in Section 5.3. Upon completion of integration and checkout, the cargo element (consisting of the payload and its carrier) is integrated either horizontally or vertically with the other cargo elements comprising the total cargo.

If the cargo is to be integrated horizontally, the cargo element and all payload equipment to be flown in the aft flight deck are transported to the Orbiter Processing Facility (OPF) for installation in the Orbiter. The Orbiter-to-cargo element interfaces are then verified. The Orbiter, with its fully integrated cargo, is then transported to the Vertical Assembly Building (VAB) where it is raised to the vertical position and mated with

5-4

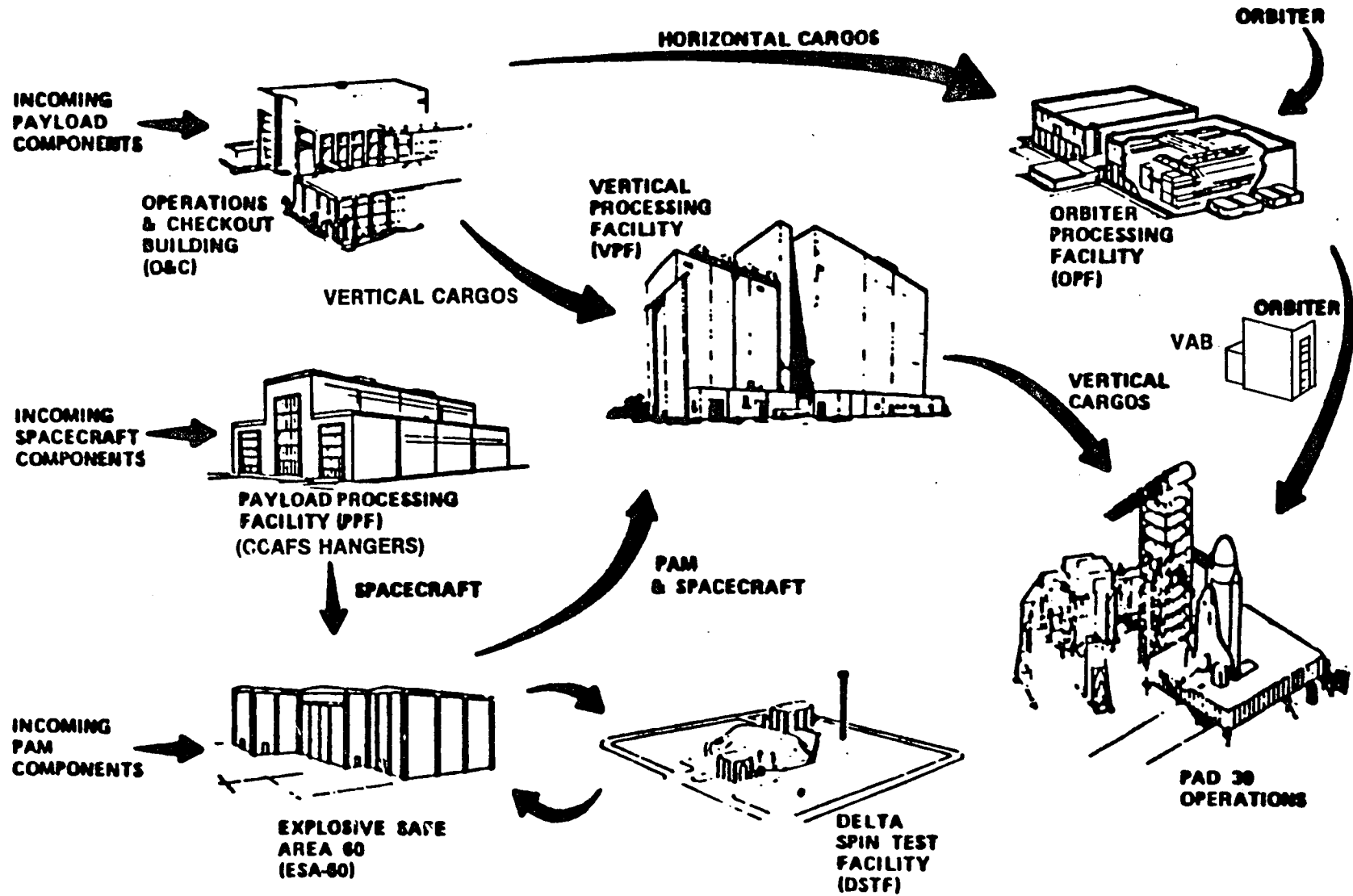


FIGURE 5-2. FLOW FOR MIXED PAYLOADS

two Solid Rocket Boosters (SRB's) and an External Tank (ET). The resulting launch configuration is transported to the pad via the Mobile Launch Platform (MLP) for launch.

If the cargo is to be integrated vertically, the cargo element must be raised to the vertical position and transported to the VPF for cargo integration. After checkout in the VPF, the cargo is transported to the pad for installation into the cargo bay of the Orbiter. Payload equipment to be flown in the Aft Flight Deck (AFD) must be transported to the OPF for installation in the Orbiter.

The decision of horizontal versus vertical integration is made by NASA and can have an impact on the user. For example, in the horizontal case, both the AFD and cargo bay payload equipment are integrated into the Orbiter at the same time in the OPF. By contrast, in vertical integration, the AFD and cargo bay equipment are tied together for the first time on the launch pad. Obviously, working conditions on the pad are less than optimum and any malfunction of payload equipment can be very expensive to correct. Another factor in the vertical case is that the VPF, unlike the OPF, is an explosive safe area because of the orbital transfer stages handled there. As a result, access to the VPF is more limited in the interest of safety.

The following sections give more detail on handling, support and integration of payload equipment at KSC.

5.2 PAYLOAD HANDLING AND SUPPORT EQUIPMENT

KSC follows a "host" concept applicable to all STS users. Under this concept, all non-unique interfaces and services are made available to all users. Arrangements for the KSC facilities and services required by the payload are made through a Launch Site Support Plan (LSSP) usually prepared 18 to 24 months prior to launch. KSC appoints a Launch Site Support Manager (LSSM) to serve as a single point of contact for the user

for administration of the LSSP. Any non-standard facilities and/or services required by the user are included in the LSSP and must be paid for in advance by the user. Policy and prices for these services are described in "STS Reimbursement Guide", JSC 11802. Effort is underway to develop optional services packages which can be offered to users for a fixed price. These prices will be added to the Reimbursement Guide as they become available.

Transportation of payload pieces from off-site facilities to KSC is the responsibility of the users. Any special handling equipment is also a user responsibility. Packaging and transportation mode are user options, provided they are consistent with KSC safety requirements. In special cases, the Pallet Environmental Transportation System (PETS) can be made available to support unique payload requirements. The user also transports to KSC the non-standard GSE required to support his ground operations and makes arrangements for its return.

After the payload pieces (including experiment packages) arrive at KSC, all handling and transportation are the responsibility of KSC. Adequate trucks, cranes, dollies, fork lifts, etc. are part of the capabilities.

Transportation between the O&C Building, Vertical Assembly Building (VAB), VPF, and pad is provided by the Multiuse Mission Support Equipment (MMSE) canister and transporter (Figure 5-3). The MMSE provides environmental control, power, fluids and gases as required and a cushioned ride. The canister can be carried by the transporter in either the vertical or horizontal position, but must be taken to the VAB in order to change positions.

The various pieces of the payload should arrive at KSC completely checked out, ready to be installed onto the carrier at the start of the integration activity. Any special test equipment, handling equipment, and data reduction systems are to be delivered with these elements.

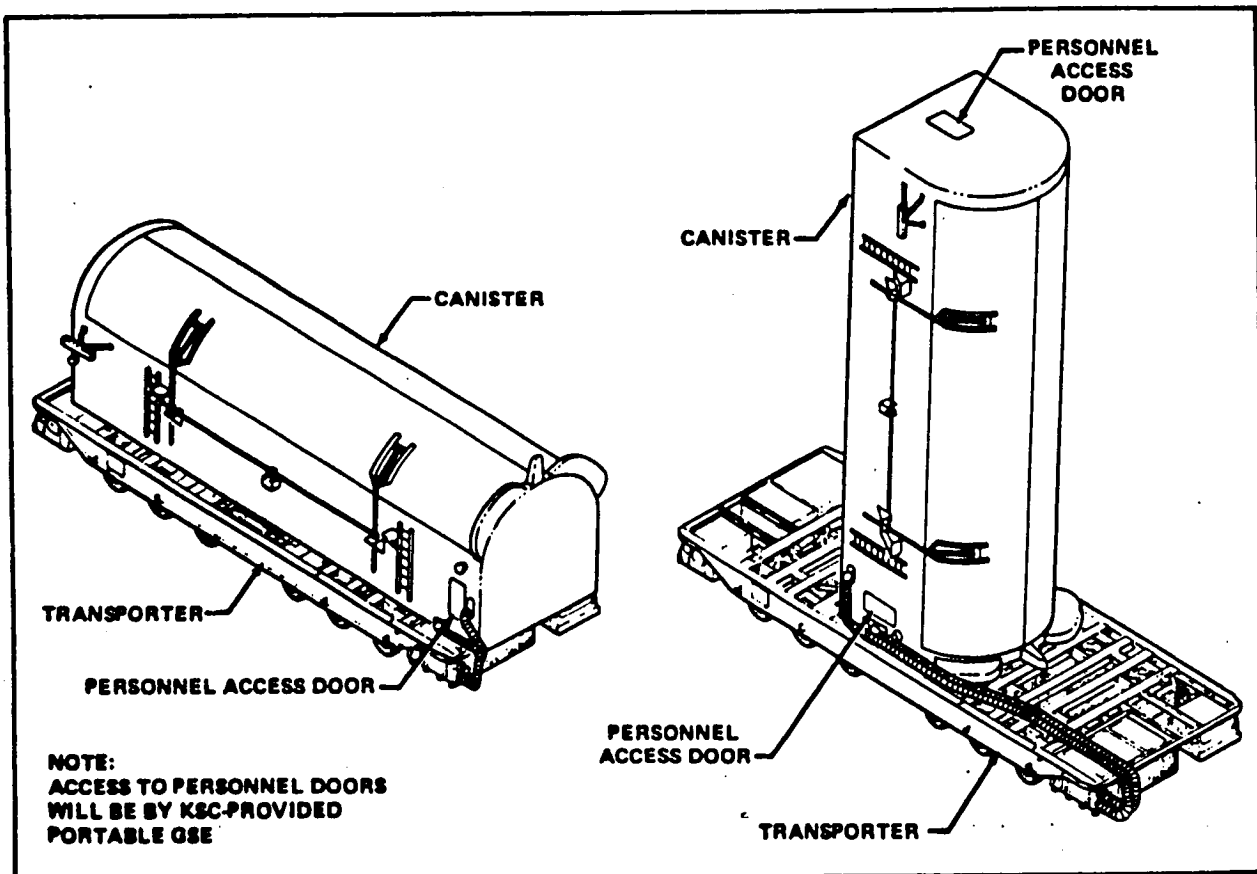


FIGURE 5-3. PAYLOAD CANISTER SHOWN MOUNTED ON ITS TRANSPORT

When payload-to-carrier integration and test in the O&C Building is completed, the cargo element is loaded into the canister. If the integration mode is horizontal, the canister is transported to the OPF where the cargo is transferred into the Orbiter cargo bay. If the integration mode is vertical, the canister is rotated to the vertical and transported to the VPF. When cargo integration in the VPF is complete, the canister is again employed (in the vertical position) to transport the cargo to the pad. Upon arrival, the cargo is transferred into the Orbiter. Interfaces with Orbiter are verified and final installation/connection of cargo ordnance is completed.

Special requirements for such things as continuous purge, battery charging, and super-cooling will require early identification to be accommodated. Special GSE and facility modification may be required to satisfy such requirements. The major facilities at KSC are environmentally controlled. Additionally, the Shuttle is purged with conditioned air in order to meet environmental requirements for both the Shuttle and the payload. However, when operations are completed in the OPF, the Orbiter is powered down and no power or purge is available until completion of the Shuttle vehicle assembly in the VAB. This is a period of about 35 hours. Following completion of VAB activities, air purge of the cargo bay is resumed, supplied by the Mobile Launch Platform (MLP). Approximately 5-1/2 hours before lift off, the purge is switched to gaseous nitrogen in order to maintain an inert payload bay during launch.

5.3 O&C BUILDING ACCOMMODATIONS

The O&C Building is a five-story structure containing 600,000 ft² of offices, laboratories, astronaut quarters, and payload Assembly and Test (A&T) areas. It is in the KSC Industrial Area immediately east of the KSC Headquarters Building. The O&C Building A&T area was used for assembly and test of the Apollo spacecraft during the Apollo Program and has been modified for the STS era.

The O&C Building is designed to accommodate attached payloads including special structures, Spacelab configurations, and certain other STS cargos. These payloads are generally processed through payload-to-carrier, cargo element-to-cargo, cargo-to-simulated Orbiter integration and postlanding deintegration.

The O&C Building is divided into four basic areas (Figure 5-4):

- a. Administration
- b. Laboratory, Control, and Monitor
- c. Assembly and Test (A&T)
- d. Service and Support

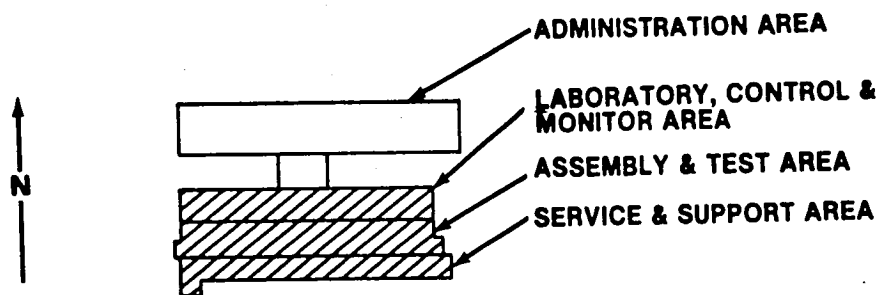


Figure 5-4. O&C Building Key Plan

Actual hands-on mechanical and electrical payload and cargo integration are performed primarily in the A&T area. Laboratories and shops provide the off-line payload support to the integration conducted in the A&T area. Control and monitor functions are provided in support of the A&T integration. The service area contains support systems for the A&T area such as shipping and receiving, air-conditioning, and vacuum pumping. Bonded storage areas are included in the shaded portions of Figure 5-4. Access to the shaded portions is controlled. A KSC badge and area permit with number 16 and the letter D are required for access.

The A&T area in the O&C Building (Figure 5-5) is divided into a high bay area 175 ft long and 104 ft high, and a low bay 475 ft long and 70 ft high. The high bay on the east end contains the storage and refurbishment area for the Multiuse Mission Support Equipment (MMSE) Strongback which is used for handling the horizontally integrated cargo in the O&C Building and in the OPF. The high bay also serves as the parking area for the MMSE payload canister and transporter during cargo preparation and canister loading for transport.

The low bay is the main A&T area for horizontally processed payloads. The major facility elements in the low bay are:

- a. Two experiment integration stands
- b. Two integrated assembly and checkout workstands
- c. One Cargo Integration Test Equipment (CITE) workstand

The A&T area processing activities include staging, experiment integration, cargo integration and verification (at CITE stand), and postlanding deintegration for horizontally processed payloads. The A&T high/low bay area provides a visually-clean working area. Air quality is rated Class 100,000 clean. Temperature is regulated and humidity is maintained below 50%.

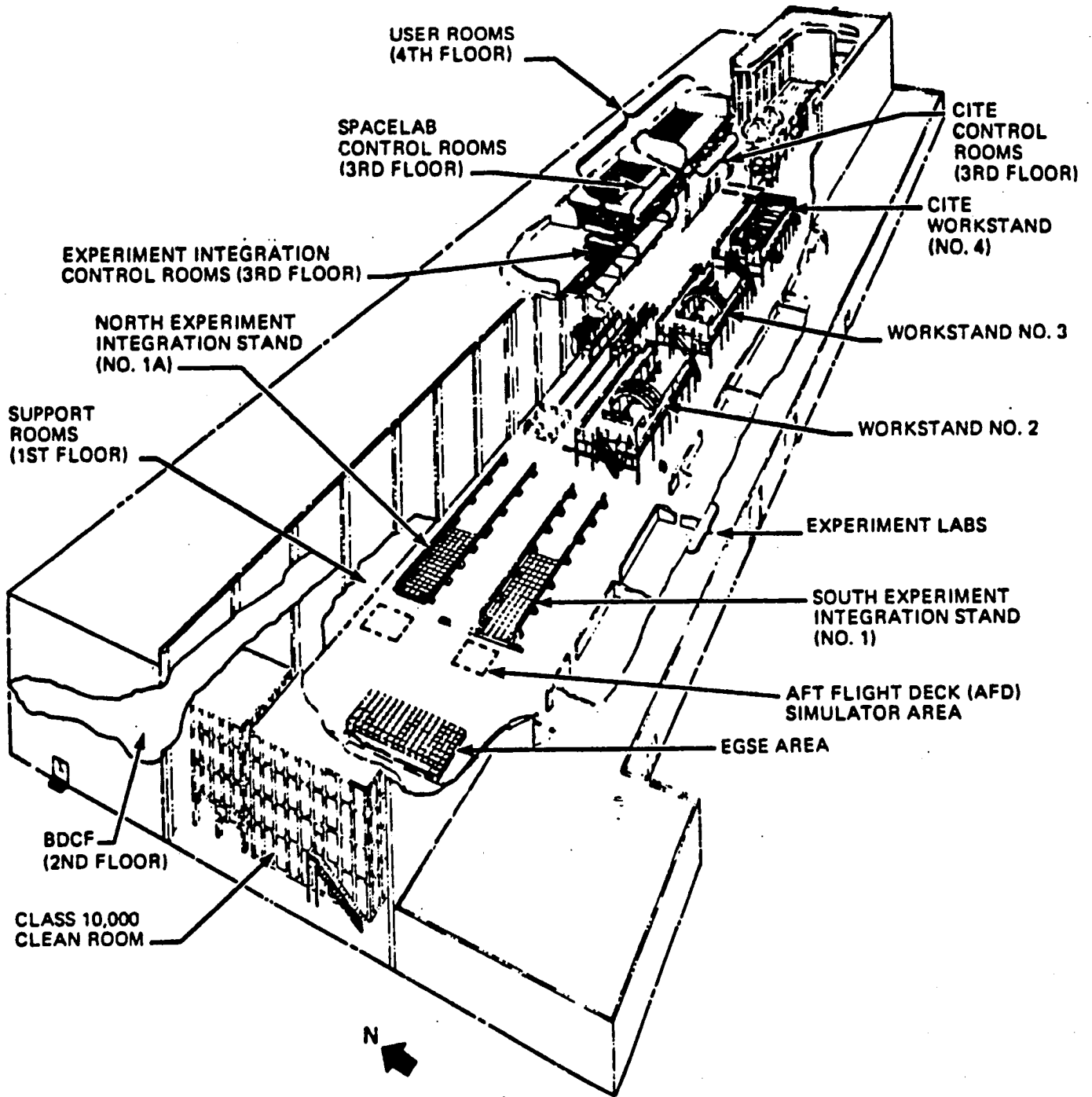


FIGURE 5-5. O & C BUILDING A & T AREA LAYOUT

Mechanical and electrical GSE and services required to support payload assembly and testing are located on and around the workstands. The GSE and services available include ac and dc power, compressed air, fluids, gases, and handling and access equipment. AC power of 120/208V, 60 Hz, 1 and 3 \emptyset , 20 and 30 A and 480V, 60 Hz, 3 \emptyset , 30 A is located on the north and south walls of the A&T area. Three overhead electrical bridge cranes service the A&T area. One crane services only the high bay area while the other two cranes service both the high and the low bays. The lifting capability of these units is 27.5 tons.

The following communications and data handling services are available:

- (1) Operational Intercommunications System (OIS). The OIS is a multi-channel voice communication network that interconnects operational areas required for payload processing at KSC and the Cape Canaveral Air Force Station (CCAFS).
- (2) Operational Television (OTV). OTV can provide video surveillance and recording of payload processing in the operational areas to control and monitor areas in the O&C Building.
- (3) Telephones. The A&T area contains commercial telephones in several places available from floor level.
- (4) Paging and Area Warning System. The high and low bays are part of the KSC All Area Paging and Area Warning System.
- (5) Timing. Timing in standard Inter-Range Instrumentation Group (IRIG) A, B, and H formats for Greenwich Mean Time (GMT) and Mission Elapsed Time (MET) is provided in the A&T area. Countdown clock displays are located on or near each workstand.

- (6) Workstand Bulkhead Interface Assembly. Each workstand has wideband transmission lines for command and data transmission between user rooms and workstands.
- (7) S-Band Antenna. There is a rotor-equipped S-band antenna on the high bay roof for S-band communication with other buildings in the area.

The following subsections describe in the chronological order of their use the O&C Building facilities used in the processing of a typical payload. These are (1) the Experiment Labs, (2) the Experiment Integration Stands, (3) Workstands 2 and 3, and (4) the CITE (Cargo Integration Test Equipment) Workstand. Flight hardware generally flows from west to east in the A&T low bay as the integration process occurs.

5.3.1 Experiment Labs

The O&C Building contains laboratory and shop areas to support the STS and payload ground processing activities, as well as the routine operations and maintenance of the KSC facilities. Use of these laboratories and shops and their services must be requested and scheduled as an optional service. Some of the areas are dedicated for payload support; other areas can support payload activities on an as-available basis only.

The experiment laboratories (See Figure 5-5) are a group of rooms on the first and second floors of the O&C Building that are assigned for particular experiment off-line operations. They are used for both preflight and postlanding operations.

The air handling equipment in these laboratories, as for most of the O&C Building, is set to maintain the temperature between 65°F and 80°F with a maximum relative humidity of 60%.

The cleanliness level of these laboratory areas is maintained at least to Class 100,000 requirements.

Each off-line laboratory has single phase, 60 Hz, 120V ac power receptacles. Some 208V ac, 3 \emptyset power is available.

All areas have telephones and the public address system.

5.3.2 Experiment Integration Workstands

The Experiment Integration Stands (No. 1 and No. 1A) are located in the west end of the A&T area (See Figure 5-5). The purpose of the Experiment Integration Stand is to provide a work area for the mechanical assembly of payload hardware to the carrier. This process is referred to as "Level IV" integration. The Level IV stands (No. 1 and No. 1A) are equipped with bridge structures which simulate the rails in the Orbiter cargo bay. The reusable carrier hardware complement required by the payload is "staged" and installed in the Level IV stand via its longeron trunnion fittings as in the actual Orbiter cargo bay.

The Level IV stands are operated by KSC personnel, and although procedures are less formal than in Workstands 2, 3, and 4, some documentation is required from the user. Responsibility for handling payload hardware passes from the user to KSC when Level IV integration commences and remains with KSC until the hardware is returned to the user after the mission.

At Level IV, testing verifies experiment interfaces and experiment-to-experiment compatibility. This checkout consists of the integration and checkout of experiment equipment with the individual experiment mounting element, such as the pallet. Level IV is a KSC "hands-on" experiment integration controlled by the Ground Integration Requirements Document (GIRD) and Test Assembly Procedures (TAPS) system with 72 hour/11 day schedules. Users are expected to contribute to these schedules and define

any special experiment requirements.

At the completion of Level IV integration and testing, the Keel Fitting will be installed and aligned, and weight and CG activities will be performed. This may be accomplished at any workstand available and convenient to the mission flow.

5.3.3 Workstands 2 and 3

Payloads being carried on dedicated Spacelab missions and mixed cargo payloads using the "Igloo" configuration of the Spacelab Pallet System (Refer to the SPS Payload Accommodations Handbook, MDC G9836B) are transferred from the Level IV stand to either Workstand 2 or 3 (they are identical) for continuation of the integration, test and checkout process. This activity is referred to as "Level III/II" integration and has the primary purpose of verifying the rather complex avionics interface between Spacelab and its payload. All operations in these stands are performed by resident KSC contractor personnel using formal, computerized Operations and Maintenance Instructions (OMI's) and automatic test equipment.

5.3.4 CITE Workstand

Workstand 4, the CITE stand, simulates the Orbiter accommodations for all payload interfaces. The CITE is used to verify compatibility between payloads/cargos and the simulated Orbiter mechanical and electrical/electronic interfaces. Closed-loop Payload Operations Control Center (POCC) interface tests, when required by the payload, are conducted with the payload in this stand.

CITE testing will include an interface verification test, a mission-sequence test (if appropriate), required cargo element tests, and operations to validate planned on-line pre- and postflight operations including emergency, contingency, and scrub/turnaround procedures. A time-compressed mission

sequence test will be included when it is judged to be an effective demonstration of multiple systems compatibility, either cargo-to-cargo or cargo-to-Orbiter. During CITE testing, participation will include payload owners and flight crew members. A block of serial time is provided for payload-peculiar operations.

The mechanical equipment located on this stand includes an AFD structure, a forward Cargo Bay bulkhead assembly, an aft bulkhead assembly, simulated Orbiter cable trays, fluid lines, and a midbody assembly. Openings are provided to duplicate Orbiter access hatches..

The AFD Simulator provides a working platform and support for a Payload Specialist Station (PSS), an On-Orbit Station (OOS), and a Mission Specialist Station (MSS). Space is available for mission-peculiar consoles and electrical interface panels.

At the CITE Workstand all cargo elements are mated. The total mission cargo interfaces are checked out with a simulated Orbiter. Cargo interface tests, using flight software in a ground version General Purpose Computer (GPC), will be performed along with any required experiment alignment checks. When required, the full mission cargo interface test and Mission Control Center (MCC)/Payload Operations Control Center (POCC) closed loop test are completed in the CITE.

5.3.5 Control and Monitoring

Within the O&C Building is the control and monitoring area for horizontal payload processing. This includes the experiment integration control room, the Spacelab control rooms, the CITE control room, and three user rooms.

The experiment integration control room, located in Room 3259, is used for control and monitoring of experiment integration testing and for processing

and monitoring data transmitted via the Spacelab.

The Spacelab control rooms (Rooms 3247 and 3251) house computer-controlled equipment used for electrical power-up testing of the Spacelab in the A&T area.

The CITE control room, located in Room 3233, contains hardware like that developed for the KSC Launch Processing System (LPS). This LPS-type hardware is integrated with the CITE electrical/electronic set test stand hardware to provide display, monitoring, control, data conversion, and data processing for the cargo interface verification. The test stand hardware serves as the simulated Orbiter interfaces to the cargo. Cargo interface verification for both vertically and horizontally processed payloads is conducted from Room 3233.

The user rooms are located on the fourth floor of the O&C Building in Rooms 4239 and 4245 (User Room C), Rooms 4249 and 4255 (User Room B), and Room 4265 (User Room A). Each room may be divided by sound-absorbing moveable partitions to accommodate the space requirements of the experiments assigned to the mission.

The support provisions in the user rooms include lighting, environmental control, electrical power, intercom, master timing signals, and signal distribution interfaces with the workstands in the A&T area. User provided ground support equipment on the integration floor and in the user rooms can be interconnected by means of dedicated twisted shielded pair cables and coaxial cables.

5.3.6 Miscellaneous Support

Miscellaneous support available as optional services include clean rooms, biomedical support, human life sciences support, material analysis, electronics lab, environmental test lab, fluid mechanics, machine shop, photo/optical lab, and bonded storage.

5.4 VERTICAL PROCESSING FACILITY

The Vertical Processing Facility (VPF) is functionally similar to the CITE Workstand in the O&C Building, previously described in Subsection 5.3.4. The differences are (1) all work is performed with the simulated cargo bay in the vertical position, and (2) deployable as well as attached payloads are processed. Integration activities in the VPF will include installing payloads into a workstand in their relative flight positions, conducting simulated Orbiter-to-cargo interface verification tests, and performing pre-Orbiter tasks such as category B ordnance installation and connection.

The VPF consists of an environmentally-controlled high bay and airlock and single-story support structures attached directly to the sides of the high bay. An external view of the VPF is shown in Figure 5-6.

Before entry into the high bay, cleaning operations for carriers, payloads, and transporters will be conducted in the airlock. Environmental cover removal, hazardous gas checks, and receiving inspections and preparations for entry into the high bay may also be performed in the airlock.

The high bay houses two cargo workstand cells located in the north end of the building. Cargo elements are installed in the workstand as they will be in the actual Orbiter cargo bay on the pad. Simulated Aft Flight Deck racks are provided on top of each cell where user control panels and other AFD equipment can be mounted and checked out.

Several support rooms are located in single-story support structures on each side of the high bay, including a T Minus Zero (T-0) umbilical integration area, an electrical equipment room, a RF-test equipment room, and a workroom with one window for viewing the high bay. Along the west side of the high bay are the special areas for cleaning equipment and personnel before entry into the high bay. A new operations support building is planned to be located on the east side of the southeast parking lot. Space for

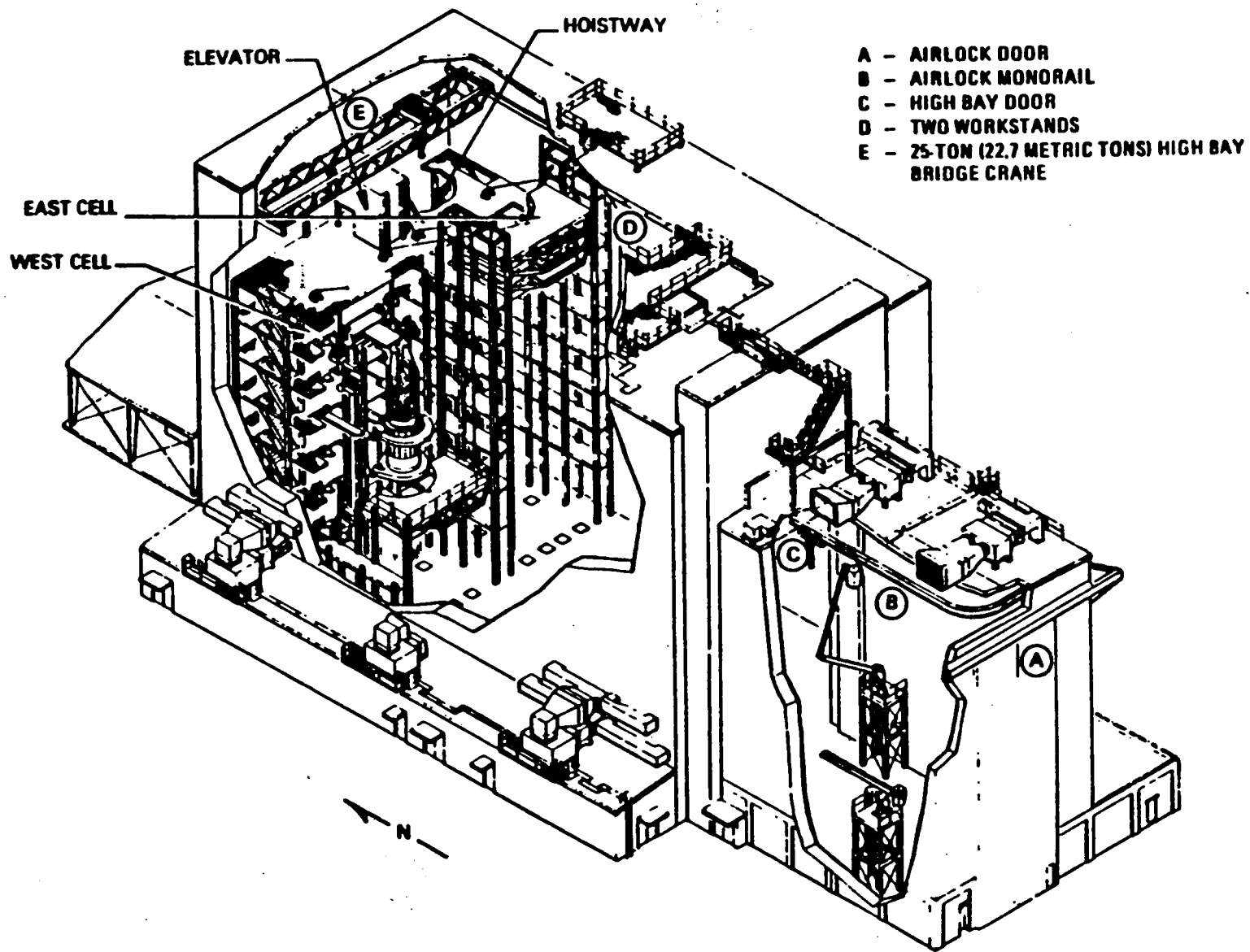


FIGURE 5-6. VERTICAL PROCESSING FACILITY

minor electrical or mechanical staging work activities, support organizations personnel (Quality, Engineering, etc.), quality records, etc. will be provided in this building.

Upon completion of the cargo integration test equipment (CITE) test, the payload canister supported vertically on the transporter is moved to the appropriate cell. The canister is positioned so that the Vertical Payload Handling Device (VPHD) can transfer the entire Orbiter cargo into the canister for movement to the Rotating Service Structure (RSS) at Pad A or Pad B, Complex 39.

5.5 ORBITER PROCESSING FACILITY

The Orbiter Processing Facility (OPF) is used for removal of payloads returning from space and for the installation of all horizontally processed payloads. In addition, all payload-unique Aft Flight Deck equipment is installed and checked out in the OPF. Payload integration activities in the OPF and at the pad are termed "Level I" or "on-line" integration. On-line serial time at KSC is approximately 20 times more expensive than off-line time. Consequently, the user should keep Level I payload activities to an absolute minimum.

The OPF consists of two large high bay areas, each capable of processing an Orbiter, and a low bay area for related support functions (Figure 5-7). OPF activities include:

- a. Towing the Orbiter from the landing area to the OPF and positioning the Orbiter in the OPF.
- b. Safing and deservicing the Orbiter and the payload as necessary.
- c. Payload removal.
- d. Mission-unique payload accommodation equipment removal and installation (in parallel with Orbiter maintenance on a non-interference basis).
- e. Orbiter maintenance.

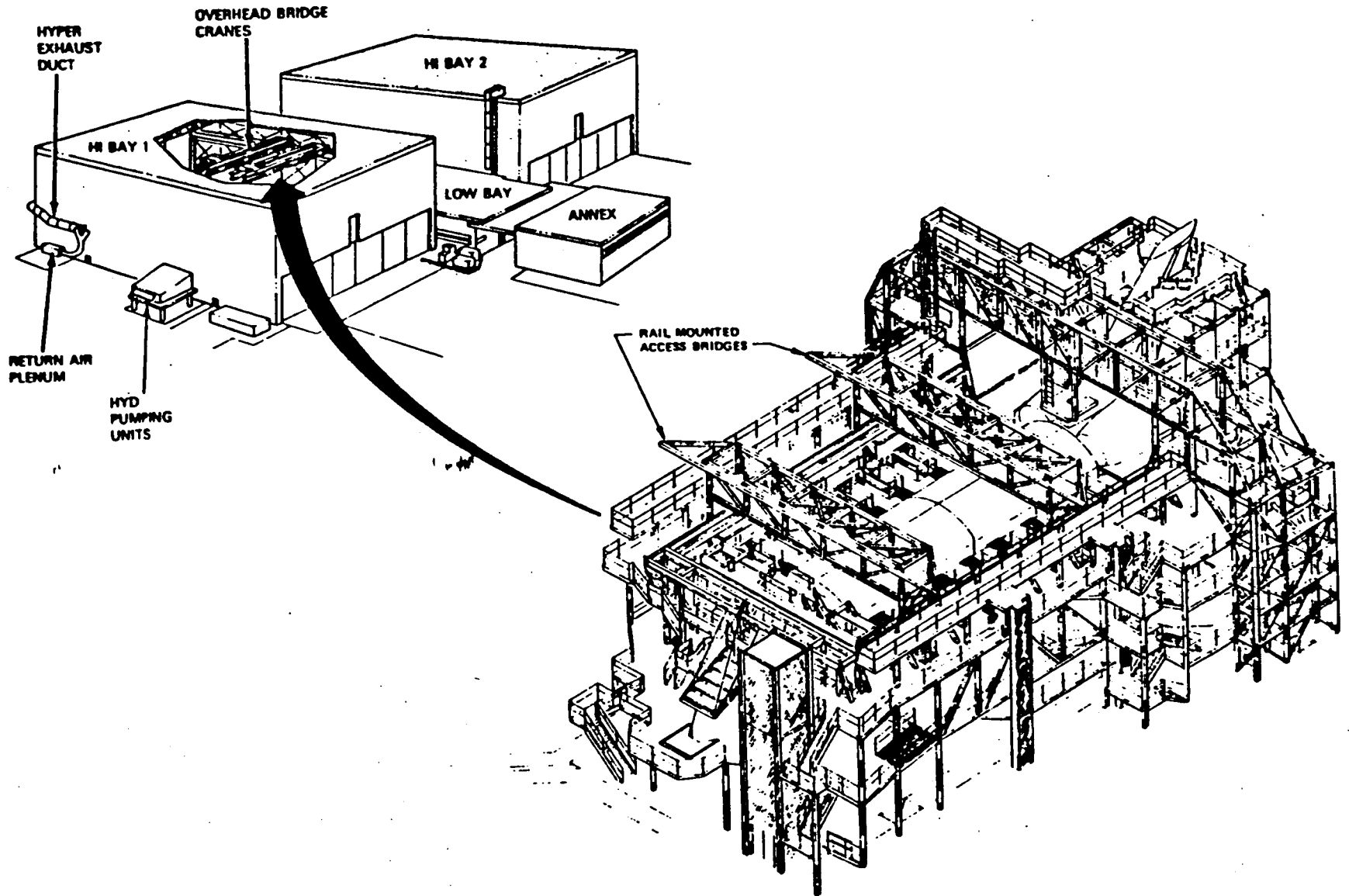


FIGURE 5-7. ORBITER PROCESSING FACILITY

- f. Payload installation and verification.
- g. Orbiter integrated checkout.
- h. Preparations for mating.

Payload installation and verification starts with lifting the payload from its transporter and ends with the final closeout of the cargo bay doors prior to transfer of the Orbiter to the VAB. Orbiter integrated checkout is performed following completion of payload installation. The checkout consists of tests to verify Orbiter systems compatibility and to verify Orbiter/payload interfaces. The necessary Orbiter and payload systems (such as power, cooling, instrumentation, data processing and software, displays and controls, and the general purpose computer) are activated to support the tests. Payload-peculiar control panels in the Aft Flight Deck and the wiring from the panels to the payloads are verified. Next, all data transmissions to and from the Orbiter are verified. There may be some payload systems reverification required as a result of its being installed into the Orbiter; however, this should be kept to an absolute minimum and use of "one-g" support devices or "drag-on" test equipment should be avoided.

5.6 PAD OPERATIONS

Launch pad operations start with rollout of the Shuttle vehicle from the VAB to the launch pad and end at lift-off. If the payload is to be integrated vertically, this operation is performed at the pad. If the payload has been integrated horizontally, the cargo bay doors normally are not opened at the pad. All necessary activities are performed to bring the Shuttle to a "standby for launch" condition, which corresponds to the T-2 hours point in the countdown. The Shuttle can be held in the standby condition for up to 24 hours. When the countdown is resumed, main propellant loading takes place. The Shuttle switches to internal power at T-2 minutes and to internal computer control at T-30 seconds. Main propulsion is initiated and the T-0 umbilical is dropped at lift-off.

Vertically integrated cargos are brought to the pad in the MMSE canister and transferred to the Rotating Service Structure (Figure 5-8). Operations in the RSS may start with completion of launch pad refurbishment and checkout. Payload installation into the cargo bay is followed by launch readiness verification. This process is similar to that for horizontally integrated payloads as described in Subsection 5.5. Upon completion of verification, all ground support equipment is removed and the cargo bay doors are closed. From this point forward, payload services and constraints are the same for both vertically and horizontally integrated payloads.

No payload access is possible after cargo bay door closure. Aft Flight Deck stations are accessible through the crew compartment until crew compartment closeout. All KSC ground systems and Orbiter internal systems providing services to payloads are available at the pad on an "around the clock" basis. The Shuttle ground system and Orbiter vehicle provide payload power and environmental control services. Payload data monitoring and communications are interleaved with those of the Shuttle. The interface for payload equipment connection to the direct (non-Orbiter/Payload interleaved data) payload data bus via the T-0 umbilical is the Launch Control Center (LCC) data terminals. The user is required to furnish the data bus from the Orbiter Aft Bulkhead interface to his specific payload. A payload can be removed from the Orbiter on the launch pad and a new payload installed by the use of the Payload Ground Handling Mechanism (PGHM) within the RSS. However, changeout operations are not baselined nor consistent with the current timeline allocations.

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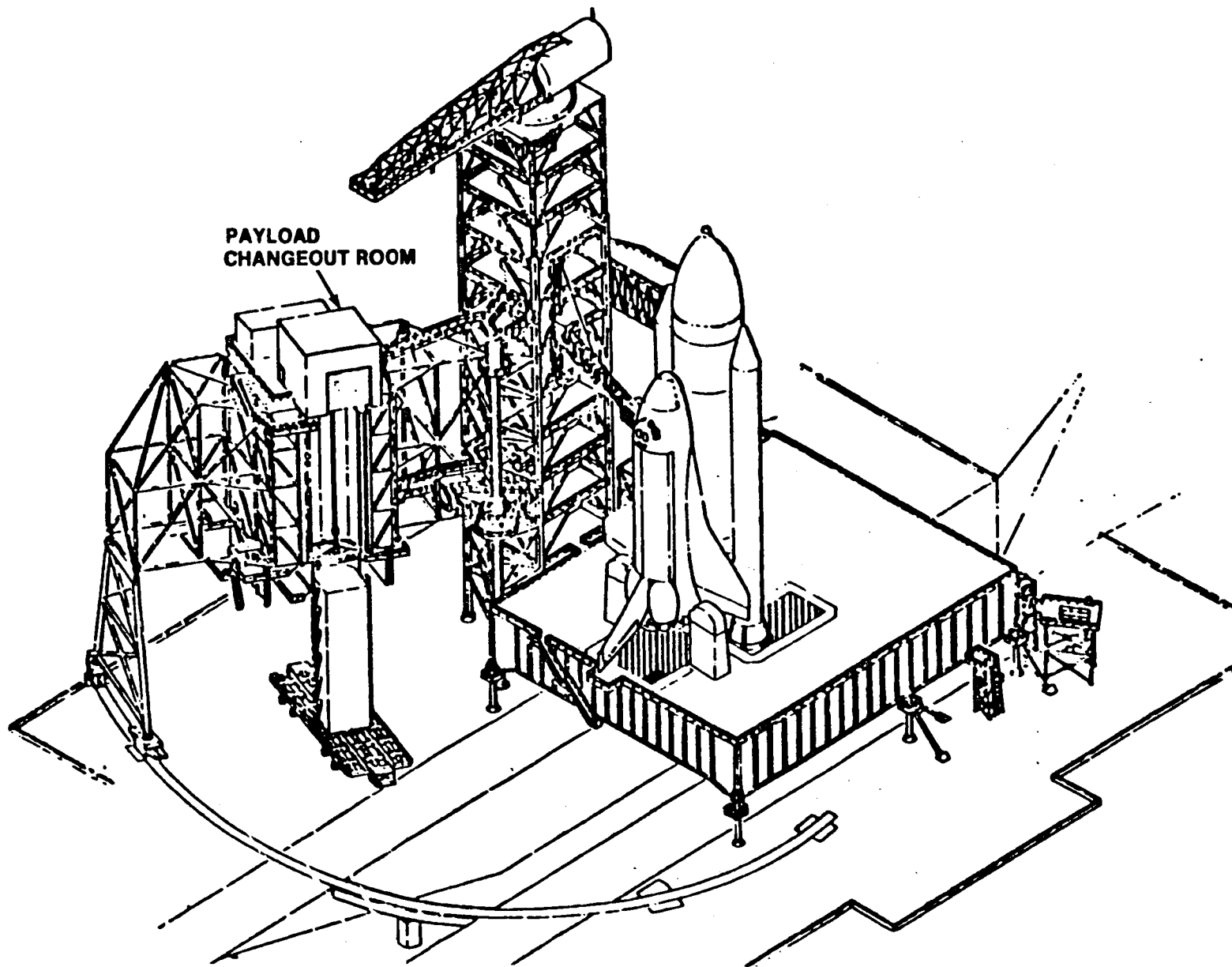


FIGURE 5-8. ROTATING SERVICE STRUCTURE (RETRACTED)

5.7 POST-LANDING CONSIDERATIONS

The primary landing site for Shuttle flights launched from KSC is the runway adjacent to the OPF. When the Orbiter rolls to a stop, the flight crew egresses and ground personnel take over. Ground servicing and towing equipment is connected and the Orbiter is towed to the OPF.

Access to the payload by opening the cargo bay doors is not available at the landing area. However, the Orbiter vehicle and the ground system provide for physical access (on a non-interference basis) to the Aft Flight Deck stations and to the payload or cargo bay through the Orbiter crew compartment and airlock hatches. Any special hardware required for personnel access to payloads must be provided by the user as flyable "one-g" equipment (not ground support equipment). Equipment planned to be removed from the payload or the cargo bay via the Orbiter airlock hatches and the Orbiter crew compartment main hatch must be sized for removal by personnel without assistance of ground support equipment. The Orbiter vehicle and ground system provide power and cooling to the payload. Electrical power will be supplied by the Orbiter fuel cells at the landing area. Ground cooling is initiated within 15 minutes of Orbiter landing-rollout.

After the Orbiter has arrived at the OPF, the hypergolic modules are safed and cryogenic storage equipment is purged. The cargo bay doors are opened and access equipment is installed. The payload is removed from the Orbiter and placed on its transporter for return to the O&C Building. Changeout of mission-unique equipment mounted within the Orbiter starts with payload removal and is a parallel activity with Orbiter scheduled maintenance. The use of such equipment should be kept to a minimum to avoid excessive ground processing cost.

Edwards AFB, California, has been designated as the secondary landing station for the Space Shuttle program. At Edwards AFB, the capability is provided for safing and securing systems, and for ground cooling.

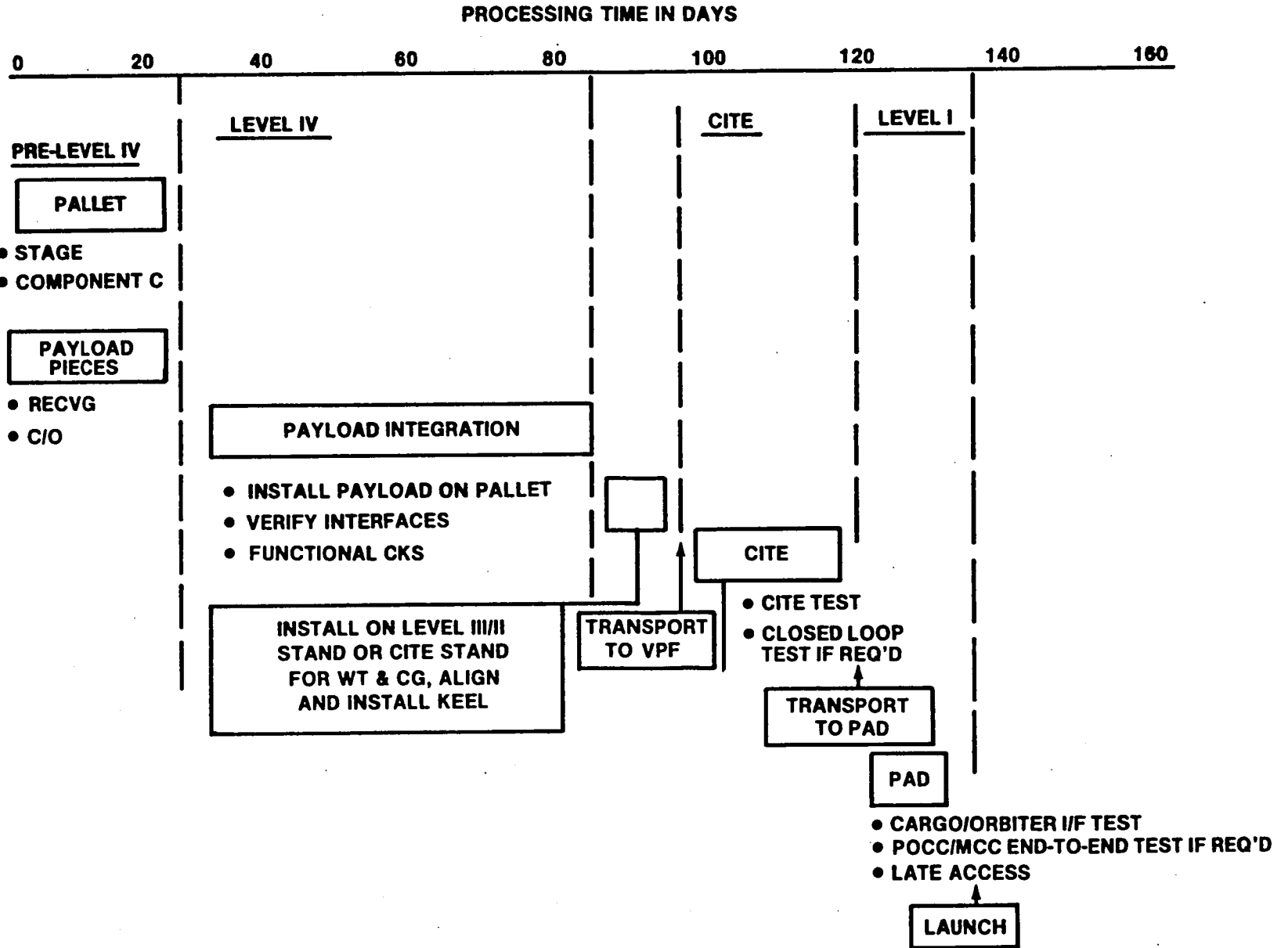
Provisions will also be made for payload removal and mating the Orbiter to the carrier aircraft. The Edwards AFB ground operations can provide access to the payload through the crew compartment within one hour after ground crew ingress. Payload services will be provided to maintain payload integrity until payload removal. Access to the payload through the cargo bay doors will be made available at approximately 35 hours after landing. Payloads will be removed in an uncontrolled environment starting at approximately 38 hours after landing. Any clean environment required for payload removal is the responsibility of the user. Payload handling, maintenance, and transportation after payload removal is also the responsibility of the user. Payload access and removal requirements will be negotiated and documented in the payload integration plan.

A number of contingency landing sites are designed throughout the world for emergency use. Contingency landing stations have only the provisions for safe landing and accommodations for crew and passengers. After contingency landing, a ground operations team will be dispatched with all the necessary equipment to safe/deservice the Orbiter and remove the payload. However, up to six weeks may be required before the payload can be returned to the owner.

5.8 PROCESSING TIME AT KSC

The typical processing time to be expected for the pallet system and its payload is as shown in Figure 5-9.

• ALL PROCESSING AT KSC



5-27

FIGURE 5-9. TYPICAL TIMELINE, VERTICALLY INTEGRATED PAYLOAD

6.0 PAYLOAD OPERATIONS CONTROL CENTER

The National Space Transportation System (NSTS) operations era will introduce many important opportunities to the payload community. A significant advance is in the Payload Operations Control Centers (POCC's) which will give the average user an opportunity to monitor and control his own payload.

There are three basic POCC's in the NSTS that support space operations. These POCC's are described, according to purpose, as follows:

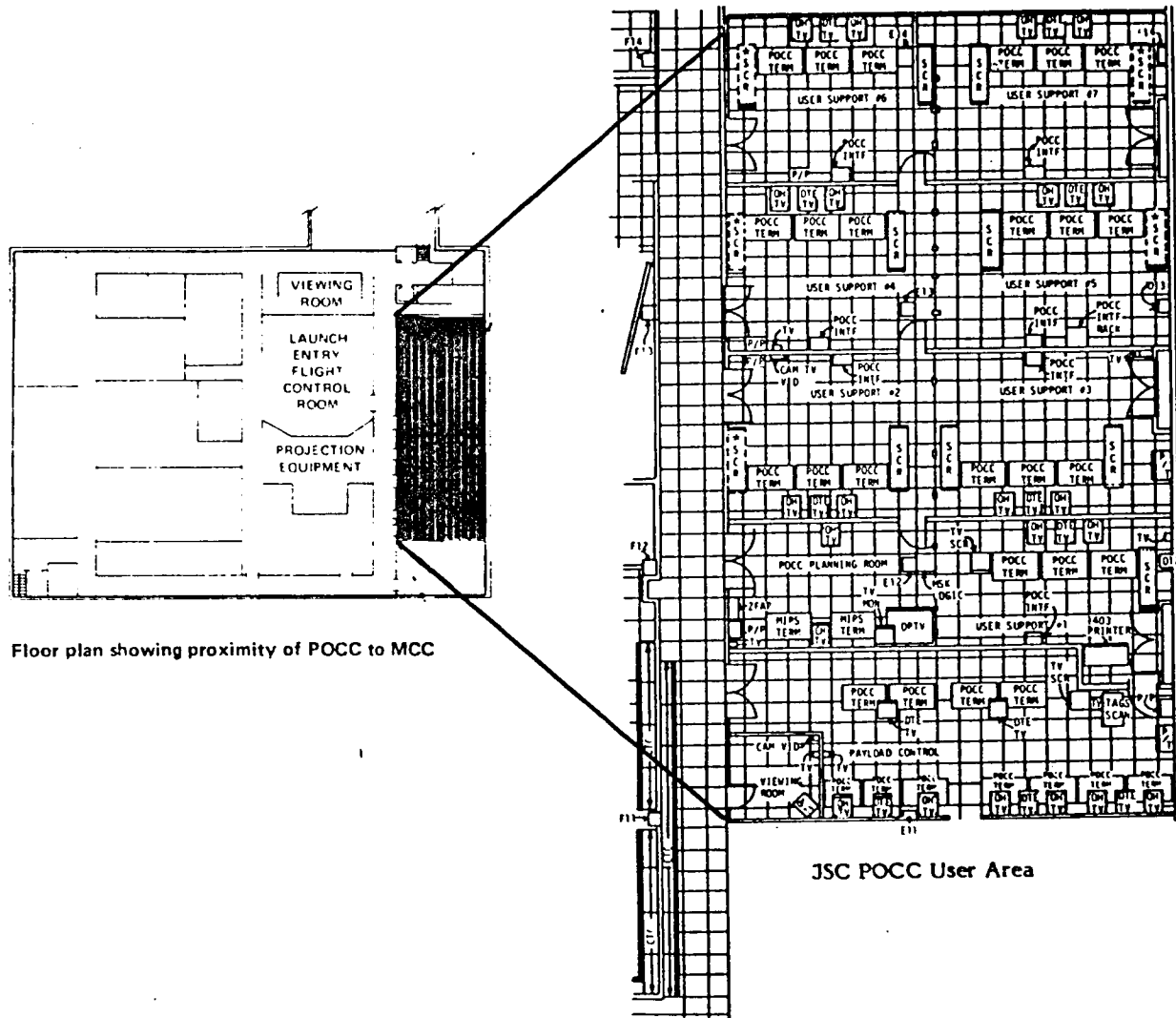
- a) Attached payloads, such as Spacelab and/or pallet carriers, are controlled from the POCC located at JSC.
- b) Free-flying payloads that are deployed, retrieved, or serviced in earth orbit are controlled by the POCC located at GSFC.
- c) Interplanetary and deep space probes are controlled by the POCC located at the Jet Propulsion Laboratory (JPL) in Southern California.

For the purpose of this document, only the POCC located at JSC will be discussed. Remote POCC's will also be addressed.

6.1 POCC FOR ATTACHED PAYLOADS

The current philosophy for NASA missions is that attached payloads and those payloads requiring extensive crew activity will normally be controlled from the POCC at JSC. The POCC adjoins the Mission Control Center (MSS) in the mission operations wing of Building 30 at JSC. Figure 6-1 depicts the location and basic floor plan of the JSC MCC/POCC.

The JSC POCC contains the facilities and systems resources that will allow a payload user to monitor and control a payload or experiment during the flight operations phase of a mission. These resources are available



Floor plan showing proximity of POCC to MCC

JSC POCC User Area

Figure 6-1 JSC MCC/POCC Floor Plan

3 months (maximum) before a mission which will allow a user to test and verify that they are properly configured and prepared for individuals payload needs.

Currently the POCC can only support one mission at a time and that support is sequential. Also the POCC does not provide facilities or system resources for postmission operations.

6.1.1. MCC/POCC Operations Support

For mission operations, in support of the SSV, all preflight planning and inflight command control are provided through the Flight Control Rooms (FCR's) and various support rooms in the MCC. During on-orbit operations, the FCR personnel are responsible for operating the SSV two-way communications system; for flight planning; for management of trajectory, software, and consumables; and for telemetry configuration.

Flight operations activities for the command and control functions of payload systems and science operations are the responsibility of the POCC personnel. The POCC will normally be managed and staffed by the user. However, the user may select the level of support needed in the POCC for payload operations activities. There are three basic support modes that a user can select:

- a) Host - In this mode, the POCC provides host facilities with a standard complement of capability for payload monitoring and commanding and voice communications with the crew and MCC personnel. The user provides all the payload operations personnel necessary to support real-time crew activity planning, crew procedures changes, command and control planning, system monitoring, science processing, and analysis. JSC MCC will man one console position in the POCC to provide command interface management support to the payload. This mode is available as a standard service to the user.

- b) Limited - In this mode, the user provides partial support and NASA provides support in selected areas. This mode is provided as an optional service and chargeable to the user.
- c) Full Service - In this mode, NASA provides all of the required payload support to conduct the user's payload operations. However, as in the other modes, the user will be responsible for overall payload management decisions. This mode is also an optional service.

The most practical and cost effective support mode will be determined during PIP negotiations.

6.1.2 General POCC Capabilities

As stated earlier, the POCC contains the facilities and resources that will allow a user to monitor and control a payload or experiment during the on-orbit mission phase.

The MCC/POCC monitor and control data processing capabilities are depicted in Figure 6-2. Payload data acquisition and preprocessing provisions includes the receipt, routing, recording, playback, and the preprocessing of selected user telemetry data. Currently, the MCC/POCC does not have the capability to process payload analog or PDI data. These data are acquired, preprocessed, and routed to user provided processing equipment located in the POCC work station(s). However, the MCC/POCC has the capability to process selected payload parameters for display in the MCC and in the PCC. In addition to payload data, access to SSV trajectory-related is provided to the POCC work station(s).

The MCC/POCC provides a user the capability to command/control his payload while in flight. This capability is under the direction of the Mission Manager.

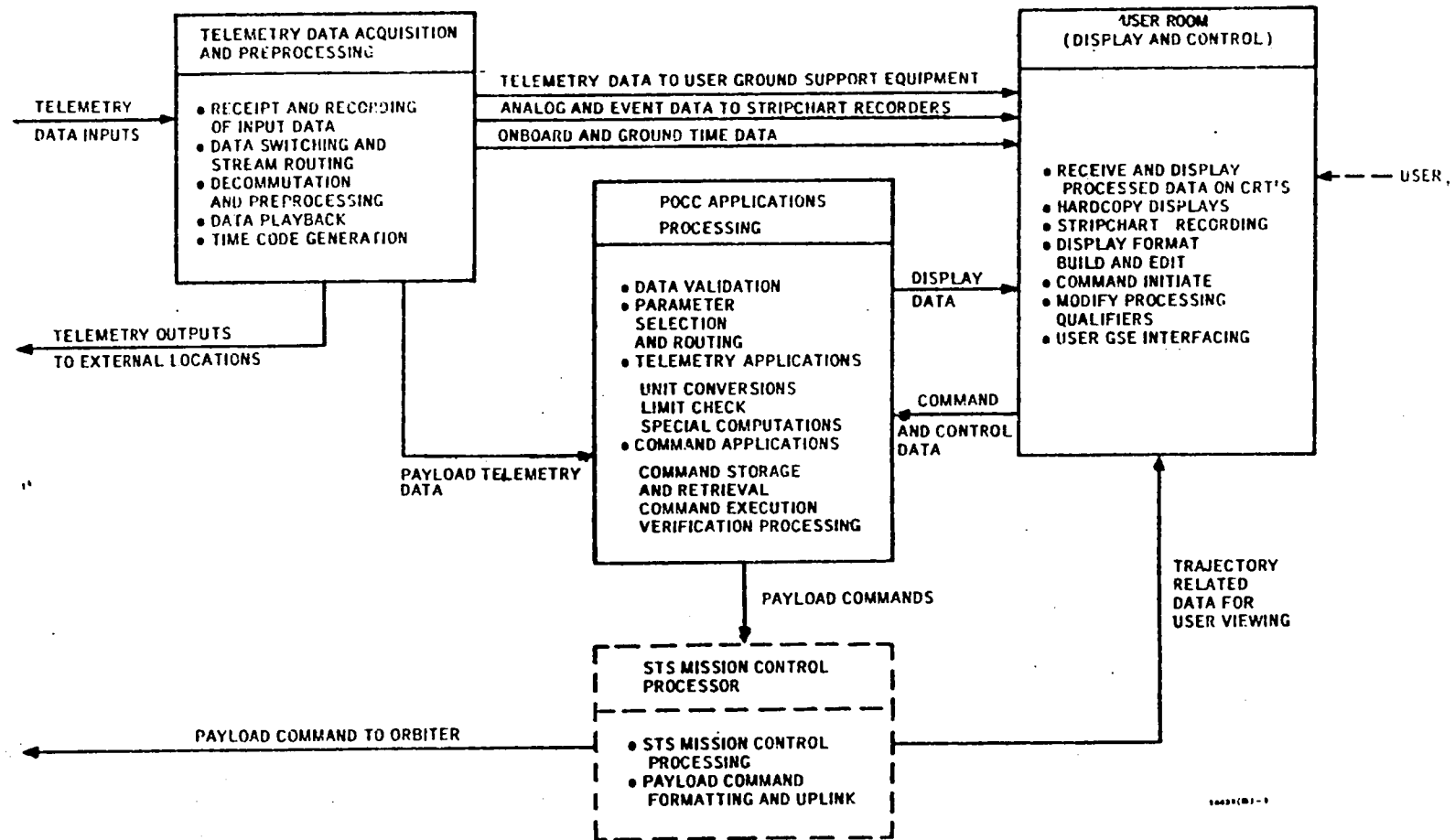


Figure 6-2 POCC Command and Control Data Processing Functional Flow

The MCC/POCC command systems available to a user consist of a 2KBPS link, thru the SSV DPS, and a 128KBPS link that interfaces directly with a payload control system.

The 2KBPS link is basically used for simple on-off (discrete) commands or for simple instructions to a payload computer/processor to initiate a set of sequential functions. This link is provided as a standard service and offers the user an option of using a "single stage" or a "two stage" command process.

A "single stage" command is processed by the SSV DPS and routed immediately to its destination. This process does not provide for command verification.

A "two stage" command stores the command in the GPC until a comparison can be made, on the ground, to verify the command before routing to its destination.

A factor that may be important to the user is the delay factor from the time a command is initiated until it arrives at its destination.

Ground elements plus the SSV DPS contribute to a finite delay, nominally on the order of a few seconds. An additional few seconds will be consumed for the "two stage" command process. The 128KBPS link is available to a user as an optional service and provides a capability to uplink large data blocks, such as mass memory or computer memory loads. Use of this link is on a time share basis with the SSV and/or other payload users. The delay factor associated with this link is negligible. In all cases, the Mission Manager controls all uplink command operations.

Other resources and services include voice communications (both internal and external to the POCC) and video distribution and display. In addition, an external communications interface is available that allows a user to monitor and control his payload from a remote location.

These capabilities (facilities and resources) are summarized in Table 6-1. Specific details of these capabilities can be found in JSC-14433 Volume I, JSC Attached POCC Capabilities Description.

6.1.3 POCC User Requirements

The identification of the user's POCC requirements begins after initial contact with the NASA and the payload has been manifested. Such areas that could affect flight or facilities scheduling, optional services, and long-lead development items are described and documented in the PIP. These requirements are further defined at a detailed level in the Flight Operations Support Annex and in the POCC Annex development process.

The user will develop the operations support documentation that will be required during POCC operations. This documentation will include command plans, system trouble-shooting procedures, training requirements, payload specific documents, and operation concepts. In addition, the user will provide a Mission Manager magnetic tape that will contain a simulated or real composite operational downlink data stream, a high density data stream (if required) and a payload command data set. This mag tape will be used to test and verify the POCC monitor and command/control operational configuration.

Table 6-1 JSC POCC Capabilities

Facility	<ul style="list-style-type: none"> ● Terminals, desks, chairs, tables, recorders, telephones, headsets for voice monitoring, conference areas
Voice Communications	<ul style="list-style-type: none"> ● Voice loops (both internal and external to JSC) for coordinating STS/payload flight planning activities ● Two-way voice communications with crew during flight ● Voice tapes of crew conversations
Command Data (serial digital data uplink)	<ul style="list-style-type: none"> ● Commands can be initiated from an assigned console position in the POCC ● Command histories can be retrieved from real-time processors and displayed on the console ● Command histories may be obtained from off-line processors (printouts or tapes-crew cmds not available)
Telemetry Data (downlink)	<ul style="list-style-type: none"> ● Real-time monitoring of the STS systems data (same capability as STS controllers) ● Real-time processing and display of payload command and control data ● Limited real-time processing and display operations data contained in independent science downlinks ● Limited near-real-time processing and display of payload operations data contained in independent science downlinks
Communications Terminals	<ul style="list-style-type: none"> ● Real-time or playback data can be routed over user circuits to a user remote facility ● Optional data processing is available to package data to user specifications for transmission to a user facility
Data Processing	<ul style="list-style-type: none"> ● Standard unit conversion, limit sensing, and simple arithmetic computations ● Analysis program support (the amount of support will be negotiated on a case-by-case basis)
Trajectory	<ul style="list-style-type: none"> ● All ongoing trajectory and Orbiter attitude information will be made available to users as required (same capability as STS controllers) ● Orbit phase processing of trajectory will be performed as negotiated to support payload operations
Output Devices	<ul style="list-style-type: none"> ● Digital television equipment displays ● Strip-chart recorders ● Tabular reports ● Raw data tapes
Video Downlink	<ul style="list-style-type: none"> ● Can monitor in real time all STS-compatible video downlink

6.2 MCC/REMOTE POCC CONSIDERATION

A payload user may elect to monitor and control his payload from a location other than the JSC MCC/POCC - a remote POCC. For all missions in which a payload will be exercised from outside the MCC itself, the remote POCC will be the focal point for payload operations and control. The payload system and subsystem specialists will be located at the remote POCC and, as such, the payload status determination will be performed and controlled for all mission phases. As the focal point, the remote POCC will direct payload operations, evaluate on-orbit performance and develop data acquisition and command requirements.

6.2.1 MCC/Remote POCC Interface

The MCC provides a standard data interface to support a remote POCC. These standard interfaces are delineated as follows:

- o Payload telemetry interface
- o Payload Command interface (serial digital only)
- o Trajectory-related data interface
- o STS ancillary data
- o Voice Interface
- o Video interface
- o Text and Graphics interface
- o Teletype interface
- o Facsimile interface
- o Interface test capability

A detailed description of these interfaces are found in JSC 14433, Volume II, MCC/Remote POCC Interface Capabilities description.

For those users that opt for the remote POCC, JSC requires that:

- a) The user specify his requirements in terms of standard services.
- b) The user identify any optional service requirements.
- c) The user provide JSC with the specific command and control data necessary to perform MCC configurations peculiar to his payload and/or individual experiment (mission managers tape).
- d) The user provide the required communications lines between his remote POCC and the MCC.

These data are identified and defined in the same manner as for the JSC MCC/POCC.

6.3 TRAINING CONSIDERATIONS

JSC offers a standard set of training aids to a user as part of the standard service package. This standard set consists of text books and audio-visual aids.

As an optional service, each POCC console team member can receive a foundation of basic training in various areas such as MCC, POCC, and FCR familiarization and operations of the console. Additional training is dictated by the requirements of the payload. For example, command operations would be a specific area of training necessary for the POCC operator supporting a payload requiring commands. Other such areas of training include telemetry operations, ground data systems, and Orbiter systems.

APPENDIX A
ABBREVIATION & ACRONYM LIST

ABBREVIATIONS AND ACRONYMS

AC	- Alternating Current
AFB	- Air Force Base
AFD	- Aft Flight Deck
AMPS	- Amperes
A&T	- Assembly and Test
ATCS	- Active Thermal Control System
AUX	- Auxillary
BPS	- Bits Per Second
BTU	- British Thermal Unit
CCAFS	- Cape Canaveral Air Force Station
CCTV	- Closed Circuit Television
CDMS	- Command and Data Handling System
CITE	- Cargo Integration Test Equipment
CRT	- Cathode Ray Tube
CWEA	- Caution and Warning Electronics Assembly
DAP	- Digital Autopilot
DBC	- Data Bus Coupler
DC	- Direct Current
DOD	- Department of Defense
DPP	- Deploy/Pointing Panel
ET	- External Tank
ETR	- Eastern Test Range
EVA	- Extra Vehicular Activity
FAM	- Flight Assignment Manifest
FAP	- Flight Assignment Process
FM	- Frequency Modulation also JSC mail code

FMDM - Flexible Multiplexer/Demultiplexer

 GFE - Government Furnished Equipment
 GIRD - Ground Integration Requirements Document
 GMT - Greenwich Mean Time
 GN&C - Guidance, Navigation and Control
 GN₂ - Gaseous Nitrogen
 GPC - General Purpose Computer
 GSE - Ground Support Equipment
 GSFC - Goddard Space Flight Center

 HDR - High Data Rate
 HEMI - Hemispherical
 H_z - Hertz

 ICD - Interface Control Document
 I/O - Input/Output
 IRIG-B - Inter-Range Instrumentation Group

 JSC - Lyndon B. Johnson Space Center

 KBPS - Kilobits Per Second
 KDU - Keyboard/Display Unit
 KM - Kilometer
 KSC - Kennedy Space Center
 KWH - Kilowatt Hour
 KW - Kilowatt

 LCC - Launch Control Center
 LDR - Low Data Rate
 LPS - Launch Processing System
 LSA - Launch Service Agreement
 LSSM - Launch Site Support Manager

LSSP - Launch Site Support Plan
 LVLH - Local Vertical Local Horizontal

 MAX - Maximum
 MBPS - Megabits Per Second
 MCC - Mission Control Center
 MCDS - Multifunction CRT Display System
 MDC - McDonnell Douglas Corporation
 MDTSCO - McDonnell Douglas Technical Services Company
 MDM - Multiplexer/Demultiplexer
 MET - Mission Elapsed Time
 MHz - Megahertz
 MLI - Multi-Layer Insulation
 MLP - Mobile Launch Platform
 MMSE - Multiuse Mission Support Equipment
 MPES - Multi-Purpose Experiment Support Structure
 MSFC - Marshall Space Flight Center
 MSDP - Mission Station Distribution Panel
 MSS - Mission Specialist Station

 NASA - National Aeronautics and Space Administration
 Nmi - Nautical Mile

 O&C - Operations and Checkout
 OIS - Operational Intercommunications System
 OMI - Operations and Maintenance Instructions
 OMS - Orbital Maneuvering System
 OODP - On-Orbit Distribution Panel
 OOS - On-Orbit Station
 OPF - Orbiter Processing Facility
 OPS - Operations
 OSTA - Office of Space and Terrestrial Applications
 OTV - Operational Television

PAM-D - Payload Assist Module - Delta Class
 PCMMU - Pulse Code Modulation Master Unit
 PDI - Payload Data Interleaver
 PETS - Pallet Environmental Transportation System
 PGHM - Payload Ground Handling Mechanism
 PI - Payload Interrogator
 PIP - Payload Integration Plan
 PIRN - Preliminary Interface Revision Notice
 PM - Pulse Modulation
 POCC - Payload Operations Control Center
 PRCS - Primary Reaction Control System
 PSDP - Payload Station Distribution Panel
 PSS - Payload Specialist Station

 RCS - Reaction Control System
 RF - Radio Frequency
 RMS - Remote Manipulator System
 RSS - Rotating Service Structure

 SIP - Standard Interface Panel
 SMCH - Standard Mix Cargo Harness
 SPAS - Shuttle Pallet Satellite
 SPIF - Shuttle Payload Integration Facility
 SPS - Spacelab Pallet System
 SRB - Solid Rocket Booster
 SSO - Space Shuttle Orbiter
 SSP - Standard Switch Panel
 STEP - Space Technology Experiments Pallet
 STS - Space Transportation System
 SRB - Solid Rocket Booster

 TDM - Time Division Multiplexing

VAB - Vehicle Assembly Building
VAFB - Vandenberg Air Force Base
VLS - Vandenberg Launch Site
VPF - Vertical Processing Facility
VPHD - Vertical Payload Handling Device
VRCS - Vernier Reaction Control System

W-B - Wideband

XLV - Local Vertical, X axis

ZLV - Local Vertical, Z axis
ZOE - Zone of Exclusion

APPENDIX B
GLOSSARY OF TERMS

Aft Flight Deck

That part of the Orbiter cabin on the upper deck where payload controls can be located.

Attached Payload

A payload designed to remain within the Orbiter cargo bay throughout the mission and return to earth.

Azimuth

True launch heading from KSC or VLS measured clockwise from 0° north.

Barbecue Mode

Orbiter is slow roll for thermal conditioning.

Beta Angle

Minimum angle between the Earth-Sun line and the plane of the orbit.

Cargo

The total complement of payloads (one or more) on any one flight. It includes everything contained in the Orbiter cargo bay plus other equipment, hardware, and consumables located elsewhere in the Orbiter that are user-unique and are not carried as part of the basic Orbiter payload support.

Cargo Bay

The unpressurized midpart of the Orbiter fuselage behind the cabin aft bulkhead where most payloads are carried. Its maximum usable payload envelope is 15 feet (4.6 meters) in diameter and 60 feet (18.3 meters) long. Hinged doors extend the full length of the bay.

Cargo Element

A self-contained package of flight hardware carried in the cargo bay as part of a mixed cargo.

Commander

The crewmember who has ultimate responsibility for the safety of embarked personnel and has authority throughout the flight to deviate from the flight plan, procedures, and personnel assignments as necessary to preserve crew safety or vehicle integrity. The commander is also responsible for the overall execution of the flight plan in compliance with NASA policy, mission rules, and Mission Control Center directives.

Crew Activity Planning

The analysis and development of activities to be performed in flight by the crew, resulting in a time line of these activities and reference data for each flight.

Deployable Payload

A payload designed to be removed from the cargo bay in space and not returned to earth.

Deployment

The process of removing a payload from a stowed or berthed position in the cargo bay and releasing that payload to a position free of the Orbiter.

Experimenter

A user of the Space Transportation System, ordinarily an individual whose experiment is a small part of the total payload.

External Tank

Element of the Space Shuttle system that contains liquid propellant for the Orbiter main engines. It is jettisoned before orbit insertion.

Extravehicular Activity

Activities by crewmembers conducted outside the spacecraft pressure hull or within the cargo bay when the cargo bay doors are open.

Flight

The period from launch to landing of an Orbiter - a single Shuttle round trip. One flight might deliver more than one payload or more than one flight might be required to accomplish a single mission.

Flight Manifest

The designation of a flight, assignment of the cargo to be flown, and specific implementing instructions for STS operations personnel.

Free-Flying System

Any satellite or payload that is detached from the Orbiter during operational phases and is capable of independent operation.

Inclination

The maximum angle between the plane of the orbit and the equatorial phase.

Interface

The mechanical, electrical, and operational common boundary between two elements of a system.

Level I Integration

Assembly and verification of the cargo element within the Orbiter cargo bay.

Level III/II Integration

Assembly and verification of carrier avionics system (usually Spacelab) with configuration resulting from Level IV integration.

Level IV Integration

The mechanical assembly of an attached payload to its payload carrier.

Mission

The performance of a coherent set of investigations or operations in space to achieve program goals. A single mission might require more than one flight, or more than one mission might be accomplished on a single flight.

Mission Kit

Optional hardware (including consumables) to provide additional, special, or extended services to payloads. Kits are packaged in such a way that they can be installed and removed easily.

Mission Specialist

The crewmember who is responsible for coordination of overall payload/STS interaction and, during the payload operation phase, directs the allocation of the STS and crew resources to the accomplishment of the combined payload objectives. The mission specialist will have prime responsibility for experiments to which no payload specialist is assigned and/or will assist the payload specialist when appropriate.

Mission Station

Location on the Orbiter aft flight deck from which payload support operations are performed, usually by the mission specialist.

Mixed Cargo

Cargo containing more than one type of payload.

Orbital Maneuvering System

Orbiter engines that provide the thrust to perform insertion, circularization, or transfer; rendezvous; and deorbit.

Pallet

An unpressurized platform, designed for installation in the Orbiter cargo bay, for mounting instruments and equipment requiring direct space exposure.

Pallet Train

Two or more pallets rigidly connected to form a single unit.

Payload

The total complement of specific instruments, space equipment, support hardware, and consumables carried in the Orbiter (but not included as part of the basic Orbiter payload support) to accomplish a discrete activity in space.

Payload Assist Module

Propulsive upper stage designed to deliver spacecraft of the Delta and Atlas-Centaur classes to Earth orbits beyond the capabilities of the Space Shuttle.

Payload Carrier

One of the major classes of standard payload carriers certified for use with the Space Shuttle to obtain low-cost payload operations. The payload carriers are identified as habitable modules (Spacelab) and attached but uninhabitable modules (pallets, free-flying systems, satellites, and upper stages).

Payload Operations Control Center

Central area, located at any of three NASA centers, from which payload operations are monitored and controlled. The user, in many instances, will have direct command of a payload from this control center.

Payload Specialist

The crewmember who is responsible for the operation and management of the experiments or other payload elements that are assigned to him or her, and for the achievement of their objectives. The payload specialist will be an expert in experiment design and operation and may or may not be a career astronaut.

Payload Station

Location in the Orbiter aft flight deck from which payload-specific operations are performed, usually by the payload or mission specialist.

Pilot

The crewmember who is second in command of the flight and assists the commander as required in the conduct of all phases of Orbiter flight.

Radiator Kit

Two additional deployable radiator panels, mounted on the aftermost section of each payload door, that provide maximum SSO heat rejection capability.

Reaction Control Subsystem

Thrusters on the Orbiter that provide attitude control and three-axis translation during orbit insertion, on-orbit, and reentry phases of flight.

Remote Manipulator System

Mechanical arm on the cargo bay longeron. It is controlled from the Orbiter aft flight deck to deploy, retrieve, and move payloads.

Solid Rocket Booster

Element of the Space Shuttle that consists of two solid rocket motors to augment ascent thrust at launch. They are separated from the Orbiter soon after lift-off and recovered for reuse.

Sortie Payload

A payload that is located in the cargo bay and is not deployable.

Space Shuttle Orbiter

The manned orbital flight vehicle of the Space Shuttle system.

Space Shuttle

Orbiter, external tank, and two solid rocket boosters.

Space Transportation System

An integrated system consisting of the Space Shuttle (Orbiter, external tank, solid rocket booster, and Mission kits); upper stages, Spacelab, and any associated flight hardware and software.

Standard Mixed Cargo Harness (SMCH)

One of four identical cable harness sets within the Orbiter cargo bay available to the user as a standard service for provision of Orbiter avionics power and signal accommodations.

Tracking and Data Relay Satellite System

Two-satellite communication system providing principal coverage from geosynchronous orbit for all STS flights.

User

An organization or individual requiring the services of all Space Transportation System.

APPENDIX C
APPLICABLE DOCUMENTS

APPLICABLE DOCUMENTS

The following reference material, of the latest issue, was used in the development of this document.

Government

JSC 07700 Volume 14	Space Shuttle System Payload Accommodations, Rev. G, Change No. 39
ICD-2-19001	Shuttle Orbiter/Cargo Standard Interfaces, including PIRN's SD-254 (Power) and SD-262A (SIP) (Attachment 1 to Volume 14)
JSC-08118	Space Shuttle Telemetry and Command Data Characteristics Handbook
JSC-11174	Space Shuttle Systems Handbook
JSC-14363	Shuttle/Payload Integration Activities Plan
JSC-14091 Annex 2	Data Requirements for the Flight Planning Annex
STDN No. 101.2 (GSFC)	Tracking and Data Relay Satellite System (TDRSS) User Guide
(No JSC Number)	Payload/Cargo Integration Schedules/Planning Guidelines Vol. 1, NASA and Commercial Payloads
NHB 1700.7A	Safety Policy and Requirements (for Payloads using the STS)

Contractor

MDC G9836 (MDTSCO)	Accommodations Handbook, Spacelab Pallet System (SPS)
SLP 2104	Spacelab Accommodations Handbook
K-STSM-14.1	Launch Site Accommodations Handbook for STS Payloads
K-STSM-14.1.12	Vertical Processing Facility Handbook
K-STSM-14.1.13	Orbiter Processing Facility Handbook
K-STSM-14.1.14	O&C Facility Handbook

1. Report No. NASA CR-172223		2. Government Accession No.		3. Recipient's Catalog No.	
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15. Supplementary Notes This work was done under a Langley supported TASK attached to the referenced Marshall Space Flight Center Contract (NAS 8-32350). Technical Monitor for the Langley task was J. W. Johnson.					
16. Abstract This report is an input to a study conducted to define a set of carrier avionics for supporting large structures experiments attached to the Space Shuttle Orbiter. It defines the "baseline" Orbiter interface used in developing the avionics concept for the Space Technology Experiments Platform, STEP, which Langley Research Center has proposed for supporting experiments of this sort. Primarily, it addresses flight operations capabilities and considerations and the avionics systems capabilities that are available to a payload as a "mixed cargo" user of the Space Transportation System. Ground operations for payload integration at Kennedy Space Center, and ground operations for payload support during the mission are also discussed.					
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