Assembly Operations Handbook (AOH)/Data Book (DB): Japanese Exposed Facility/External Section

Mission 2J/A

Mission Operations Directorate Operations Division

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PREFACE

This document was prepared by the Cargo Integration and Operations Branch, Operations Division, Mission Operations Directorate (MOD), National Aeronautics and Space Administration (NASA), Lyndon B. Johnson Space Center (JSC), Houston, Texas, with editorial support from Integrated Documentation Services (IDS) on the Space Program Operations Contract (SPOC).

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1.0 INTRODUCTION

1.1 PURPOSE

The Assembly Operations Handbook (AOH) serves as a flight- and stage-specific assembly operations technical handbook for console operators. A new stage begins at every U.S. shuttle launch to the International Space Station (ISS) and continues until the next shuttle launch. This document is useful as a mission familiarization and reference tool for assembly team members.

This AOH also serves as a baseline for a future Data Book (DB) for the Japanese segment. As a result, the reader will find more detailed information about the topic systems (Japanese segment) than will be found in a typical AOH. The transition of the information in this handbook to a DB will be done by the JSC International Liaison Group (DO32) after the 2J/A mission per NASA Memorandum DO5-04-030. Until the transition is complete, this book will be referred to as the AOH/DB (Assembly Ops Handbook/Data Book).

1.2 SCOPE

Component Common name

This handbook/DB addresses nominal and contingency operations for the third of three Japanese Experiment Module (JEM) missions, Flight 2J/A, and the increments before and after, focusing on how systems affect assembly and activation operations, with the emphasis on multisystem functions required to support assembly tasks. This flight information includes schematic drawings, operations, systems constraints, and notes from previous missions that may affect this mission. This handbook/DB focuses on how systems affect assembly and operations for the JEM Exposed Facility (JEF), rather than on system-specific data.

Additional technical data on specific systems can be found in the International Space Station Systems Handbook (ISSSH), as well as in handbooks developed by the disciplines responsible for individual ISS systems.

In this handbook/DB, the following components are referred to by their common name:

Details covered in this document address the assembly configuration specific to the 2J/A mission.

2.0 STAGE ARCHITECTURE DATA

The focus of this section is on the hardware architecture changes made to the ISS systems due to the 2J/A mission.

2.1 STAGE 15A AND 2J/A CONFIGURATION

At Stage 15A, the USOS consists of Node 1, Node 2, the U.S. Lab, ESA Columbus Module, JAXA JEM (JPM, JLP, and JEMRMS), PMA-1, PMA-2, PMA-3, the Joint Airlock, the Z1 truss segment, all components of the primary truss, and all major components of the MSS: MT, MBS, SSRMS, and SPDM. Stage 15A adds the last of two power channels on the S6 truss.

The RS consists of the FGB, the SM, Docking Compartment-1 (DC-1), two Soyuz-TMA vehicles, and a single Progress-M1 vehicle.

The ISS on-orbit configuration at the completion of mission 2J/A is shown in Figure 2-1. The following sections provide an overview of the change in ISS capabilities from Stage 15A to Stage 2J/A.

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Figure 2-1. ISS configuration – Stage 2J/A

2.1.1 Structures and Mechanisms

Table 2-1. Structures and mechanisms (continued)

Table 2-1. Structures and mechanisms (continued)

Table 2-1. Structures and mechanisms (concluded)

2.1.2 Electrical Power System

The ISS has eight fully functional power channels at the completion of mission 15A. Table 2-2 provides an overview of the EPS capability at the completion of Stages 15A and 2J/A, and Figure 2-2 presents the EPS functional overview at Stage 2J/A.

System	15A Stage	2J/A Stage
Primary power system		
Primary power generation USOS	All power channels fully functional, including S6 channels 1B and 3B, which were delivered, activated, and fully functional during 15A	No change
Solar array tracking	Port SARJ is fully functional. Starboard SARJ is constrained to directed position (not autotracking) due to anomalous vibrations during rotation, despite lubing performed on ULF-2. The effects of work done on ULF-2 are still being investigated All BGAs (eight) tracking on all gimbals/joints	No change
MBSUs	All four MBSUs on S0 active and cross-tied	No change
	MBSUs 2 and 4 receiving power from channels 2A, 2B, and 4A, 4B	
	MBSUs 1 and 3 receiving power from channels 1A, 1B, and 3A, 3B	
DCSUs	Eight DCSUs on board (one for each power channel)	No change
BCDUs	24 BCDUs on board (three on each power channel)	Six new batteries manifested and installed on P6. The expended P6 batteries (six) are returned in the PLB on ICC-VLD

Table 2-2. Power systems capability summary at Stages 15A and 2J/A

Table 2-2. Power systems capability summary at Stages 15A and 2J/A (continued)

Table 2-2. Power systems capability summary at Stages 15A and 2J/A (concluded)

Figure 2-2. EPS overview at Stage 2J/A

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2.1.3 Command and Data Handling System

Mission 2J/A does change the C&DH capability of the station, but only in relation to the JEM segment. Table 2-3 provides an overview of the C&DH system capability at the completion of Stages 15A and 2J/A. Figure 2-3 presents the C&DH functional overview for the USOS.

System	15A Stage	2J/A Stage
	Russian segment C&DH system	
SM computers	Control of SM DMS-R; control of RS MCS; control of MCS (selectable)	No change
FGB computers	Control of FGB systems	No change
	USOS segment C&DH system	
C&C MDMs	Processing of ISS level software; coordinate C&W between ISS segments; crew interface with C&DH system (via PCS); connect to MCC via ISS communication subsystems	No change
	Tier 1 : Three MDMs - primary, backup, and standby	
GNC MDMs	Monitor and control of CMGs; perform calculations supporting USOS attitude control; coordinate overall ISS attitude control with RS Tier 2:	No change
	Two MDMs – primary and backup	
Int MDMs	Monitor and control of internal ECLSS, EPS, and TCS systems of ISS	No change
	Tier 2: Two MDMs – primary and backup	
Payload MDM	Control of USOS Payload C&DH network	No change
	Tier 2: Two MDMs – primary and backup	

Table 2-3. C&DH capability summary at Stages 15A and 2J/A

System	15A Stage	2J/A Stage
	USOS segment C&DH system (continued)	
PMCU MDMs	Control of EPS secondary power distribution	No change
	Tier 2: Two MDMs – primary and backup	
EXT MDMs	Monitor and control inboard integrated truss segments (i.e., S0, S1, P1, P3, and S3) systems	No change
	Tier 2 : Two MDMs – primary and backup	
Node 1 MDMs	Control of Node 1, PMA, and Z1 heaters; control of PCU ops; control of CBM ops	No change
	Tier 3: Two MDMs $-$ N1-1 and N1-2 (considered tier 2.5 with characteristics of both)	
Node 2 MDMs	Control of Node 2 internal systems, command and control routing to IP elements; control of CBM Ops	No change
	Tier 3 : Two MDMs - N2-1 and N2-2	
PVCU MDMs	Control of S4, P4, and P6 solar arrays and power flow	No change
	Control of S6 solar arrays and power flow	
	Tier 3: Eight MDMs - PVCU-2A and PVCU-4A, PVCU-2B and PVCU-4B, PVCU-1A and PVCU-3A, PVCU-1B and PVCU-3B	
A/L MDM	Control of ISS joint airlock systems	No change
	Tier 3: One MDM - A/L MDM	

Table 2-3. C&DH capability summary at Stages 15A and 2J/A (continued)

System	15A Stage	2J/A Stage
USOS segment C&DH system (concluded)		
LAB MDMs	Monitor and control of U.S. LAB-related functions	No change
	Tier 3 : Three MDMs LA-1, LA-2, and LA-3	
S0 MDMs	Monitor and control ITS S0 systems	No change
	Tier 3 : Two MDMs $-$ S0-1 and S0-2	
S1 MDMs	Monitor and control ITS S1 systems	No change
	Tier 3 : Two MDMs $-$ S1-1 and S1-2	
S3 MDMs	Monitor and control ITS S3 systems	No change
	Tier 3 : Two MDMs $-$ S3-1 and S3-2	
P1 MDMs	Monitor and control ITS P1 systems	No change
	Tier 3: Two MDMs $-$ P1-1 and P1-2	
P3 MDMs	Monitor and control ITS P3 systems	No change
	Tier $3:$ Two MDMs $-$ P3-1 and P3-2	
STR/PTR MDMs	Monitor and control systems on the starboard/port TRRJ that are primarily related to radiator and RBVM operations	No change
	Tier 3 : Two MDMs - STR and PTR	
PCS	Crew interface with USOS C&DH system	No change

Table 2-3. C&DH capability summary at Stages 15A and 2J/A (continued)

 $\overline{}$

System	15A Stage	2J/A Stage
	ESA segment C&DH system	
Columbus Data Management System (DMS)	Monitor and control Columbus-related functions. Interfaces with U.S. international buses	No change
	Tier 3: Four Standard Portable Computers (SPCs) - Data Management Computer (DMC), Mission Management Computer (MMC), P/L Command Unit (PLCU), plus a spare SPC	
	JEM segment C&DH system	
JEM Control Processor (JCP)	The JPM contains two JCPs. There are two JCPs for redundancy (one in active mode and the other in secondary power off mode). The JCP interface with the C&C MDMs on the control buses	No change
Data Interface Unit (DIU)	Eight nonredundant DIUs delivered with the JPM. DIUs translate commands and telemetry between JPM systems and the JCPs DIU-I (quantity six) DIU-III (quantity two)	No change
Payload Data Handling Unit (PDH)	The JPM contains two PDHs. There are two PDHs for redundancy. PDHs handle payload data	No change
Management Data Processor (MDP)	The computer that provides top-level management of the JEMRMS	No change
Minimum Keep Alive and Monitor (MKAM)	Is used as the SLT and is available for minimum keep-alive monitoring of JLP, if required	No change
Station Laptop Terminal (SLT)	Crew interface with JEM C&DH system	No change

Table 2-3. C&DH capability summary at Stages 15A and 2J/A (continued)

System	15A Stage	2J/A Stage
JEM segment C&DH system (concluded)		
EF System Computer (ESC)	N/A	JEF has two ESCs (primary and backup) that receive commands from JCP for JEF components, performs JEF FDIR, and communicates with local controllers within JEF
Electronic Control Unit (ECU)	N/A	The ECU is located on the JLE and will be returned to Earth with the JLE at the end of mission 2J/A. The ECU interfaces with all JLE electronics and routes telemetry and commands to and from the JCP. The ECU is located on the JLE and will be returned to Earth removed along with the JLE at the end of mission 2J/A
Berthing Mechanism Electronics package (BEP)	The BEP controls the JEM EFBM	The BEP controls the JEM EFBM.
	Unstowed and checked out	Not planned to be used after 2J/A
Berthing Mechanism Control and Display unit (BCDU)	Crew interface to the BEP to control the EFBM	Crew interface to the BEP to control the EFBM
	Unstowed and checked out	Not planned to be used after 2J/A

Table 2-3. C&DH capability summary at Stages 15A and 2J/A (concluded)

Figure 2-3. C&DH overview at Stage 2J/A

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2.1.4 Communication and Tracking System

Mission 2J/A does not change the USOS communication and tracking capabilities of the station. However, it does add capabilities to the JEM C&T system. Table 2-4 provides a summary description of the C&T system capability at the completion of Stages 15A and 2J/A.

System	15A Stage	2J/A Stage	
	USOS C&TS segment		
S-band	Provides the primary source of commands, voice, and telemetry for the ISS and can be used in both high and low data rate modes	No change	
	String 1 S-band located on S1 String 2 S-band located on P1		
Ku-band	Provides ISS with two-way file transfer via the OCA, two-way video (including teleconferencing), and high-rate payload telemetry downlink (~150 Mbps); single string (both forward and return links)	Mission 2J/A manifests a spare SGANT, which is stowed on ESP-3	
Internal audio	Distributes voice and C&W tones onboard the ISS; interfaces with other subsystems so that the audio signals can be distributed to the RS, the orbiter, EVA crews, and the ground	No change	
Video	Generates, routes, displays, records, and plays back video images; also has interfaces for video transmissions to and from the ground (via the Ku-band system) or to the orbiter (while docked)	No change	

Table 2-4. C&TS capability summary at Stages 15A to 2J/A

System	15A Stage	2J/A Stage	
USOS C&TS segment (concluded)			
UHF comm	Two-way RF voice between: ISS and an EVA crew; ISS and the orbiter; MCC-H and an EVA crew (uses both UHF and S-band subsystems)	No change	
	Orbiter commanding of critical ISS functions (e.g., moding to free drift) via RF link during arrival and departure (undocked) ops		
	ISS transmission of critical telemetry (e.g., GNC mode) to the orbiter via RF link during arrival and departure (undocked) ops		
Russian C&TS segment			
Regul	Russian segment equivalent to S-band system	No change	
Lira	Russian segment equivalent to Ku-band	No change	
VHF	Russian segment equivalent to UHF; VHF-2 used primarily for space-to- space communications; VHF-1 and 2 can be used to talk with MCC-M when ISS is over ground sites	No change	
ROS television subsystem	Russian segment video system	No change	
ESA segment C&TS system			
Columbus Video Distribution System (VDS)	Collects video data and sends it for downlink via USOS or JEM assets	No change	
Columbus	Two Audio Terminal Units (ATUs)	No change	
internal audio	One IAA		
JEM segment C&TS system			
Internal audio	Two ATUs (JEM ATU1, JEM ATU2) in the JPM	No change	
	Two IAA - one in JLP, one in JPM. Each interfaces directly with the USOS SSSR system		

Table 2-4. C&TS capability summary at Stages 15A to 2J/A (continued)

System	15A Stage	2J/A Stage	
	JEM segment C&TS system (concluded)		
Video	Seven TVCs on the JEM that interface with the USOS Video Distribution System (VDS)	Two external TVCs will be installed on JEF during 2JA FVAs	
	Three TVCs are internal (one in JLP, two in JPM)		
	Two TVCs are installed externally on the JPM		
	Two TVC are installed on the JEMRMS (one Elbow, one End Effector)		
Interorbit Communications System (ICS)	The ICS allows direct communication between SSIPC and the JEM Segment for data, commanding voice and video - no USOS assets required. ICS-PM components launched in the JLP and were transferred to JPM. ICS-EF launches on 2JA	Mission 2J/A installs ICS-EF to JEF, allowing direct communication between ICS-EF and SSIPC through DRTS. It transmits JEM systems data, payload data and commands, telemetry, and audio and video signals using Ka-Band frequency	

Table 2-4. C&TS capability summary at Stages 15A to 2J/A (concluded)
2.1.5 Motion Control System

Mission 2J/A adds no new functionality to the ISS MCS or GNC system. Table 2-5 provides an overview of the MCS capability at the completion of Stages 15A and 2J/A.

System	15A Stage	2J/A Stage
Guidance	RS thrusters used for reboost	No change
Navigation	RS systems: star mappers, horizon sensors, Sun sensors, magnetometers, GLONASS	No change
	Four Global Positioning System (GPS) units located in the lab	No change
	Two GPS Antenna Assemblies (AAs) located on S0	No change
	Two RGAs located on S0	No change
	Two JEM GPS antennae installed on JLP for HTV	No change
Control	Four CMGs on Z1 truss	No change
	RS thrusters	No change

Table 2-5. MCS capability summary at Stages 15A to 2J/A

2.1.6 Environmental Control and Life Support System

Mission 2J/A adds no new functionality to the ISS Environmental Control and Life Support System (ECLSS). Table 2-6 presents the ECLSS functional overview at the end of stage 2J/A. Figure 2-4 depicts the USOS ECLSS Overview at the end of Stage 2J/A.

Subsystem	15A Stage	2J/A Stage	
USOS ECLSS (continued)			
ORCA	Located in the airlock; only functional when orbiter is docked	No change	
Airlock depress pump	Crew Lock (C/L)	No change	
ARS			
CDRA	Located in LAB1D6; interfaces with LTL of the thermal control loop	No change	
	Requires more power to regenerate, so is kept as backup for Vozdukh; used when more than three crewmembers are present on ISS		
TCCS	Located in LAB1D6	No change	
MCA	Located in LAB1D6	No change	
SDS	Located throughout USOS; provides samples for MCA	No change	
TOCA	Installed in the LAB. Analyzes Regen ECLSS samples for potability	No change	
THC			
CCAA	Two located in the LAB, one in Node 2, and one in Airlock; includes ducts and the following:	No change	
	HEPA filters (six)		
	WS		
	CHX		
	TCCV		
	Airlock CCAA used for campout and provides cooling to ORCA		
IMV	Located throughout USOS and connected to RS through drag-through ducts; Russian IMV does not have isolation valves like US IMV does	No change	

Table 2-6. ECLSS capability summary at Stages 15A and 2J/A (continued)

Table 2-6. ECLSS capability summary at Stages 15A and 2J/A (concluded)

Figure 2-4. USOS ECLSS overview at Stage 2J/A

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2.1.7 Thermal Control System

Mission 2J/A adds to the active thermal control system of the JEM external segment. Table 2-7 provides an overview of the TCS capability at the completion of Stages 15A and 2J/A. Figure 2-5 and Figure 2-6 present the TCS external and internal overview at the end of Stage 2J/A.

System	15A Stage	2J/A Stage
USOS External Thermal Control System		
Active system	ETCS active	No change
Heat collection	Two Interface Heat Exchangers (IFHXs) (U.S. Lab) rejecting heat to External Thermal Control System (ETCS)	No change
	Six IFHXs (Node 2) rejecting heat to ETCS	
	Other truss components rejecting heat to ETCS	
Heat transportation	ETCS interfaces with IFHXs for both LAB and Node 2	Spare PM2 launched on 2J/A and transferred to ESP-3 during
	ETCS stats:	mission
	Working fluid: Ammonia	
	Two independent loops	
	Loop A interfaces with LAB LTL IFHX, COL MT IFHX, and N2 MT IFHX	
	Loop B interfaces with LAB Moderate Temperature Loop (MTL) IFHX, COL LT IFHX, and N_2 LT IFHX	
	One Pump Module (PM) in each loop	
	One Ammonia Tank Assembly (ATA) and one Nitrogen Tank Assembly (NTA) in each loop	

Table 2-7. TCS capability summary at Stages 15A and 2J/A

System	15A Stage	2J/A Stage	
USOS External Thermal Control System (concluded)			
Heat rejection	ETCS: All ETCS radiators deployed	No change	
	Each radiator capable of rejecting 11.67 kW		
Controlling MDMs	EXT, truss MDMs, Port Thermal Radiator (PTR), Starboard Thermal Radiator (STR): loop control, RBVM control	No change	
Internal Thermal Control System			
Heat collection	Cold plates	No change	
	USOS heat exchangers (CCAA, AAA, payload HXs, Regen HX)		
	Columbus TCS		
	JEM TCS		
Heat transportation	LAB: Two connectable Loops: Low Temperature Loop (LTL) and Moderate Temperature Loop (MTL)	No change	
	Normally operated in single LT mode		
	Working fluid: Water		
	One Pump Package Assembly (PPA) for each loop		
	Node 2: LTL and MTL loops		
	Columbus MTL and LTL loops		
	JEM MTL and LTL loops		
Heat rejection	Two Lab IFHXs (interface with the ETCS)	No change	
	Six Node 2 IFHXs (interface with the ETCS)		

Table 2-7. TCS capability summary at Stages 15A and 2J/A (continued)

System	15A Stage	2J/A Stage	
	Internal Thermal Control (concluded)		
Controlling MDMs	INT MDMs: IATCS system control, generate Caution and Warning (C&W) messages, failure recovery, leak recovery, heater control, cmd/telemetry routing, PPA control	No change	
	LA-1: LTL hardware		
	LA-2: MTL hardware		
	N2-1: MTL hardware		
	N2-2: LTL hardware		
	COL MDMs control the Columbus TCS		
	The MDMs control the JPM active TCS		
	Russian Segment Thermal Control System [COTP]		
	SM Internal TCS		
Heat collection	Some equipment air-cooled by Ventilation System [CB]	No change	
	Warm air is cooled by Air Conditioner [CKB-1 and 2]		
	Some equipment cooled by one of 25 coldplates; both loops flow through each coldplate		
Heat transportation	Two Internal Thermal Loops [KOB-1, KOB-2]	No change	
	Working fluid: Triol		
	One loop usually works as prime with the other as backup; however, the two loops can be connected		
	Two replaceable pump panels per loop [CNH1-4], each with two pumps in series (total of eight pumps)		

Table 2-7. TCS capability summary at Stages 15A and 2J/A (continued)

Table 2-7. TCS capability summary at Stages 15A and 2J/A (continued)

Table 2-7. TCS capability summary at Stages 15A and 2J/A (continued)

Table 2-7. TCS capability summary at Stages 15A and 2J/A (continued)

Table 2-7. TCS capability summary at Stages 15A and 2J/A (concluded)

Figure 2-5. 2J/A External active thermal control system

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Figure 2-6. 2J/A TCS module overview

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2.1.8 Robotics Systems

Mission 2J/A delivers a spare Linear Drive Unit (LDU) for the MT on the ICC-VLD and the JEM SFA Storage Equipment (SSE) on the JEF. Table 2-8 provides an overview of the ISS robotics capability at the completion of Stages 15A and 2J/A. Figure 2-7 and Figure 2-8 show overviews of the robotics configuration and MSS worksites.

System	15A Stage	2J/A Stage
USOS Robotics system (concluded)		
MBS	Contains four Power and Data Grapple Fixture (PDGFs) for SSRMS connection and a POA for storage of payloads or ORUs	No change
	Powered only when MT is docked at a worksite	
	Sends/receives video and data through TUS	
JEM segment Robotics system		
JEMRMS	No comments	Small Fine Arm (SFA) Storage Equipment (SSE) launched on Flight 2J/A, located on the JEF. SFA is not yet manifested; when launched, it will be installed on JEMRMS or stored on SSE when not in use
JEM RWS	JEMRWS deployed in JPM and activated	No change
Backup Drive System (BDS)	Available as backup RMS controller in the event of a JEMRMS failure	No change

Table 2-8. Robotics capability summary at Stages 15A and 2J/A (concluded)

Figure 2-7. Robotics overview at Stage 2J/A

Represents an MSC worksite with four hardened MT latch fittings, two passive MT positions sensors (zenith rail) and utility port (prime and redundant passive UMAs).

Each box in each truss segment denotes a truss bay, with the corresponding truss bay number below it.

Note: MT/CETA rails and WS 9 and WS 10 UMAs were deleted from S5, S6, P5, and P6 per ISS SSCN 009951A, approved on 08/29/06. As a result, WS 9 and WS 10 (formerly planned for P6 and S6) are no longer part of the ISS baseline assembly complete configuration.

Figure 2-8. MSS WS locations

2.1.9 EVA Systems

Mission 2J/A adds no EVA system hardware. Table 2-9 provides an overview of the EVA capability at the completion of Stages 15A and 2J/A.

System	15A Stage	2J/A Stage
E/L	Contains equipment and tools for EVA operations	No change
C/L	Depressurizes to facilitate transfer of crew and equipment to and from space during EVA ops	No change
CETA	Two CETA carts allow for translation of crew and equipment along ISS truss	No change
$DC-1$	RS docking port that doubles as EVA portal for Orlan EVAs	No change

Table 2-9. EVA capability summary at Stages 15A and 2J/A

2.2 MISSION 2J/A HARDWARE

This section provides a description of the external ORU hardware flown on mission 2J/A. The activities during the mission involving the hardware are only briefly mentioned. Refer to Section 3.0, Operations Summary, for more details on the integration of the hardware. Descriptions of the JEM hardware flown on mission 2J/A can be found in Section 5.

2.2.1 Integrated Cargo Carrier-Vertical Light Deployable

The Integrated Cargo Carrier-Vertical Light Deployable (ICC-VLD) is installed on the launch pad in the orbiter aft Payload Bay (PLB), Bays 10-12, via four longeron and one keel trunnion. The ICC-VLD has two Power and Video Grapple Fixtures (PVGFs) for grapple by the SRMS and SSRMS.

The launch configuration of the ICC-VLD includes a Space-to-Ground Antenna (SGANT), Pump Module 2 (PM2), Linear Drive Unit (LDU), and six P6 batteries. The LDU, SGANT, and PM2 are each attached to a Passive Flight Releasable Attachment Mechanism (PFRAM) on the ICC-VLD.

Figure 2-9 shows the launch configuration of the ICC-VLD, with a better view of the SGANT, PM2, LDU on the carrier shown in Figure 2-10.

Figure 2-9. ICC-VLD launch configuration

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Figure 2-10. ORU locations on the ICC-VLD

The SRMS removes the ICC-VLD from the PLB, then hands it off to the SSRMS for temporary installation on the Mobile Base System (MBS) Payload/ORU Attachment (POA). The process is reversed to berth the ICC-VLD in the PLB for return. The ICC-VLD return complement consists of the six expended P6 batteries and three empty PFRAMs, as shown in Figure 2-11.

Figure 2-11. ICC-VLD return configuration

There are two power systems for the ICC-VLD. When in the PLB, the ICC-VLD receives 28 V dc power from the orbiter payload buses via an EVA-removable LTA cable. When attached to ISS (either to the MBS POA or through the SSRMS), it receives 124 V dc power. The ICC-VLD Launch to Activation (LTA) heaters (28 V dc) are planned to be activated ~1 hour after opening of the PLB Doors (PLBDs). Thermal analysis indicates that the ICC-VLD can remain unpowered for a maximum of 60 hours, but any time the ICC is powered off over 36 hours could significantly impact the ICC's ability to withstand planned powerdowns (see Flight Rule 2JA_C2-73).

The LTA cable is disconnected by EVA prior to the removal of the ICC-VLD from the payload bay (planned for EVA1). The ICC-VLD is not repowered after it is reberthed in the payload bay; it returns unpowered.

Figure 2-12 shows the ICC-VLD power configuration when in the PLB. Figure 2-13 shows the power configuration when attached to ISS.

Figure 2-13. ICC-VLD power feed diagram on ISS

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2.2.2 Linear Drive Unit

The LDU is one of the three ORU spares launching on the ICC-VLD (see Figure 2-10) on mission 2J/A, and is transferred by an EVA crewmember to the ESP-3 during the joint mission. The LDU weighs approximately 596 lbm and launches attached to a PFRAM, which remains behind on the ICC-VLD when the LDU is removed, returning empty.

Located on the zenith side of the Mobile Transport (MT), the LDU is the mechanism that allows the MT to translate along the truss to a predetermined worksite, serving as both an "engine" and "transmission." Additionally, it acts as the third support of a three-point suspension, the other two being the Roller Suspension Units (RSU) on the nadir side of the MT. The LDU is made up of several components: Engagement Drive (ED), Translation Drive (TD), and the Bogie Wheel Assembly. Figure 2-14 and Figure 2-15 show the LDU and its components.

Figure 2-14. LDU assembly

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Figure 2-15. LDU assembly cross-section

2.2.3 Pump Module 2

Weighing approximately 1392 lbm, the Pump Module 2 (PM2) is another ORU spare launching on the ICC-VLD as part of the mission 2J/A manifest. Refer to Figure 2-16 for a photo of PM2 on PFRAM. PM2, like the LDU, is removed from the ICC-VLD during the mission and installed on ESP-3 by an EVA crewmember.

The PM circulates liquid ammonia through the External Thermal Control System (ETCS) cooling loops, to the Interface Heat Exchangers (IFHX), and cold plates for collection of heat. The warm ammonia is pumped to the radiators for cooling, then returned to the IFHXs and cold plates to continue the cycle. Failure of a PM results in the loss of one external ammonia loop which eliminates half of the heat rejection capability on ISS.

Figure 2-16. PM2 on PFRAM

2.2.4 Space-to-Ground Antenna

The final spare ORU on the ICC-VLD is the SGANT assembly, which weighs approximately 742 lbm. Refer to Figure 2-10 for the location of the SGANT on the ICC-VLD. The SGANT is part of the ISS Ku-band subsystem, enabling high-rate data communications to and from ISS. Payload data, video, crew procedures, IP phone, and other high-rate data is communicated via this link. The SGANT is transferred to ESP-3 by an EVA crewmember. Figure 2-17 is a drawing of the SGANT, and Figure 2-18 is a photo of the SGANT.

Figure 2-17. SGANT assembly

Figure 2-18. SGANT antenna assembly

2.2.5 P6 Batteries

The batteries (see Figure 2-19) are the sole method in the USOS Electrical Power System (EPS) for storing electrical power for use during orbit eclipse and contingency events. During the eclipse pass of an orbit or at any time there is little to no power generation by the solar arrays, the batteries discharge to feed the downstream loads. When the ISS enters insolation, the batteries draw current from the primary power channel to replenish their State of Charge (SOC). This charging and discharging cycle is controlled by the Battery Charge/Discharge Units (BCDU).

Figure 2-19. Battery ORU

Two battery subassembly ORUs are connected in series to create a "battery set," supported by one BCDU. The batteries and BCDUs for each power channel are located external to the ISS on the Integrated Equipment Assembly (IEA) of each Photovoltaic Module (PVM), as shown in Figure 2-20. Also located in the IEA is a Direct Current Switching Unit (DCSU) and a DC-DC Converter Unit (DDCU).

Figure 2-20. ORU locations in the IEA

Flight 2J/A brings up six battery ORUs on the ICC-VLD to replace the six Channel 2B batteries located on P6. The ICC-VLD is grappled by the SSRMS and moved to the vicinity of the P6 truss to aid the EVA crewmembers in the Removal and Replacement (R&R) of the batteries. The six old batteries are installed on the ICC-VLD for return to Earth, as seen in Figure 2-11, depicting the ICC-VLD return configuration.

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3.0 OPERATIONS SUMMARY

This section summarizes the flight operations for mission 2J/A.

3.1 2J/A MISSION OVERVIEW

Mission 2J/A (STS-127) flies on the Space Shuttle Endeavour (OV-105). This flight consists of a seven-person crew, which includes one ISS crewmember for rotation. STS-127 has a mission duration of 16 days (+0 for an unscheduled docked day, +2 days for Orbiter and weather contingencies = $16 + 0 + 2$). The flight provides 10 full hatch-open docked days for ISS assembly, activation, and checkout activities (a total of 12 docked days if docking day and hatch-closure day are included). This extended docked timeframe is due to the capability of the Station/Shuttle Power Transfer System (SSPTS). The SSPTS is installed in the Orbiter PLB and converts 120 V dc power routed from the ISS into conditioned Orbiter 28 V dc power, allowing the Orbiter to conserve cryogenic fuel used to generate its electrical power. See Section 4 for more details on the SSPTS.

The 2J/A mission to the ISS is the third of three JAXA partnership missions to deliver and assemble the major components of the JEM to the ISS. On this flight, there are five EVAs (see Section 3.4) and 8 days of heavy robotics activity.

The primary objectives of the flight are as follows:

- a. Rotate an ISS crewmember.
- b. Deliver, install, and activate the JEF on the JPM EFBM.

Before EVA1, the SSRMS (based on the Node 2 PDGF) grapples the JEF while in the Shuttle PLB. On EVA 1, the EVA crew removes the EFBM MLI (both passive and active) disconnects the LTA cable connecting the JEF to the PLB and stows it on the EVA Cable Stowage Hardware (ESCH). After the EVA activities are complete, the SSRMS unberths the JEF and maneuvers to a handoff position, where the SRMS takes the JEF. The SSRMS walks off to the MBS PDGF3, releases the Node 2 PDGF, and takes the JEF back from the SRMS at a new handoff position. The SSRMS installs the JEF and the IV crew performs EFBM ops. JAXA activates the JEF from the ground.

c. Transfer ORUs from ICC-VLD to ISS.

The ICC-VLD LTA cable is disconnected during EVA 1 and stowed on the ECSH. However, the ICC-VLD remains in the Shuttle PLB until after Focused Inspection (FI) on FD5, if FI is required, when it is removed by the SRMS. It remains on the Shuttle arm overnight until retrieved by the Station arm on the morning of FD6. On FD5, the SSRMS is located on the Node 2 PDGF and used for stowing the OBSS after FI. At the end of the crew's OBSS Stow activities, they leave the SSRMS at the MBS PDGF 3 pregrapple position. Overnight, the ground performs the grapple of the MBS PDGF 3, releases the Node 2 PDGF, and

translates the Mobile Transport (MT) from Worksite 6 to Worksite 7. After the crew wakes on FD6, they maneuver the Station arm from the MBS Transfer Stow position to the ICC-VLD handoff position, where it receives the ICC-VLD from the Shuttle arm. The SSRMS then maneuvers the ICC-VLD to the MBS and stows it on the POA.

If FI is not required, the ICC-VLD is removed from the PLB by the SRMS on the morning of FD5 and is handed off to the SSRMS later that afternoon. In the "FI-Required" plan, the SSRMS was planned to be on the Node 2 PDGF to assist with OBSS operations. Since the SSRMS is not required to help with the OBSS activities in a "No FI-required" plan, the SSRMS remains on the MBS PDGF 3, and the walk-off from Node 2 PDGF to the MBS is not required. The MT was left at WS6 at the end of JEF installation so it needs to translate to WS7 prior to the SSRMS grapple of the ICC-VLD.

During the EVA on FD6, the crew transfers the SGANT, the Linear Drive Unit (LDU), and the Pump Module (PM) to ESP-3. On FD7, the SSRMS removes the ICC-VLD from the POA and maneuvers to the Translate Stow position. The ground then translates the MT from Worksite 7 to Worksite 8. The ICC is powered through the SSRMS. On the morning of FD8, the ICC-VLD is maneuvered to the EVA worksite for the P6 battery R&R. During EVA 3, four of the six P6 batteries are R&R'd. On EVA 4, the remaining two P6 batteries are R&R'd. After EVA 4, the ICC-VLD is handed off from the SSRMS to the SRMS, and the SRMS berths it in the PLB.

d. Transfer the three JAXA payloads from the JLE onto JEF.

The SRMS unberths the JLE from the PLB on FD7 and hands it over to the SSRMS. The SSRMS installs the JLE onto JEF EFU 10. The crew had previously prepared the payloads on the JLE by removing MLI from the ICS-EF, releasing the ICS-EF AHM, and releasing the SEDA-AP BLM. Later in the mission, the three payloads are transferred by the crew operating the JEMRMS. After the transfers are complete, the SSRMS uninstalls the JLE and hands it off to the SRMS, which berths it in the PLB.

Secondary objectives include two payload deploys (ANDE-2 and DRAGONSAT) that deploy four satellites after undocking and multiple DTOs.

See Figure 3-1 for the launch layout of the Orbiter PLB, including the JEF, JLE, the ICC-VLD, and the two deployables. See Drawing 3.1 for more details of the Shuttle cargo bay layout.

Reference the latest NSTS-17462-127, Flight Requirements Document (FRD) for STS-127, for additional flight information.

Figure 3-1. STS-127-2J/A PLB layout (launch)

3.2 INSTALLATION, ACTIVATION, AND CHECKOUT OPERATIONS

This section provides details on the operations required for JEF installation, activation and checkout, and for JLE and ICC-VLD operations during the docked timeframe.

The 2J/A mission delivers several pieces of hardware to ISS that must be installed by EVA/Robotics and then checked out. Some of this hardware has thermal constraints that complicate the choreography of installation and checkout activities. Reference the STS-127/ISS-2J/A flight-specific Flight Rules (FR) for all thermal constraints for this mission.

3.2.1 JEF Installation

The JEF is a multipurpose experiment space carrier where various experiments (such as science, communication, scientific and engineering, material or Earth observation) can be attached and conducted in the vacuum of space (see Figure 3-2). The JEF consists of multiple subsystems that are all described in detail in Section 5.1. When the JEF is berthed to the JPM EFBM, it receives power, cooling, and C&DH services from the JPM and transmits commands and telemetry to and from the attached payloads.

Figure 3-2. Photo of JEF (with MLI)

The JEF is launched in Shuttle PLBs 4 through 7 (see Figure 3-2). APCU 1 supplies 124 V dc power to the JEF ESC-b, SSE, HCE-b, and Vision Equipment (VE) via the EVA LTA cable.

Note: The APCU requires active cooling from the Orbiter.

Before unberthing the JEF, power is removed from the JEF, and the LTA cable is demated during EVA 1 (see Figure 3-3 and Figure 3-4). The LTA cable is wrapped around the EVA Cable Stowage Hardware (ECSH) attached to the PLB sill and returned to Earth.

Receptacle (850J001)

Receptacle (850J002)

Receptacle (850J003)

Figure 3-3. JEF LTA cables (photo)

Figure 3-4. JEF LTAB launch config

In the launch config, power is routed from the LTA cable/APCU through a cap on the JEF Launch to Activation Box (LTAB) receptacle J002 that is specially designed to supply power to the JEF in its PLB configuration (power to HCE-b, SSE, ESC-b, and the VE-Aft and VE-fwd in their launch locations). When the JEF is attached to the ISS, the power routing requirements change, as power now is routed through the PDB to the HCE-b and ESC-b (rather than the HCE-b, ESC-b, and SSE being powered directly). The VE still must be powered in their launch locations, however, so a special cap, CAP-ISS2, is installed on the J002 connector, which routes the power in this intermediate config (see Figure 3-5). After both of the VE are moved to their final positions, another cap, CAP-ISS, is installed on the J002 receptacle of the LTAB, which allows all equipment to receive power per the nominal paths (see Figure 3-10).

See Section 3.3.1 for more information on these activities during EVA 1. See also Drawing 3.2 for the JEF power configuration while in the PLB.

When the JEF is ready to be removed from the PLB, the SSRMS grapples the Flight Releasable Grapple Fixture No. 1 (FRGF1), removes the JEF, and hands it off to the SRMS. The SRMS maneuvers the JEF to a second handoff position while the SSRMS moves to another location. Then the SSRMS regrapples the JEF from the SRMS and installs it on the JPM EFBM using the SRMS wrist camera and JEMRMS camera as additional views.

Note: There are no payloads attached to the JEF when launched, although the VE is installed in positions where they can receive heater power.

Figure 3-5. JEF LTAB in ISS2 configuration

3.2.2 EFBM Operations

As shown in Figure 3-6, Active EFBM operations for JEF berthing involve the crew setting up the Berthing Mechanism Control and Display Unit (BCDU), connecting it to the Berthing Mechanism Electronics Package (BEP), deploying the capture latches, capturing the JEF, structurally securing the JEF using the structural latches, and connecting the fluid/data/power umbilicals.

Figure 3-6. Active EFBM operations

After the BCDU has been connected to the BEP, as shown in Figure 3-7, and the BEP has been activated, the capture latches are deployed via crew command from the BCDU. Upon successful capture latch deployment, the SSRMS unberths the JEF from the Orbiter PLB. Previously, SSIPC was expecting the BEP upper-temperature limit to be reached within 3 hours of activation; however, on-orbit data indicate that the BEP can remain powered on for a longer period of time. The BEP may still be turned off during berthing operations to keep the temperatures at preflight analysis levels; however, that is done by SSIPC (not the crew), if required. (Maintaining the temperatures similar to those used in preflight analysis is important because elevated temperatures may affect the expected signatures of a nominal berthing; i.e., current draw during berthing.) After the SSRMS operator maneuvers the JEF to the Ready to Latch (RTL) position, the EFBM operator initiates capture latch closing. At this point, no crew exercise or thruster firings are permitted until at least three structure latches (bolts) have been fully extended into the Passive EFBM on the JEF.

Figure 3-7. BCDU-BEP setup

After the four capture latches are closed, Structural Latches (SLs) 1 and 2 are extended, then SLs 3 and 4 are extended. SLs 1 and 2 are then retracted and reextended. During the connection of the structural latches, the crew monitors the current flowing from PDB A2 to the BEP using a FLUKE current probe in conjunction with a scopemeter, as detailed in Figure 3-8. A plot of the current profile allows the ground (SSIPC) to assess bolting torque. The absence of an expected peak current indicates failure of the torque detection circuit. Before the BEP activities, the crew sets up a G1 camcorder to downlink the scopemeter readout.

Figure 3-8. Current monitoring of BEP

Upon completion of structural latching, the umbilical actuators are driven to the connected position to permit fluid/data/power flow between the JPM and the JEF.

More detail on the EFBM, BCDU, and the BEP can be found in Section 5.1.1.2.

3.2.3 JEF Activation

When the JEF is installed on the JPM EFBM, JEF is activated. A flow diagram summarizing JEF installation and activation activities are shown in Figure 3-9. More details of the major steps for JEF activation are as follows.

- a. Pre-JEF Activation
	- 1. Increase flow to JPM ATCS EFHX (to preclude water freezing in EFHX).
	- 2. IV crew to connect 1553B jumpers to JEF. (This enables communication between the JPM JCP and the JEF ESC.)
- b. JEF Activation
	- 1. JEF is powered, ESC, thermal control components are activated, and the heaters are configured. The order of the activated components is as follows:
		- (a) EF-PDB a, EF-PDB b, and ESC a are activated first.
		- (b) HCE a, HCE b, and TIU a are activated.
		- (c) SPB a and SPB b are activated.
	- 2. JEF ATCS Activation
		- (a) Cycle valve (open/closed) to allow fluid into line.
		- (b) Perform leak check in JPM fluid line (from EFHX to JEF).
		- (c) If leak check successful, then pump is activated.
		- (d) Warm up EF ATCS fluid, as required. (Fluid must be greater than 8° C to preclude water freezing in the lines
		- (e) Start JEF ATCS fluid flow to EFHX.
		- (f) Configure JEF ATCS for steady state operations.
	- 3. Decrease flow to JPM ATCS EFHX (for nominal operations).

Figure 3-9. JEF activation sequence

3-11

When the JEF is installed on the JPM and JEF activation is complete, the primary (10) and backup (9) Exposed Facility Units (EFUs) for JLE installation are checked out. On EVA 2, the JEF forward VE is relocated and activated. After the JLE is installed, the JAXA payloads are transferred, and then the JEF Aft VE is relocated and activated on EVA 4. (The Aft VE cannot be installed until after the JAXA Payloads are transferred off of the JLE due to clearance issues.) Finally, the LTAB cap is configured to its nominal ISS configuration. The final LTAB configuration allows for power to be provided to the VE and the SSE in their final on-orbit locations. See Figure 3-10 for the final on-orbit LTAB cap configuration for nominal ISS operations. See Section 3.2.4 for JLE operations. See Sections 3.3.1.2.6 and 3.3.1.4.2 for the VE installation during EVA operations.

Figure 3-10. JEF LTAB in nominal ISS configuration

3.2.4 JLE Operations

The JLE is a logistics carrier that is launched and returned on mission 2J/A in bays 8 and 9. See Figure 3-1 for the location of the JLE in the PLB and Figure 3-11 for a photograph of the JLE unloaded. Three JAXA payloads are launched on the JLE: Interorbit Communication System - Exposed Facility (ICS-EF), Monitor of All-sky X-ray Images (MAXI), and Space Environment Data Acquisition equipment - Attached Payload (SEDA-AP). See Figure 3-12 for a depiction of the JLE loaded with all three payloads in its vertical configuration in the PLB.

Figure 3-11. JLE (unloaded)

Figure 3-12. JLE with JAXA payloads

The JLE is planned to be unberthed from the PLB on FD7. The crew installs the JLE on the JEF at EFU 10. While in the Orbiter, redundant 28 V dc power is provided to the JLE and its payloads from PL PRI MN C through the ROEU and a Payload Power Switching Unit (PPSU). Before unberthing the JLE from the PLB, 28 V dc power is removed from the JLE heaters and the ROEU is demated (see Figure 3-13). The SRMS grapples the JLE, removes it from the PLB, and maneuvers it to a handoff position. The SSRMS receives the JLE and then berths it to the JEF. The JLE remains attached to the JEF for several days and is returned to the PLB at the end of the docked mission. The JEMRMS transfers the payloads to the respective EFUs.

Note: There is no active cooling to the JLE.

Figure 3-13. ROEU power configuration to JLE in PLB

When all JAXA payloads are successfully transferred to the JEF, the SSRMS unberths the JLE from JEF, hands it off to the SRMS, and is returned (unloaded) to the PLB. A keel camera in the Orbiter and keel target on the JLE is used to assist in berthing the Cargo Element (CE) back into the PLB. The JLE Orbiter interface cable is not required to be reconnected as there is nothing that requires thermal conditioning.

3.2.5 ICC-VLD Operations

The ICC-VLD is a cross-bay carrier with mounting provisions for the following ORUs: SGANT, LDU, PM, and six P6 batteries. The ICC-VLD (also sometimes referred to as the VCC or vertical cargo carrier) consists of a vertical octagonally shaped flatbed pallet.

The SRMS removes the ICC-VLD from the PLB and hands the ICC-VLD off to the SSRMS for installation on the Mobile Base System (MBS) Payload/ORU Attachment (POA). While located on ISS, the LDU, SGANT, and PM ORUs are transferred to ESP-3 during EVA 2.

Before removal of the ICC-VLD from the Orbiter cargo bay, the 28 V dc power from the Shuttle is powered off via SSP 2 switch throws. The EVA crew disconnects the two EVA connectors (J01 and J02), stows the LTA cable on the ECSH, and installs the LTA connector caps onto the ICC-VLD. While the ICC-VLD is attached to the SSRMS and installed on the POA, the ISS provides 124 V dc via an SSRMS Payload and Video Grapple Fixture (PVGF) interface.

The SSRMS removes the ICC-VLD from the MBS POA on FD07. On the morning of FD08, the SSRMS maneuvers ICC-VLD to the P6 IEA battery R&R position for EVAs 3 and 4. After the R&R is complete, the SSRMS hands the ICC-VLD back to the SRMS for reberth into the PLB. A keel camera in the Orbiter and keel target on the ICC-VLD is used to assist in berthing the CE back into the PLB. The ICC-VLD return configuration consists of six P6 Channel 2B batteries and three empty PFRAMs.

3.3 EVA OPERATIONS SUMMARY

Details on each of the five 2J/A EVA tasks are given in this section. An overview of the tasks for each EVA is given in Table 3-1.

Table 3-1. EVA task overview

Table 3-1. EVA task overview (concluded)

3.3.1 Scheduled EVA Tasks

This section presents an overview of the EVA tasks that are planned for mission 2J/A at the time of publication. Five EVAs are scheduled for mission 2J/A. The latest EVA timeline and information can be found in the STS-127/2J/A EVA checklist or the EVA Web site (http://mod.jsc.nasa.gov/DX/DX32/STS127/STS-127timelines.html). Figure 3-14 shows an overview of locations on ISS where EVA activity occurs.

Figure 3-14. EVA worksites

3.3.1.1 EVA 1

3.3.1.1.1 JPM External Facility Berthing Mechanism Preparation

This activity consists of the active EFBM MLI cover removal and the JEMRMS grounding tab tiedown.

3.3.1.1.1.1 JPM Active EFBM MLI Removal

Figure 3-15 shows the location of the JPM EFBM on the ISS. This is the active side of the berthing mechanism and is used to connect the JEF to the JPM. The JPM launched with four small MLI covers and one large MLI cover installed on the JPM EFBM (see Figure 3-16). The four small covers were removed on ULF2, and the large MLI cover is removed on mission 2J/A. Figure 3-17 shows the post-ULF-2 configuration. The covers are released by turning 1/4-turn fasteners (see Figure 3-18).

Figure 3-15. PM EFBM relocation

Figure 3-16. JPM EFBM MLI covers

Figure 3-17. Post ULF-2 EFBM MLI cover configuration

Figure 3-18. EVA points of interest – active EFBM

3-19

3.3.1.1.1.2 JEMRMS Grounding Tabs

After the JPM EFBM MLI removal is complete, EV1 translates to the JEMRMS End Effector (EE) to restrain two grounding tabs on the EE that are obstructing the field of view of the JEMRMS Wrist Vision Equipment (WVE) (see Figure 3-19). EV1 wraps the two protruding grounding tabs around the WVE interface cables, ensuring that both grounding tabs are tucked underneath the covers (see Figure 3-20). Inhibits are put in place to prevent JEMRMS motion and are listed in Table 3-2.

Figure 3-19. JEMRMS EE protruding grounding tab

Figure 3-20. Depiction of JEMRMS EE grounding tabs tucked under MLI

3-20

Table 3-2. JEMRMS EE inhibits

3.3.1.1.2 Payload Bay Preparation

This activity consists of the passive EFBM MLI cover removal; the JEF LTAB disconnect, reconfiguration, and stow; the MAXI contamination cover removal, the ICC-VLD LTA disconnect, reconfiguration, and stow; and the NOD2 Zenith CBCS Flap Opening. These tasks are scheduled to take an hour and 15 minutes and require one crewmember.

3.3.1.1.2.1 JEF Passive EFBM MLI Removal

There is one large MLI cover located on the JEF EFBM (see Figure 3-21). This is the passive side of the berthing mechanism and is used to connect the JEF to the JPM. The MLI cover is released by turning 1/4-turn fasteners located on the port zenith, port nadir, starboard nadir, and starboard zenith sides and is stowed in the TSA after removal.

Figure 3-21. JEF (passive) EFBM location and MLI cover

3-21

3.3.1.1.2.2 JEF LTA Disconnect and Preparation

The JEF is powered by APCUs while it is in the Shuttle PLB via a LTA cable. Before unberthing the JEF, the power connection needs to be demated. See Figure 4.4 for APCU details and Section 3.2.1 for more details on the LTAB reconfigurations. See Figure 3-22 for the launch configuration of the LTAB. The crewmember removes the LTA MLI cover and disconnects the LTA cable from the LTAB after both APCUs have been powered off. A connector cap is installed to LTA EVA cable jack J001, then the LTA mode plug P002-S is removed and brought back inside. A special cap, CAP-ISS2 (brought out from inside), is installed on J002 to replace the CAP-LTA (a.k.a. the LTA mode plug) that was removed. Afterwards, the LTA MLI is reinstalled. There is one last cap configuration change that takes place during EVA 4 as a part of the Aft VE installation. Eight TA clamps on the LTA cable are released, and the LTA cable is stowed on the ECSH attached to a dummy connector. The ECSH is shown in Figure 3-23. Inhibits for this task are given in Table 3-3.

Receptacle (850J001)

Receptacle (850J002)

Receptacle (850J003)

Figure 3-22. JEF LTAB in launch config

Figure 3-23. JEF LTA cable stowed on EVA Cable Stowage Harness

Table 3-3. Inhibits for JEF and ICC-VLD LTA cable demate

3.3.1.1.2.3 MAXI Contamination Cover Removal

The MAXI is one of three JAXA-exposed payloads that launch on the JLE (see Figure 3-24). After ensuring that the Adjustable Equipment Tether (AET) is clear of the JEF removal path, the EVA crew removes and stows the MAXI GORE-TEX® contamination cover in the TSA. Figure 3-25 shows both the Payload Interface Unit (PIU) and contamination covers.

Note: The PIU cover was removed on the ground prior to launch.

Figure 3-24 . JLE payloads

Figure 3-25. MAXI with PIU and contamination covers

3.3.1.1.2.4 ICC-VLD LTA Disconnect and Reconfiguration

To prepare the ICC-VLD for its removal from the PLB on FD 5, the LTA cable is disconnected on EVA1.

During this task, the P01 and P02 ICC-VLD LTA cables are disconnected from the LTA box and inspected for FOD or damage. If there is no damage or debris, caps are installed on the J01 and J02 ports. The three TA clamps securing the LTA cables are released, and the cables are stowed on the ECSH brackets. Inhibits for this task are given in Table 3-3. See Section 2.2.1 for detailed information on the ICC-VLD.

3.3.1.1.2.5 NODE2 Zenith CBCS Flap

The Node 2 Zenith CBCS Flap is opened during 2JA to protect for HTV Contingency berthing at Node 2 Zenith (rather than Nadir). The crew translates to the Node 2 Zenith CBM and simply opens the flap and ensures it is attached to the Velcro on the CBM cover.

3.3.1.1.3 CETA Cart Reconfig

There are two tasks included in this activity: 1) the Brake handle and WIF reconfiguration and 2) the S3 MT stop stow.

The Port CETA Cart (CETA Cart 2) is being reconfigured to alleviate interference with the SARJ. This reconfiguration includes rotating WIFs 4 and 5 back at a 45 $^{\circ}$ angle, rotating the TFR outboard and tying back the brake handles. See Figure 3-26 for locations of these items on CETA Cart 2.

Figure 3-26. CETA Cart 2

The P3 MT stop is currently deployed, which prevents the MT from translating to Worksite 8 with a CETA cart outboard of it. This MT stop will be rotated in so that translation will be allowed to Worksite 8, even with a CETA cart outboard. Translating to Worksite 8 with a CETA cart outboard is required for the P6 Battery R&R on EVAs 3 and 4. There is concern, however, that certain failures would allow the MT to translate further outboard than Worksite 8, potentially causing a collision between the CETA cart and SARJ hardware. To mitigate the risk, it is required to lock the SARJ at a preapproved angle (0° , 50 $^{\circ}$, or possibly 45 $^{\circ}$) that would prevent a SARJ/CETA collision if the MT does not stop. Figure 3-27 shows an MT stop deployed.

Figure 3-27. P3 MT Rail Stop

3.3.1.1.4 P1 ATA FGB Bolts

To prepare for the 17A ATA R&R, the P1 Ammonia Tank Assembly (ATA) Fixed Grapple Bar (FGB) bolts will be released during EVA 1. This saves time for the 17A crew and also allows time for troubleshooting, if the bolts are tight, without impacting the 17A EVA timeline. The FGB that is currently on the Pump Module on ESP-2 is also relocated during 2J/A in prep for 17A. That task takes place during EVA 2 and is described in Section 3.3.1.2.5.

3.3.1.1.5 Node 1 Port CBCS Flap Opening

The Node CBM Flap is opened to allow viewing by the Centerline Berthing Camera System (CBCS) in preparation for the PMA3 relocation during stage 19S. One of the crewmembers accesses the Node 1 Port CBCS Flap by moving along the center disk cover edge. After the flap fastener is released, the EV crewmember rotates the flap to open, opens the Velcro cover, secures the flap to the Velcro, and secures the flap fastener.

3.3.1.1.6 Z1 Tool Retrieval

This activity requires one crewmember and is scheduled to take 45 minutes. EV2 retrieves the external square scoop from the Z1 port toolbox and the square torque multiplier, square recessed socket wrench, and external square scoop from the Z1 starboard toolbox. These tools are used for subsequent EVA activities.

3.3.1.1.7 P3 Nadir UCCAS Deploy

The ISS Common Attach System (CAS) is composed of two Unpressurized Cargo Carrier Attachment System (UCCAS) sites and four Payload Attachment System (PAS) sites. Figure 3-28 shows the UCCASs located on the P3 truss segment and the PASs

on the S3 truss segment, as well as the mission each component was delivered. The UCCAS and PAS are identical except that the UCCAS contains a redundant Integrated Motor Controller Assembly (IMCA). The nominal deploy procedures are identical for UCCAS and PAS. Figure 3-29 shows the PAS (and UCCAS) in its stowed and deployed configurations.

Figure 3-28. CAS locations on the ISS

Figure 3-29. Stowed and deployed PASs

The P3 Nadir UCCAS must be deployed prior to STS-129/ULF-3, when ELC 1 will be installed. It was scheduled for deployment on STS-119/15A, but during the deploy, it became stuck in the detent position. Troubleshooting procedures were developed during 15A, and another attempt was made to free the UCCAS on a subsequent EVA. However, this was unsuccessful. A new tool has since been developed and will fly on STS-127/2JA to aid in getting the UCCAS past its detent.

3.3.1.1.8 S3 Outboard/Zenith PAS Deploy (Get-Ahead)

If the crew is complete with all prior tasks at an EVA PET of 4:15, they move on to the S3 Outboard/Zenith PAS deploy. If they have not finished their previous tasks prior to PET 4:15, the APFR and tool stanchion are relocated (see Section 3.3.1.1.10) during EVA 1, and the S3 Outboard/Zenith PAS deploy takes place on EVA 5. This task was originally scheduled for STS-119/15A but was deferred when the EV crew had difficulty deploying the P3 Nadir UCCAS.

3.3.1.1.9 Floating Connector Insulating Sleeve Installation (Get-Ahead)

A possible hot-to-shell fault occurring on floating interfaces of some of the EVA connectors could energize plugs, jacks, and backshells to 120 V dc, but would be undetectable to crew and ground. To provide an extra layer of protection on these connectors, insulating sleeves are installed on several of these connectors during 2J/A. The connectors being insulated on this flight are all related to the SSPTS wiring. Table 3-4 lists the inhibits for this activity. Size 21/25 sleeves are installed on P113/J113A and P114/J114A (Figure 3-30) located on Lab Fwd/Stbd; P16/J16A on PMA2 Stbd (Figure 3-31); and P3/J3A on PMA2 Port (Figure 3-32). Size 33/37 MLI booties are installed on P430/J430A and P440/J440A on Node 1 forward (Figure 3-33).

Table 3-4. Inhibits for insulating sleeve installation on SSPTS connectors

JSC-36536 Final, CPN-1

Figure 3-30. Location of J113A/P113 and J114A/P114 interfaces

Figure 3-31. Location of J16A/P16 interface

Figure 3-32. Location of J3A/P3 interface

Figure 3-33. Location of J430A/P430 and J440A/P440 interfaces

3.3.1.1.10 Tool Stanchion and Articulating Portable Foot Restraint 5 Retrieval

This task is scheduled to take 45 minutes, and two crewmembers are required. This task is performed on EVA 1 if there is not time to perform the S3 Zenith Outboard PAS deploy (which must be started by PET 4:15). The APFRs were launched with heat shields that prevent them from being installed in side-mounted WIFs. To give more flexibility to the EVA program, the heat shields are being removed as the opportunity presents. APFR 5 is retrieved and brought inside during EVA1, which allows the crew to remove the heat shield and return the APFR outside on a subsequent EVA. See Figure 3-34 for a picture of the thermal shield on the APFR. Currently, a tool stanchion is installed on the APFR so that EV1 can retrieve it (Figure 3-35) from APFR 5 in PMA1 WIF2, move to the port CETA cart, and install the stanchion in the zenith socket (Figure 3-36). EV2 assists.

Figure 3-34. APFR heat shield

Figure 3-35. Tool stanchion with APFR

Figure 3-36. Tool stanchion socket location on CETA cart

3.3.1.2 EVA 2

3.3.1.2.1 ICC-VLD ORU Transfer to ESP-3

This activity transfers the Linear Drive Unit (LDU), Pump Module (PM), and SGANT ORUs from the ICC-VLD to the ISS. The ORU transfers are scheduled to take 4 hours 15 minutes, and two crewmembers are required. Refer to Figure 3-37 for the ICC-VLD configuration.

Figure 3-37. ORU locations on the ICC-VLD

3.3.1.2.2 Space-to-Ground Antenna (SGANT) Transfer

The SGANT assembly is transferred from the ICC-VLD to ESP-3 Worksite (WS) 5. EV1 removes the SGANT from the ICC-VLD PFRAM, the SSRMS maneuvers the SGANT to the install position, and then crewmembers install the antenna. NO TOUCH areas include the antenna dish (Z93 Paint). Refer to Figure 3-37 for the SGANT antenna on the ICC-VLD and Figure 3-38 for its installation location on ISS. Section 2.2.4 describes the SGANT hardware.

3.3.1.2.3 Pump Module (PM) Transfer

The Pump Module (PM) is transferred from the ICC-VLD to ESP-3 WS 3. EV2 removes the PM from the ICC-VLD PFRAM, the SSRMS maneuvers the PM to install position, and both crewmembers install the pump module. Refer to Figure 3-37 for the location of PM on the ICC-VLD and Figure 3-39 for the ISS installation locations of PM. Section 2.2.3 describes the PM hardware.

3.3.1.2.4 Linear Drive Unit (LDU) Transfer

The Linear Drive Unit (LDU) is transferred from the ICC-VLD to ESP-3 WS 4. The LDU is the drive mechanism of the ISS MT that provides movement of the MT along the truss. Section 2.2.2 describes the LDU hardware. The LDU location on the ICC-VLD is shown in Figure 3-37, and its location on ESP-3 WS 4 on the P3 truss is depicted in Figure 3-39. Similar to the SGANT, EV1 removes the LDU from the ICC-VLD and installs it when it has been transferred by the SSRMS.

Figure 3-38. Location of SGANT on ISS

Figure 3-39. Location of Pump Module (PM) and Linear Drive Unit (LDU) on ISS

3.3.1.2.5 Fixed Grapple Bar Relocation

This task is scheduled to take 50 minutes, and one crewmember is required. To complete the Ammonia Tank Assembly (ATA) R&R on flight 17A, an FGB must be relocated from its position on the spare PM on ESP2 to the nadir side of the P1 ATA. ATA R&R is a two-EVA task, so the installation of the FGB is being performed on 2J/A to allow sufficient time on 17A to complete the R&R. EV2 moves the FGB from ESP2 to P1 ATA, maintaining a 2-ft distance from the radiator beam while it is not locked. When the FGB is soft docked, the crew first torques GP2, followed by GP3, GP4, and GP1, in that order. Figure 3-40 shows the FGB installed on the ATA during a fit check.

Figure 3-40. Fixed Grapple Bar (FGB) installed on ATA

3.3.1.2.6 Forward JEF Vision Equipment (VE) Install

This task is scheduled to take 1 hour, and two crewmembers are required. Table 3-5 lists inhibits for this task. This task is highly desired for JLE installation. Two connector caps are brought out by the EV crew to be used during this task. Before the VE is installed, it must be prepped and removed from the Launch Lock (LL). Refer to Figure 3-41 for the location of the VE prior to being installed in their on-orbit configuration and Figure 3-42 for a picture of the VE with MLI covers. The crewmembers detach the cable from the VE, being careful to avoid the NO TOUCH areas. These are areas with white paint, silver Teflon, and solid lubricant and the DC-DC Converter Unit (DCU). The EV crewmembers remove and stow the VE interface cable from the VE and install a connector cap on JEF deck J007.

To begin removing the VE, the crewmembers remove the four EVA bolts, then the LL structure, and then remove the VE from the mount (two EVA bolts). A round scoop is then installed between the bolt releases.

The VE is installed onto the Exposed Facility (EF) mount (two EVA bolts), and the scoop is removed.

Note: There is a pinch point between the VE and mount.

Lastly, P009 is demated from dummy jack J009 and installed on VE J004.

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Table 3-5. Inhibits for forward JEF-vision equipment install

Figure 3-41. VE launch configuration location

3-40

Figure 3-42. VE MLI launch configuration

3.3.1.3 EVA 3

3.3.1.3.1 NOD2 WIF 14 Relocation/JEF OIH & OIW Installation

This task involves moving the NOD2 WIF 14 to COL WIF2 and installing three JPM On-Orbit-Installed Handrails (OIH) and two On-Orbit Installed WIFs (OIW). See Figure 3-43 for views of the old and new WIF locations and Figure 3-44 for OIH and OIW installation locations. The NOD2 WIF needs to be moved prior to HTV berthing due to tight clearances during berthing. The OIH and OIW is used for contingency EVA operations on the JEF and/or the HTV.

Old location NOD2 WIF 14

New location COL WIF2

Figure 3-43. WIF Relocation from NOD2 to COL

Figure 3-44. JPM OIH and OIW Installation Locations

3.3.1.3.2 Payload Prep of ICS-EF and SEDA-AP

Two crewmembers remove covers from ICS-EF and SEDA-AP and prepare them for transfer. This activity is scheduled to take 30 minutes. During this task, JLE Power Control Unit (PCU) RPC1 should be open to inhibit power to the Electronics Control Unit (ECU).

3.3.1.3.2.1 ICS-EF MLI Removal

The ICS-EF MLI removal is required prior to transferring the payload to the JEF. When each cover is removed, it is jettisoned. Refer to Figure 3-45 for the ICS-EF and an exploded view with all the covers to be removed.

The PIU cover is removed first by peeling off the top flap then releasing and pulling the two belt strap flaps. Contact with the PIU-lubricated areas shall be avoided.

The next cover to be removed is the top cover located on the forward side. First, the top cover Velcro is removed from the sensor cover. The belt strap is then pulled and the top cover removed. Caution should be used as there is a pinch point between the ICS-EF structure and the antenna. Also, the Earth and Fine Sun sensors are NO TOUCH areas.

Next is the Antenna Holding Mechanism (AHM) release. The EV crew should use caution on this step due to sharp edges on the worm wheel gear and on the optical sensor (if it is broken). To release the AHM and complete this task, the crewmembers loosen AHM B- and A-bolt (in that order) and then remove the sensor and bottom covers.

After the crew releases the SEDA-AP BLM (see next section), they return to the ICS-EF and remove the sensor cover and bottom cover. The crew jettisons the PIU, top, and bottom covers.

Figure 3-45. ICS-EF with covers (left) and without covers (right)

3.3.1.3.2.2 SEDA-AP Prep for Transfer

The SEDA-AP has a Beta cloth cover that remains installed on orbit, and no temporary MLI covers are removed. To put the SEDA-AP in a configuration to be moved by the JEMRMS, the crewmembers push the "Backup Launch Lock Mechanism (BLM) RELEASE" button and verify that it is depressed. Refer to Figure 3-46. SEDA-AP is then berthed using the JEMRMS.

Figure 3-46. SEDA-AP pushbutton detail

3.3.1.3.3 P6 Battery Remove and Replace R&R

This task is scheduled to take 4 hours 45 minutes, and two crewmembers are required. During this EVA, four of the six batteries installed on the ICC-VLD are removed and replaced on P6. Refer to Figure 3-47 for the P6 battery R&R worksite location. Table 3-6 lists inhibits for this procedure.

Batteries 1 through 4 (from the IEA) are swapped with batteries A through D (launched on the ICC-VLD) during EVA 3. Batteries 5, 6, E, and F are swapped during EVA 4. Crewmembers refer to the battery cue card for battery layouts of ICC-VLD and P6 IEA (Figure 3-48).

There are two EVA bolts set in microsquare fixtures that attach each battery to the ICC-VLD. H1 is a secondary bolt; H2 is the primary jacking bolt that connects or disconnects the blind-mate connectors. To remove a battery, the crewmembers drive the H1 bolt first then the H2 bolt. To install a battery, the crewmembers perform this step in the opposite order. Refer to Figure 3-49 for a photo of a battery installed on the IEA and Figure 3-50 for a photo including the NO TOUCH zones on a battery.

There is an antirotational locking device present. It is important to note that the status indicators are not always reliable, so the crewmembers are to use the torque and number of turns before relying on a status indicator reading to determine engagement.

EVA R&R'd	IEA (EVA nomenclature)			
	Before	After	Op Nom	Inhibit
3		A	2B11	DCSU 2B RBI 2 - Open BCDU 4B1 CP RBI - Open
3	\mathfrak{p}	D	2B12	DCSU 2B 4BI 2 - Open BCDU 4B1 CP RBI - Open
3	3	C	2B21	DCSU 2B RBI 3 - Open BCDU 4B2 CP RBI - Open
3	4	B	2B22	DCSU 2B RBI 3 - Open BCDU 4B2 CP RBI - Open
4	5	Е	2B31	DCSU 2B RBI 4 - Open BCDU 4B3 CP RBI - Open
4	6	F	2B32	DCSU 2B RBI 4 - Open BCDU 4B3 CP RBI - Open

Table 3-6. List of inhibits for battery R&R

Figure 3-47. ISS worksite overview for the P6 battery R&R

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Figure 3-48. IEA and ICC-VLD Battery Layouts

Figure 3-49. Battery installed on integrated equipment assembly

Figure 3-50. NO TOUCH areas of battery

3.3.1.4 EVA 4

3.3.1.4.1 P6 Battery R&R

This activity is a continuation of the battery R&R from the previous EVA to install the two remaining batteries. It is scheduled to take 4 hours, and two crewmembers are required. Batteries 5, 6, E, and F are swapped during this procedure. Refer to Table 3-6 for a list of inhibits for this task and Figure 3-48 for the battery layout.

3.3.1.4.2 Aft JEF Vision Equipment (VE) Install

This activity is scheduled to take 1 hour 15 minutes and is a continuation of the VE installation activities from EVA 2. In this EVA, crew installs the Aft VE on the JEF (refer to Section 3.3.1.2.6 for the installation of Forward VE). The AFT VE installation is required for HTV pallet relocation; it requires two crewmembers. Refer to Table 3-7 for inhibits for this task. Additionally, the EV crew performs the final LTAB reconfiguration during the VE install. The EV crew removes CAP-ISS2 which was installed during EVA 1 from the J002 port. The CAP-ISS is removed from J003 and installed on J002 to allow the JEF to reach its final LTAB configuration. MLI is reinstalled at the end of this activity. Reference Figure 3-10 for a graphical representation of the final LTAB reconfiguration.

Table 3-7. Inhibits for Aft JEF Vision Equipment (VE) install

3.3.1.5 EVA 5

3.3.1.5.1 SPDM Covers

There are several covers on the SPDM that are reconfigured on this flight: one 2.6 flap on the SPDM Arm 2 Wrist needs to be tacked down to prevent interference with the roll joint rotating surface, and 1.5 flaps on the SPDM OCTM2 Wrap blanket need to be rolled up to cover aluminum ground tabs. See Figure 3-51.

Figure 3-51. SPDM Cover details

3.3.1.5.2 Z1 Patch Panel Reconfiguration

The Z1 Patch Panel task reconfigures CMG2 power from RPCM Z13B-B to RPCM S02B-D. CMG2 was originally configured to RPCM S02B-D. During UF-1, RPCM S02B-D failed, resulting in loss of power to CMG2. To recover CMG2, an EVA crew reconfigured it to draw power from RPCM Z13B-B. RPCM Z13B-B also feeds power to CMG3. In the current configuration, if RPCM Z13B-B fails, power is lost to both CMG2 and CMG3. RPCM S02B-D has been R&R'd and is fully functional, but CMG2 was never reconfigured back to RPCM S02B-D. It was attempted on STSS-123/1JA, but the bail on the P2 connector would not release. As a workaround, it was decided to swap the back-side connectors instead of the front-side connectors. This was scheduled for STS-119/15A, but the EV crew ran out of time after the UCCAS deploy required troubleshooting.

First, RPC 18 of the Z13B RPCM and RPC 17 of the S02B RPCM must be opened with the close command inhibits in place. Once in place, the EV crew translates to the Z1 patch panel and demates the P2 connector from the J4 receptacle and connects it back into the J2 receptacle. Figure 3-52 shows a picture of the front side of the Z1 Patch Panel, and Figure 3-53 shows a picture of the back side of the panel.

Figure 3-52. Z1 Patch Panel Front Side

Figure 3-53. Z1 Patch Panel Back Side

3.3.1.5.3 S3 Lower Outboard PAS

The S3 Lower Outboard PAS is being deployed as a backup site for the payloads launching on ULF-3 and is also required for Stage 20A, when ESP-3 moves here to make room for ULF-6 ELC-3 payload at the P3 Zenith UCCAS (where ESP-3 is currently located). Reference Figure 3-28 for PAS locations.

3.3.1.5.4 S3 Lower Inboard PAS

The S3 Lower Inboard PAS is required to be deployed prior to flight ULF-5, during which ELC-4 will be installed. Reference Figure 3-28 for PAS locations.

3.3.1.5.5 CP1 WETA Install

Wireless Video System External Transceiver Assembly (WETA) 3 is being installed at the S3 Camera Port 1 (CP1). This task was planned as a get-ahead for both STS-124/1J and STS-119/15A, though neither flight had time to complete this task. The crew retrieves the WETA from the ISS Airlock and translates to S3. Using the PGT, one EV crewmember removes the dummy box and installs the WETA by sliding it in the stanchion. The other EV crewmember mates the electrical and data umbilicals. Figure 3-54 shows a WETA being installed, and Figure 3-55 shows the location of CP1.

Figure 3-54. WETA Installation

Figure 3-55. Camera Port 1 Location

3.3.2 Unscheduled EVA Tasks

There are presently no unscheduled EVAs for the 2J/A mission.

3.3.3 Contingency EVA Tasks

The contingency EVAs for the 2J/A mission are as follows:

- a. Orbiter TPS inspection/repair
- b. Manual EFBM operations for EF berthing
- c. SRMS or SSRMS End Effector (EE) release of JEF, JLE, or ICC-VLD
- d. Launch mechanism release of ICS-EF
- e. Deployment mechanism deployment of ICS-EF
- f. Deployment latch mechanism latch of ICS-EF
- g. JEMRMS EE release of ICS-EF, SEDA-AP, and MAXI
- h. Release ICS-EF antenna hold mechanism
- i. EE payload release from PAM
- j. EEU manual release

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- k. JLE PIU manual release
- l. PLM release of SEDA-AP
- m. MST extension of SEDA-AP
- n. ROEU demate from JLE

3.3.4 Stage 2J/A EVA Tasks

There are no 2J/A stage EVAs.

3.4 MIDDECK PAYLOADS

Mission 2J/A launches several payloads that are transferred to the ISS during joint operations. Other payloads are transferred from the ISS to the Orbiter for return to Earth on STS-127.

3.4.1 General Laboratory Active Cryogenic ISS Experiment Refrigerator

The General Laboratory Active Cryogenic ISS Experiment Refrigerator (GLACIER) operates in the Orbiter middeck as a continuously powered, rear-breathing cryogenic freezer designed to provide transportation and preservation capability for cryogenic experiment samples.

GLACIER is designed to support experiments that require thermal control between +4° and -160° C.

GLACIER is continuously powered by the nominal 28 V dc 20 Amp (A) source from MUP in the Orbiter middeck. Power outage for preservation of samples should be limited to 120 minutes for the returning -95 $^{\circ}$ C unit. Door openings for preservation of samples should be limited to the minimal amount possible, not exceeding 2 minutes. Sample transfer is a time-critical operation, and individual samples may have mission-specific time constraints.

The crew is required to perform a temperature status check after installation the day of transfer, again prior to crew sleep, then twice a day each day following, with one check the morning of entry day. The desired separation of these status checks is 8 to 12 hours. A status check is required within 1 to 2 hours after door opening to verify that the GLACIER is ramping toward the set-point temperature. Although, a door opening is currently not planned during the flight.

Other nominal crew operations include transferring the GLACIER unit located in EXPRESS Rack 6 to the orbiter middeck, still and video footage of GLACIER activities, and hardware configuration for landing.

The GLACIER front panel is shown in Figure 3-56.

Figure 3-56. GLACIER front panel

3.4.1.1 Mechanical and Structural Interface

GLACIER interfaces to the middeck wiretray through mounting panels. GLACIER nominally uses dual Vented Payload Mounting Panels (VPMPs) (see Figure 3-57) but can be configured to use one VPMP and one PMP. The two mounting panels must be preinstalled in the middeck prior to GLACIER installation. Tool guide access is provided for the four mounting panel captive fasteners located in the corners of GLACIER. The GLACIER interface to these hard-mounting locations is through a nickel-plated aluminum backplate. For ease of mounting, GLACIER comes equipped with interface fasteners at the four corners of the backplate. These fasteners are captive to the GLACIER backplate. The fasteners are equipped with locking patches to prevent unintentional fastener back off. They also provide approximately 0.030 inches of radial float to accommodate potential misalignment. These captive fasteners were analyzed for three standard installation torque cycles and two additional installations, if necessary, for a total of five torque cycles. Therefore, these four captive fasteners are replaced prior to each flight to limit the torque cycles on the locking patch below the manufacturer's suggested limits.

Figure 3-57. GLACIER with VPMP mounted

GLACIER is designed to accommodate 14.3 lbm (6.5 kg) of sample mass/support hardware installed within the cold volume.

3.4.1.2 Thermal Interface

For middeck operations, GLACIER operates in an air-cooled only mode. When GLACIER is installed in the U.S. Lab Express Rack 6 (ER6), GLACIER uses the Avionics Air Assembly (AAA) system for air cooling inside the rack and the TCS MTL to reject heat from GLACIER and to achieve the cryogenic temperatures necessary to support experiment samples. The backplate incorporates cutouts that are aligned with the AAA air inlet and outlet in the Express Rack 6 (LAB1O4) (see Figure 3-58). GLACIER may be configured to receive air through the top inlet only or through a combination of the top and bottom inlets while using the top exhaust in either configuration. Air flows into the GLACIER system from the AAA and is ducted across air heat exchangers located on the cryocoolers and back into the AAA.

GLACIER uses two software-controlled axial fans that provide 36 Cubic Feet per Minute (CFM) of airflow across the GLACIER heat exchanger. The system is closed to the remainder of the GLACIER system, thereby preventing mixing of AAA air and cabin air. Thermistors are also located at the GLACIER air inlet and outlet to provide direct feedback on cooling air temperatures for GLACIER.

Figure 3-58. GLACIER backplate

3.4.1.3 Power Interface

GLACIER is powered by nominal 28 V dc with a 20 A power resource from the Orbiter Middeck. GLACIER has an estimated peak power consumption of 215 W (7.6 A) and a steady-state power consumption of 160 W.

All electrical connections to GLACIER are made with the connectors unpowered; and these hazards are controlled via the crew procedures. When the power connection has been made to J1 and +28 V dc applied, GLACIER is turned ON by closing the "POWER" circuit breaker on the front panel. A green Light Emitting Diode (LED) turns on to indicate that main power has been applied. To enable battery-backed data logging, the battery switch is toggled to the "ON" position. The data logger continuously lights up a separate green LED when the battery voltage is good and the main power is on. The battery LED flashes when the main power circuit breaker is open or upstream power is not available, and the unit is logging data on battery power.

When 28 V dc power is interrupted, GLACIER uses two disposable 9 V alkaline batteries to provide up to 96 hours of temperature data logging capability. The battery power circuit is fused at 1 A (1/2 A per battery). Battery logging backup is enabled by turning on the battery toggle switch on the front panel. No battery charging is performed for the batteries, and replacement of the 9 V batteries is not planned.

GLACIER has one circuit breaker located on the front panel for main power. The breaker is engaged when pushed in (CLOSED). When the breaker is disengaged or has tripped, it is in the pulled-out (OPEN) position, and a white band shows around the base of the breaker. The main circuit breaker controls the main power feed from the power source to the unit. The breaker serves both as overcurrent protection and as an ON-OFF switch. The main circuit breaker is rated at 15 A and does not reset automatically.

To ensure that GLACIER remains within its power resource limitations and to monitor operation, the current draw from the main input is continuously measured. The GLACIER microcontroller reads the current value and reduces the cryocooler stroke length if the current is above the nominal value for the current mounting location. Also, the main input voltage is measured at the power distribution board and reported in the health and status data.

3.4.1.4 Command Interface

The GLACIER flight unit is manually controlled and operated by the crew through the use of the front panel Liquid Crystal Display (LCD) and pushbuttons (see Figure 3-59).

Figure 3-59. Crew command interface

The three front panel pushbuttons are located below a 4-row by 20-column LCD. Pushbuttons operating in conjunction with the LCD are aligned with the LCD so that each button corresponds with the software command option located on the bottom row

of the LCD. These buttons provide a soft tactile click when pressed. These are used to issue commands, as well as to monitor GLACIER.

LEDs on the front panel provide visual indication of power status (main power and battery) and command activity. The STATUS LED blinks when there is an error detected.

The main software functions of GLACIER are thermal control, air management, health and status, communication, command, and control.

3.4.1.5 Data Connections

There are no data connections for the middeck configuration.

3.4.1.6 Cold Volume

The core of GLACIER is the cold volume, which is used for sample storage. The cold volume provides a controlled environment to store experiment samples. Sample temperature within the cold volume is maintained by circulating dry air over the samples in the cold volume and removing heat from the sample into the air stream. The air is then circulated through the heat exchangers located within a vacuum jacket at the rear of the cold volume. Access to the samples is obtained through an outer door that provides sample volume insulation and four inner aperture doors that are used to isolate segments of the cold volume during sample access. The GLACIER outer door also provides structural load bearing capability for the cold volume support structure and for crew-applied loads. Figure 3-60 shows details of the outer door configuration and inner aperture doors.

Figure 3-60. GLACIER internal doors

Three temperature detectors are located within the cold volume of GLACIER to indicate the temperature of the sample environment. One is located at the heat exchanger inlet, one at the heat exchanger outlet, and one in the cold volume air flow. One or more of these may be selected as feedback sensors for cold volume temperature control.

A sensor in the outer door is used to detect door position. When the sensor detects the door open position, the internal impeller is shut off to reduce the amount of heat leaked into the system.

The cold volume is maintained with a dry air environment to prevent the formation of ice. Periodically, it is necessary to replenish the dry air environment due to air losses to the cabin during cabin pressure changes, cold volume temperature changes, door openings, and system idle scenarios. This replenishment is accomplished by incorporating pumps, valves, a humidity sensor, a pressure sensor, a delta pressure sensor, filters, and desiccant into a closed-loop system. The system monitors the moisture content and replenishes the system by cleaning the environment present inside the GLACIER and using the AAA air supply as necessary. The desiccant particles that fill the desiccant canister are 2 mm in diameter and are contained within a canister with filter paper at the air entrance and exit. These filters trap particles down to the micron range to control release into the crew environment. Since the GLACIER is powered at turn over, the replenishment of the dry air environment is not a nominal activity for flight.

The crew is required to wear personal protection equipment (i.e., gloves) for sample insertion and removal as the temperature is below -18º C.

3.4.1.7 GLACIER Mechanisms

GLACIER uses five types of mechanisms; a failure to the first four (door latch, door captive locks, door hinges, and the VPMP/Locker Captive Fasteners that attach the GLACIER to the hard mounting locations and cryocooler launch/landing locks) is considered catastrophic and the cryocooler launch/landing locks is considered necessary for mission success.

The following descriptions provide an overview of the GLACIER mechanisms.

3.4.1.7.1 Door Latch

The GLACIER door latch (see Figure 3-61) consists of the system necessary to gain access to the experiment volume contained within the GLACIER and to secure its contents during launch and landing environments. The door latch is designed to support the weight of the samples in the cold volume in the x-axis during launch and landing and to provide thermal isolation during on-orbit operations by maintaining the door in the closed position. The latch is engaged prior to turnover for flight and is operated by the crew during on-orbit activities. The door latch is located on the left side of the front panel between the door and circuit breakers.

Figure 3-61. GLACIER door latch

When the crewmember is ready to open the front door, the latch-lock plate must be rotated to an unlocked position. The door-latch mechanism is activated by compressing two handles between the thumb and index finger. This movement compresses a spring that is installed and contained between the two handles, thereby allowing the handles to retract the latch mechanism to the unlatched position. The door-latch mechanism is intended to be engaged for launch, landing, and on-orbit operations. This mechanism should remain in the closed position, except for those times when GLACIER is accessed for sample insertion or removal.

The crew is required to use the door latch to access the inner doors during sample transfer. The crew is required to verify that this latch is locked before landing.

3.4.1.7.2 Door-Captive Locks

The GLACIER door also contains two captive locks or fasteners (see Figure 3-62), located at the top and bottom of the door on the latching side. These fasteners are used only to provide redundancy during launch and landing. Captive fasteners are replaced after each mission. The captive locks are operated by inserting a tool into the hex drive.

If necessary, the crew is required to unlock the door-captive locks before sample transfer. The locks have a limited lifetime of five cycles so when disengaged, the locks should not be reengaged until just before landing.

3.4.1.7.3 Door Hinge

The GLACIER door hinge provides a means of rotating the door into an open position for sample insertion and rotating back to the closed position. There are two hinges incorporated into the door design, one at the top of the door and one at the bottom of the door. The only structural load applied to the hinges is created by sample restraint during launch and landing.

Figure 3-62. Door-captive lock (qty two)

The door-hinge mechanism is utilized to provide positive retention of the door in the open position during microgravity operations. The front panel incorporates a doorretention spring, retention-spring cover, and a retention-spring shim for each hinge. As the door rotates into the open position, the small protrusion on the door hinge engages the door-retention spring at the 90° point. When the door goes past that point, it is prevented from returning to the closed position without active crew intervention.

3.4.1.7.4 VPMP/Locker-Captive Fasteners

For launch and landing in the middeck, GLACIER attaches to two mounting panels in two places on each panel, by means of four captive fasteners, one in each corner (see Figure 3-63). GLACIER uses these captive fasteners for all structural attachments, and they are required to be installed before launch or landing. The captive fasteners are replaced after each flight.

Figure 3-63. Locker-captive fasteners (qty four)

3.4.1.7.5 Cryocooler Launch/Landing Locks

Cryocooler launch/landing locks (Figure 3-64) are used in the GLACIER design to provide for vibration isolation of the cryocoolers during on-orbit operations and for securing GLACIER during launch and landing. There are a total of four locks, two that restrain x-y motion and two that restrain x-z motion within the wire tray coordinate system. The locks are important to mission success; however, failures associated with the launch locks do not present catastrophic or critical hazards. Prelaunch procedures require that the locks be engaged for launch. The locks are also to be engaged for descent/landing. In the event of failure to close the latches, the cryocoolers are contained by the back plate, cold volume, and within foam packaged around the cryocoolers.

Figure 3-64. Cryocooler launch/landing locks

3.4.1.7.6 GLACIER Intravehicular Activity Handle Assembly

A GLACIER Intravehicular Activity (IVA) Handle, Figure 3-65, is provided to support IVA transfers between Shuttle and ISS. The IVA Handle attaches either diagonally (preferred) or vertically to the GLACIER front panel by inserting the handle ball-lock pins into two of the four IVA receptacles, one located on each corner of GLACIER. The GLACIER IVA Handle is a single assembly that collapses for easy stowage.

3.4.1.8 Malfunctions

If the crew experiences an off-nominal situation during a status check or sample insert or removal, the procedures direct them to the GLACIER Error Message malfunction procedure. In the event of further off-nominal situations, the ground can direct the crew to one of the following malfunction procedures: GLACIER Fail to Repower, GLACIER LCD Blank, GLACIER Fail to Hold Set Point, GLACIER Power Cycle, GLACIER Shutdown, GLACIER Reboot, GLACIER Manual Reconfigure, or GLACIER Record Diagnostic Data.

Figure 3-65. Intravehicular activity handle assembly

3.4.1.9 Flight History

STS-127/2J/A is the third flight of GLACIER. Two GLACIER units flew for the first time on STS-126/ULF2; one was powered in the middeck; and one was an unpowered unit mounted in EXPRESS Rack 6 in the MPLM, then transferred to the U.S. LAB. STS-119/15A launched a GLACIER unit in the middeck, which was then swapped with the mission ULF2-launched unit in EXPRESS Rack 6. After the first STS-119 launch attempt was scrubbed, S/N 005 was removed from the orbiter due to an overcurrent error message on the display. The backup GLACIER, S/N 006, was flown instead. S/N 005 checked out fine and was determined that the overcurrent issue came about when the fuel cell was connected to Main Bus B. On STS-127/2J/A, no GLACIER unit is launched in the middeck. Two lockers in the middeck will be swapped with the mission 15A GLACIER in EXPRESS Rack 6. Table 3-8 lists the missions on which the various GLACIER units are launched and returned.

3.4.1.9.1 Anomalies

STS-119/15A

PAR Glacier-HW-0002: At GMT 066/14:22, the vacuum jacket pressure had been trending upward over the previous couple of months. This GLACIER, S/N 003, had been unserviced since it went up in the ULF2 MPLM 10 months prior. The Glacier Payload Developer (PD) nominally services the vacuum every 90 days. The vacuum on S/N 003 was determined to be critical in terms of power draw and STS transfer on or about March 6, 2009. The GLACIER cooling system depends on maintaining the heat exchanger within a vacuum system located at the rear of the unit. A characteristic of the hardware is for the vacuum level to decrease over time, which results in lower efficiency in the cooling system. This vacuum is replenished prior to each GLACIER flight. With a newly replenished vacuum, GLACIER is working at maximum performance to maintain -95° C with a 160W power limit. The PD plotted out the vacuum trend over the last 10 months since installation into the MPLM and has noted a slight increase in the pressure. The PD was concerned that with the slightly diminished vacuum, GLACIER may not be able to maintain -95° C in the shuttle middeck with a 160W power limit. Therefore, the PD requested a higher limit of 220W, of which they expected the unit to use approximately 180W for middeck operations. The PD contends this is not an anomaly but a characteristic of the hardware, as noted above, and this PAR should be closed.

PAR Glacier-HW-0003: At GMT 085/12:00, the crew of Discovery called down that the Glacier Status Light was blinking and that the top line of the LCD was reading Error Pending, Over Temp Error. They also reported that the current temperature was -95° C. Glacier's initial belief is that the cause of this is the Vacuum Jacket Temperature Sensor. The following five temperature sensors can create an over temperature indication but cannot be read using the front panel interface. They all have error trip settings of 70° C. The information below includes the maximum reading seen on S/N 004 during the ULF2 sortie:

- a. CV Fan Saw 60.5° C on ULF2. This is a thermistor on the circuit board inside the CV Fan motor.
- b. Front Panel Saw 30°.5 C on ULF2. This is a thermistor mounted to the inside front panel.
- c. CV Outer Wall Saw 34.9° on ULF2. This is a thermistor mounted to the outside wall of the cold volume.
- d. Vacuum Jacket Saw 27.5° C on ULF2. This is a thermistor mounted to the outside of the vacuum jacket assembly.
- e. Pump Saw 37.5° C on ULF2. This is a thermistor mounted to one of the AMS pumps.

Of the five, the most likely to have caused the error seen on S/N 003 are the Vacuum Jacket and the CV Fan. The CV Fan is suspect because it normally runs within 10° C of the trip limit. The Vacuum Jacket is suspect most likely because it was showing unusually high readings while on EXPRESS. A similar error was seen during ground testing of a nonflight GLACIER when condensation formed on a cold vacuum jacket, reducing the apparent resistance of the thermistor. The error can be acknowledged and the unit allowed to continue to operate nominally. The unit should continue to be monitored for correct internal temperature.

3.4.1.10 Flight-Specific Operations

For STS-127/2J/A Orbiter middeck operations, descent GLACIER operates on air cooling with its thermal control system set to -95° C.

The configuration for STS-127/2JA is four Type V sample trays with support hardware.

3.4.2 PCDF Process Unit

The Protein Crystallization Diagnostics Facility (PCDF) is an ESA multiuser facility to investigate crystal growth mechanisms in proteins or other macromolecules under microgravity. It provides all means to conduct crystallization experiments according to different crystallization methods (dialysis or batch) and is capable of observing the crystallization process with various optical means as video observation, interferometry, and dynamic light scattering. For experiment sessions, PCDF is hosted in the European Drawer Rack (EDR) in the Columbus Module on the ISS.

PCDF has the following two major units:

- a. Electronics Unit (EU) For the control of the overall performance; it is an integral part of EDR (launched on mission 1E).
- b. Process Unit (PU) It contains the experiment itself and the diagnostic instruments (optical, interferometer, dynamic light scattering).

A Shuttle middeck locker is used for return of the PCDF Process Unit. STS-119/15A was the first flight of the PCDF PU. The 15A unit returns on STS-127/2J/A. The Advanced Protein Crystallization Facility (APCF), the precursor to PCDF, was also an MDL payload and has been flown several times before (e.g., SpaceHab1, IML-2, USML-2, LMS, and ISS Increment 3). The PCDF PU is the only part of PCDF that is the subject of flight in the Orbiter middeck; therefore, the following hardware description is focused on this item and its middeck operation.

PCDF PU is continuously powered by the nominal 28 V dc 10-A source from the Orbiter middeck. Continuous power maintains the constant temperatures required by the protein crystallization experiments. The maximum time without power is limited to 100 minutes. In the event of an off-nominal condition, the PCDF Off Nom Recovery procedure is performed.

The PCDF PU installed in an ISS locker is shown in Figure 3-66.

Figure 3-66. PCDF PU installed in an ISS locker

3.4.2.1 Mechanical Structural Interface

The integral part of the PU is the layers of thermal isolation and packing foam that are covered by a Nomex bag, as shown in Figure 3-67. This assembly is compliant to MDL internal dimensions and fits into the locker as an MDL insert. No trays or additional packing foam inside the locker are required. The crew handles the whole assembly as one single piece covered by the Nomex bag during transfer from ISS.

Figure 3-67. Principle of PCDF PU installation into MDL

The whole PCDF PU assembly, including the Nomex bag, must be accommodated in an MDL with the door panels removed to facilitate front panel access and cutouts at the locker rear to use the VPMP of the Shuttle middeck.

The PU is transferred from the ISS/EDR to the middeck. The outer layer of the PU is a Nomex bag with slings. Using these slings, the PU is extracted from the EDR locker, transferred to the middeck, and installed into an ISS locker. The same ISS locker used for launch of the PU on 15A is used for return on 2J/A.

3.4.2.2 PCDF PU Front Panel

Figure 3-68 shows the PU front panel. It contains the following:

- a. A circuit breaker in combination with the Power On/Off switch
- b. Electrical power supply connector, J01
- c. LEDs for status indication that have to be operated during middeck activities
- d. Two quick disconnects for cooling water inlet and outlet (used in EDR only)
- e. Two light fiber connectors (used in EDR only)

- f. Further electrical connectors, J02 through J05, for connection to PCDF Electronics Unit (used in EDR only)
- g. Fire port for the portable fire extinguisher

Figure 3-68. PCDF PU front view after installation into MDL

In the standalone operation in the Orbiter middeck, the status of the PCDF PU is displayed by the following five LEDs:

- a. EDR POWER ON LED is ON External power outlet is providing power, and PU is switched on
- b. POWER ON LED is ON Secondary power of PU is on
- c. CONTR FAILURE LED is OFF Microcontroller watchdog is operational
- d. NOMINAL PROCESS TEMP LED is ON Experiment sample temperature is within appropriate range
- e. STANDALONE MODE LED Displays operations mode either standalone or connected to and controlled by EU

3.4.2.3 Power Interfaces

From transfer from the ISS to removal on the ground, electrical power of 140 W must be provided from Orbiter to the PCDF PU via front panel connector (POWER J01).

The PCDF PU is continuously powered by the nominal 28 V dc 10 A source from the Orbiter middeck. The only planned period without power is the transfer from the ISS/Columbus to the Orbiter middeck. The maximum time without power is limited to 100 minutes at 25° C maximum cabin temperature.

3.4.2.4 Thermal Interfaces

The PCDF PU is a rear-breather, and internal heat dissipation is conducted via its internal Ammonia heat pipes to the rear heat exchangers.

The PCDF PU has two thermal interfaces to the Orbiter.

- a. PUE1 fan on the front panel, rejecting about 7 W of heat to cabin air
- b. Rear-breather interface to rear air panel air flow, at air flow rate of 17 L/s (36 CFM with temperatures <27° C, maximum heat rejection of 133 W)

3.4.2.5 Structural Interfaces

The PU is inserted into an MDL using packing foam that is an integral part of the facility. The fully packed locker is then fixed to the Orbiter via the four standard locker fasteners. The PU accommodation has to be such that before launch, the front panel is looking to the opposite of the Orbiter nose to keep the heat pipes properly working before reaching the microgravity environment.

A summary of the Orbiter interfaces is given in Table 3-9.

Table 3-9. PCDF interfaces

3.4.2.6 Data Connections

There are no data connections for the STS-127/2J/A middeck configuration.

During standalone operations, a set of housekeeping data is stored periodically in nonvolatile memory for later readout via the electronics of the EU. There is no required data communication with the Orbiter foreseen.

The DATA J02 and J05 connectors, as well as the POWER J03 and J04 connectors are not connected to the Orbiter as they provide the electrical EU-PU connection inside EDR.

3.4.2.7 Safety

The safety of the PCDF is discussed in Safety Data Package (SDP) (PCDF-DP-DO-01, issue H). During phase III review, the related hazard reports were approved and signed.

The following hazards are of specific interest for the PCDF PU in the Orbiter. (Operations and hazard controls in Columbus/EDR are covered elsewhere.)

- a. PCDF-01: Rupture/leakage of heat pipes (ammonia heat pipes)
- b. PCDF-03: Release of sample material
- c. PCDF-05: Structural failure (verification 2.1 crew procedures during transfer)
- d. PCDF-STD-14.2.3 switch off upstream power during power cable mating (CAUTION)

3.4.2.8 ISS Interfaces That Affect PCDF PU Transfer Operations

The PCDF PU is transferred from the EDR in the Columbus Module and installed in the Shuttle middeck. The entire PU is transferred, including its Nomex bag, leaving its locker shell behind in the EDR locker, which is already housed in Columbus. The returning PCDF PU is removed from the EDR locker and inserted into the empty ISS locker shell.

The EDR configuration with installed PCDF is shown in Figure 3-69. See Figure 3-70 for a depiction of the power/data harness (J02 through J05) between PCDF PU and the electronics unit.

Figure 3-69. EDR including PCDF (isometric view)

Figure 3-70. PCDF front panel connections

3.4.3 Double Coldbags

Additional ISS cold science samples are packed and transferred in three double coldbags just prior to Shuttle hatch closure.

3.5 OBSERVATION PAYLOADS

An observation payload is one that consists only of observations of the Shuttle, either from a ground site or from another spacecraft. The following three observation payloads are accommodated on STS-127/2J/A: Maui Analysis of Upper-atmospheric Injections (MAUI), Shuttle Ionospheric Modification with Pulsed Localized Exhaust (SIMPLEX), and Shuttle Exhaust Ion Turbulence Experiments (SEITE). All three are Department of Defense (DoD) experiments designed to analyze the Orbiter's thruster firings for purposes of improving space surveillance and space asset characterization.

No hardware is flown to support the payloads, as existing ground and in-space resources are already in place to record data.

3.5.1 Maui Analysis of Upper-Atmospheric Injections

MAUI is designed to observe the Orbiter exhaust plumes via the optical telescopes at the Air Force Maui Optical and Supercomputing Site (AMOS) located on Maui, Hawaii. An example of an Orbital Maneuvering System (OMS) burn viewed from the ground is shown in Figure 3-71. The images and data taken by the telescope system are analyzed to better understand the interaction between spacecraft plumes and the upper atmosphere. AMOS is capable of capturing data from both Reaction Control System (RCS) and OMS burns. Two other MAUI ground sites are available to capture OMS burns only and are located on the Kwajalein Atoll and Christmas Island.

Figure 3-71. Low resolution all-sky imagery from OMS burn

3.5.2 Shuttle Exhaust Ion Turbulence Experiments

SEITE uses space-based sensors to investigate plasma turbulence in the ionosphere using the firing of the Orbiter's OMS engines while within range of the available diagnostic satellite, as shown in Figure 3-72. Various sensors provide data on neutral flows, electron and ion distributions, electric fields, plasma waves, and radio scintillations. Furthermore, the data obtained through SEITE enables development of quantitative models of the plasma disturbance, which degrades tracking and imaging radars.

Figure 3-72. Satellite diagnostics of artificial plasma turbulence

3.5.3 Shuttle Ionospheric Modification with Pulsed Localized Exhaust

The objective of SIMPLEX payload of opportunity is to determine the source of Very High Frequency (VHF) radar echoes resulting from the Orbiter OMS engine firings. Figure 3-73 shows a dual OMS burn. There is no payload hardware; rather, SIMPLEX uses six ground-based radar and radio telescope installations to record the ionospheric distortions caused by the OMS burns.

Figure 3-73. Symmetrical RCS burn during orbital daylight

3.6 DEPLOYABLE PAYLOADS

This section is dedicated to summarizing the two deployable payloads flown on STS-127 and deployed during Shuttle free flight following ISS undocking.

3.6.1 ANDE 2

The Atmospheric Neutral Density Experiment 2 (ANDE 2) is a DoD deployable payload, similar to its predecessor flown on STS-116. The two goals of the ANDE 2 mission are to provide high quality satellites with stable and well-determined coefficient of drag, for calibrating techniques and models for precision orbit determination and to provide atmospheric composition for validating Air Force sensors.

ANDE 2 consists of two spherical satellites (Castor and Pollux) that are housed inside the Internal Cargo Unit (ICU), which is deployed during Shuttle free flight. The payload ejection from the Shuttle PLB uses a nonpyrotechnic, low-shock separation system with an NEA. The crew interfaces with the payload via SSP switches for Power, Pre-Arm, Arm, and Deploy. When deployed, the ICU has a timed separation to release each sphere to preclude recontact with the Shuttle and itself. The crew also performs a separation burn after deploy to ensure that no recontact occurs. Refer to Figure 3-74 for an overview of the ICU and ANDE 2 deploy.

When deployed, the satellites communicate directly with DoD resources to provide total atmospheric density for orbit determination and collision avoidance, validate fundamental theories on drag coefficient calculations, provide calibration objects for radar fence upgrades, and establish methods to validate neutral density outreach sessions at high schools and grade schools.

For more information on the ANDE 2 payload, reference JSC-35016 Cargo Systems Manual (CSM): ANDE 2.

Figure 3-74. ANDE 2 satellite deploy

3.6.2 DRAGONSAT

Dual RF Autonomous Global Positioning System (GPS) On-orbit Navigator Satellite (DRAGONSAT) represents the first of a series of missions designed to establish autonomous spacecraft rendezvous and docking capabilities. The first mission is primarily focused on data collection for future control algorithms and is a cooperative effort of Texas A&M University, the University of Texas at Austin, and NASA.

DRAGONSAT is composed of two individual pico-satellites, AggieSat2 and PARADIGM, that are launched in a mated configuration, as seen in Figure 3-75. The satellites are ejected on orbit and immediately begin to separate (the satellites are not structurally attached). The satellite systems activate as the cubes separate and inhibit switches depressed while the satellites are together are released. The GPS data are acquired from a NASA-JSC Aeroscience and Flight Mechanics Division-provided GPS device in each satellite as the cubes overfly the satellite control centers located at the sponsoring universities' campuses.

Figure 3-75. DRAGONSAT launcher and satellite

DRAGONSAT is launched during a free flight period from the Space Shuttle Picosatellite Launcher (SSPL) 5510. The SSPL 5510 is a DoD provided launcher that is designed to launch a 5- by 5- by 10-inch payload via spring force. The launcher is equipped with a safing latch and a safing spring so that the satellite does not deploy inadvertently. A one-time use actuator device releases the door of the launcher to allow the satellite to eject. The crew operates Standard Switch Panel (SSP) switches to Pre-Arm, Arm, and Deploy the DRAGONSAT payload from the SSPL 5510 launcher. Upon deployment of DRAGONSAT, the switches are returned to their "Safe" positions, and power is removed by opening two circuit breakers.

For more information on the DRAGONSAT payload, reference JSC-35017, CSM: DRAGONSAT.

3.7 DETAILED TEST OBJECTIVES

The following section describes the Detailed Test Objectives (DTOs) on Mission 127/2J/A.

3.7.1 DTO 701B, DragonEye Flash LIDAR

Per Space Act Agreement NNJ06TA26S, Space Exploration Technologies, Inc. (also known as "SpaceX") flies three demonstration missions of an unmanned crew cargo vehicle for use with ISS. The cargo vehicle is called "Dragon" and launches on SpaceX's Falcon 9 launch vehicle. Demo mission C1 is a brief orbital flight to demonstrate core vehicle and ground segment functionality. Demo mission C2 accomplishes additional on-orbit checkout objectives and flies a close approach trajectory within 2.5 km of ISS. Demo mission C3 performs a full rendezvous with ISS, culminating in SSRMS grapple of the free-flying Dragon vehicle, CBM berthing, and approximately 24 hours of hatch-open time before Dragon closeout, unberth, departure, and reentry.

Demo mission C3 requires use of Dragon's target tracking sensors for navigation. Final Dragon navigation sensors selection has not yet occurred, pending on-orbit performance data to be collected during two DTOs of different sensors. DTO 701A is a test of the Neptec-provided "TriDAR" scanning LIDAR sensor system and is currently scheduled to fly on STS-128. The Constellation Program is the sponsor for DTO 701A, as the TriDAR sensors are planned for use on the Orion vehicle. DTO 701B is a test of the Advanced Scientific Concepts (ASC) "DragonEye" flash LIDAR sensor system and is manifested on STS-127 (ISS 2J/A). SpaceX is the sponsor for DTO 701B.

No in-space ASC LIDAR demonstrations are currently planned prior to SpaceX's Dragon demonstration flight C3 in March 2010. DTO 701B would decrease mission risk for flight C3 by reducing uncertainty regarding sensor performance in space, as well as providing reference data of the ISS as imaged by the DragonEye sensor.

SSP 50448, Station Development Test Objective (SDTO) Catalog, is the authoritative source for DragonEye operational requirements and constraints. A summary of requirements and constraints is provided here for reference only.

3.7.1.1 DragonEye Design and Performance Details

The DragonEye LIDAR is of a "flash" type with a 128 by 128 array of Avalanche Photodiodes (APDs), providing a 3D image based on time of flight of a single laser pulse from the sensor to the target and back. Pulses occur at rates up to 20 Hz. The system is capable of operating at over 1 km against retroreflective targets (such as those on nadir sides of JEM, PMA2, and other locations on ISS) to provide range and bearing information. The sensor unit can operate with retroreflectors in the field of view even at close range and is protected against direct Sun exposure.

DTO 701B packaging has not yet been finalized. The sensor and data acquisition units may be in two separate boxes connected via wire harness, or they may be integrated into a single box.

The unmodified terrestrial sensor is shown in Figure 3-76, below (for familiarization only; on-orbit version is packaged differently (heat sink fins on top replaced by radiator, etc.)).

Figure 3-76. ASC DragonEye sensor (terrestrial version, case hidden)

The data acquisition system is shown in Figure 3-77.

Figure 3-77. DragonEye acquisition system

3.7.1.2 DragonEye Shuttle Resource Requirements

DragonEye DTO mass is less than 55 lbm (~ 24.9 kg). DragonEye DTO operational power consumption is 85 W at 28 V dc. Heater power consumption is 40 W.

3.7.1.3 DragonEye Operational Constraints

The DragonEye nominal operating temperature range is -20° to +40° C. There are no lighting constraints or on-orbit contamination constraints. DTO data collection periods are managed to avoid exceeding the data acquisition unit storage capacity. (The data acquisition unit can hold at least 6 hours of data.)

3.7.1.4 DragonEye Test Objectives

The primary goal of the DragonEye DTO is a full demonstration of the sensor performance in a space environment (e.g., solar irradiance, radiation, thermal, vacuum, atomic oxygen, UV, etc.), using the ISS itself as the test target. Testing the sensor as it is used during its nominal operations on the Dragon vehicle avoids the deficiencies of ground testing: inaccuracy in matching real ISS reflectivity; test rig clutter effects impacting sensor performance; inability to replicate orbital illumination conditions, relative velocities on-orbit, etc.; ensuring adequate ISS retroreflector performance at 1.57 micron laser wavelength, etc.

3.7.1.5 DragonEye Safety Considerations

DragonEye is a laser device, and eye safety is a consideration. Per DragonEye Payload Hazard Report DE-F-04 (part of the DragonEye Flash LIDAR DTO Phase I-II Safety Data Package Rev 1 (D001110-001), dated 9/24/2008), the DragonEye DTO laser is eye safe for unaided eye viewing at any distance and is also eye safe for on-orbit worst-case optically aided viewing.

3.7.1.6 DragonEye Crew Interface and Operations

DragonEye operational and heater power is commanded via the Standard Switch Panel (SSP) and panel R1, respectively. The crew has no insight into DragonEye health or status other than the SSP switch talkbacks. The ground has no direct insight into DragonEye health or status; power draw is likely too low to be visible in Shuttle power bus current telemetry.

DragonEye heaters are thermostatically controlled. Heaters are turned on during Post-Insertion and remain on until Payload Deact during Deorbit Prep.

During Shuttle rendezvous with ISS, DragonEye operational power is applied no earlier than 15 minutes before MC3 and no later than MC3 and remains on until Shuttle capture confirmed. Operational power should be removed as soon as practical after Shuttle capture. During Shuttle departure, DragonEye operational power is applied no earlier than undock minus 30 minutes and no later than undock minus 5 minutes. Operational power is removed no earlier than the completion of the SEP2 burn and no later than SEP2 plus 30 minutes. It is expected that all DragonEye operations can be implemented by directly calling out the necessary switch throws in the Shuttle Flight Plan, and that no DragonEye procedures are required.

The ACO flight control position is responsible for all DragonEye operations.

3.7.2 DTO 695, Thrust Oscillation Seat

Testing was done during the Gemini program to determine acceleration and frequency acceptability for crew performance. This was never validated with flight data. This DTO gathers vibration data on crewmember seats during launch.

Before flight, the accelerometers are installed on the vehicle seat. The cabling may be attached to the accelerometer and coiled until seat installation. Before seat install, the sensor bag is attached to the vehicle floor studs. The cabling is routed and secured to the seat. All installation is documented on the Crew Compartment Configuration Drawing (CCCD).

Postflight data must be downloaded from sensors, and new batteries must be installed for the next flight. JSC/EV supports the first download and battery swap. For STS-127 and STS-128, KSC may be asked to support via a chit or OMRS.

The only crew activity with this DTO is the removal and stowage of the hardware postinsertion (see Table 3-10).

Table 3-10. DTO 695 hardware removal and stowage

Activity	Duration	Occurrence	Requirement
Hardware removal and stow	10 minutes	Post Insertion	Must be removed before seat stow

3.7.3 SDBI 1904, VISUAL PERFORMANCE

The primary objective of human factors SDBI 1904 is to determine visual performance limits during operational vibration and g-loads, specifically through the determination of minimal usable font size using prototype Orion display formats. The goal of SDBI 1904 is to provide supplementary data to that collected by the seat vibration DTO (695). The visual performance data collected by this SDBI (i.e., font size for proposed Orion display formats), coupled with subjective comments, lead to a better understanding of visual performance under the varied vibration and g-loading in an operational setting.

Three matte-finish placards are mounted on middeck lockers and are observed by three crewmembers on the middeck during ascent. Each placard depicts a representative Orion display format in each of four quadrants (four numbered display formats per placard). Each display format contains one of four effective font sizes: 10, 12, 14, or 17 point. The placards are developed, fabricated, and certified in conjunction with the Flight Data File group. Placement of placards on lockers is critical, and the location is developed with FDF and crew. A video camera and recorder system on middeck is used to record subjects throughout SRB burn. A Data Card/Questionnaire is available to the crew on a kneeboard and is completed before MECO then stowed in return-to-Houston bag during postinsertion.

A list of the flight activities is shown in Table 3-11.

Table 3-11. SDBI 1409 flight activities

3.8 JAXA EXTERNAL PAYLOADS

This section is dedicated to describing the three JAXA payloads manifested on Mission 127/2J/A and transferred from the JLE to the JEF via the JEMRMS. Figure 3-78 depicts the primary EFU location for each payload.

Figure 3-78. JEF payload transfer EFU locations

The JLE has no temporary MLI covers to be removed but has a Beta cloth cover that remains installed on orbit.

3.8.1 ICS-EF

The ICS-EF is described in more detail in Section 5.1.4.2 along with the other JEF Communication and Tracking (C&T) System equipment. ICS-EF is manifested on JLE PAM 1 and is transferred to EFU 7 with EFU 5 as a backup payload location (see Figure 3-78).

ICS-EF has four temporary MLI (Beta cloth) covers to be removed prior to transfer: a PIU cover, top cover, bottom cover and sensor cover. See Figure 3-21 for the covers to be removed from ICS-EF.

3.8.2 Monitor of All-sky X-ray Image

The MAXI is an X-ray camera with a wide Field of View (FOV) designed to monitor active astronomical objects and the universe. It monitors the variations of the x-ray intensity of various sources in the entire sky at the highest sensitivity so far achieved with such an instrument. MAXI scans the "sky" every 90 minutes and has two types of X-ray detectors: a Gas Slit Camera (GSC) and a Solid state Slit Camera (SSC). These slit cameras can scan nearly the entire sky without using any pointing mechanism by using ISS's attitude change. They determine direction of X-ray sources within the narrow FOV of the slit that is orthogonally oriented to a one-dimensional position-sensitive X-ray detector.

The MAXI payload is manifested on JLE PAM 3 and is transferred to EFU 1 with EFU 3 as a backup payload location. Reference Figure 3-78 for the berthing location and Figure 3-79 for a picture of MAXI.

3-83

MAXI has one contamination cover to be removed before transfer that covers the various sensors. The contamination cover is GORE-TEX® and is used to protect the cameras while in the Shuttle PLB.

The expected mission life MAXI is approximately 2 years with a planned disposal via the H-II Transfer Vehicle (HTV).

3.8.3 SEDA-AP

The purpose of the SEDA-AP is to measure the space environment (such as, neutrons, plasma, heavy ions, high-energy light particles, atomic oxygen, and cosmic dust) in the ISS orbit and to observe how the space environment affects electric components. It is also expected to conduct on-orbit verification of Attached Payload Bus (APBUS) technology, which furnishes necessary functions when mounted on the JEF. It has SEDA and APBUS sensors and an extendable mast (MST) that extends approximately 1 m from the main structural body and has a Neutron Monitor Sensor (NEM-S). The MST has a Launch Lock Mechanism (LLM) to enable the payload to withstand Shuttle launch and landing loads. The Micro-Particles Capturer (MPAC) and Space Environment Exposure Device (SEED) are retrieved via EVA and returned to Earth in a pressurized carrier.

SEDA-AP is manifested on JLE PAM 2 and is transferred to EFU 9, with EFU 11 as a backup payload location. (Reference Figure 3-78.) Reference Figure 3-80 for a picture of SEDA-AP.

Figure 3-80. SEDA-AP

SEDA-AP has no temporary MLI covers to be removed; however, it has a Beta cloth cover that remains installed on orbit.

The expected mission life SEDA-AP is approximately 3 years.

3.8.4 Payload Transfer to JEF

All three JAXA payloads are transferred from the JLE to the JEF via the JEMRMS. During the transfer, the following actions are performed with each payload transfer (see also Figure 3-81):

- a. JEMRMS maneuvers to the unloaded hover position; the PAM/EFU operator performs PAM status check; and the Space Station Integration and Promotion Center (SSIPC) performs EFU status check and opens EFU.
- b. Sync point JEMRMS operator, PAM/EFU operator and SSIPC sync point to report arm position, PAM and EFU status checks.
- c. JEMRMS grapples payload and PAM commanded to release payload.
- d. Payload is unberthed and maneuvered to a loaded hover position at the PAM.
- e. Payload is maneuvered to a loaded hover position at the JEF EFU and then installed.
- f. PAM/EFU operator performs mating operations to mate payload to EFU.
- g. JEMRMS ungrapples payload; PAM is closed and deactivated; and EFU postmating operations are performed by SSIPC.

ISS external cameras and MSS cameras (depending on the worksite) are used for JEMRMS operations viewing support.

jsc36536_008**r2**.cvx

Figure 3-81. JAXA payload transfer operations overview

3.8.5 Payload Activation Sequence

In preparation for transferring the JAXA payloads from the JLE to JEF, SSIPC checks out all three primary berthing locations (EFU 9, 7, and 1).

Prior to transferring the payloads, the EV crew assist by performing the following:

- a. For ICS-EF Remove the thermal covers and release the AHM.
- b. For MAXI Remove the contamination cover.
- c. For SEDA-AP Release the backup launch lock mechanism.

When ICS-EF is transferred, the SSIPC activates the ICS survival heaters and then partially activates the ICS. To deploy the antenna, the following three components require powering on: the Baseband Data Processing Unit (BDPU), the Antenna Pointing Equipment - Controller (APE-C), and the Heater Control Equipment (HCE). The APE-C is required to control the antenna deployment, and the HCE keeps the

ICS temperatures within operational range. The last step of ICS activation is to input the initial settings, including a file transfer.

When MAXI is transferred successfully to the JEF, its survival heaters are activated. The thermal clock for MAXI transfer is 73 hours (based on worst case beta of +65). (All other Betas had clocks that exceeded 73 hours. Reference Flight Rule 2JA_C2-73).

The ICS-EF antenna is deployed after MAXI is transferred (to preclude antenna clearance issues). For ICS antenna deployment, the Deployment Mechanism/Deployment Latch Mechanism (DM/DLM) is powered on, the DM deployed, the DLM latched, and the DM/DLM powered off again. The ICS-EF has a relatively short thermal clock, between 2.3 and 5.7 hours, depending on Beta angle (reference Flight Rule 2JA_C2-73).

When SEDA-AP is transferred to the JEF, its survival heaters are activated. SEDA-AP has no thermal time constraint (reference Flight Rule 2JA C2-73).

3.8.6 Payload Constraints

3.8.6.1 ICS-EF Antenna Deploy

After ICS-EF activation, MAXI transfer is to occur before ICS-EF antenna deploy to preclude clearance issues in the event MAXI berthing to EFU 1 fails and must be installed on the backup location (EFU 3).

3.8.6.2 Thermal Constraints

3.8.6.2.1 JEF Thermal Constraints

The JEF Thermal Constraints are dependent on which Beta angle the mission flies. Flight Rule 2JA_C2-73 is the official documentation for thermal constraints. Analysis shows that for all negative Betas, the thermal limit is at least 60 hours from removal of heater power to the JEF to HCE activation. The nominal flight plan has this timeframe scheduled for ~13 hours.

3.8.6.2.2 ICS-EF Thermal Constraints

For ICS-EF, thermal analysis indicates the worst case Beta angle is -60° with approximately 2.3 hours before the payload reaches its temperature limit. Analysis was not completed for Betas greater than $\pm 60^\circ$. The most critical component on the ICS-EF is the Down Converter (DNC).

Note: Analysis assumes heaters and no temporary MLI covers.

At the worst case Betas analyzed, MAXI had a limit of 73 hours and SEDA-AP had no limit.

4.0 FLIGHT SPECIFIC UNIQUE INTERFACES AND SYSTEMS

This section is intended to provide an overview of orbiter systems and capabilities that directly impact mission 127/2J/A. A general description of the respective system is provided along with information on related orbiter interfaces and flight-specific configurations. The systems discussed in this section as they pertain directly to the activities of mission 127/2J/A are the Station-Shuttle Power Transfer System (SSPTS), the Payload Deployment and Retrieval System (PDRS), the Remotely Operated Electrical Umbilical (ROEU), and the crew interfaces used during the assembly process.

4.1 ORBITER SYSTEMS

The following section describes the two unique orbiter configurations for mission 127/2JA, the SSPTS, and the PRLA parallel latching configurations.

4.1.1 Station-Shuttle Power Transfer System

SSPTS is an orbiter system that accepts 124 V dc ISS power and converts it to 28 V dc orbiter power to supplement power from the orbiter fuel cells. Load sharing with the fuel cells reduces the use of orbiter O_2 and H_2 cryogenic reactants, providing increased docked mission duration for increasingly complex assembly missions. SSPTS also incorporates converters to provide 28 V dc orbiter power to 124 V dc orbiter payloads and/or the OBSS sensors. Figure 4-1 gives a simplified schematic of ISS-shuttle SSPTS wiring paths.

Figure 4-1. SSPTS architecture (OV-103 and -105)

4.1.1.1 Hardware and Configuration

SSPTS has two principal components: two Power Transfer Units (PTUs), consisting of an Assembly Power Converter Unit (APCU), two Orbiter Power Converter Units (OPCUs), and the wiring to provide power through the Androgynous Peripheral Attachment System (APAS) "X"-connectors to two (main A and main B) of the three orbiter main buses. The capability of the APCUs to provide power to ISS has been eliminated due to the removal of return feeds through the X-connectors to the ISS.

The PTUs are installed under the payload bay liner in the same locations (bay 5, shelf 6) originally occupied by the non-SSPTS APCUs (Figure 4-2). Each PTU is actively cooled via a coldplate interfacing with the orbiter Freon loops. Trade studies show that the thermal capacity of the bay 5, shelf 6 coldplate is adequate for simultaneous operation of both the APCU and OPCU functions. The new configuration applies only to shuttle orbiters Discovery (OV-103) and Endeavour (OV-105) with Endeavour being used for mission 127/2JA.

Figure 4-2. PTU installation locations

Each PTU includes one APCU and two OPCUs in a single Line Replacement Unit (LRU) (see Figure 4-3).

Figure 4-3. Integrated PTU with additional hardware

The JEF heaters can be powered in the PLB by APCU1. APCU2 powers the OBSS camera inspection equipment. Both APCUs 1 and 2 are activated immediately after postinsertion to provide power to the JEF and the OBSS. Each APCU activation/deactivation takes 5 minutes, plus roughly another 5 minutes for crew translation time to the A15 panel and for bringing up the appropriate Specialist (SPEC) Function page.

The APCU connects to the JEF heaters via the LTA EVA heater cable. This cable is disconnected by the EVA crew before removal of the JEF from the payload bay by the SSRMS.

The APCU configuration is shown in Figure 4-4. APCUs are also shown as part of Drawing 3.2.

Figure 4-4. APCU configuration

The OPCU has the sole function of converting 124 V dc ISS secondary power to 28 V dc power. Each OPCU converter draws 2.2 kW of 124 V dc power from station RPCs and converts it to 2 kW of 28 V dc orbiter-usable power (each PTU input power draw from the orbiter is 20 watts maximum when the OPCU (is in the OFF state). There are four OPCU converters total (two per PTU), designated 1a/1b and 2a/2b, capable of supplying a total of 8 kW should all four OPCU converters operate simultaneously. The orbiter fuel cells are certified to operate at a minimum power level of 2 kW. The system is either manually controlled by the flight crew or via command by ground personnel to achieve the desired fuel cell power level*.* The OPCU 1 converters are directly connected to the orbiter bus Main A (MNA), via Fuel Cell 1 (FC1), and OPCU 2 converters to Main B (MNB), via FC2 (see Figure 4-5). SSPTS is capable of operating with any orbiter main bus tie configuration. Typically, whichever bus has two OPCU converters activated is bus-tied to orbiter bus Main C (MNC) to allow better power transfer capability; therefore, if OPCU converters 2a/2b are on, the bus-tie is MNB-C. If OPCU converters 1a/1b are on, then the bus-tie is MNA-C. With SSPTS operating at full capacity, the docked mission duration can be extended by approximately 3 days, depending on overall orbiter power usage.

4.1.1.2 Interface and Controls

The front panel of the PTU (Figure 4-6) has input/output connectors for the OPCU and APCU, as well as connectors for control power and Ground Support Equipment (GSE) test equipment. Once installed, only the test cables are left disconnected.

Figure 4-6. SSPTS PTU front panel connections

4.1.1.3 Crew/Ground Interfaces

The crew interfaces with the PTUs via switches on panel A15 and maintains system insight via a crew SPEC display. The APCU controls remain unchanged in form from previous missions and consist of converter and output ON/OFF switches for both APCUs. The OPCU controls include converter ON/OFF and voltage-adjust switches, as well as a PNL/CMD switch to allow ground commanding to the system (see Figure 4-7). OPCU power levels can be adjusted using ground commands or by the voltage-adjust switches on panel A15.

Figure 4-7. A15 panel switches for PTUs

Systems management display SPEC 179 is incorporated into the orbiter flight software to provide information to the crew for both APCUs and OPCUs (Figure 4-8).

	1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1							
$\mathbf{1}$	XXXX/XXX/179 POWER TRANSFER XX X DDD/HH:MM:SS							
2							DDD/HH:MM:SS	
3			1/AXXXX			2/BXXXX		$3 / C$ X X X X
4	FC POWER (KW) XX.XS			XX.XS XX.XS				
5	MAIN VOLTS XX.XXS			XX.XXS				XX.XXS
6	PTU/MAIN BUS	X X X			X X X			
$\overline{7}$								
8	OPCU	A	\overline{B}		A	\overline{B}		
9	OUT VOLTS XX XXS XX XXS				XX.XXS	XX . XXS		
10		AMPS XX.XS XX.XS				XX.XS XX.XS		
$\mathbf{1}$	TEMP	XXXS XXXS			XXXS	XXXS		
2	TRIP	XX XX XX XX			XX XX	$X X$ $X X$		
3		XX XX XX XX				XXXXXXXXX		
4		XXX XX XXX XX		XXX XX		XXX XX		
5		XXX XX XXX XX			XXX XX	XXX XX		
6	APCU							
$\overline{7}$	OUT VOLTS		XXX.XS			XXX.XS		
8	AMPS		XX XS			XX.XS		
9	IN AMPS		XX XS			XX XS		
20	TEMP		XXXS		XXXS			
$\mathbf{1}$	OUTPUT		X X X		X X X			
2	TRIP XXXX XXXXX							
3		XXX XX	XXX XX		XXX XX	XXX XX		
4								
5								(XX)
6								

Figure 4-8. SPEC 179 - Power Transfer

4.1.2 Payload Deployment and Retrieval System

The orbiter PDRS comprises the SRMS, the Payload Retention Latch Assemblies (PRLAs), the Manipulator Positioning Mechanism (MPM)/Manipulator Retention Latches (MRLs), Payload (P/L) handling aids and guides, the Closed-Circuit Television (CCTV) system, and the General Purpose Computers (GPCs). This section of the AOH concentrates on the SRMS and the PRLAs as they apply to ISS assembly during mission 127/2JA. Further details, including descriptions of the other PDRS elements, can be found in other sources (e.g., training documents and JSC-11174, Space Shuttle Systems Handbook (SSSH)). PDRS operations for 127/2JA include inspections (early, focused, and late) using the OBSS, temporary holding of the JEF while the MT is translating, and removal of the JLE from the payload bay. The SRMS unberths the OBSS on FD02 for initial inspection. On FD05, the SSRMS unberths the OBSS and hands it off to the SRMS for focused inspection, if necessary. Final inspection occurs after undock with the SRMS again unberthing the OBSS on FD15.

On FD03, the SRMS moves to the JEF UNBERTH CLEAR position then grapples and unberths the JEF on FD04, with the SSRMS at the handoff position. The SSRMS then

does a walkoff to MBS PDGF no. 3 to reach the installation site. When the walkoff is complete, the SRMS hands the JEF back to the SSRMS. The SSRMS then berths the JEF to the JLP.

On FD05, the SRMS unberths the ICC-VLD and hands off to the SSRMS, which subsequently attaches it to the MBS POA. On FD07, the SRMS removes the JLE from the PLB. It then hands off the JLE to the SSRMS, which installs it on the JEF. The SSRMS uninstalls the JLE from the JEF on FD11, hands it off to the SRMS, which reberths it back into the PLB for return to Earth.

The JEF, JLE, and ICC-VLD are secured in the orbiter PLB by a total of 15 active PRLAs. In addition to these 15 latch controls, 3 are needed for the ROEU, resulting in a total of 18 active latch controls required. As the orbiter control panel provides controls only for up to 15 latches, several latches are connected in parallel such that 2 latches are operated with a single command. These parallel latches are highlighted in yellow in Figure 4-9. The latch controls from panel A6U are also shown. Although the crew cannot control the PRLAs or ROEU from the GPCs, they can monitor the status using SPEC 097 (in OPS 2 or 4); for example, checking to see if the latches drive in single or dual motor time.

Figure 4-9. Latch controls and assignments for STS-127

The motorized PRLAs and ROEU are opened and closed by the crew on orbit using the panel shown in Figure 4-9. The keel latches are used to take the side loads on a P/L and help center the P/L in the cargo bay. When berthing elements in the PLB, the keel latches must be closed first to center the P/L before closing the longeron latches, as the keel latches do not have the force to overcome the longeron latches. The locations of the PRLAs on the PLB are shown in Figure 4-10 with a picture of a PRLA shown in Figure 4-11.

Figure 4-10. PRLA latch locations

Figure 4-11. PRLA

4.1.3 Remotely Operated Electrical Umbilical

For Mission 2J/A, the ROEU provides 28 V dc power from the orbiter electrical buses to JLE heaters while the JLE is berthed in the (PLB). The ROEU connection to the JLE is controlled remotely from the orbiter Aft Flight Deck (AFD) on the P/L retention system panel, A6U, before JLE removal from the PLB. With the P/L Select Switch in the "2" position, Latch switches 1, 2, and 3 are used to relax, demate/remate, and latch/release the ROEU, respectively, with the associated talkbacks reflecting the position of the ROEU, either LAT (latch) or REL (release). If remote disconnection or connection of the ROEU fails, an EVA backup capability exists.

4.1.3.1 Hardware

a. **Payload Disconnect Assembly (PDA) –** The PDA, shown in Figure 4-12, is the umbilical portion of the ROEU that is mounted on the P/L. The PDA contains the connector pins and latching lugs required for interfacing with the Orbiter Disconnect Assembly (ODA) during ROEU mating. Coarse alignment guides ensure that a proper connection is made.

Figure 4-12. PDA

b. **Orbiter Disconnect Assembly (ODA)** – The ODA, shown in Figure 4-13, is the umbilical portion of the ROEU that is mounted on the end of the ROEU arm. The ODA includes the pinholes and latching hooks required for interfacing with the PDA; it also contains the other half of the coarse alignment guides for ensuring a proper connection. This is where the EVA crew performs the latching/unlatching, if necessary.

Figure 4-13. ODA

c. **Orbiter Arm Drive Mechanism (ODM)** – The ODM, shown in Figure 4-14, is the arm portion of the ROEU and includes the ODA. The ODM is mounted on an orbiter longeron and is driven by redundant motors to swing about its Y-axis for mating/demating of the umbilical. There is also an EVA capability for driving the arm.

Figure 4-14. ODM

d. **ROEU motors** – Redundant motors drive the ODM and latching mechanism. The motors use standard orbiter 115 V, 400-Hz ac power. Limit switches provide the control logic for end-of-travel power removal and position indication. Each drive motor in a set has its own power source and control. ODM1 and ODA1 are driven by MMC1; ODM2 and ODA2 are driven by MMC3.

4.1.3.2 Disconnect Operations

Prior to disconnect, the ROEU must first be deadfaced. The JLE heaters are turned off and the APCU1 and APCU2 output relays are opened. The ROEU overlay is installed on panel A6U to use the first three switches, the third talkback (tb) in the first row, and the first three talkbacks in the second row.

Figure 4-15. ROEU overlay for panel A6U

At the start of disconnect operations, the switches are in the OFF position, and the talkbacks are as shown in Figure 4-16.

Figure 4-16. ROEU talkbacks prior to disconnection and after reconnection

- a. **ROEU release** Release refers to the unlatching of the ODA hooks from the PDA lugs and the separation of the ODA holes from PDA pins by ~0.53 in. At the end of the hook travel, a limit switch deactivates power to the drive motors and drives the talkback and indications. ROEU release is accomplished by taking switch 3 (LATCH/RELEASE) to the RELEASE position (tb-REL) then back to OFF.
- b. **ROEU demating** Moving latch switch 2 (DEMATE/MATE) to DEMATE moves the arm to the stowed position along the longeron after the latches are released. The ROEU is fully constrained by the drive bellcrank that moves over center with respect to the drive link in the Y_0 direction and by a V-block fitting and clevis roller in the Z_0 direction. The force-control bungee is in tension, and the talkback shows "REL."

At the completion of ROEU disconnect, all switches are in the OFF position, and the talkbacks should now look like Figure 4-17 . The overlay can be removed.

Figure 4-17. ROEU talkbacks after disconnection and prior to reconnection

4.1.3.3 Reconnect Operations

When the JLE is reberthed in the PLB by the SRMS, the ROEU can be reconnected to the JLE to provide heater power for the remainder of the mission. However, as of publication, it is not expected that the JLE will be powered for descent. The reconnection steps are included here as reference in case the decision is made to reconnect the ROEU. Before reconnection, the ROEU overlay is installed on panel A6U. The switches are in the OFF position, and the talkback configuration is as shown in Figure 4-17.

- a. **ROEU mating** Mating of the ROEU to the JLE is accomplished by moving switch 2 (MATE/DEMATE) to the MATE position (tb-LAT) to extend the ROEU arm toward the P/L to coarsely align the ODA and PDA by interleaving their alignment guides using ~100 lbf. At this point, the ODA holes are ~0.53 in. from the PDA pins, and the force-control bungee is fully compressed. A cam on the actuator's intermediate drive bellcrank activates a limit switch that disables power going to the drive motors and activates the talkback and indications.
- b. **ROEU latching** This refers to the latching of the ODA/PDA interface and pulling the connectors together using $~400$ lbf. At the end of the hook travel, a limit switch deactivates power to the drive motors and drives the talkback and indications. Latching is accomplished by moving switch 3 (LATCH/RELEASE) to the LATCH position (tb-LAT), then to OFF.

c. **ROEU relaxing** – Relaxing refers to the force on the force-control bungee. When performed after latching, the relax operation completely relaxes the force on the bungee. This is at the midtravel of the bungee free-play and is performed to relieve any Y-axis spring force imposed on the P/L at its maximum Y_0 deflection. It is important to understand that there is no ROEU arm motion that can be observed; only the bungee and drive linkage move, and this is not visible.

In addition to the previous condition, the relax indications and talkback are active (tb-REL) throughout demate and at the beginning of the mating sequence. The indications are lost, and the talkback shows gray/barberpole (bp) when the bungee begins to compress and the arm drive intermediate bellcrank moves past the relax position from the demate position. To relieve the tension, switch 1 is moved to the RELAX position then back to OFF (tb-REL).

Upon completion of ROEU reconnect, the switches are in the OFF position, and the talkbacks are as depicted in Figure 4-16.

4.2 CREW INTERFACES

This section is dedicated to the interfaces the crew has with the ISS and shuttle that are used in the assembly process. Displays for mission 127/2JA assembly activities are included in this section with the exception of the standard switch panel descriptions, which are located in the mission 127/2JA Assembly Operations Procedures (AOP).

4.2.1 Portable Computer System

There are no JEF- or JLE-specific Portable Computer System (PCS) displays for Flight 2J/A.

4.2.2 Station Support Computer

There are no flight-specific Station Support Computer (SSC) applications for Flight 2J/A.

4.2.3 System Laptop Terminal

For the System Laptop Terminal (SLT) displays, see the respective JEF and JLE systems sections in Section 5.

4.2.4 Payload Laptop Terminal

There are no flight-specific Payload Laptop Terminal (PLT) displays for Flight 2J/A.

4.2.5 Robotics Laptop Terminal

There are no flight-specific Robotics Laptop Terminal (RLT) displays for Flight 2J/A.

4.2.6 Multifunction CRT Display System

There are two flight-specific Multifunction Cathode Ray Tube (CRT) Display System (MCDS) displays for mission 127/2JA. One is SPEC 210 (S210) for the JEF PRLA parallel latches and the other is S211 for the JLE PRLA parallel latches. Parallel latching provides the ability to command to multiple latches with a single switch throw. Without this capability, there is an insufficient number of switches available to command all the latches. For additional information about parallel latching configuration, see Section 4.1.3. A description of both Specialist Function displays follows. For more information about these and other SPEC displays, reference JSC-19478-127, STS-127 Payload Management Level C Flight Software Requirements.

4.2.6.1 JEF PRLA and AKA Status

The JEF (also known as JEM-EF) PRLA and Active Keel Actuator (AKA) Status display (Figure 4-18) is dedicated to depicting the microswitch status for the four PRLAs and single Active Keel Actuator (AKA) used when berthing the JEF back into the PLB. Microswitch data is displayed onlywhen the Payload Select rotary switch is configured to the "1" or "MON" position. The first two rows of the display are static text fields identifying the switch nomenclature for each mechanism and the mechanism being driven, respectively. The "RDY-FOR-LAT" fields display a "1" when the corresponding payload trunnions have actuated the ready-for-latch striker arm of the corresponding PRLA or AKA; otherwise, these fields display a "0." When a PRLA pair or the AKA has reached the fully latched position, the "LAT" fields display a "1" and the "REL" fields display a "0." When the PRLA pair or the AKA has reached the fully reached position, the "LAT" fields display a "0," and the "REL" fields display a "1."

4.2.6.2 JLE PRLA and AKA Status

The JLE (also known as ELM-ES) PRLA and Active Keel Actuator (AKA) Status display (Figure 4-19) is dedicated to depicting the microswitch status for the four PRLAs and single Active Keel Actuator (AKA) used when berthing the JLE back into the PLB. PRLA microswitch data is displayed only when the Payload Select rotary switch is configured to the "1" or "MON" position. AKA microswitch data is displayed only when the Payload Select rotary switch is configured to the "2" or "MON" position.

Note: The "MON" position does allow both PRLA and AKA data to be displayed simultaneously.

The first two rows of the display are static text fields identifying the switch nomenclature for each mechanism and the mechanism being driven, respectively. The "RDY-FORLAT" fields will display a "1" when the corresponding payload trunnion has actuated the ready-for-latch striker arm of the corresponding PRLA or AKA; otherwise, these fields display a "0." When a PRLA pair or the AKA has reached the fully latched position, the "LAT" fields display a "1" and the "REL" fields display a "0." When the PRLA pair or the AKA has reached the fully released position, the "LAT" fields display a "0" and the "REL" fields display a "1."

	10 XXXX/220/XXX	15 20	25 JEM-EF LATCH	30 35	40 XX X	50 45 DDD/HH : MM : SS DDD/HH & MM & SS	
		PL SEL 1 LATCH 1		PL SEL 1 LATCH ₂		PL SEL LATCH 3	
10	MECHANISM	PRLA 1 PRLA 4 PRLA 2 PRLA 3				AKA	
15	RDY-FOR-LAT	X X	X X	X X	X X	X X	
	LAT/REL	X X \prime X X		X X \prime X X		XX/XX	
20							
25	لتناط والملمئية والماما والماملون والمندار وأوال والملحاء والملحا والملحا والملط والملحاط والماما والمامانة والمنافل					(XX)	

Figure 4-18. S210: JEF PRLA and AKA parallel latching statuses

JSC-36536 Final

	XXXX/221/XXX	15 20	25 ELM-ES LATCH	30 35	XX X	50 DDD/HH 8 MM 8 SS DDD/HH & MM # SS	
		PL SEL 1 LATCH 4		PL SEL 1 LATCH 5		PL SEL 2 5 LATCH	
10	MECHANISM			PRLA 1 PRLA 4 PRLA 2 PRLA 3		AKA	
15	RDY-FOR-LAT	X X	X X	X X	X X	X X	
	LAT/REL	X X \prime X X		X X \prime X X		XX/XX	
20							
25						(XX)	

Figure 4-19. S211: JLE PRLA and AKA parallel latching statuses

5.0 JEM SYSTEMS INFORMATION

This section provides details about the systems on two of the five components of the JEM segment. The five components of the JEM are the JLP (delivered on 1J/A), the JPM and JEMRMS (delivered on 1J), and the JEF and JEM Logistics Module-Exposed Section (JLE) (delivered on 2J/A). Only the JEF and JLE are discussed in detail here as they are delivered on mission 2J/A.

5.1 JAPANESE EXPERIMENT MODULE - EXPOSED FACILITY

The JEF is one of the JEM elements located on the port-side of the JPM. The JEF can attach JEF payloads, the JLE, and the H-II Transfer Vehicle (HTV) Exposed Pallet (HTV-EP) to itself via one of the available robotic manipulator systems. The JEF payloads are directly exposed to the space environment. Therefore, the JEF can provide a space-unique environment for JEF payloads, such as microgravity, vacuum, and a broad field of view. Crewmembers can monitor and control the JEF system components from the JPM using the System Laptop Terminal (SLT). Figure 5-1 shows the JEF and JLE attached to the JPM.

Figure 5-1. JEF and JLE

The JEF has interfaces to provide JEF payloads with installation mechanisms and resources. The benefits for experiments in the JEF are to be able to use a high-vacuum environment without limitation (as in the JPM) and also a space view capability. Additionally, there are low safety requirements compared with the JPM and JLP. The JEF payloads differ from payloads in the JPM and JLP in that they are not operated by the crew directly, but by commands and/or a remote manipulator. The JLE, which is launched and returned with payloads and JEF system equipment by the Shuttle, is berthed at EFU 10 on the JEF and supplies power for preservation of the payloads and the equipment.

The JEF has 12 attachment mechanisms, of which 1 is for the ICS exposed unit, 1 is for the JLE, and the other 10 are for payloads and interim places for payload exchange. Each attachment provides a payload with necessary resources and services.

Figure 5-2 and Table 5-1 show the installation location of payloads and the resources and services supplied to each position, respectively.

Figure 5-2. JEF payload installation locations

Table 5-1. Resources available to JEF payloads

Note 1 - EFU 5 is a Backup for EFU 7 (ICS) a, b = JEF PDB that provides power at this site

Note 2 - EFU 9 is a backup for EFU 10 (JLE and HTV EP) o= service is available at this site

Note 3 - EFU 12 is interim place for exchange - = service is not available at this site

Note 4 - Power channel b of EFU 2 and channel b of EFU 12 are not available at the same time because the power for both these EFUs comes from the same branch

5.1.1 STRUCTURES AND MECHANISMS

5.1.1.1 Primary Structure

The JEF has a box-shaped structure of dimensions 5.6 by 3.8 by 1.6 m, as shown in Figure 5-3. There are several ORU attachment plates, where the robotics compatible ORUs (R-ORUs) on the zenith side and EVA essential ORUs (E-ORUs) on the nadir side are attached. The R-ORU and E-ORU are JEF system components. There are two FRGFs, four longeron trunnions, and one keel trunnion on the JEF. Also, the JEF has many Translation Aids and Attachments (TA&As) for use during EVAs. The following components are R-ORUs: JEF PDB a and b, SPB, ESC a and b, Fluid Pump Package (FPP) a and b, and the Video Switcher (VSW). The following components are E-ORUs: EDU, Thermal Interface Unit (TIU), and Heater Control Equipment (HCE) a and b.

* 2 Keel Trunnions are not shown in this figure.

Figure 5-3. Assembled JEF structure

The JEF main structure is an assembly of aluminum alloy panels and frames (see Figure 5-4). The structure is covered with MLI. The internal space is divided into 12 sections and cannot be accessed while on orbit. The JEF has four longeron trunnions and one keel trunnion that are made of titanium alloy. These trunnions are used to attach the JEF in the Shuttle cargo bay for transport to ISS.

Figure 5-4. Exploded view of JEF structure

5.1.1.2 External Facility Berthing Mechanism

The EFBM allows for a rigid connection between the JEF and the JPM. The EFBM consists of an active half and a passive half. The active half is bolted to the exterior of the JPM. During berthing, the passive half of the EFBM (on the JEF) is captured and pulled by the capture arms on the active half of the EFBM, as shown in Figure 5-5. Upon capture, the JEF is secured by the structural latches (motor-driven fasteners). The EFBM has 20 Quick Disconnects (QDs) that allow for electrical and fluid connections. The active EFBM is operated by crewmember commands from the Berthing Mechanism Control and Display Unit (BCDU) via the Berthing Mechanism Electronics Package (BEP) (see Section 3.2.2 for more details).

Figure 5-5. EFBM

The active half of the EFBM has four capture latches, four structural latches (bolts) and twenty QDs (data, power, fluid). Ten QDs are contained in each of the two umbilical mechanisms that drive the umbilicals to connect. Figure 5-6 shows the layout of the active EFBM.

Figure 5-6. Active EFBM layout

The passive half of the EFBM contains the corresponding capture points, umbilical receptacles, and bolt sockets for the active EFBM. Figure 5-7 shows the layout of the passive EFBM.

Figure 5-7. Passive EFBM layout

Figure 5-8 shows an overview of crew control of the EFBM. The BCDU provides a crew/hardware interface for EFBM commands and statuses. Capture latch, structural latch, and umbilical mate commands are issued via switches located on the BCDU. The BEP routes EFBM commands and statuses between the BCDU and the EFBM. Power to the BEP is supplied via PDB a2 RPC 1 (see Appendix D, JAXA Drawing 1.1).

Figure 5-8. EFBM control overview

The layout of the BCDU is shown in Figure 5-9. Fault, capture latch, structural latch, and umbilical mechanism statuses are all indicated on the unit. Emergency stop, capture latch open/close, structural latch connect/disconnect, and umbilical connect/disconnect commands can be issued by BCDU switch throws.

Figure 5-9. BCDU

As an example of BCDU operation, a stop command can be issued at any time if berthing operations are determined to be off-nominal. When this switch is thrown, the red STOP LED turns on, and the INTLK LED turns off. The Interlock turns off to allow out-of-sequence commands to be sent to resume operations. The STOP can be released, and EFBM operations can continue by throwing the ALARM RESET switch, at which point the STOP LED turns off.

Each EFBM status is provided by sensors that measure either revolutions, torque, or indicate a spatial limit. Table 5-2 details how each status is measured and the time for each operation.

Mechanism	Position	Position sensed by	Approx. time	
Capture latch	Open	Limit switch	$Cl \rightarrow Op$:	70 sec
	Soft capture	Revolution count	$Op \rightarrow$ Sf Cp:	10 _{sec}
	Close	Revolution count	$St Cp \rightarrow Cl$:	60 sec
Structural latch	Connect	Revolution count and torque	Denct \rightarrow Cnct: 200 sec	
	Disconnect	Limit switch		
Umbilical	Connect	Limit switch	Denct \rightarrow Cnct: 65 sec	
	Disconnect	Revolution count		

Table 5-2. EFBM latching

A schematic of the BCDU, BEP, and EFBM can be seen in Figure 5-10.

Figure 5-10. BCDU, BEP, EFBM schematic

5.1.1.3 Equipment Exchange Unit

The Equipment Exchange Unit (EEU) is the mechanism used to attach payloads, the Inter-orbit Communication System - Exposed Facility (ICS-EF) Antenna, the JLE, and the H-II Transfer Vehicle (HTV) - Exposed Pallet to the JEF. The EEU consists of

two parts: the EFU, an active element, and the Payload Interface Unit (PIU), a passive element. The EFU is driven by the EEU Driver Unit (EDU) installed on the JEF. Figure 5-11 depicts an EEU, showing both an EFU (left) and a PIU (right).

The EEU provides the following functions:

- a. Payload berthing and unberthing
- b. Monitoring the EFU arm and berthing of the payload
	- 1. Three limit switches enable the crew to confirm the Arm position (open, softdock, or closed).
	- 2. After the EFU and PIU are connected, the crew can check berthing completion using the status data from the PIU.
- c. Resource supply and data communication with JEF payloads

EFU and PIU QDs enable electrical, communication, and heat transfer interfaces between the JEF and payloads.

Note: EFU 7, where the ICS-EF is attached, does not have a fluid interface.

Figure 5-11. Equipment exchange unit

5.1.1.3.1 Exposed Facility Units

The EFUs are capable of capturing payloads with PIUs based on commands sent from the Exposed Facility System Computer (ESC). The JEF has 12 EFUs, most of which are shown with attached payloads in Figure 5-12.

Figure 5-12. EFU locations on JEF

Each EFU is made up of the following major components described in Table 5-3 and also shown in Figure 5-11.

The EFU arm motion and mechanical components are shown in Figure 5-13. The figure shows the arm motion from the point of being completely open, to a softdock position, and finally closed. The mechanics of the arm closure make use of a simple motor and screw gear assembly that forces the arm open or closed via several linkages. As shown in the figure, an EVA crew can operate the arm manually using a power tool in the event of a malfunction.

Figure 5-13. EFU arm motion and construction

Resources provided via the EFU to the JEF payloads are shown in Figure 5-14.

Figure 5-14. Payload resources provided by EFU

Safety functions that prevent the JEF payloads from inadvertent release are as follows:

- a. Software: Internal double check for payload release commands
- b. Hardware: microswitches check the EFU arm status

In addition, the EFU arms, which capture the payload, are capable of manual operation by EV crew in the event there is a system failure.

5.1.1.3.2 Payload Interface Unit

The PIU is the passive side of the EEU and is located on the payload or JLE. The PIU is made up of the following five major components described in Table 5-4 and is shown in Figure 5-11.

Table 5-4. PIU major components

5.1.1.4 EEU Driver Unit

The EDU is located on the JEF nadir (see Figure 5-15) as one EVA Essential ORU (E-ORU) consisting of the EDU and an E-ORU box (described in Section 5.1.1.6.2). The EDU, consuming a maximum of 72 W, provides electrical power to the EFU and monitors the EFU status. The following are the major functions of the EDU:

- a. The EDU selects 1 of 12 EFUs on the JEF and drives the EFU based on ESC commands. The motor clock signals, which are generated by the ESC, drive the motor in the EFU.
- b. The EDU monitors the EFU Arm status (open, softdock, close) and Berthing status (berthed, unberthed) and makes inputs to the ESC.
- c. The E-ORU box has EVA interfaces so that it is possible to replace the EDU via EVA.
- d. The EDU has a BIT function.

Figure 5-15. JEF EDU location (on JEF nadir)

5.1.1.5 Payload Berthing and Deberthing

To berth or deberth a payload, a crewmember must select an EFU where a payload is attached and control the EFU arms via the SLT. Figure 5-16 depicts the general berthing sequence of a payload. To assist with berthing, the EFU provides a visual indicator to the JEMRMS via a Target Marker. The Target Marker allows the JEMRMS to enable ranging parameters for the berthing/deberthing operations, after which the JEMRMS carries the payload to the capturing area automatically. After the payload is aligned with the capturing area by the JEMRMS, the EFU arms capture the PIU and attaches the payload to the JEF. Three microswitches on the EFU allow the crew to confirm if the arm is open, in softdock, or closed. After the payload has been berthed, the ESC checks the status of the microswitches, temperature data from the PIU, and ensures that some pins have been shorted between the PIU and EFU. The ESC checkpoints are shown in Figure 5-17.

Note: If the ESC detects a failure or communication anomaly with the EDU at any time during the berthing sequence, it stops the motion of the EFU arm.

The berthing/deberthing sequence requires three commands, namely release, softdock, and capture. The operational time from release to softdock is 3 minutes and a total of 6 minutes for softdock to capture. The operational life of the EEU is expected to be greater than 50 berthing/deberthings on orbit.

Figure 5-16. Payload capture

Figure 5-17. ESC berthing verification

Figure 5-18 shows an overview of the power and command/telemetry path required during the berthing/deberthing of a JEF payload.

Figure 5-18. Power/command/telemetry for JEF payload berthing and status

5.1.1.6 JEF ORU Components

Each of the main JEF system components is housed in an ORU. There are two types of ORUs, R-ORU and E-ORU. There are eight R-ORUs located on the zenith side of the JEF and four E-ORUs located on the nadir side of the JEF. There is also an R-ORU temporary attachment plate for use when an R-ORU is replaced that is located on the zenith side of the JEF.

5.1.1.6.1 Robotics Compatible ORU

There are eight Robotics Compatible ORUs (R-ORUs) on the JEF: JEF PDB a, JEF PDB b, SPB, ESC a, ESC b, Fluid Pump Package (FPP) a, FPP b, and VSW.

An R-ORU consists of an R-ORU box and an R-ORU attachment plate. An R-ORU has mechanical, electrical, communication, thermal, and fluid interfaces with the JEF. R-ORUs have two tool fixtures to be handled by the Small Fine Arm (SFA), and have handhold and microconical fittings to be handled via EVA in the event that the JEMRMS is not available. An R-ORU can be seen in Figure 5-19.

Figure 5-19. General view and picture of R-ORU

5.1.1.6.2 EVA Essential ORU

There are four Essential ORUs (E-ORUs) on the JEF: EDU, Thermal Interface Unit (TIU), Heater Control Equipment (HCE) a, and HCE b. An E-ORU consists of an E-ORU box and an E-ORU attachment plate. Each E-ORU has six main bolts and two QD bolts that can be installed or removed by an EVA crewmember using the EVA tool. An E-ORU has mechanical, electrical, and communication interfaces with the JEF and

has handholds and microconical fittings to be handled via EVA. An E-ORU can be seen in Figure 5-20.

Figure 5-20. General view of E-ORU

5.1.1.7 SFA Storage Equipment

The JEF has a mechanism called the SFA Storage Equipment (SSE) that is used to store the Small Fine Arm (SFA) when it is not in use. The SSE uses a Structural Latch Mechanism (SLM) to secure the SFA trunnion. The SFA can receive heater power and

communication resources from JEF via the SSE. In the event of a malfunction, the SFA can be released from the SLM via EVA. The SSE/SFA interface is shown in Figure 5-21.

Figure 5-21. SSE and SFA interface

The SSE has two power lines to allow for redundancy. Primary power is supplied from JEF Power Distribution Box (PDB)-b, with redundant power from the Survival Power Distribution Box (SPB)-a. The crew can provide power to the SFA via the SSE using the SLT.

The Target Marker helps the crew monitor the arm motion when the SFA is attached to the SSE. The SFA is berthed to the Tool Fixture (Type II) on the SSE. The Tool Fixture provides power and communication interfaces for the SFA.

The SLM E-ORU consists of the SLM, SLM electronics, a stand, an Interface (I/F) board, and EVA bolts. The SLM consists of claws, links, and gears that are driven by a DC motor. The status of the SLM is monitored via six independent microswitches. The SLM electronics control motor actuation, control and monitor the temperature of the SLM and Tool Fixture II, conduct a Built-In Test (BIT) via commands from the JEF, allow crew to stop the SLM, and can switch power channels. The SLM electronics unit is replaceable by EVA.

5.1.2 Electrical Power System

Electrical power to the Japanese complement is generated from SAWs 1B, 3A, 4A, and 2B. Power conversion from primary to secondary is accomplished via DDCUs N2S4A, N2S1B, N2O2B, and N2O3A. DDCUs N2S4A and N2S1B provide power to the Japanese A-string power units, and N2O2B and N2O3A provide power to the B-String. The JEF receives power from the PDUs located on the JPM. Figure 5-22 shows an overview of electrical power flow to the Japanese segments.

The JEF EPS distributes electrical power to the JEF components, the JLE, the ICS-EF, and the JEF payloads. The EPS consists of two JEF Power Distribution Boxes (PDBs) and a Survival Power Distribution box (SPB). The JEF PDB supplies the main electrical power to the JEF components, the JLE, SSE, ICS-EF, and the JEF payloads. The SPB supplies survival power to the ICS-EF, JEF payloads, and the SSE. Survival power is another source of electrical power that is not used for daily mission operations, rather, in the event of a contingency.

Table 5-5 summarizes the JEF power distributed to the EFUs.

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Figure 5-22. Power overview of Japanese Segment

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5.1.2.1 JEF Power Distribution

The JEF receives electrical power from the JPM via two lines (Power Bus a and b), which are independent of each other. This power is received by one of the two JEF PDBs, each of which is packaged in an R-ORU and located on the zenith side of the JEF as shown in Figure 5-23. Each JEF PDB can receive 6 kW (120 V dc) of electrical power from the JPM. The total electrical power that the JPM can provide for the JEF is 11 kW (120 V dc). This power is then distributed to the JEF components, ICS-EF, JEF payloads (EFUs), the SSE, and the JLE.

Figure 5-23. PDB and SPD locations on JEF

Figure 5-24 shows the layout of the JEF EPS. Each of the JEF components, including the JEF PDB and SPB, has a semiredundant system called the -a system and the -b system. The JEF PDB-a receives electrical power from the Power Bus-a and distributes it to the JEF components included in the -a string, and similarly, the JEF PDB-b distributes electrical power to the JEF components included in the -b string. Exposed facility units EFU 1 and 2 receive electrical power from both JEF PDB-a and JEF PDB-b. The other 10 EFUs receive their main electrical power from either JEF PDB-a or JEF PDB-b.

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Figure 5-24. JEF EPS layout

5.1.2.1.1 Power Distribution Box

A PDB is similar to an RPCM in that it functions like a circuit breaker box that can be remotely controlled. Figure 5-25 shows the outer portion of a PDB.

Figure 5-25. PDB

The purpose of the PDB is to distribute power, allow for RPC operation, and provide for load protection. Input power to a JEF PDU is 120 V dc (6 kW, 1 line). JEF PDU output power is 25 A (6 lines), 10 A (2 lines), 5 A (2 lines), and 1.5 A (6 lines). Figure 5-26 shows the architecture for PDB-a and PDB-b as viewed on the SLT.

Figure 5-26. SLT display of PDB architecture (left-PDBa, right-PDBb)

5.1.2.1.2 Survival Power Box

There are two SPBs, SPB-a and SPB-b, and the units are packaged together in one R-ORU. Each SPB can provide survival power for JEF payloads, the ICS-EF, and the SSE. A payload can receive survival power from an SPB in the event that the payloads PDB is lost. Provided there is at least one PDB, the SPB provides survival power to the units that were once powered by the failed PDB. A payload receives the main power and the survival power from different lines. For example, when a payload receives main power from the JEF PDB-a, that payload receives survival power from the SPB-b.

Note: The power of an SPB is less than that of a JEF PDB.

The SPB input power is 120 V dc (12 kW, 2 lines), with 12 output lines at 1 A and 2 lines at 5 A. Figure 5-27 shows the architecture for SPB-a and SPB-b as viewed on the SLT.

Figure 5-27. SLT display of SPB architecture

5.1.2.2 Operations

The SLT is used to control the JEF PDB. Using it, a crewmember can start the power supply for components and payloads attached to the JEF. The PDB starts up within 1 second after receiving input power without requiring a command.

In the event of loss of cooling, the PDB is continuously operative for more than 1 hour without the flow of cooling water (if the load current for each output is no greater than 80 percent of the amp rating and the total load power is no greater than 1 kW). At least 10 minutes of operational use is assured if the load current for each output is full. After an RPC trips due to overloading or overvoltage, the RPC can be reset to a normal state (once the overcurrent/overvoltage condition is corrected) by first commanding it open, then commanding it closed. The JEF EPS components are designed as R-ORUs, which can be replaced by the JEMRMS SFA in the event of a failure.

5.1.3 JEF Command and Data Handling System

The JEF Command and Data Handling System consists of four types of computer communication environments, namely, low-rate, serial, medium-rate, and high-rate communication. The low-rate system provides for command, control, and safety monitoring of JEF components. Serial communication is used internally between JEF systems and the JEF System Controller (ESC). Medium-rate and high-rate communication is used for payload data. High rate communication is primarily used for payload data transfer.

The ESC transfers commands to and data from JEF components and payloads for monitoring and control purposes. The ESC controls and monitors JEF components under the direction of the JEM Control Processor (JCP). The ESC can detect and isolate failures of JEF components and is considered one of the most important components installed on the JEF. Refer to Drawing 5.1 for details on the C&DH overview (low-rate) of the Japanese segment.

A general overview of the Japanese complement C&DH system follows.

The JPM C&DH system controls the JPM systems and payloads automatically or by commands issued by the ground, USOS C&DH, and the crew. It provides the following functions: JEM Mode Control, Command and Data Processing, Off-nominal Operations Support, and Procedure Execution.

There are two main computers in the JPM, JCP a and JCP b, which are redundant to one another. The C&C MDMs communicate with the prime JCP via the External (EXT) buses. The JPM C&DH system has two systems buses, five payload buses, one local bus for CHeCS, and one local bus for U.S. payloads in the JEM. These buses are not redundant.

Additionally, the C&C MDMs communicate with the Management Data Processor (MDP), which is the JEMRMS processor, via the EXT-2 bus, and with the four CBM controllers for the JPM/JLP interface on both EXT buses. The Node 2 MDMs control two U.S. C&W panels in the JPM. A layout of the JPM/JEF interface can be seen in Figure 5-28. The C&DH overview can be seen in Figure 5-29. Nominally, crewmembers control the JEF from the SLT located in the JPM.

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Figure 5-29. Japanese C&DH overview

5.1.3.1 JEF System Controller

The ESC, an R-ORU, controls and monitors all the JEF system components under direction of the JCP on System Local Bus (LB) 2 (MIL-STD-1553B). The ESC is a 16-bit microprocessor with 64 kB Random Access Memory (RAM) and 128 kB Read Only Memory (ROM). There are a total of two ESCs, ESC-a and ESC-b, each controlling its own string for redundant command, control, and monitoring. One operational constraint of the ESC is that while one ESC is running, it is not possible to activate the other. Both ESCs are located on the zenith side of the JEF as detailed in Figure 5-30.

The ESC receives commands via the JCP and sends them to JEF system components. The ESC also receives Health and Status (H&S) telemetry from the JEF system components. The ESC can detect and isolate failures of JEF components.

Under control of the JCP, the ESC communicates with local controllers in the JEF, such as the JEF PDBs and HCE using serial communication (RS422). Figure 5-31 shows an overview of the systems from which the ESC interfaces.

Figure 5-30. ESC locations

JEM Exposed Facility (JEF)

Figure 5-31. JEF C&DH system interface overview

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5.1.3.2 JEF C&DH Control of Payloads

The following C&DH lines run from the JEF payloads to the JPM via the EFU/PIU:

- a. System LB 2 (MIL-STD-1553B)-Low Rate
- b. LB Payload JEM-direct line to USOS (MIL-STD-1553B)-Low Rate
- c. Payload Bus 2 (MIL-STD-1553B)-Low Rate
- d. Payload Ethernet-Medium Rate
- e. High rate data link

5.1.3.2.1 Low-Rate Data

The JEM low-rate communication network forms the Japanese portion of the USOS tiered C&DH architecture. This network provides for the command path along with the low-rate telemetry for JEF systems. Low-rate communication to the JEF occurs via three buses, namely, the LB Payload bus controlled by the US P/L MDM, the JEM System LB 2 controlled by the JCP, and the JEM Payload Bus 2 controlled by the Payload Data Handling (PDH) unit. All these data paths consist of MIL-STD-1553B communication. Figure 5-32 shows the low-rate communication path network.

The JEM System LB 2 connects the JCPs to the system processors, including the Management Data Processor (MDP), the Baseband Data Processing Unit (DPU), the ESC, and the Electronic Control Unit (ECU). These processors support operation of the JEMRMS, ICS, EFUs, and components on the JEF and JLE, respectively.

The JEM System Local Bus 2 also exchanges data (including payload safety data) and files between the JCP and PDH for payload operations; however, payload experiment data is not on this bus. JEM System Local Bus 2 interfaces with the SLT via a UOP connection. Only one of the two PDHs is operational and controlling the Payload Bus 2 at a time. Payload safety data from the JEF is transferred from the PDH via Payload Bus 2 to the JCP via the JEM System LB 2 and, finally, the C&C MDM via the Control Bus. The LB Payload provides for a direct interface with the US P/L MDM for payloads located on the JEM. This data bus is extended from the USOS through the JEM and to the JEF.

Note: The JEM also has one Utility Outlet Panel (UOP) that can be used to link the US PLT into this payload bus located on the left side of JEM UOP b1.

Figure 5-32. Low-rate communication

5.1.3.2.2 Medium-Rate Data

Medium rate communication, with rates of up to 10 Mbps, uses IEEE 802.3 protocol. The ISS common Payload Ethernet Hub Gateway (PEHG) serves as the "hub" for the JEM medium rate communication. The JEM PEHG links the JEM Payload Laptop Terminal (PLT) to seven payload locations on the JEF. EFUs 1, 2, 3, 6, 9, 11, and 12, or Microgravity Measurement Equipment (MME), are the optional sources of mediumrate data. The JEM PEHG interfaces with the ICS for data uplink and downlink. The JEM PEHG also interfaces with the USOS PEHG (for payloads in the USOS and for the USOS Ku-band subsystem).

The JEM PEHG also has gateway capability to support transfer of IEEE 802.3 data from payloads to the USOS Automated Payload Switch (APS) using a Fiber Distributed Data Interface (FDDI). Figure 5-33 shows the medium-rate data architecture.

Figure 5-33. Medium-rate communication

5.1.3.2.3 High-Rate Data

The high-rate communication capability (up to 100 Mbps) uses FDDI fiber-optics lines. This capability is used for downlink or uplink of payload data. The High-Rate Multiplexer and Switcher (HRMS) is installed in the JEM-WS rack. It collects, switches, and multiplexes Japanese payload data on the high-rate fiber-optic communication lines to/from the USOS APS or JEM ICS.

The PDH collects/edits payload H&S data and experiment data and then uses FDDI to output the edited data to the High-Rate Frame Multiplexer (HRFM)/Ku-band via APS in the USOS and to the ICS/Ka-band via the HRMS in the JEM.

The payloads in the JPM and on the JEF send payload data to the ICS or HRFM via the HRMS. Payloads in the JPM also interface directly to the APS in the USOS via FDDI. Uplink data from ground are demultiplexed by the ICS DPU and sent to the HRMS. The high-rate communication path can be seen in Figure 5-34. There are up to eight payloads on the JEF that use the FDDI to the HRMS for Ku downlink. The FDDI can also send data to the ICS for downlink.

Figure 5-34. High-rate communication overview

The high-rate data input/output of the HRMS is shown in Figure 5-35. The HRMS has 23 FDDI input channels; 1 is for internal multiplexed data, and the rest are for external data sources. The HRMS sends 4 of 10 output channels of high-rate data to the APS in the USOS; 3 of 4 are amplified by an internal repeater. The HRMS has two output channels for ISPRs and four output channels for the ICS multiplexer in the ICS rack (located on the JPM). The HRMS is capable of multiplexing 4 of the 22 external inputs to a single output. Crewmembers change the input/output cable connections manually on the HRMS patch panel, and they use the SLT to initiate JCP commands for HRMS power on/off.

Figure 5-35. HRMS data input/output

5.1.3.2.4 Serial Communication

The ESC, controlled by the JCP, communicates with JEF local Remote Terminals (RTs), such as the JEF Power Distribution Boxes (PDBs) and Heater Control Equipment (HCE), using Serial Communication (RS422). The RS422 is also used for other JEF subsystem controllers.

5.1.3.3 JEF C&DH Modes

The three different modes to manage JEF systems are normal, manual, and payload operations stop. Normal mode is primarily used for nominal crew-tended operations of the JEF. See Table 5-6.

Table 5-6. Definition of JEF mode

The JEF mode transitions are described in Figure 5-36. When a crewmember sends a command to the JCP to change the JEF Mode, the JCP checks the current JEM mode. If the commanded JEF mode is not allowed in the current JEM mode, the JCP does not change the mode.

Figure 5-36. JEF mode transitions

5.1.3.4 Command and data processing

This section describes the following functions:

- a. Command processing
- b. Telemetry processing
- c. Configuration management
- d. Data logging

5.1.3.4.1 Command Processing

The crew, C&C MDM, and ground controllers can issue commands to the JCP. The JCP also handles commands generated by Operations Data File (ODF) procedures or by the Flight Application Software (FAS) in the JCP. The JEM command flow is shown in Figure 5-37.

Figure 5-37. JEM/JEF command flow

Crewmembers can issue system commands by using the SLT. The commands are then transferred to each destination, such as local components in the JEM. To ensure safety, a two-step command function is used for hazardous and override commands. Hazardous commands are commands that may create an unsafe or hazardous condition, endangering the crew or the Station when the command is issued inappropriately. Override commands are commands that can be forced to execute when system conditions would normally restrict issuance.

There are two kinds of command restrictions in the JEM. The JCP/FAS controls one; the other is controlled at the local controller level. JCP/FAS restricted commands can be forced to execute using the override function, as mentioned above; the locally controlled restricted commands cannot. Crewmembers can send payload commands to payloads through the PDH using the PLT.

Crewmembers and ground controllers can issue commands via the C&C MDM to the DIU IIIs (i.e., EPS1 DIU a and EPS2 DIU b) for activation of the JEM while the JCP is not activated. The C&C MDM can also command (without the JCP) to the JEMRMS MDP for file transfer and RMS control, excluding robotic ops.

5.1.3.4.2 Telemetry Processing

H&S data from JEM systems is collected and processed by the JCP. Experiment data and payload H&S data (including payload safety data) from Japanese payloads are collected and processed by the PDH. Payload safety data are sent from the PDH to the JCP.

Data collected from JEM systems and payloads are written to the Onboard Operation Data Table (OODT), which functions similarly to the USOS Current Value Table (CVT) in the C&C MDM. In addition to the current telemetry data, the OODT also stores "static" data for control of JEM configuration.

The JCP sends the system H&S data and payload safety data to the SLT for display. All JEM H&S data sent to the C&C MDM are downlinked for ground monitoring and analysis (via the low-rate communication scheme described earlier). EPS1 DIU a and EPS2 DIU b provide the H&S data for JEM activation and send it to the C&C MDM via the EXT bus. Telemetry flow is shown in Figure 5-38.

Note: Data downlink is not indicated above.

Figure 5-38. JEM/JEF telemetry flow

5.1.3.4.3 Configuration Management

The JEM changes configuration throughout its life on orbit; thus, the JCP must change control parameters as the JEM is reconfigured. The JCP uses the OODT to accommodate these reconfigurations. In addition to the current telemetry data, the OODT contains static control parameters, such as limit values and Fault Detection, Isolation, and Recovery (FDIR) enable/disable status. By altering the OODT (either by specific parameter commands, such as changing a limit value or full OODT upload), the JCP can control the JEM appropriately in various configurations without changing the source program in the JCP.

Flight Software (FSW) and OODT updates are uploaded from the ground. The JEM can store several FSW loads and OODT versions. OODT version and FSW load can be selected when JCP is activated.

The OODT contains the following information:

- a. Automated procedure enable/inhibit
- b. Event detection enable/inhibit (C&W)
- c. Limit value (C&W)
- d. Limit check valid/invalid
- e. Limit set (C&W)

Certain OODT data is identified for use when a scheduled (commanded) JCP switchover occurs and can be transferred to the backup JCP.

5.1.3.4.4 Data Logging

The JCP maintains a log of Tier 1 commands that have been sent and received for a period of approximately 24 hours, replacing the oldest data with the newest data. The command log is downlinked to the ground, on request, using the file downlink function. The PDH also has a command logging function; the logged data can be downlinked by memory dump.

The SLT stores messages that have been displayed on the SLT as historical data. Normally, no crew operation is necessary to log the history data.

5.1.3.4.5 Automated Procedures

Crewmembers are able to see automated ODF procedures using the Automated Procedure Viewer (APV) on the SLT. The automated procedures are developed on the ground and uplinked to the on-orbit system before execution is required. There are two kinds of formats for automated ODF. They are called ODF procedures for display and ODF procedures for execution. ODF procedures for display are sent to the SLT, and ODF procedures for execution are sent to the JCP. Both crewmembers and ground controllers can issue the commands to the JCP to control and execute automated ODF procedures. ODF procedures for display in User Interface Language (UIL) format are uplinked via the C&C MDM/JCP, and they are stored on the SLT hard disk. The compiled ODF procedures for execution are uplinked and stored in the External Data Storage Unit (EDSU) in the JCP.

The JCP executes automated ODF procedures stored in the EDSU when receiving an ODF execution command from the U.S. C&C MDM/crewmember. The JCP provides the ODF execution status to the SLT (APV) and to the ground via the C&C MDM. Automated procedures, which are executed in the JCP, are classified as FAS procedures and ODF procedures.

a. FAS procedures

FAS procedures are generally written for system malfunctions and mode transitions in the JEM. FAS procedures can be categorized as follows:

- 1. FDIR procedures
- 2. Mode transition procedures
- 3. Other procedures
- b. ODF procedures

ODF procedures are written to support various on-orbit operations. Execution of automated procedures is controlled by the JCP (each procedure having a different priority and processing speed).

5.1.3.4.6 Automated Procedure Viewer

The APV is used to execute automated procedures that are processed by the JCP. The automated procedures include both FDIR procedures and user-defined ODF procedures. Typical use of the APV is to perform a defined operation. APV has two types of displays, summary and procedure.

The summary display is mainly used for the commanding and monitoring associated with an automated procedure. See Figure 5-39 and Table 5-7.

Figure 5-39. APV summary display

Table 5-7. APV summary display functions

The procedure display is mainly used to control procedure execution (see Figure 5-40). The SLT has automated procedure files modified for display. These files are different from those in the JCP/EDSU. On this display, crewmembers can monitor and control the detailed steps of the automated procedure.

5.1.3.4.7 System Laptop Terminal Displays and Controls

The SLT screens are classified as follows:

- a. JEM homepage
- b. Element screen
- c. Subsystem screen

5.1.3.4.7.1 JEM Homepage

The JEM homepage displays the mode status of each element. By clicking the element area, the screen switches to the selected element screen.

There is no C&W message area in this display (different from USOS PCS). When the JEM C&W button (upper-left side of the display) is clicked, a C&W summary window appears. See Figure 5-41.

Figure 5-41. JEM homepage

5.1.3.4.7.2 Element Page

Figure 5-42 shows an example of an Element Screen (for the JPM). The system area of this screen is organized on a rack-by-rack basis rather than a subsystem basis.

This screen has the system toolbar, which contains element buttons (JPM, JLP, JEF, and JLE) and subsystem buttons (EPS, C&DH, TCS, ECLSS, C&T, ESS, Mech, and P/L). By selecting one of the element buttons, the selected element screen appears. By clicking on one of the subsystem buttons, the selected subsystem screen appears.

Figure 5-42. Element screen

5.1.3.4.7.3 Subsystem Page

Figure 5-43 shows an example of a subsystem screen (in this case, for the JEF C&DH). The subsystem screen displays equipment, wiring, and piping for the selected subsystem.

Figure 5-43. Subsystem page (example)

5.1.3.4.7.4 Command and Telemetry Windows

Figure 5-44 shows an example of a status display window.

Figure 5-44. Status display window

Figure 5-45 shows an example of a command input window.

Figure 5-45. Command input window

Telemetry field colors can be found in Table 5-8.

5.1.4 JEF Communications and Tracking System

5.1.4.1 Interorbit Communication System Exposed Facility

The primary C&T component on the JEF is the ICS-EF. The Interorbit Communication System Exposed Facility (ICS-EF) provides the Japanese segment's communication link directly to the JAXA ground system using the Japanese Data Relay Test Satellites (DRTS). The ICS-EF is attached at EFU 7. It has functions similar to those of the antenna group assembly in the Ku-band subsystem in the USOS: to point, track, and communicate with data relay satellites. To wholly understand how commands are received and telemetry is sent by JEF components, this section details some items from the JEM that are critical in the communication link.

The JEF C&T is divided into two major subsystems, video and ICS. An outline of these subsystems is provided in Table 5-9. The JEM C&T also interfaces with the USOS C&T (see Figure 5-46), and a brief description of this interface is described below.

Table 5-9. JEF C&T systems

The JEM video system collects video signals from both internal and external television cameras, such as those on the JEF, and payloads and distributes these signals to the television monitors in the JPM or to the USOS video systems via the Common Video Interface Unit (CVIU). The JEM video system also distributes sync signals to all television cameras including payloads. The JEM video system has an interface with the JEM ICS for downlink.

The ICS is similar to the Ku-band subsystem in the USOS C&T. The uplink data goes through the Japanese DRTS, ICS EF that is installed on the JEF, ICS PM that is installed in the JPM and JEM C&DH. The downlink data goes through the same equipment in the opposite order.

JEM payload and system data collected by the ICS-PM through JEM C&DH and the JEM video system are downlinked to the ground (SSIPC). The JEM ICS is capable of transmitting 43 Megabits per second (Mbps) of serial data. The ICS also supports an added voice communication link between the JPM and the ground (SSIPC).

Nominal JEM C&T operations are similar to those in the USOS C&T, such as command and monitoring via a laptop (SLT) and Television Camera/Pan Tilt Unit (TVC/PTU) control using manual commands via an interface panel, referred to as the Camera Control Panel (CCP).

Figure 5-46. JEM C&T overview

5.1.4.2 Interorbit Communication System

The JEM ICS is divided into two subsystems.

- a. ICS PM installed in the JPM
- b. ICS EF installed on the JEF

The ICS-PM interfaces with the JEM systems that are necessary to handle the data and to control the whole ICS system. The ICS-EF provides the capability to communicate with the ground through the DRTS (see Figure 5-47).

The JEM ICS is designed so that it can be operated semiautomatically through the use of time-tagged commands uplinked from the ground and stored in the ICS. The ICS is operated by the crew via SLT commands if the operation is hazardous or if an ICS failure requires crew commands.

Similar to the USOS Ku-band subsystem, the JEM ICS is only single-string.

The JEM ICS has a capability to receive data from DRTS at 2.6 Mbps and to transmit data to DRTS at 43 Mbps. These data include both JEM system data and payload data, such as command, telemetry, audio, and video signals. The data that JEM ICS can handle are summarized in Table 5-10.

Figure 5-47. JEM ICS communication overview

	Capacity	
Data	ICS to JEM system (uplink)	JEM system to ICS (downlink)
JEM FDDI data (from payloads via HRMS)	N/A	1 ch (0.5 Mbps)
USOS FDDI data (from payloads via APS)	N/A	4 ch (40 Mbps) max)
Compressed National Television Standard Committee (NTSC) video data (to payload via HRMS)	1 ch (1.5 Mbps)	N/A
NTSC video data (from Video Control Unit (VCU))	N/A	1 _{ch}
Medium rate data (Ethernet)	1 ch	1 ch
Low rate data (1553B)	1 ch	1 ch
Audio data	1 _{ch}	1 _{ch}
Total capacity	2.6 Mbps	43 Mbps

Table 5-10. ICS input/output data overview

All data for downlink is collected in the Data Multiplexer (MUX) where it is multiplexed and sent to the ICS antenna. The data that are input to the MUX may contain recorded data from the High Rate Data Recorder (HRDR). The maximum data rate that can be input to the MUX is 43 Mbps. Uplink data from the ground are demultiplexed in the baseband DPU and routed to the appropriate component. The overall ICS architecture is shown in Figure 5-48.

The DPU controls all the ICS-PM components. Antenna Pointing Electronics (APE) control all the ICS-EF components. See Figure 5-49.

Figure 5-48. JEM ICS overview

Figure 5-49. Command and control architecture of the JEM ICS

As described previously, the ICS-EF has functions similar to those of the antenna group assembly in the Ku-band subsystem in the USOS: to point, track, and communicate with data relay satellites. The ICS-EF ORU is an assembly of many components. However, most of them do not require crew operation. The components that require crew operation include the Up Converter (UPC), the High-Power Amplifier (HPA), and the Antenna Pointing Mechanism (APM). Sensors in the ICS-EF provide the ability to identify the attitude of the antenna.

The UPC up-converts the S-band signal, which is received from the Modulator (MOD) into a Ka-band signal. The HPA amplifies the low-power Ka-band signal, which is received from the UPC, into a high-power RF signal.

The APM physically moves the antenna along two-axes to point toward the data relay satellites. The ICS-EF also has a function to receive and transmit the data that comes from the Japanese data relay satellites.

In the case of an off-nominal condition, crewmembers operate these three components using the SLT to stop operation.

Note: The antenna is folded during launch and assembly. Figure 5-50 shows the ICS-EF.

Figure 5-50. ICS-EF

5.1.4.2.1 ICS Fault Detection, Isolation, and Recovery

The ICS stops emitting RF automatically when it emits RF to the masked area, which is predefined by the ground. Some components in the ICS-PM contain thermostats to allow automatic shutdown of the component if a temperature anomaly (high) occurs.

The ICS has a capability to stop emitting RF automatically when the ICS-EF fails and the ICS LB (1553B) fails. The actual detecting conditions, such as detected telemetries or limit values, can be flexibly defined in a table in the DPU by the ground. The table can also define the contents of the FDIRs, such as macro commands that are supposed to be executed in the failures.

5.1.4.2.2 ICS Interface

The ICS-PM has mechanical, electrical, command, telemetry, and thermal interfaces. The ICS-PM also interfaces with the USOS to receive high-rate data from the APS. The ICS-EF has mechanical, electrical, command, telemetry, and thermal interfaces with the JEF. See Figure 5-51.

Figure 5-51. JEM ICS interface

5.1.4.3 Video

The JEM video system provides functions to generate, route, and display video images. The system generates the images from both internal and external cameras in the JEM system and payloads, routes the signals, and displays the images on TV monitors at both the WS rack and the JEMRMS console.

There are a total of seven TVCs onboard the JEM. There is an Internal Overhead TVC port in the JLP (number 7 in Figure 5-47), but the TVC was removed on the ground and there is no planned use for this port. Only two of these cameras are in the JPM. Reference Figure 5-52 and Table 5-11.

Figure 5-52. JEM video overview

	Camera	String	Object area
1	Internal Stbd TVC *	A	JPM inboard
2	Internal Port TVC	в	
3	External Fwd TVC	A	
4	External Aft TVC	в	
5	JEF Fwd TVC	В	JEF
6	JEF Aft TVC	A	
7	Internal Overhead TVC * (camera removed on ground; no planned use for this port)	B	JLP inboard
8	External Stbd	A	Node 2/JPM CBM side

Table 5-11. JEM TVC views

These cameras are not installed.

Crewmembers select a video source and destination via command from the SLT. Table 5-12 lists the sources and destinations for video.

Table 5-12. Sources and destinations of video signal

Two Video Control Units (VCUs) provide functions of the switching and distribution for all video. The role of the VCU is the same as that of the Video Switcher Unit (VSU) in the USOS. However, the VCU has the additional function to process camera control commands. On the USOS, this processing function is included in the Sync and Control Unit (SCU) and not the VSU.

All video signals are collected by the two VCUs and are distributed to two CVIUs (for the USOS or downlink), ICS (for downlink), ISPRs, and television monitors (MONS) that are installed in the WS rack and JEMRMS console. A VCU has the capability to receive 15 channels of signals and to output 11 channels of signals. Five of the output signals are the same and are distributed to International Standard Payload Racks (ISPR).

The VSW handles video signals from the JEF payloads. The VSW has a capability to receive eight channels of signals and to send two of them to VCU a.

The USOS VDS interfaces with the JEM video system through the JPM CVIUs. Note that the CVIU has a function to distribute electrical power, but this is not used in the JEM video system.

The JPM TVCs receive electrical power from Camera Power Boxes (CPBs). JEF TVCs receive electrical power from JEF PDBs. The TVCs on the JEMRMS receive electrical power from PDB RMS.

The functional diagram of the JEM video system is shown in Figure 5-53.

Figure 5-53. JEM video system overview

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5.1.4.3.1 JEM Video Command and Control

Crewmembers control operations, such as routing signals, turning power on/off, and monitoring H&S via the SLT; the JCP provides these functions in response to SLT inputs.

Crewmembers also control camera functions, such as pan/tilt, shutter speed, focus, zoom, and iris control from the CCP. The VCU receives the control signal directly from the CCP (crew control). If the ground controls the camera, the VCU receives the control signal from the JCP. The VCU generates a "sync and control" signal by superimposing a "control" signal onto a "sync" signal that comes from the USOS (via the CVIU) and distributes the signal to all "destinations," such as TVC/PTUs, ISPR, and JEF payloads. Both ISPRS and JEF payloads do not use the "control" signal; they use only the "sync" signal.

The VCU can receive camera control commands from three different sources: two CCPs and ground. When the CCP is selected for camera control, both CCP a and CCP b are active. This can cause simultaneous commanding to the camera, which is highly undesirable as it can confuse the system. The SLT is used to select the required CCP.

USOS JEM C&C MDM Bus (MIL-STD-1553B) Command (from ground or USQS) **JCP** System Local Bus (MIL-STD-1553B) Command and **SLT** DIU donitor ESC CPB **VSW** TVC/PTU Control Crewmember Command VLU CCP **VCU** CVIU Sync signal Sync signal (from USOS) TVC/PTU | ●

The management and control architecture of the JPM C&T is shown in Figure 5-54.

Figure 5-54. JEM video command and control

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Figure 5-55 shows the SLT display the crew will use to monitor control the JEM video system

Figure 5-55. JEM video SLT display

5.1.4.3.2 Video System Fault Detection, Isolation, and Recovery

The JCP has some automatic FDIR functions for the JEM video system that are described below. Crewmembers can monitor the execution status of these procedures.

- a. When the JCP, the JPM LB, or the DIU experiences an anomaly, the video equipment remains in the current configuration.
- b. Power to the VCU is removed if a VCU temperature anomaly is detected.
- c. Power to the CPB is removed if a temperature anomaly of the CPB is detected.
- d. Power to the internal TVC is removed if a temperature anomaly is detected.
- e. Power to the WS MON is removed if a temperature anomaly is detected.

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5.1.4.3.3 Video Interface

The JEM video system interfaces with other JEM subsystems and with the USOS, as shown in Figure 5-56. The CVIUs provide the interface to the USOS VDS. Resources, such as electrical power and heat rejection, are provided by the JEM subsystems.

Figure 5-56. Video interface

5.1.4.3.4 Video Switcher

The VSW, shown in Figure 5-57, is an R-ORU attached on the JEF that can be handled by the JEMRMS.

The VSW can receive up to eight JEF payloads video signals and route two of them to VCU-a. It also distributes "sync and control" signals to eight JEF payloads.

Figure 5-57. VSW

5.1.5 Environmental Control and Life Support System

The JEF does not contain any ECLSS systems or system interfaces.

5.1.6 Thermal Control System

The JEF TCS controls the temperature of the equipment and payloads within the acceptable range. It consists of both passive (MLI and heaters) and active (coolant loop) thermal control.

5.1.6.1 JEF Passive Thermal Control System

The JEF Passive Thermal Control System (PTCS) consists of the following: insulation, coatings, and heaters. The PTCS is capable of the following:

- a. Maintaining adequate component temperature via the heaters
- b. Protecting the JEF structure and components from solar radiation via the MLI
- c. Monitoring the temperature data of each component

The PTCS heaters are a redundant system comprised of PTCS-a and PTCS-b, which are independent of each other. When one PTCS is in use, the other PTCS is in standby. Each PTCS contains Heater Control Equipment (HCE), heaters, and temperature sensors (Figure 5-58). The heaters are automatically controlled by the ESC through the HCE.

Note: The heaters keep their state (on/off) if the ESC is shut down by system failure.

Figure 5-58. JEF PTCS

Multilayer Insulation (MLI) covers most of the JEF and JLE structure and equipment to minimize the thermal effect from the space environment. Some surfaces that are difficult to cover with MLI are coated to obtain adequate thermal emissivity and absorptivity. MLI and coating help maintain the temperature in a permissible range.

5.1.6.1.1 Crew Interfaces

Figure 5-59 shows the power and control flow of the JEF and JLE PTCS. Crew can control the PTCS via an SLT. Temperature sensors on the JEF system components and payloads provide feedback to the HCE (discussed later) and ESC for heater operations.

Figure 5-59. JEF PTCS power and control

5.1.6.1.2 Heater Control Equipment and Thermal Interface Unit

The heaters on the JEF are controlled by HCE-a and HCE-b. The HCE collects the temperature data from the temperature sensors on the JEF and sends the data to the ESC. The temperature of each heater is automatically kept within acceptable range by the use of the feedback temperature data received from JEF units. Power on/off commands from the ESC to the HCE control each heater. The HCEs are designed as E-ORUs.

The HCE performance characteristics are as follows:

- a. Input power (max.): 1.2 kW
- b. Number of heater channels: 56 Ch
- c. Number of temperature measurement channels: 95 Ch
- d. Voltage drop: Less than 1.6 V

Figure 5-60 shows the physical location of the HCEs and the TIU (discussed in JEF ATCS section) on the JEF nadir.

Figure 5-60. HCE/TIU Locations (view from JEF nadir)

5.1.6.2 JEF Active Thermal Control System

The JEF Active Thermal Control System (ATCS) is composed of one coolant loop that controls the temperature of equipment and payloads located on the JEF within an acceptable range. The ATCS is capable of the following:

- a. Acquiring heat rejection from payloads and JEF equipment
- b. Transferring the thermal energy to the JPM ATCS MTL via the Exposed Facility Heat Exchanger (EFHX)
- c. Controlling the flow rate (rounding rate of FPP) to keep differential pressure in the fluid loop
- d. Detecting and isolating system failures or switching to the redundant system. The TIU holds the configuration of the fluid circuit even if the ESC is shut down by a system failure
- e. Detecting and isolating a fluid leak
	- Note: At this time, lost fluid cannot be replenished because the fluid supply equipment is not yet developed. When developed, it is able to replenish fluid through EFU 11 and EFU 12.

Figure 5-61 shows an overview of the JEF ATCS. The JEF ATCS consists of a coolant loop, Fluid Accumulator (FA), Fluid Pump Package (FPP), Thermal Interface Unit (TIU), and valves. The ESC controls the JEF ATCS equipment through the TIU. Both of these units have a backup unit.

The FA, FPP, JEF Inlet Valve, JEF Outlet Valve, and JEF Bypass Valve has a redundant unit; however, the ATCS is composed of only one flow loop as a whole. When FA-a, FPP-a, JEF Inlet Valve-a, JEF Outlet Valve-a, and JEF Bypass Valve-a are working or open, the -b systems of these components are in standby or closed. After activation of the ATCS the coolant loop is automatically controlled by the ESC. The valves keep their status (open/close) when the ESC is shut down by system failure. The working fluid of the JEF ATCS is single phase Perfluorocarbon (FC-72).

Figure 5-61. JEF ATCS

A more detailed schematic of the JEF ATCS is shown in Figure 5-62. Every valve shown in Figure 5-62 is a latching solenoid valve controlled by the ESC via the TIU. The EFU inlet and outlet valves have capabilities to start/stop supplying the coolant flow into an attached payload and to isolate the payload in the event of a coolant leak in the payload line. The same capabilities exist for the valves of JEF PDBs, SPB, and FPP. In addition, the valves of a deactivated FPP prevent backflow from a running FPP. Each of the FAs has an inlet valve that allows switchover from one FA to the other. Each of the EFHX-inlets and EFHX-outlets has two valves for redundancy. The bypass line, which, when open, diverts the working fluid from the EFHX to prevent water from freezing in the heat exchanger when the coolant temperature is low, has two valves for redundancy. The sensors with a subscript "1" are connected to the TIU a. The sensors with a subscript "2" are connected to the TIU b. The sensors with no subscript are connected to both TIUs.

Figure 5-62. Detailed JEF ATCS

Table 5-13 summarizes the coolant loop characteristics.

Total heat loads		11 kW max
Loop temperature	$JEF \rightarrow JPM$ (EFHX Inlet)	16 - 50 deg C
	JPM \rightarrow JEF (EFHX Outlet)	16 - 24 deg C
Flow rate at pump exit		1940 kg/hr max
Approximate coolant quantity (in main circulation line)		25L
FPP power channel		Channel A or Channel B

Table 5-13. Summary of JEF ATCS characteristics

5.1.6.2.1 Fluid Pump Package

The FPP circulates the coolant in the JEF coolant loop. The pump speed setpoint (in rpm) can be commanded by a crewmember via the SLT. The performance characteristics of the FPP is as follows:

- a. Flow rate: 2,200 kg/hr
- b. Pressure rise: 363 kPA (3.7 kgf/cm²)
- c. Pump inlet pressure: 167 392 kPA (1.7 4.0 kgf/cm²)
- d. Pump speed: 0 11,000 rpm
- e. Max Design Pressure (MDP): 1,177 kPA (12.0 kgf/cm²)
- f. Coolant type: Perfluorocarbon (FC-72)
- g. Pump control method: Pulse Width Modulation (PWM) method

The FPP is an R-ORU and can be maneuvered by the JEMRMS SFA.

Note: The JEMRMS SFA is not on orbit before or during mission 2J/A.

5.1.6.2.2 Fluid Accumulator

The FA controls pressure and compensates for volume changes in the JEF coolant loop. It is not designed as an ORU because of its simple structure that cannot break easily. The performance characteristics of the FA are as follows:

- a. Type: metal bellows
- b. Pressure range:
	- 1. Average: $101 392$ kPA (1.03 4.0 kgf/cm²)
	- 2. Nominal: 167 392 kPA (1.7 4.0 kgf/cm²)
- c. Allowable leak: < 3.35 L/10 years
- d. Volume: 75.4 (fluid and gas)
- e. Range of fluid volume: 3.1 32.8 L
- f. Max Design Pressure (MDP): $1,177$ kPA (12.0 kgf/cm²)

5.1.6.2.3 Thermal Interface Unit

The TIU controls and monitors the temperature sensors, valves, and pump packages. It also monitors the R-ORU temperatures.

The ESC controls the FPP and valves via the TIU. The TIU has a redundant unit and is designed as an E-ORU.

The TIU performance specifications are as follows:

- a. Monitor interfaces
	- 1. Temperature sensor
	- 2. Pressure sensor
	- 3. Volume sensor
	- 4. ORU attachment sensor
	- 5. Difference of pressure
	- 6. FPP revolutions
- b. Valve control interface
- c. FPP control interface

- d. SFA stowage equipment interface
- e. Video Light Unit (VLU) ON/OFF interface

The ESC monitors the loop telemetry data from sensors through the TIU. If an anomaly is detected in the loop, the ESC executes auto FDIR. An example of this FDIR response is to stop the pump or change the valve configuration.

In the event the ESC is shut down due to failure, the TIU maintains the configuration of the JEF cooling loop.

5.1.6.2.4 Loop Control Algorithm Capability

The ESC has a feedback control algorithm that adjusts the pump speed automatically to regulate the loop differential pressure between the supply line and return line (see Figure 5-62). The nominal value of the target differential pressure is 67.7 kPa. JEF system equipment and payloads are developed to receive sufficient cooling flow from the nominal differential pressure. The target differential pressure can be set by ground/crew command.

Unlike the JPM ATCS, the JEF ATCS has no feedback algorithm to control the loop temperature. As a result, the JEF system equipment and payloads waste heat rejection is constrained.

Note: System equipment rejects less than 1 kW and all payloads reject less than 10 kW.

Also unlike the JPM ATCS, JEF ATCS has no feedback algorithm to control loop pressure. The Fluid Accumulator (FA), which contains sealed gas in a bellows, regulates the pump inlet pressure within the required range.

5.1.6.2.5 JEF TCS Crew Interfaces

A crewmember sends commands to the ATCS and monitors the ATCS using the SLT. The FPPs and all remote shutoff valves in the JEF cooling loop can be controlled by either of the ESCs via either of the TIUs. The JEF thermal control function architecture is shown in Figure 5-63.

Figure 5-63. JEF ATCS control

Figure 5-64 and Figure 5-65 show the SLT displays that can be used by the crew to monitor and control the JEF PTCS and ATCS.
JSC-36536 Final

Figure 5-64. JEF PTCS SLT display

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Figure 5-65. JEF ATCS SLT display

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5.1.7 JEF Robotics

The JEMRMS was launched on 1J. There are no new JEM robotics systems manifested on 2J/A.

5.1.8 JEF Extravehicular Activity

The JEF EVA system consists of translation aids and worksite aids. As detailed throughout Section 5.1, there are several E-ORUs located on the JEF. During berthing/deberthing of a payload, if a failure occurs resulting in an EFU becoming inoperable, there exists an EVA accessible point for manual operation to open/close the EFU arm (see Figure 5-66).

EVA access point for Power Tool

Figure 5-66. EFU EVA manual access point

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5.2 EXPERIMENT LOGISTICS MODULE - EXPOSED SECTION

The JLE is a logistics carrier that transports and stores payloads for the JEF. The JLE is attached to the port side of the JEF, as shown in Figure 5-67. It can also be berthed at the top of the JLP, but only temporarily.

Figure 5-67. Location of the JLE

5.2.1 Structures and Mechanisms

The JLE is designed to spend multiple months/years on orbit and then return to the ground with payloads attached. While on orbit, the JLE is attached to the port side of the JEF to the EFU 10 with EFU 9 as a backup location (see Figure 5-68.) The JLE can also temporarily be attached to the JLP when the HTV exposed pallet is on orbit or for exchanging two JLEs on orbit.

The JLE is primarily a flat structure and is covered with multiple pieces of MLI (see Table 5-14 for the JLE structures specifications). There are only two Flight Releasable Grapple Fixtures (FRGF), five trunnions, a PIU, and several TA&As.

Figure 5-68. JEF berthing locations for the JLE

Two FRGFs are installed on the JLE, making it compatible with the JEMRMS, SSRMS, and SRMS.

The JLE structures and mechanisms consists of the following elements that are discussed in detail in the following sections:

- a. Primary structure
- b. Trunnions
- c. Secondary structure
- d. Payload Attach Mechanism
	- 1. Structural Latch Mechanism
	- 2. Umbilical Connect Mechanism
- e. ORU attachment plate

Table 5-14. JLE structures specifications

5.2.1.1 JLE Primary Structure

The primary structure, shown in Figure 5-69 (object on the left), is the main structure of the JLE. The primary structure of the JLE consists of the grid panels, core frame, primary longeron trunnion structure, stabilizing longeron trunnion structure, and keel trunnion structure.

The primary structure is constructed from aluminum and titanium and consists of three frames: the core frame, the upper grid panels and the lower grid panels. Hard Point Plates (HPPs) are installed as needed at upper grid panel crosspoints to allow components to be flexibly arranged.

Figure 5-69. JLE primary structure

Trunnions

The trunnions, shown in Figure 5-70, are used to fix the JLE inside the cargo bay of the Orbiter. A total of five trunnions (three different types) are installed so that the JLE can withstand launch and landing. These trunnions are categorized according to their locations and components. The types of trunnions are

- a. Primary longeron trunnion
- b. Stabilizing longeron trunnion
- c. Keel trunnion

Figure 5-70. JLE trunnions

5.2.1.2 Secondary Structure

The secondary structure of the JLE subsystem includes the following components:

- a. PIU stand
- b. Grapple fixture attachment plate
- c. ECU attachment plate
- d. PCU attachment plate
- e. Target marker stand
- f. PDA stand
- g. Scuff plate

The locations of the secondary structure on the JLE are shown in Figure 5-71.

Figure 5-71. JLE secondary structure

A maximum of three ORUs can be attached at the location of PAM 1 instead of a payload, if desired. ORUs carried by the JLE include the ORU attachment plate, which is fastened to the JLE for ORU on orbit exchange. Refer to the JEF section for details on each type of ORU and associated hardware.

There are three payload-loading configurations for the JLE

- 1. Three JEF payloads
- 2. Two JEF payloads and two E-ORUs
- 3. Two JEF payloads and three R-ORUs

Configurations 1 and 3 can be seen in Figure 5-72. For STS-127/ISS-2J/A, the JLE manifests three JEF payloads: the ICS-EF, MAXI, and SEDA-AP. The ICS-EF is described in more detail in Section 5.1.4.2 and Section 3.8.1, and the MAXI and SEDA-AP payloads are described in more detail in Section 3.8.2 and Section 3.8.3, respectively. Figure 5-72 also depicts the three PAM locations.

JEF Payload

Figure 5-72. JLE loading configurations

5.2.1.3 Payload Attach Mechanism

The PAM is a mechanism unique to the JLE used to secure a JEF payload onto the JLE. The PAM provides a mechanical and power interface to the payload. A maximum of three PAMs can be attached to the JLE to transport three payloads (see Figure 5-73).

The PAM is composed of the following (reference Figure 5-74):

- a. Structural Latch Mechanisms
- b. Alignment Guides (A/G)
- c. Umbilical Connect Mechanism (UCM) Exposed Section half (UCM-E)

As previously mentioned, for STS-127/ISS-2J/A, the JLE uses all three PAMs in that it is carrying three JEF payloads: the ICS-EF, MAXI, and SEDA-AP. These payloads are described in more detail in Section 3.8 on the JAXA payloads.

Figure 5-74. PAM components

5-85

5.2.1.3.1 Structural Latch Mechanism

Each PAM has four SLMs to capture and structurally engage JEF payloads. The SLMs are controlled by the ECU. A single command is issued from the SLT to drive all four SLMs. Only the ground can operate the SLMs independently. If required, EVA override capability exists to release the SLMs manually. See Figure 5-75.

Figure 5-75. Structural latch mechanism components

SLM major features

- a. Each PAM has four SLMs.
- b. SLM is composed of claws, linkage, and gears.
- c. SLM provides a structural engagement with a preloaded condition for the attached payload.
- d. SLM is driven by a brushless DC motor actuator.
- e. The status of each SLM is monitored by five independent microswitches: open, softdock, overcenter 1, overcenter 2, and preload prism.

The SLM has three states: open, softdock, and closed, as seen in Figure 5-76.

Figure 5-76. SLM states and claw positions

The positions of the claws in softdock and closed states look almost identical. The major difference is the position of the linkage. When the SLM is in the closed state, the position of the linkage is overcentered as shown in the figure. Also, both of the overcenter microswitches indicate "closed" at this state.

Even if the trunnions are pulled upward by accident after the payload capture is completed, this overcentered linkage mechanically prevents the trunnion from being released. In addition, the status of the preload prism microswitch indicates "closed" when the payload is captured. This prism state means that the trunnion installed on the payload is completely pulled into the SLM. This is one of the SLM safety functions to prevent an unexpected release of the payload.

When the SLM is in its closed state and payload capture is completed, three microswitches (overcenter 1, 2, and preload prism) indicate "closed." The microswitch positions and sensor status can be seen in Table 5-15.

Table 5-15. SLM microswitch positions and sensor status

5.2.1.3.2 Umbilical Connect Mechanism

The UCM is another component of the PAM. The UCM provides the mechanical and electrical interfaces to the attached JEF payloads. The UCM consists of the UCM-Payload half (UCM-P), installed on the JEF payload, and the UCM-Exposed Section half (UCM-E) installed on the JLE. The UCM components can be seen in Figure 5-77.

Structural Latch Mechanisms (SLMs)

Figure 5-77. Umbilical connect mechanism components

Figure 5-78. Power/command/telemetry of PAM actuation

Because an inadvertent release of a JEF payload from the JLE could cause a catastrophic hazard, the following safety features were included in the design to minimize the risks of inadvertent release and mechanical failure.

5-90

5.2.1.3.3 PAM actuation and safety features

Each PAM has four SLMs to capture and structurally engage the JEF payloads. When driving the PAM, the crewmember sends commands via the SLT to the JCP, which, in turn, communicates the issued command to the upstream (C&C MDM) and downstream components (ECU to SLMs). Status telemetry is sent in the reverse order from the SLMs to the ECU, JCP, and C&C MDM, and from the JCP to the SLT. See Figure 5-78 for a diagram detailing this functional flow.

- a. Inadvertent Release
	- 1. Three inhibit switches with two-fault tolerance on PAM SLM power line to preclude incorrect PAM selection.
	- 2. Separate control path features of software/hardware design of JLE ECU such that each software unit can perform only a single task per JCP command.
- b. Mechanical Failure
	- 1. SLM overcenter microswitches used to verify the SLM claw positions in order to mechanically prevent the SLM from unexpectedly releasing the captured JEF payload.
	- 2. During PAM actuation, the ECU compares the downstream Field Effect Transistor Switch (FET SW) voltage of the PAM On command (second inhibit switch) and the PAM softdock command (third inhibit switch) to verify that the correct PAM is actuated (see Figure 5-79).
	- 3. Launch/landing loads can be tolerated with only three of four SLMs engaged.

Figure 5-79. PAM actuation inhibit switches

5.2.1.4 ORU Attachment Plate

If an ORU is required to be transported into space, an ORU attachment plate is installed at the PAM 1 location instead of a PAM. A maximum of three ORUs can be attached at this location.

5.2.2 Electrical Power System

The PCU normally receives power from the JEF PDBb (EFU10) or from PDBa (EFU9) as a backup. A crewmember closes an RPC in the JEF PDB to supply the JLE system power. Once the system power is supplied to the JLE, the ECU automatically receives power via the PCU. Then a crewmember supplies power to the JLE using the SLT.

The PCU is described below in Section 5.2.2.1. The ECU, which is part of the C&DH system, is described in Section 5.2.3.2.

5.2.2.1 Power Control Unit

The PCU is installed on the JLE lower grid panel (see JLE Structures and Mechanisms Section) near the PIU. The major features of the PCU are

- a. Provides heater power for all JLE components and attached payloads
- b. Provides power to the ECU via two different lines; one powers the ECU, and the other provides PAM operation power
- c. Controls the RPC installed in the PCU

Figure 5-80 shows the location and photo of a PCU.

Figure 5-80. PCU

5-92

The PCU is the only external interface point for electrical power and does not have a redundant power line. A failure of the power line during JLE operations does not result in a hazardous condition. Although the failure of heater power supply to the attached payloads could cause a malfunction of the payloads, they can be released manually by EVA as backup and transferred to the JEF using the JEMRMS or by an EVA crewmember.

5.2.2.2 Power Distribution

The functional flow of the JLE power supply when the JLE is berthed at an EFU on the JEF is shown in Figure 5-81. The PCU, which receives power from the JEF PDB, distributes power to other JLE components and attached payloads. The PCU provides power to the ECU over two different lines; one is used for the ECU power, and the other is used for the PAM operation.

The RPC installed in the PCU, which supplies power to the ECU, is a nominally closed RPC. Once a crewmember closes an RPC in the JEF PDB to supply the JLE system power, the ECU automatically receives power via the PCU. A crewmember then supplies power to the JLE using the SLT.

Figure 5-81. JLE power flow

5-94

5.2.2.3 JLE Power Consumption

The JLE has a total of six power lines that can be provided to the attached payloads. Each line can provide power at the maximum of 120 W for a total possible power draw of 720 W. However, the total power applied to the payloads must be less than 600 W.

In the flight configuration shown at the top of Figure 5-82, two power lines can be supplied to each payload. However, this is not designed exclusively for redundancy; some of the JEF payloads need more than 120 W, thus requiring two power lines. When two JEF payloads and three R-ORUs are attached on the JLE, as shown in the bottom half of the figure, just one power line is to be provided to each ORU: one line to one JEF payload and two lines for the other payload.

Figure 5-82. JLE power supply diagram

5-95

To preclude overcurrent hazards, the PCU and ECU have overcurrent monitoring inside the RPC and FET switches. When these devices detect an overcurrent condition, they trip, removing power from the downstream loads.

Table 5-16 details the breakdown of JLE power consumption.

Table 5-16. JLE power consumption

* When JLE is attached to JLP

** Indicates DC trip level

5.2.3 Command and Data Handling System

The JLE command and data functions include

- a. JLE activation/deactivation
- b. JLE H&S monitor (including temperature)
- c. PAM control and monitor
- d. Heater control of the PAMs
- e. Heater power supply and control (optional) of the attached JEF payloads/ORU attachment plates
- f. Temperature monitor of the attached JEF payloads/ORUs

The SLT provides the only crew interface for the command and data operations of JLE. Of the JLE command and data functions, only the JEM System LB 2, which directly comes to the ECU from the JCP through the JEF, has a redundant line.

5.2.3.1 JLE Management and Control Architecture

The management and control architecture of the JLE command and data is shown in Figure 5-83. The JCP is used for top-level management of JLE operations and contains the FAS. The SLT is the crew interface to control the JLE. The JCP also processes status data coming from the JLE.

JLE: JEM Experiment Logistics Module Exposed Section

- JPM: JEM Pressurized Module
- SLT : System Laptop Terminal
- ECU: Electronic Control Unit
- ORU: Orbital Replacement Unit PCU: Power Control Unit
- PAM: Payload Attach Mechanism
- (*1) A maximum of three ORU Attachment Plates can be installed at the location of PAM 1 instead of a JEF Payload. (*2) Robotics Compatible ORU (R-ORU)
- mount configuration
- (*3) EVA Essential ORU(E-ORU) mount configuration

Figure 5-83. Management and control architecture of the JLE

5.2.3.2 JLE C&DH Components

5.2.3.2.1 PIU

The PIU provides the mechanical, command and data, and electrical power interfaces with JLE components. The PIU distributes commands and telemetry to and from the ECU via a 1553B databus.

5.2.3.2.2 ECU

The ECU, shown in Figure 5-84, is installed on the lower grid panel and is located near the PIU and controls JLE equipment.

Figure 5-84. ECU

The ECU provides the following major functions:

- a. Provides PAM operating power
- b. Controls the PAM operation and monitors its status
- c. Receives commands from the JCP and operates each component of the JLE
- d. Controls PAM, JEF Payload, and ORU heaters power supply
- e. Sends status data of each component on the JLE to JCP
- f. Performs a Built-In-Test (BIT)

Ground controllers manage heater controls for the ECU and PCU. ECU specifications are shown in the Table 5-17.

5-98

Table 5-17. Major ECU specifications

The ECU performs EPS and C&DH functions in that it is connected with all electronic equipment on the JLE and provides status of equipment to the JCP and receives commands from the SLT.

The ECU receives commands from the JCP via the System LB 2 and provides local management of the JLE, including JLE health and status monitor, PAM operation, heater power supply to the JLE and its attached JEF payloads/ORUs, and temperature monitor of the JEF payloads/ORUs. This interface can be seen in Figure 5-85.

Figure 5-85. JLE data and telemetry architecture

5-99

As for the ECU interface to EPS, the ECU receives power for PAM actuation from the PCU and distributes it to the PAM. If an ECU abnormality is detected, the ECU shuts off the PAM power supply. See also Section 5.2.2.

5.2.3.3 JLE C&DH Functions

The following are functions of the JLE C&DH system:

- a. JCP command and data functions for the JLE
	- 1. JLE control
		- (a) Receives commands from the SLT for the JLE control to activate-deactivate the JLE and PAM, operate the PAM, and to control heaters
		- (b) Ground commanding possible via the JCP
		- (c) Monitors the communications status between the JCP and ECU
		- (d) Shuts off PAM power supply in case of emergency
	- 2. JLE/JEMRMS coordinated operations
		- (a) Check payload capture status of the JEMRMS during payload release
		- (b) Check payload capture status of the PAM during payload attachment
		- (c) Send command to stop PAM operation in case of emergency
- b. ECU functions for the JLE
	- 1. JLE equipment control function
		- (a) Activates-deactivates PCU and PAM
		- (b) Operates PAM SLM
		- (c) Controls heaters
	- 2. Status management function
		- (a) Monitor temperature and status of JLE components
		- (b) Detect abnormal status of JLE components
		- (c) Provide BIT for failure detection

- 3. Command and data functions
	- (a) Receives command from the JCP
	- (b) Sends equipment status data to the JCP
- 4. Power distribution function receives PAM actuation power from the PCU and distributes to PAM
- 5. FDIR function If ECU abnormal status is detected, shuts off PAM power supply
- c. PCU functions for the JLE
	- 1. Receives commands from the ECU to distribute power to heaters (JLE components and payloads)
	- 2. Sends PCU status to ECU
- d. PIU functions for the JIF
	- 1. Provides the mechanical, command and data, and electrical power interfaces with JLE components
	- 2. Distributes commands and telemetry to and from the ECU via a 1553B databus

5.2.3.4 JLE C&DH Modes

For a listing of the C&DH modes affecting the JLE, reference Section 5.1.3.3 and Table 5-5.

5.2.3.5 JLE SLT Display

The SLT is the only crew interface to control the JLE. The JLE display shown on the SLT changes based on the JLE flight configuration. As an example, the JLE mechanism display with two PAMs and three ORUs is shown in Figure 5-86.

Figure 5-86. JLE mechanism display on SLT

5.2.4 Communications and Tracking System

There are no dedicated C&T systems on the JLE. Command and telemetry is provided by the C&DH system.

5.2.5 Environmental Control and Life Support System

The JLE contains no ECLSS functionality.

5.2.6 Thermal Control System

The JLE has PTCS capability and some active TCS, but only when in the Shuttle payload bay.

The JLE PTCS is similar to the JEF PTCS in that it includes insulation, coatings, and heaters.

The JLE does not have a fluid thermal control loop. Instead, the JLE TCS consists of the following active and passive thermal control hardware:

- a. MLI
- b. Heaters
- c. Thermistor
- d. Thermostat (only used while JLE is in the Orbiter)

While attached to the ISS, a crewmember turns on heater power to the PAMs and attached JEF payload/ORUs using the SLT after the JLE activation has completed.

5.2.6.1 Multilayer Insulation and Coatings

The MLI covers most parts of the JLE, including the structures, ECU, and PCU. It helps maintain the temperature in a permissible range. The surfaces that are too difficult to cover with MLI are coated to obtain the adequate thermal emissivity and absorptivity.

5.2.6.2 Heaters

Table 5-18 shows the number and locations of heaters installed on the JLE.

Purpose	Quantity	Location
Activation		ECU
Activation		PCU
Operations on orbit	$12*$	PAM (installed on each SLM)
Storage on orbit	6 (max.) $*$	JEF payload
Storage on orbit	3 (max.) $*$	ORU attachment plate
JLE assembly operations on orbit (supplied from Shuttle) **	3 (3)	ECU, PCU, PIU (payload)

Table 5-18. Quantity and location of heaters on the JLE

* Number of heaters are changed based on the JLE payload thermal design.

** The heater power is to be supplied on orbit after the Shuttle PLBD opens until prior to JLE detachment from the Shuttle. Also, the heater power can be provided to the attached payloads during this period, but the number of heaters are changed based on the JLE payload thermal design. No heater power is supplied during Shuttle launch/ascent.

Heaters are installed on the PAM to keep the temperature of equipment within the survival range after the JLE is attached to an EFU on orbit. In addition, the JLE maintains the temperature of the attached JEF payloads/ORUs on orbit. The number of heaters and their locations are changeable depending on the respective JLE payload and ORU thermal requirements. Up to 12 heaters may be used on the PAM with up to

an additional 6 for JEF payloads and 3 for the ORU attachment plate. Ground controllers, depending on the payload design, can change the controllable temperature range for the payloads. The temperature monitoring of all the JLE components listed in Table 5-18, except for the heater supply from the Shuttle Orbiter, can be conducted only by ground controllers.

The heaters for the ECU and PCU are used for activation of these boxes. Once the ECU and PCU are warmed up to their operable range, these heaters are turned off, and the temperature is maintained by normal power consumption.

The crew can command and monitor the JLE PTCS via the SLT (see Figure 5-59).

5.2.6.3 Thermistors

A total of 14 sensors (thermistors), 1 for ECU, 1 for PCU, and 12 for PAM, are installed on the JLE.

5.2.6.4 Thermostats

Thermal control of the ECU, PCU, PIU, and attached payloads are performed by six thermostats installed near the heaters while the JLE is berthed in an Orbiter. The electrical power is supplied from the Shuttle through the ROEU.

5.2.7 Motion Control System

The JLE has no motion control functionality.

5.2.8 Robotics

There is no robotic system on the JLE. JLE robotic operations are limited to being manipulated by the JEMRMS, SSRMS, and SRMS as described in previous sections.

5.2.9 Extravehicular Systems

There are no EVA systems on the JLE, only EVA interfaces. For example, it is possible to GCA the JLE during JLE berthing to the JEF, though that is not planned for the 2J/A flight. The JLE is considered an ORU whose maintenance is primarily conducted on the ground. Thus, the purpose for the JLE corrective maintenance operations on orbit is not functional recovery of the JLE but the minimum maintenance to return it to the ground. Corrective maintenance operations are limited to the following:

- a. Minimum maintenance to separate JLE from JEF/JLP
- b. Minimum maintenance to install JLE inside the NSTS
- c. Minimum maintenance to separate JEF payloads/ORUs attached on the JLE

The JLE corrective maintenance operations are shown in Table 5-19. EVA corrective maintenance is conducted only in a contingency.

Table 5-19. EVA corrective maintenance operations

5.2.10 Crew Operations

Nominal JLE operations are shown in Table 5-20.

* Operates JEF components

 $(i) = 1$ to 3

Table 5-20. JLE nominal crew operations (concluded)

* Operates JEF components

 $(i) = 1 to 3$

APPENDIX A ACRONYMS AND ABBREVIATIONS

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APPENDIX B SUPPLEMENTARY DATA

There are currently no supplementary data identified.

B-1

Verify that this is the correct version before use

APPENDIX C CHANGE CONTROL

INTRODUCTION

Purpose

The purpose of this appendix is to delineate change control procedures for the AOH. This ensures the proper coordination of changes and provides a record of proposed changes with rationale and disposition.

CONFIGURATION CONTROL PROCEDURE

Submission of Changes

Proposed changes are solicited from any individual or organization having valid input. Changes should be submitted to the AOH book manager at mail code DO5, NASA/Johnson Space Center, Houston, Texas 77058.

Individuals submitting a change should complete all applicable items on the AOH Change Request (CR) Form shown on Page C-3. This form should be typed or neatly printed. Additional pages may be used if the space provided is not adequate. Then, the original completed form should be forwarded to the AOH book manager.

The AOH book manager evaluates the proposed change and makes modifications as required. The originator is advised of any such changes.

Disposition Coordination

The AOH book manager obtains formal concurrence and comments from the necessary personnel. All proposed modifications to the CR are coordinated with all necessary personnel prior to disposition.

Upon obtaining the required concurrences, the AOH book manager presents the proposed change to the appropriate group lead for final disposition.

A copy, however, is retained by the AOH book manager for future reference.

REVISIONS/PCNs

Development

The AOH book manager compiles all approved changes and any typographical errors and incorporates them into a Revision or Page Change Notice (PCN) to the document.

Pen and ink changes may be used to correct typographical errors if there are no other changes on the page concerned.

 $C-1$

Verify that this is the correct version before use

Approval

Any revisions to this document are approved by the appropriate group lead.

Publication Schedule

Revisions/PCNs are made on an as-required basis. Revisions/PCNs are printed and distributed to the standard distribution list.

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JSC Form 1337 (March 31, 2000) (MS Word March 2000)

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Figure C-1. AOH Change Request Form sample

APPENDIX D JAXA OPERATIONS DRAWINGS

PURPOSE

The purpose of this appendix is to provide the reader with a printed subset of the operations drawings created by JAXA. These drawings are current as of publishing. The current drawings can be found at the Japanese Flight Control Team (JFCT) Web page:

https://j-fct.tksc.jaxa.jp/JFCT_WebPage/index.html (password required)

If a printed subset is not provided in this appendix, go to the JFCT Web page to obtain copies.

CONTENT

Not all of the operations drawings created by JAXA are included in this appendix. The drawings in this appendix (listed below) are the primary systems overview drawings. All other drawings can be found at the JFCT Web page listed above.

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1.1 JEM EPS O/V 1

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 Video Interface Unit ility Aft ility Forward ility Unit vard rboard Ir Antenna Assemb ommunication System

pression Unit rhead

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I Unit Jnit

Unit

Notes: $\bigcap_{h \ge 0}$ TVCs EXT A, EXT F, Elbow, MA EE, EF A, and EF F have PTU.

5.1 JEM VIDEO & AUDIO SYSTEM O/V 1

2> TVC EXT S and VLO EXT S are not shown since
launch of TVC EXT S and VLU EXT S are not planned. TVC EXT S and VLU EXT S are not shown since Also JLP TVC EXT a/b are not planned when launch. (Refer to JCX-2002049B)

F IN8

Fiber optics video

Fiber optics sync

Video

 $------$ Sync

CMD/TLM

Power

Fiber optics audio

Coaxial Audio

IAA

VSW TELEMETRY TABLE C

VIDEO EQUIPMENTS TEMP TELEMETRY TABLE D

VSW Vout1 TELEMETRY STATUS TABLEB No. | Range & Unit

 4 $>$ Sync destinations from VCU b

$$
\begin{array}{c|c}\n\text{JPM} & \text{W3006} & \text{JLP} \\
\hline\n\text{J93} & \text{J7093}\n\end{array}
$$

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VCU COMMAND PARAMETER TABLE A

VSW Vout2 TELEMETRY STATUS TABLE C
No. | Range & Unit

TVC EXT F

TVC EXT S

VSW

M2

S See Note 2

JSC-36536 Final

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