

# Assembly Operations Handbook (AOH): Node 3 Delivery

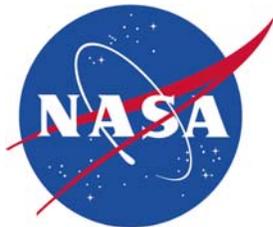
## STS-130/ISS-20A

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Mission Operations Directorate  
Cargo Integration and Operations Branch

Basic  
July 23, 2009

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National Aeronautics and  
Space Administration

Lyndon B. Johnson Space Center  
Houston, Texas

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**Assembly Operations Handbook (AOH): Node 3 Delivery  
STS-130/ISS-20A**

**Space Program Operations Contract  
Contract NNJ06VA01C  
United Space Alliance, LLC**

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**REVISION LOG**

<b>Rev letter</b>	<b>Change no.</b>	<b>Description</b>	<b>Date</b>
Basic			07/23/2009

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### LIST OF EFFECTIVE PAGES

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## **PREFACE**

The Assembly Operations Handbook (AOH): Node 3 Delivery was prepared by the National Aeronautics and Space Administration (NASA) Cargo Integration and Operations Branch.

The primary responsibility is with NASA Cargo Integration and Operations Branch.

Questions concerning the technical content of this document should be directed to Susan C. Beisert, 281-244-0233, DO52.

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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 United States (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.

### 1.2 SCOPE

This handbook addresses nominal and contingency operations for the mission to install Node 3 and Cupola, Mission 20A, 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 focuses on how systems affect assembly and operations for the Node 3 and Cupola 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, the following components are referred to by their common names:

<b>Component</b>	<b>Common name</b>
Unity	Node 1
Zarya	Functional Cargo Block (FGB)
Zvezda	Service Module (SM)
Destiny	U.S. Laboratory Module (Lab)
Quest	ISS Joint Airlock (A/L) or ISS A/L
Harmony	Node 2
Columbus	Columbus (European Space Agency (ESA) laboratory module)
Kibo	Japanese Pressurized Module (JPM)

Details covered in this document address the assembly configuration specific to the 20A mission.

## **2.0 STAGE ARCHITECTURE DATA**

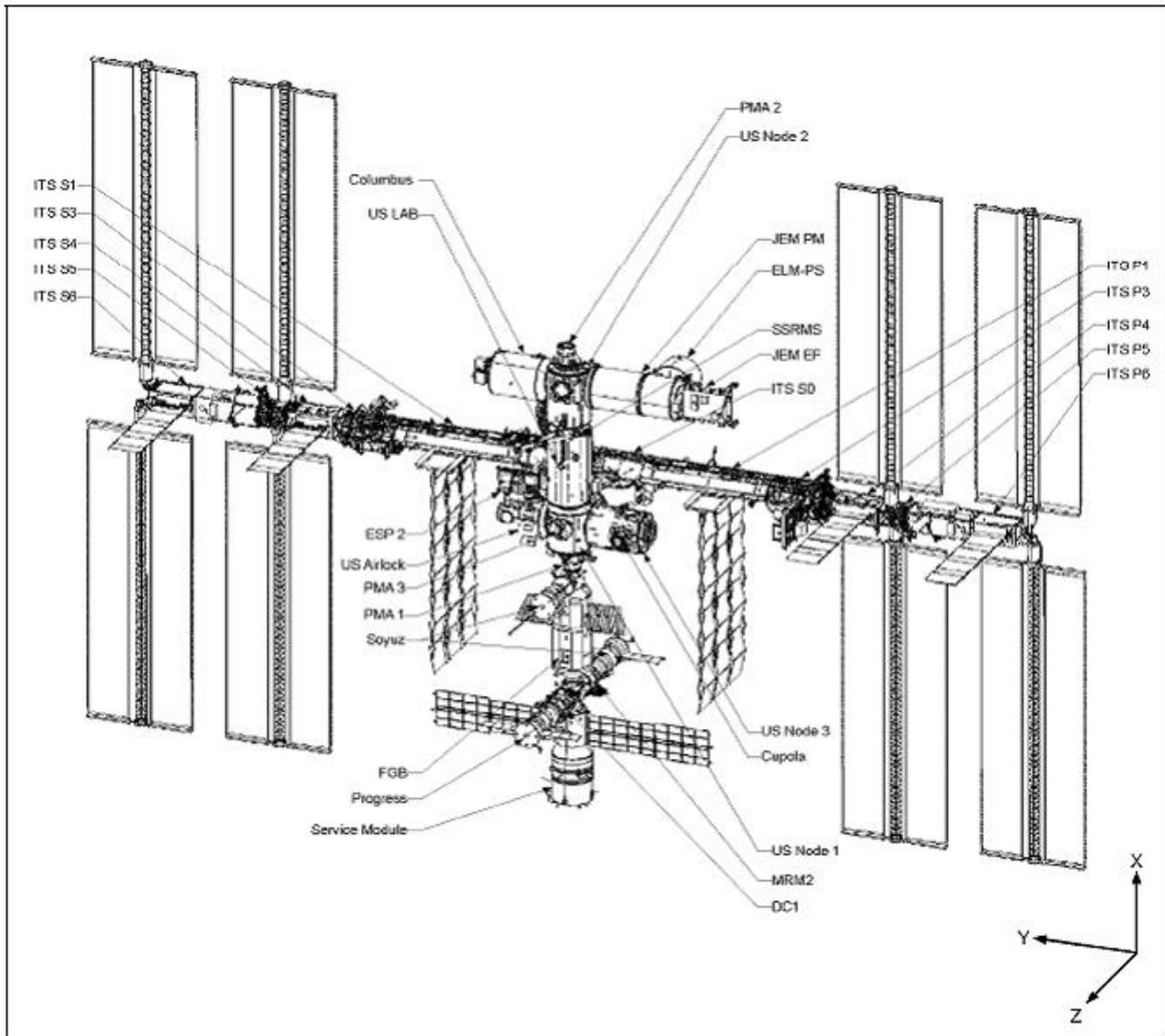
The focus of this section is on the changes made to the ISS systems due to the 20A mission.

### **2.1 STAGE ULF3 AND 20A CONFIGURATION**

At Stage Utilization Logistics Flight 3 (ULF3), the United States On-Orbit Segment (USOS) consists of Node 1, Node 2, the U.S. Lab, ESA Columbus Module, Japanese Aerospace Exploration Agency (JAXA), Japanese Experiment Module (JEM) (JPM, JEM Experiment Logistics Module - Pressurized Section (JLP), and Japanese Experiment Module Remote Manipulator System (JEMRMS)), Pressurized Mating Adapter (PMA) 1, PMA 2, PMA 3, the joint A/L, the Z1 truss segment, all components of the primary truss, and all major components of the Mobile Servicing System (MSS): Mobile Transport (MT), Mobile Base System (MBS), Space Station Remote Manipulator System (SSRMS), and Special Purpose Dexterous Manipulator (SPDM). Stage 20A adds the Node 3 and attached Cupola elements.

The Russian Segment (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 20A is shown in Figure 2-1. The following sections provide an overview of the change in ISS capabilities from Stage ULF3 to Stage 20A.



**Figure 2-1. ISS configuration - Stage 20A**

## 2.1.1 Structures and Mechanisms

Stage 20A adds the Node 3 element and Cupola. Node 3 is delivered to provide additional rack and stowage space. The Cupola provides ISS crewmembers with a 360° observation point facing in the NADIR direction. Refer to Table 2-1 for details.

**Table 2-1. Structures and mechanisms at Stages ULF3 and 20A**

Structure	Primary function	ULF3 Stage	20A Stage
<b>Pressurized modules</b>			
SM	Primary living quarters for ISS crew	No comments	No change
FGB	Instrumentation and RS onboard stowage	No comments	No change
DC-1	Docking port cargo vehicles A/L for Orlan EVAs	No comments	No change
PMA 1	Connects USOS and RS Onboard stowage	No comments	No change
Node 1	Connects USOS modules Onboard stowage	No comments	PORT ACBM now holds Node 3
Node 2	Connects USOS/IP modules Onboard stowage SSRMS operating base	No comments	No change
PMA 3	Onboard, long-term stowage	No comments	No change
A/L	Facilitates EVAs using Extravehicular Mobility Units (EMUs)	No comments	No change
U.S. Lab	On-orbit science facility Command and control of USOS systems	No comments	No change
Columbus Module	ESA on-orbit science facility	No comments	No change
PMA 2	Facilitates orbiter to dock to ISS	No comments	No change
Z1 dome	Onboard long-term stowage	No comments	No change
JPM	JEM science facility C&C of JEM systems	No comments	No change

**Table 2-1. Structures and mechanisms at Stages ULF3 and 20A (continued)**

Structure	Primary function	ULF3 Stage	20A Stage
<b>Pressurized modules (concluded)</b>			
JLP	JEM logistics/stowage facility	No comments	No change
Node 3	Onboard stowage	N/A	Delivery and installation
Cupola	Observation	N/A	Delivery and installation
<b>Unpressurized structures</b>			
Common Berthing Mechanism (CBM)	Mates USOS/IP modules together	No comments	Six delivered on Node 3 element
APAS	Used for the docking of arriving vehicles to the ISS	No comments	No change
S0 ITS	Supports main ISS truss structure	No comments	No change
S1 ITS	Supports EATCS loops and radiators	No comments	No change
P1 ITS	Supports EATCS loops and radiators	No comments	No change
P3/P4 ITS	Supports SARJ and P4 power channels	No comments	No change
S3/S4 ITS	Supports SARJ and S4 power channels	No comments	No change
P5 ITS spacer	Spacer truss between P4 and P6 provides clearance between the P4 solar array and P6 array Contains cables to pass data and power	No comments	No change
S5 ITS spacer	Spacer truss between S4 and S6 provides clearance between the S4 solar array and S6 array Contains cables to pass data and power	No comments	No change
P4 PVM	Provides power to the USOS	No comments	No change
S4 PVM	Provides power to the USOS	No comments	No change

**Table 2-1. Structures and mechanisms at Stages ULF3 and 20A (concluded)**

Structure	Primary function	ULF3 Stage	20A Stage
<b>Unpressurized structures (concluded)</b>			
P6 PVM	Provides power to the USOS	No comments	No change
S6 PVM	Provides power to the USOS	No comments	No change
Z1 ITS	Supports four CMGs	No comments	No change
Lab Cradle Assembly (LCA)	Used during 8A to temporarily secure S0 ITS to U.S. Lab	No comments	No change
Segment-to-Segment Attach System (SSAS)	Used for connecting inboard truss elements	No comments	No change
JEF	External scientific experiments	Not installed	No change
RTAS and Modified RTAS (M-RTAS)	Used for connecting outboard truss elements	No comments	No change
UCCAS/Payload Attach System (PAS)	Used for attaching unpressurized carriers to the S3/S4 and P3/P4 truss element	No comments	No change

### 2.1.2 Electrical Power System

Stage 20A adds capability to the USOS secondary power system, as shown in Table 2-2, Figure 2-2, and Drawing 5.1.

**Table 2-2. Power systems capability summary at Stages ULF3 and 20A**

System	ULF3 Stage	20A Stage
<b>Primary power system</b>		
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

**Table 2-2. Power systems capability summary at Stages ULF3 and 20A  
(continued)**

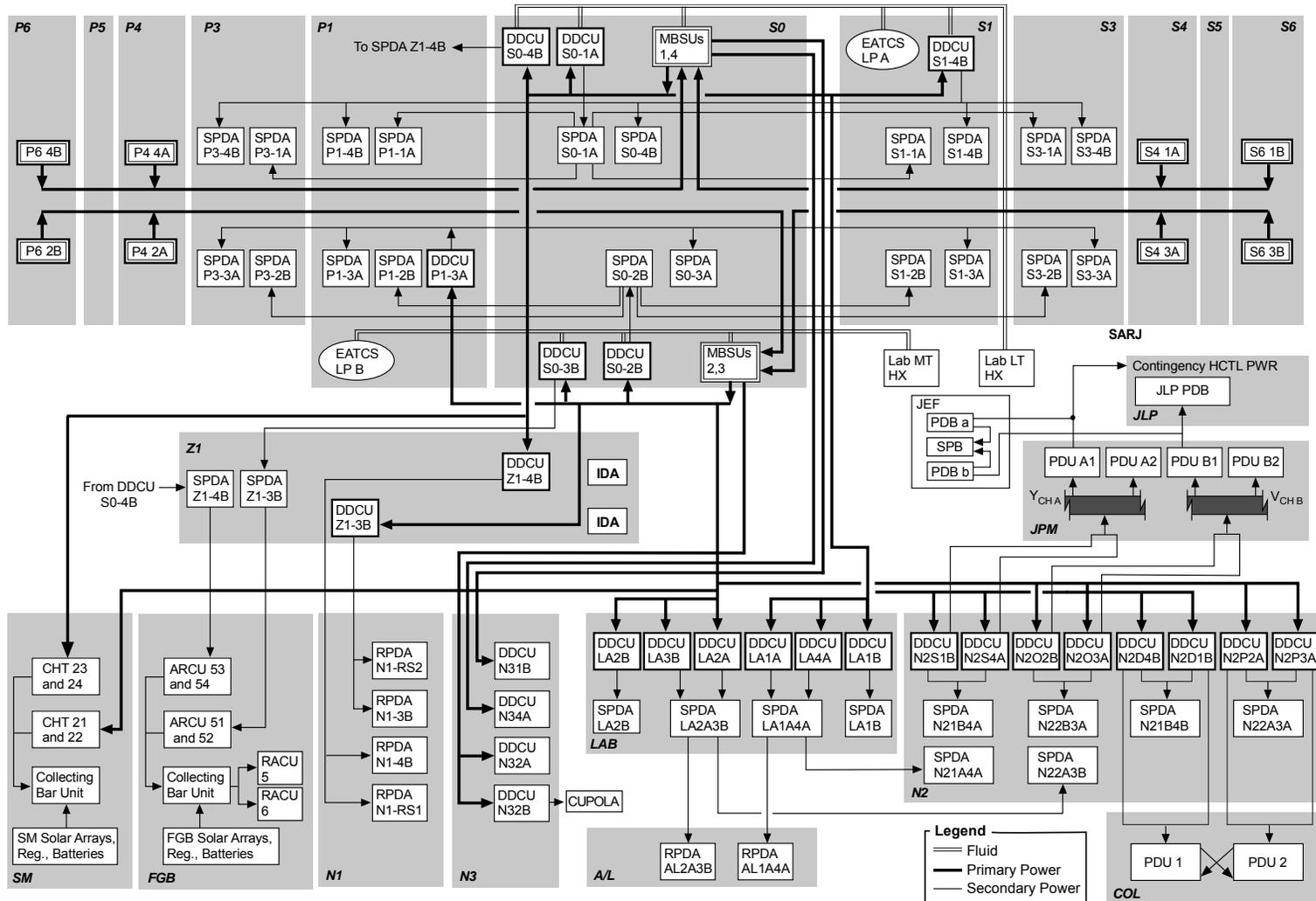
System	ULF3 Stage	20A Stage
<b>Primary power system (concluded)</b>		
Solar array tracking	PORT SARJ is fully functional. STARBOARD SARJ is constrained to directed position (not autotracking) due to anomalous vibrations during rotation, and this condition is not expected to be resolved until ULF2 at the earliest  All BGAs (eight) tracking on all gimbals/joints	No change
MBSUs	All four MBSUs on S0 active and cross-tied  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	No change
DCSUs	Eight DCSUs on board (one for each power channel)	No change
BCDUs	24 BCDUs on board (3 on each power channel)	No change
<b>USOS secondary power system</b>		
DC-to-DC Converter Units (DDCUs)	Lab: Six DDCUs Node 2: Eight DDCUs Z1: Two DDCUs S0: Four DDCUs P1: One DDCU S1: One DDCU P4: Two DDCUs S4: Two DDCUs P6: Two DDCUs S6: Two DDCUs	Added four DDCUs in Node 3

**Table 2-2. Power systems capability summary at Stages ULF3 and 20A  
(continued)**

<b>System</b>	<b>ULF3 Stage</b>	<b>20A Stage</b>
<b>USOS secondary power system (concluded)</b>		
Secondary Power Distribution Assembly (SPDA)/ Remote Power Distribution Assembly (RPDA)	Lab: Four SPDAs N1: Four RPDAs N2: Two RPDAs, four SPDAs Z1: Two SPDAs A/L: Two RPDAs S0: Four SPDAs MT: Two RPDAs S1: Four SPDAs P1: Four SPDAs S3: Four SPDAs P3: Four SPDAs	Added two RPDAs in Node 3
<b>USOS electrical power subsystems</b>		
PVTCS	P4, P6, S4, S6 PVTCS active and PVRs deployed	No change
PCU	Two PCUs are mounted on upper PORT side of Z1	No change
<b>Russian segment power system</b>		
Primary power	SM solar arrays deployed and generating power (FGB arrays retracted)	No change
Secondary power	Four FGB ARCUs receiving USOS power from Z1 SPDAs Two SM [CHTs] receiving USOS power from MBSU 2A Two SM [CHTs] receiving USOS power from MBSU 4A	No change
<b>JEM segment power system</b>		
Primary power	None	No change
Secondary power	Two JPM Power Distribution Unit (PDU)-Is Two JPM PDU-IIIs	No change

**Table 2-2. Power systems capability summary at Stages ULF3 and 20A  
(concluded)**

<b>System</b>	<b>ULF3 Stage</b>	<b>20A Stage</b>
<b>JEM segment power system (concluded)</b>		
Secondary power subsystem	JLP PDB fed from JPM Four JPM PDB-Is Seven JPM PDB-IIIs Two JPM PDU-Is Two JPM PDU-IIIs Four JPM PIBs	No change
<b>ESA segment power system</b>		
Primary power	None	No change
Secondary power	Node 2 DDCUs provide 120-V USOS secondary power to two redundant PDUs within the Columbus Electrical Power Distribution System (EPDS)	No change
Secondary power subsystem	Columbus PDUs distributes secondary power to all Columbus subsystems and payloads	No change



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Figure 2-2. EPS overview at Stage 20A

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### 2.1.3 Command and Data Handling System

Mission 20A provides additional Command and Data Handling (C&DH) capabilities to the ISS in the form of Node 3 Multiplexer/Demultiplexers (MDMs) and Caution and Warning (C&W), as shown in Table 2-3 and Figure 2-3.

**Table 2-3. C&DH capability summary at Stages ULF3 and 20A**

System	ULF3 Stage	20A Stage
<b>Russian segment C&amp;DH system</b>		
SM computers	Control of SM DMS-R; control of RS MCS; control of IMCS (selectable)	No changes
FGB computers	Control of FGB systems	No changes
<b>USOS segment C&amp;DH system</b>		
C&C MDMs	Process ISS-level software; coordinate C&W between ISS segments; crew interface with C&DH system (via PCS); connect to MCC via ISS communication subsystems  Tier 1: Three MDMs - primary, backup, and standby	No changes
GNC MDMs	Monitor and control of CMGs; perform calculations supporting USOS attitude control; coordinate overall ISS attitude control with RS  Tier 2: Two MDMs - primary and backup	No changes
INT MDMs	Monitor and control of internal ECLSS, EPS, and TCS systems of ISS  Tier 2: Two MDMs - primary and backup	No changes
Payload MDM	Control of USOS Payload C&DH network  Tier 2: Two MDMs - primary and backup	No changes

**Table 2-3. C&DH capability summary at Stages ULF3 and 20A (continued)**

System	ULF3 Stage	20A Stage
<b>USOS segment C&amp;DH system (continued)</b>		
PMCU MDMs	Control of EPS secondary power distribution  Tier 2: Two MDMs - primary and backup	No changes
EXT MDMs	Monitor and control inboard integrated truss segments (i.e., S0, S1, P1, P3, and S3) systems  Tier 2: Two MDMs - primary and backup	No changes
Node 1 MDMs	Control of Node 1, PMA, and Z1 heaters; control of PCU ops; control of CBM ops  Tier 3: Two MDMs - N1-1 and N1-2 (considered tier 2.5 with characteristics of both)	No changes
Node 2 MDMs	Control of Node 2 internal systems, command and control routing to IP elements; control of CBM ops  Tier 3: Two MDMs - N2-1 and N2-2	No change
Node 3 MDMs	N/A	Delivered  Control of Node 3 internal systems, C+C routing to IP elements; control of CBM ops  Tier 2: 2 MDMs - HCZ-1 and HCZ-2  Tier 3: 2 MDMs - N3-1 and N3-2
PVCU MDMs	Control of S4, P4, and P6 solar arrays and power flow  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	No change

**Table 2-3. C&DH capability summary at Stages ULF3 and 20A (continued)**

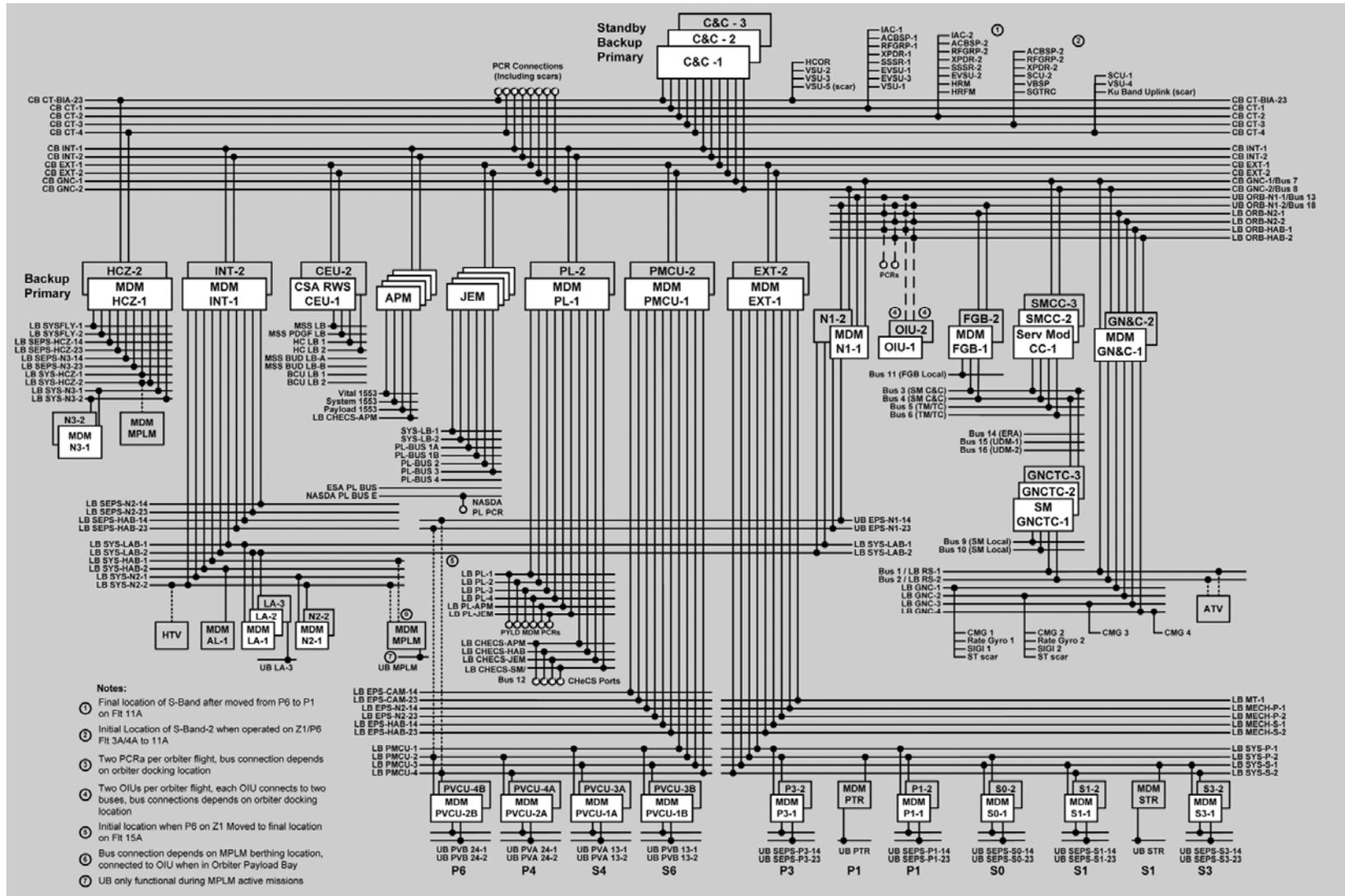
System	ULF3 Stage	20A Stage
<b>USOS segment C&amp;DH system (concluded)</b>		
A/L MDM	Control of ISS joint A/L systems Tier 3: One MDM - A/L MDM	No changes
U.S. Lab MDMs	Monitor and control of U.S.-Lab-related functions Tier 3: Three MDMs - LA-1, LA-2, and LA-3	No changes
S0 MDMs	Monitor and control ITS S0 systems Tier 3: Two MDMs - S0-1 and S0-2	No changes
S1 MDMs	Monitor and control ITS S1 systems Tier 3: Two MDMs - S1-1 and S1-2	No changes
S3 MDMs	Monitor and control ITS S3 systems Tier 3: Two MDMs - S3-1 and S3-2	No changes
P1 MDMs	Monitor and control ITS P1 systems Tier 3: Two MDMs - P1-1 and P1-2	No changes
P3 MDMs	Monitor and control ITS P3 systems Tier 3: Two MDMs - P3-1 and P3-2	No changes
STR/PTR MDMs	Monitor and control systems on the STARBOARD/PORT TRRJs that are primarily related to radiator and RBVM operations Tier 3: Two MDMs - STR and PTR	No changes
PCS	Crew interface with USOS C&DH system	No changes
C&W Panel	C&W panel provides crew interface to C&W system and visual indication of an alarm C&W event One in U.S. Lab One in Node 2	Delivered additional unit in Node 3

**Table 2-3. C&DH capability summary at Stages ULF3 and 20A (continued)**

System	ULF3 Stage	20A Stage
<b>ESA segment C&amp;DH system</b>		
Columbus DMS	Monitor and control Columbus-related functions. Interface with U.S. international buses  Tier 3: Four Standard Portable Computers (SPCs) - Data Management Computer (DMC), Mission Management Computer (MMC), P/L Command Unit (PLCU), plus a spare SPC	No changes
<b>JEM segment C&amp;DH system</b>		
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 interfaces with the C&C MDMs on the control buses	No changes
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 changes
Payload Data Handling Unit (PDH)	The JPM contains two PDHs. There are two PDHs for redundancy. PDHs handle payload data	No changes
Management Data Processor (MDP)	The computer that provides top-level management of the JEMRMS	No changes
Minimum Keep Alive and Monitor (MKAM)	Becomes Station Laptop Terminal (SLT) and available for minimum keep-alive monitoring, if required	No changes
SLT	Crew interface with JEM C&DH system	No changes

**Table 2-3. C&DH capability summary at Stages ULF3 and 20A (concluded)**

System	ULF3 Stage	20A Stage
<b>JEM segment C&amp;DH system (concluded)</b>		
EF System Computer (ESC)	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	No change
Electronic Control Unit (ECU)	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	No change



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Figure 2-3. C&DH overview at Stage 20A

Verify that this is the correct version before use

## 2.1.4 Communication and Tracking System

Mission 20A brings additional communication and tracking capability to the station in Node 3. Table 2-4 provides a summary description of the Communication and Tracking (C&T) system capability at the completion of Stage 20A.

**Table 2-4. C&TS capability summary at Stages ULF3 to 20A**

System	ULF3 Stage	20A Stage
<b>USOS C&amp;TS segment</b>		
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  String 1 S-band located on S1 String 2 S-band located on P1	No change
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)	No change
Internal audio	Distributes voice and C&W tones on board the ISS; interfaces with other subsystems so that the audio signals can be distributed to the RS, orbiter, EVA crews, and ground	Additional ATUs delivered and ABCs delivered in Node 3
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)	

**Table 2-4. C&TS capability summary at Stages ULF3 to 20A (continued)**

<b>System</b>	<b>ULF3 Stage</b>	<b>20A Stage</b>
<b>USOS C&amp;TS segment (concluded)</b>		
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)  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	No change
<b>Russian C&amp;TS segment</b>		
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
<b>ESA segment C&amp;TS system</b>		
Columbus Video Distribution System (VDS)	Collects video data and sends it for downlink via USOS or JEM assets	No change
Columbus internal audio	Two ATUs One IAA	No change
<b>JEM segment C&amp;TS system</b>		
Internal audio	Two ATUs (JEM ATU1, JEM ATU2) in the JEM module  Two IAAs - one in JLP, one in JPM. Each interfaces directly with the USOS SSSR system	No change

**Table 2-4. C&TS capability summary at Stages ULF3 to 20A (concluded)**

System	ULF3 Stage	20A Stage
<b>JEM segment C&amp;TS system (concluded)</b>		
Video	Five TVCs on the JEM that interface with the USOS VDS Three TVCs are internal Two TVCs are external Two external TVCs are on JEF	No change
Interorbit Communication System (ICS)	Direct communication between ICS-EF and SSIPC through DRTS	

### 2.1.5 Motion Control System

Mission 20A adds no new functionality to the ISS Motion Control System (MCS) or Guidance, Navigation, and Control (GNC) system. Table 2-5 provides an overview of the MCS capability at the completion of Stage 20A.

**Table 2-5. MCS capability summary at Stages ULF3 to 20A**

System	ULF3 Stage	20A 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
Control	Four CMGs on Z1 truss	No change
	RS thrusters	No change

### 2.1.6 Environmental Control and Life Support System

Stage 20A adds additional Environmental Control and Life Support System (ECLSS) hardware intended to support an increased pressurized volume, including an additional Common Cabin Air Assembly (CCAA), two smoke detectors, intramodule ventilation hardware for International Partner (IP) elements, and utility connections for gas transfer from visiting vehicles. Reference Table 2-6 and Drawing 5.4.

Table 2-6 provides an overview of the ECLSS capability at the completion of Stage 20A.

**Table 2-6. ECLSS capability summary at Stages ULF3 and 20A**

Subsystem	ULF3 Stage	20A Stage
<b>USOS ECLSS</b>		
<b>ACS</b>		
PCA	U.S. Lab, joint A/L	No change
High-pressure gas tanks	Joint A/L, external	No change
ORCA	Located in the A/L; only functional when orbiter is docked	No change
A/L depress pump	Crew Lock (C/L)	No change
<b>ARS</b>		
CDRA	Located in LAB1D6; interfaces with LTL of the thermal control loop  Requires more power to regenerate, so is kept as backup for Vozdukh; used when more than three crewmembers are present on ISS	No change
TCCS	Located in LAB1D6	No change
MCA	Located in LAB1D6	No change
SDS	Located throughout USOS; provides samples for MCA	No change
TOCA		No change

**Table 2-6. ECLSS capability summary at Stages ULF3 and 20A (continued)**

Subsystem	ULF3 Stage	20A Stage
<b>USOS ECLSS (concluded)</b>		
<b>THC</b>		
CCAA	Two located in the U.S. Lab, one in Node 2 and one in A/L; includes ducts and the following: HEPA filters (six) WS CHX TCCV A/L CCAA used for campout and provides cooling to ORCA	Additional rack provided in Node 3
IMV	Located throughout USOS and connected to RS through drag-through ducts; Russian IMV does not have isolation valves like U.S. IMV does	Additional ports, ducts, and fans provided in Node 3
<b>WRM</b>		
Condensate tank	75-kg tank located in LAB1D5; collects condensate and EMU and OGS wastewater	No change
WVA	Two-vent system for wastewater disposal in U.S. Lab	No change
Regen ECLSS	OGS installed in LAB1P1. ULF2 brings up WRS 1 and 2. They are connected and activated to OGS during the stage. These systems provide oxygen generation and water purification	No change
WHC		No change
<b>Russian ECLSS [COЖ] systems</b>		
<b>Atmosphere Control Subsystem [COГC]</b>		
Elektron oxygen generator	Primary means of adding oxygen; located in SM; interfaces with SM internal thermal control loop	No change

**Table 2-6. ECLSS capability summary at Stages ULF3 and 20A (concluded)**

Subsystem	ULF3 Stage	20A Stage
<b>Russian ECLSS [COЖ] systems (concluded)</b>		
<b>Atmosphere Control Subsystem [COГC] (concluded)</b>		
Portable Repress Unit (БНП)	Two high-pressure air tanks in transfer compartment of SM and in DC; only for off-nominal ingress or during rapid depress; manually operated valve	No change
Progress vehicle	Primary means for adding air to station; carries tanks with crew-operated manual valves	No change
Solid Oxygen Generator (ТГК)	Two located in SM with numerous cartridges on board	No change
Vozdukh	Primary means of CO <sub>2</sub> removal; located in SM; interfaces with internal thermal control loop; currently can support three crewmembers	No change

### 2.1.7 Thermal Control System

Mission 20A adds additional cooling capability to the Thermal Control System (TCS) in the form of new Moderate Temperature Loop (MTL) and Low Temperature Loop (LTL) loops with associated heat exchangers and connections to the IATCS. Table 2-7 provides an overview of the TCS capability at the completion of Stage 20A. Figure 2-4 and Figure 2-5 illustrate the system configuration.

**Table 2-7. TCS capability summary at Stages ULF3 and 20A**

System	ULF3 Stage	20A Stage
<b>External TCS</b>		
Active system	ETCS active	No change
Heat collection	Two Interface Heat Exchangers (IFHXs) (U.S. Lab) rejecting heat to External Thermal Control System (ETCS)  Six IFHXs (Node 2) rejecting heat to ETCS  Other truss components rejecting heat to ETCS	
Heat transportation	ETCS interfaces with IFHXs for both U.S. Lab and Node 2  ETCS stats: Working fluid: Ammonia Two independent loops Loop A interfaces with U.S. Lab LTL IFHX, COL MT IFHX, and N2 MT IFHX  Loop B interfaces with U.S. Lab MTL IFHX, COL LT IFHX, and N <sub>2</sub> LT IFHX  One Pump Module (PM) in each loop  One Ammonia Tank Assembly (ATA) and one Nitrogen Tank Assembly (NTA) in each loop	Spare PM2 launched on 2J/A and transferred to ESP-3 during mission

**Table 2-7. TCS capability summary at Stages ULF3 and 20A (continued)**

<b>System</b>	<b>ULF3 Stage</b>	<b>20A Stage</b>
<b>External TCS (concluded)</b>		
Heat rejection	ETCS: All ETCS radiators deployed  Each radiator capable of rejecting 11.67 kW	No change
Controlling MDMs	EXT, truss MDMs, PORT Thermal Radiator (PTR), STARBOARD Thermal Radiator (STR): loop control, RBVM control	
<b>Internal TCS</b>		
Heat collection	Cold plates  USOS heat exchangers (CCAA, AAA, payload HXs, Regen HX)  Columbus TCS  JEM TCS	
Heat transportation	U.S. Lab: Two connectable loops: LTL and MTL  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	Added Node 3 LTL and MTL loops
Heat rejection	Two U.S. Lab IFHXs (interface with the ETCS)  Six Node 2 IFHXs (interface with the ETCS)	Added two Node 3 IFHXs (interface with the ETCS)

**Table 2-7. TCS capability summary at Stages ULF3 and 20A (continued)**

System	ULF3 Stage	20A Stage
<b>Internal TCS (concluded)</b>		
Controlling MDMs	INT MDMs: IATCS system control, generate C&W messages, failure recovery, leak recovery, heater control, cmd/telemetry routing, PPA control  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	No change
<b>Russian Segment Thermal Control System [COTP]</b>		
<b>SM internal TCS</b>		
Heat collection	Some equipment air-cooled by Ventilation System [CB]  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	No change
Heat transportation	Two Internal Thermal Loops [КОБ-1, КОБ-2]  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 [СПН1-4], each with two pumps in series (total of eight pumps)	No change

**Table 2-7. TCS capability summary at Stages ULF3 and 20A (continued)**

System	ULF3 Stage	20A Stage
<b>Russian Segment Thermal Control System [COTP] (continued)</b>		
<b>SM internal TCS (concluded)</b>		
Heat rejection	Interfaces with external loops [KOX-1 and 2] through Liquid-to-Liquid Heat Exchangers [ЖЖТ]	No change
<b>SM external TCS</b>		
Heat collection	Interfaces with Internal Loops [КОБ-1 and 2] through Liquid-to-Liquid Heat Exchangers [ЖЖТ]	No change
Heat transportation	Working fluid: Polymethyl siloxane (silicone organic fluid) Two External Cooling Loops [KOX-1, KOX-2] Each loop contains two external pump assemblies with two pumps each (eight pumps total)	No change
Heat rejection	Ten radiator panels [PTO] located on external portion of PO Radiators reject total of 5.5 kW	No change
<b>FGB internal TCS</b>		
Heat collection	Four Gas-Liquid Heat Exchangers [ГЖТ] cool the crew cabin (three) and equipment (one) Nine coldplates collect heat from RACUs, ARCUs, MDMs, matching units [УС-31], and Voltage Converter [ПС]	No change
Heat transportation	Two redundant internal Thermal Control Loops [ВГК] Working fluid: Triol Each internal loop contains two replaceable pump panels [СПН] with two pumps per panel (eight pumps total)	No change

**Table 2-7. TCS capability summary at Stages ULF3 and 20A (continued)**

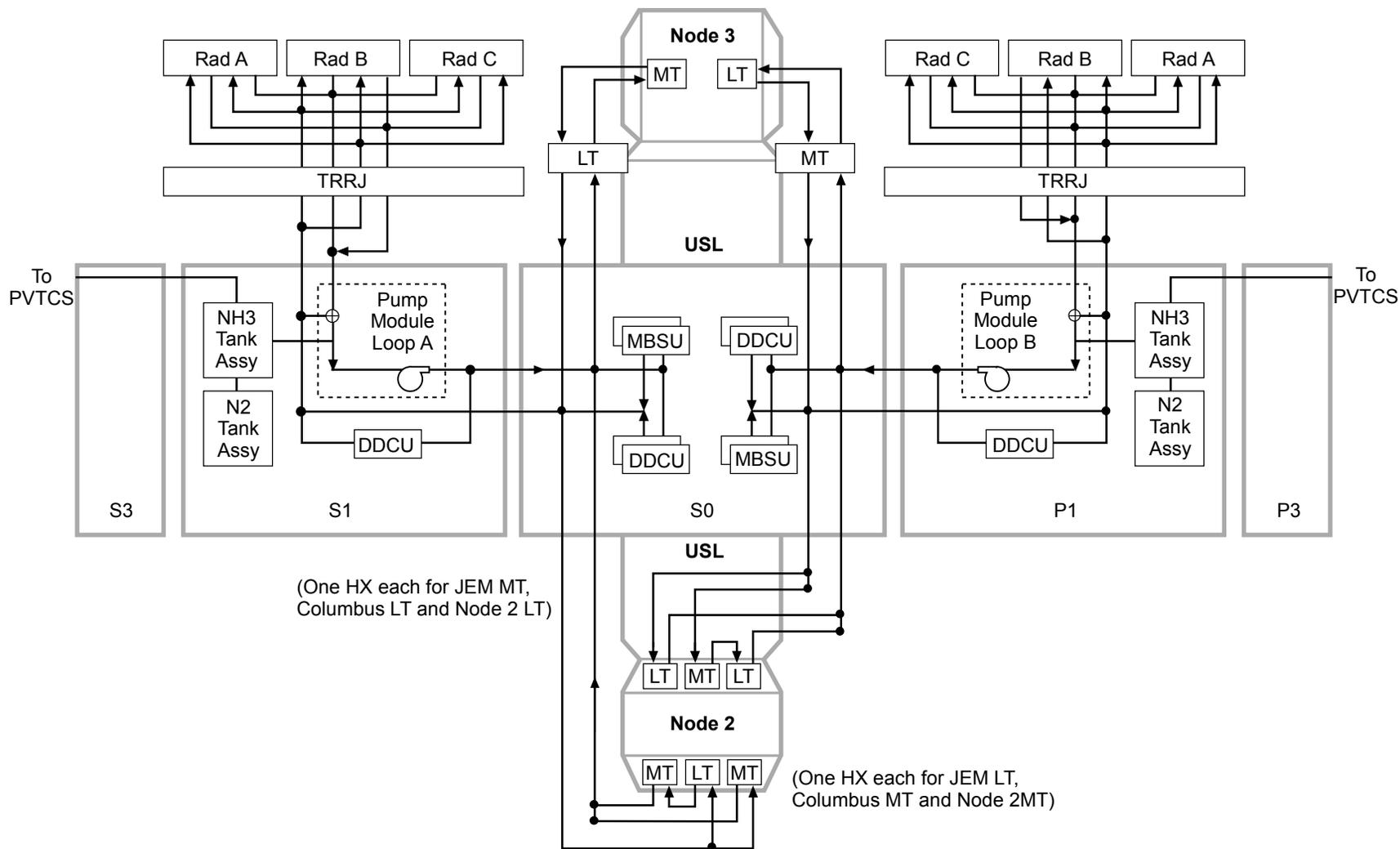
<b>System</b>	<b>ULF3 Stage</b>	<b>20A Stage</b>
<b>Russian Segment Thermal Control System [COTP] (concluded)</b>		
<b>FGB internal TCS (concluded)</b>		
Heat rejection	Interfaces with the external loops (HГK 1 and 2) through two Liquid-Liquid Heat Exchangers [ЖЖТ]	No change
<b>FGB External TCS</b>		
Heat collection	Interfaces with internal loops (BГK 1 and 2) through two Liquid-Liquid Heat Exchangers [ЖЖТ]	No change
Heat transportation	Working fluid: Polymethyl siloxane (silicone organic fluid) Two redundant External Hydraulic Loops [HГK 1 and 2] Each loop contains six pumps (four fixed, two replaceable); nominally, only 1 of the 12 pumps operates at a time	No change
Heat rejection	Twelve radiators [PTO]	No change
<b>ESA segment TCS system</b>		
<b>Columbus internal TCS</b>		
Heat collection	Twenty-one cold plates CHX removes humidity and extraneous heat from module air	No change

**Table 2-7. TCS capability summary at Stages ULF3 and 20A (continued)**

<b>System</b>	<b>ULF3 Stage</b>	<b>20A Stage</b>
<b>ESA segment TCS system (concluded)</b>		
<b>Columbus internal TCS (concluded)</b>		
Heat transportation	<p>Single water loop contains both LT and MT sections</p> <p>Two Water Pump Assemblies (WPA1 and 2); only one active at a time</p> <p>Ten Water On-Off Valves (WOOV1-10) allow for bypass of either of the CHX cores and either of the Node 2 HXs</p> <p>Four Water Modulating Valves (WMV1-4): Two per WPA (WMV1 and 3 associated with WPA1, and WMV2 and four with WPA2) control water temperature at CHX and P/L inlet branches</p>	No change
Heat rejection	Water loop interfaces with Node 2 MTL and LTL HXs	No change
<b>Columbus external TCS</b>		
Passive TCS (PTCS)	MLI covers all external surfaces of the Columbus Module	No change
<b>JEM TCS</b>		
<b>JEM internal TCS</b>		
Heat collection	<p>Cold plates collect heat</p> <p>CHX (Cabin Heat Exchanger) removes humidity and extraneous heat from module air</p>	No change
Heat transportation	<p>Two water loops (LT and MT) that can be run as a single loop</p> <p>Two H<sub>2</sub>O IFHX bypass valves for bypass of either of the Node 2 IFHXs</p>	No change
Heat rejection	Water loop interfaces with Node 2 MTL and LTL IFHXs	No change

**Table 2-7. TCS capability summary at Stages ULF3 and 20A (concluded)**

System	ULF3 Stage	20A Stage
<b>JEM TCS (concluded)</b>		
<b>JEM internal TCS (concluded)</b>		
PTCS	One JLP and two JPM heater controllers control heaters on the module shells	No change
<b>JEM external TCS</b>		
	MLI and coatings on all external surfaces of the JEM components. JEF launched on Mission 2J/A with redundant systems TCS-a and TCS-b, each containing Heater Control Equipment (HCE), temperature sensors, and heaters	No change
Heat collection	Cold plates collect heat from JEF experiments and payloads	No change
Heat transportation	JEF ATCS: Single coolant loop Two Fluid Accumulators (FAs) Two Fluid Pump Packages (FPPs) Two ea. Inlet Valves, Outlet Valves, Bypass Valves Working fluid is single-phase Perfluorocarbon (FC-72)	No change
Heat rejection	JEF ATCS interfaces with JPM ATCS MTL via the Exposed Facility Heat Exchanger (EFHX)	No change



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**Figure 2-4. 20A external active thermal control system**

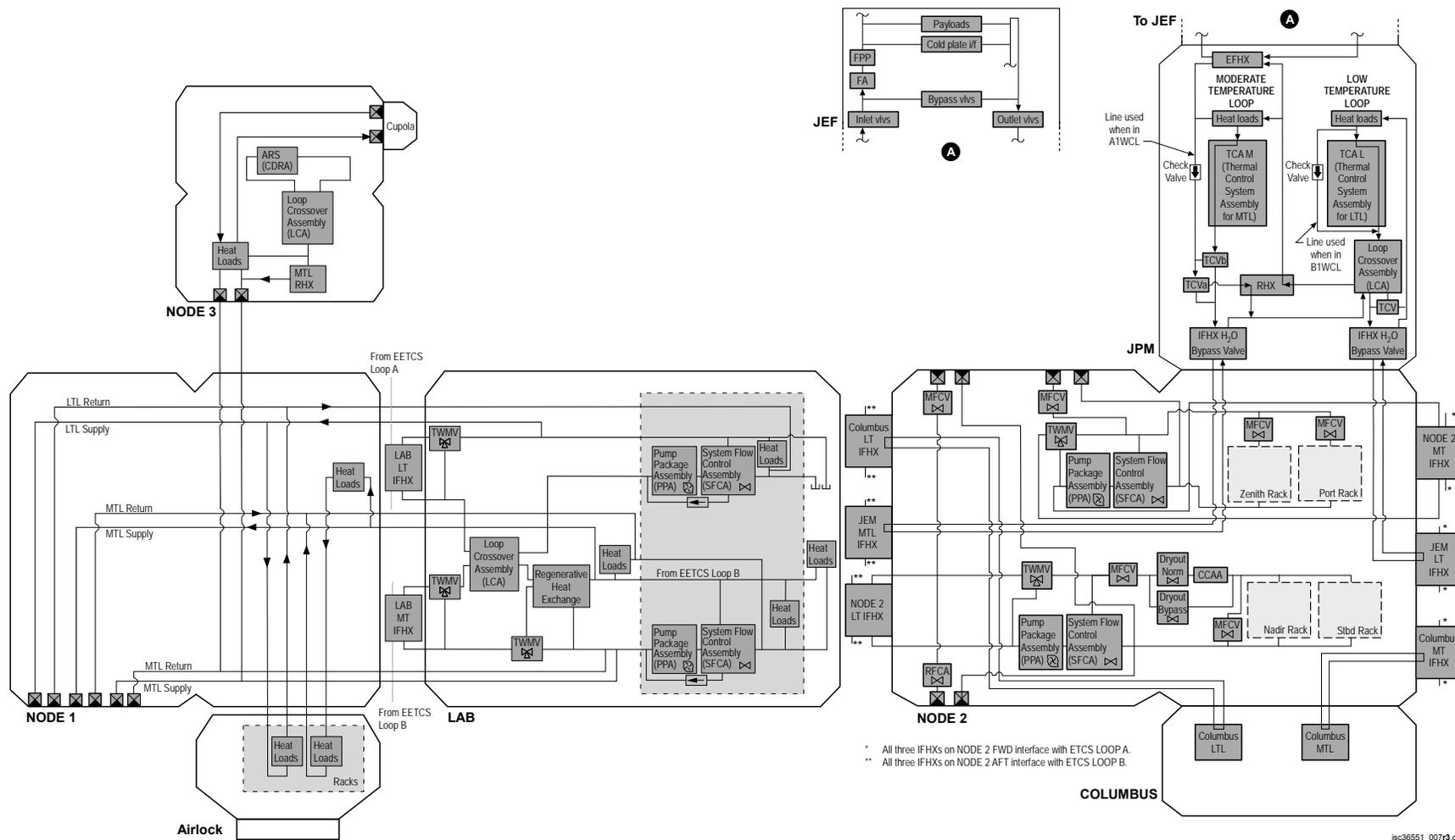


Figure 2-5. 20A TCS module overview

### 2.1.8 Robotics Systems

Mission 20A relocates one of two redundant Robotic Work Stations (RWS) to the Cupola upon its berthing to Node 3 NADIR port. The RWS installed in the Cupola allows the crew to operate the SSRMS from this location. Since the robotics operations require video, the television monitors and the hardware panel for crew control of the VDS are located at the RWS. Here, the crew can route a video image from any camera or VTR to an onboard monitor (located at the RWS), a VTR, or to the ground. The crew can also operate the external cameras from the RWS.

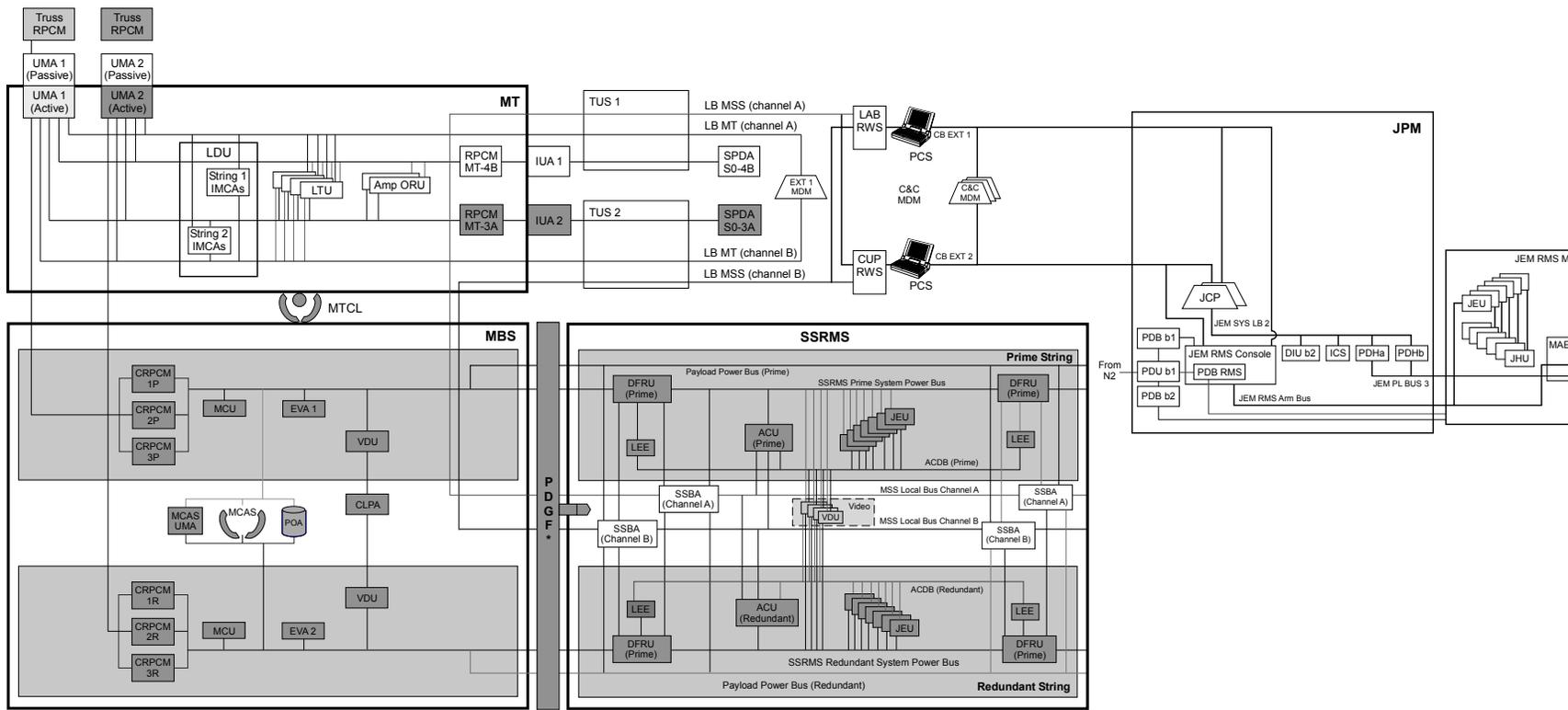
Refer to Table 2-8, Figure 2-6, and Figure 2-7 for system capabilities and configuration.

**Table 2-8. Robotics capability summary at Stages ULF3 and 20A**

System	ULF3 Stage	20A Stage
<b>USOS Robotics system</b>		
SSRMS	<p>SSRMS contains two identical strings: prime and redundant; strings cannot be cross-strapped; a failure in one part of a string causes loss of the whole string</p> <p>SSRMS contains two Latching End Effectors (LEEs), each capable of acting as a base, passing power and data through to the SSRMS</p> <p>Two PTUs: one on each boom of the SSRMS; each PTU contains one camera</p> <p>Two LEE cameras: one on each LEE tip/base</p> <p>When attached to MT, SSRMS is powered only when MT is docked at a worksite</p> <p>When attached to MT, SSRMS sends/receives video and data through TUS</p>	No change
RWS	<p>Two RWS units: LAB1P5 (U.S. Lab), LAB1S5 (Cupola)</p> <p>Only one RWS can be in active control of the SSRMS at a time</p>	No change
SPDM	Provides dexterous manipulation of ORUs	No change
MT	<p>Can dock at any of eight worksites</p> <p>MT stops located on bulkheads of S0, S1, P1, S3, and P3 trusses (six total)</p> <p>ETRS on P3 allows a CETA cart to fit outboard of the MT while at the P3 WS. ETRS on S3 was removed on flight 1J</p>	No change

**Table 2-8. Robotics capability summary at Stages ULF3 and 20A (concluded)**

System	ULF3 Stage	20A Stage
<b>USOS Robotics system (concluded)</b>		
MBS	Contains four Power and Data Grapple Fixture (PDGFs) for SSRMS connection and a POA for storage of payloads or ORUs Powered only when MT is docked at a worksite Sends/receives video and data through TUS	No change
<b>JEM segment Robotics system</b>		
JEMRMS	No comments	No change
JEMRWS	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



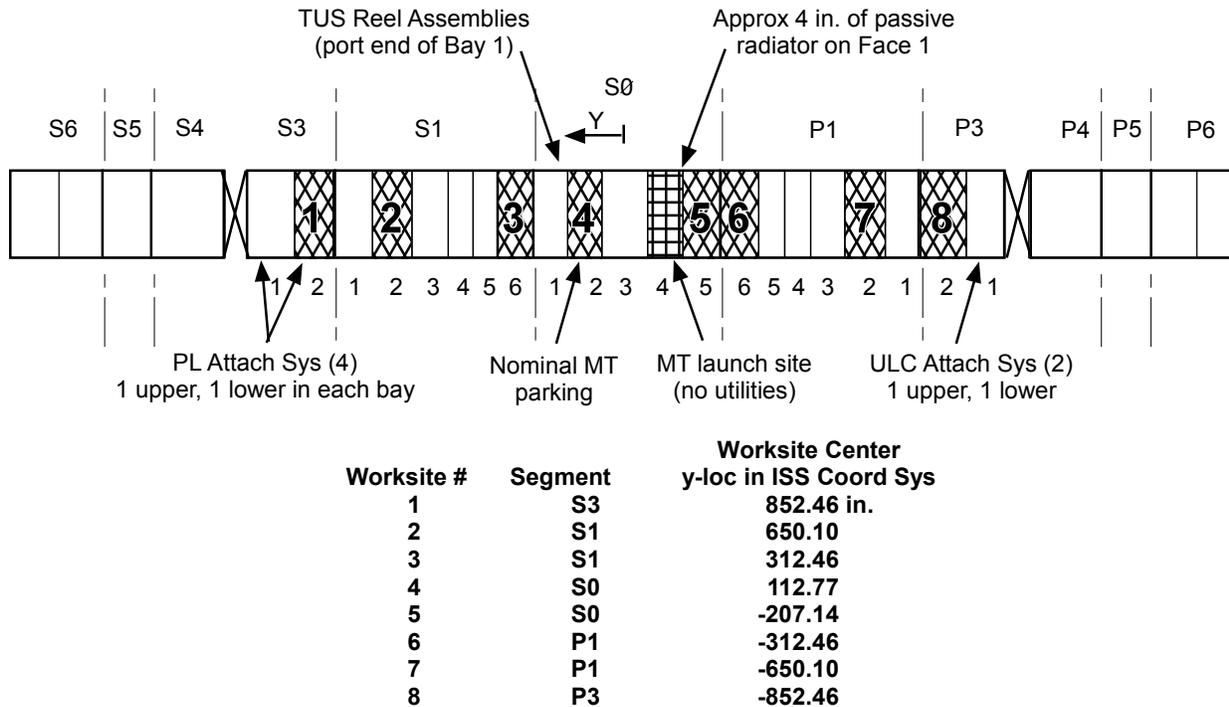
\* There are four identical PDGFs on the MBS

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Figure 2-6. Robotics overview at Stage 20A

 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.



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**Figure 2-7. MSS WS locations**

Note: MT/Crew and Equipment Translation Aid (CETA) rails and WS 9 and WS 10 Umbilical Mechanism Assemblies (UMAs) were deleted from S5, S6, P5, and P6 per ISS Space Station Change Notice (SSCN) 009951A, approved on August 29, 2006. 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.

### 2.1.9 EVA Systems

Mission 20A has no bearing on the Extravehicular Activity (EVA) capabilities. The EVA capabilities remain the same as those discussed for the previous stage (see Table 2-9).

**Table 2-9. EVA capability summary at Stages ULF3 and 20A**

<b>System</b>	<b>ULF3 Stage</b>	<b>20A Stage</b>
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

## **2.2 MISSION 20A HARDWARE**

There is no assembly hardware, other than Node 3 and Cupola elements, flown on Mission 20A. For descriptions of the Node 3 and Cupola hardware, refer to Section 5.0. Refer to Section 3.0, Operations Summary, for more details on the integration of the hardware.

### **3.0 OPERATIONS SUMMARY**

This section summarizes the flight operations for Mission 20A.

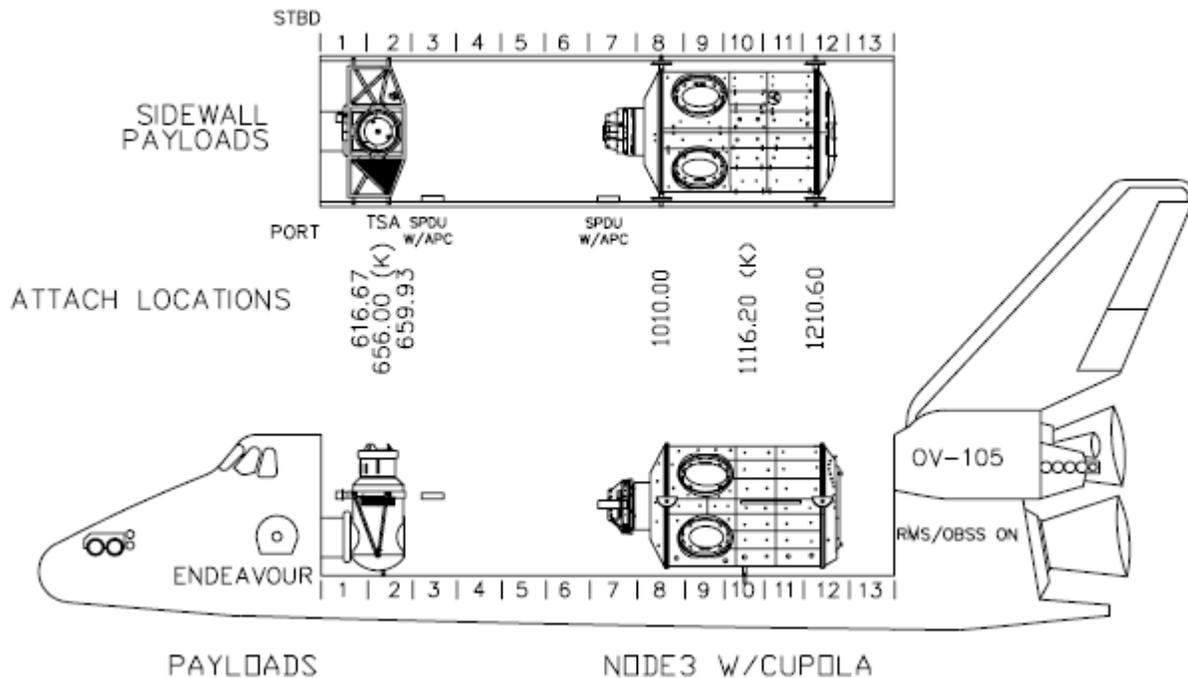
#### **3.1 20A MISSION OVERVIEW**

Mission 20A (STS-130) is launching the Space Shuttle Endeavour (Orbiter Vehicle (OV)-105). This flight consists of a six-person crew. STS-130 has a mission duration of 12 days (+1 for an unscheduled docked day, +2 days for orbiter and weather contingencies = 12+1+2). The flight provides 7 full hatch-open docked days for ISS assembly, activation, and checkout activities (a total of 9 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 payload bay 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 primary objectives for STS-130/20A are to deliver and attach the Node 3 and Cupola elements to the ISS using the ISS Robotic Arm. Node 3, with attached Cupola, is connected to Node 1. The Cupola is subsequently relocated from Node 3 PORT Common Birthing Mechanism (CBM) to Node 3 NADIR CBM. See Figure 3-1 for the launch layout of the orbiter Payload Bay (PLB), including Node 3 and Cupola.

There are three planned EVAs to perform ISS-20A Launch Package tasks as defined in NSTS 21549. See Section 3.4 for more details on the EVAs.

Reference the latest Flight Requirements Document (FRD) for STS-130 (NSTS 17462-130) for additional flight information.



**Figure 3-1. STS-130/20A payload bay layout (launch)**

## 3.2 INSTALLATION, ACTIVATION, AND CHECKOUT OPERATIONS

This section provides details on the operations required for Node 3 and Cupola installation, activation, and checkout.

### 3.2.1 Node 3 Installation

Before Node 3 is removed from the orbiter PLB, the contamination covers (eight) installed on the exterior surface of the Node 3 STARBOARD PCBM docking ring must be removed. These covers ensure that there is a clean sealing surface on the ring. Upon removal during EVA 1, the eight contamination covers are placed in two large trash bags.

Prior to unberthing of Node 3 by the SSRMS, the LTA shell heaters used to maintain the thermal environment of the node must be disconnected. These heaters are powered by the orbiter APCU via the orbiter Secondary Power Distribution Unit (SPDU). The cables connecting the shell heaters to Node 3 are removed during EVA 1.

Once Node 3 is ready for installation onto the ISS, the SSRMS is used to maneuver Node 3 from the orbiter PLB to Node 1 PORT CBM. The SSRMS maneuvers to Node 3 and grapples the module. The Payload Retention Latch Assemblies (PRLAs) and Keel latches are released, and the SSRMS subsequently maneuvers Node 3 to the Hover position. Node 3 is then maneuvered to the premate position and finally on to Node 1.

The ACBM on Node 1 port captures the PCBM on Node 3. Once bolting is complete, the SSRMS ungrapples from Node 3 and maneuvers clear.

### **3.2.2 Connect Lab Power Jumpers**

The following jumpers are installed by EVA 2 between Node 1 and Node 3:

- a. Atmospheric Revitalization System (ARS) Jumper between J40 of Node 1 and A13 of Node 3
- b. Waste water jumper between J40 of Node 1 and A02 of Node 3
- c. Fuel cell water jumper between J33 of Node 1 and A01 of Node 3
- d. MTL supply jumper between Node 1 and Node 3
- e. ML return jumper between Node 1 and Node 3
- f. 1553A/Integrated Station LAN (ISL) data jumper between J27 and J31 of Node 1 and J12 of Node 3
- g. 1553B jumper between J43 of Node 1 and J3 of Node 3
- h. MSS/video instrumentation jumper between J48 of Node 1 and J215 of Node 3
- i. MSS/instrumentation jumper (BCP) between J28 of Node 1 and J109, J121, and J122 of Node 3
- j. Ultrahigh Frequency (UHF) coax jumper between J32 of Node 1 and J20 of Node 3
- k. Audio bus A/video jumper between J29 of Node 1 and J14 of Node 3
- l. Audio bus B jumper between J41 of Node 1 and J2 of Node 3

### **3.2.3 Node 3 Activation**

Once Node 3 is installed on Node 1, Node 3 is activated and ingressed so that it becomes a functional part of the ISS. Systems that require activation are the DC-to-DC Converter Units (DDCUs), Remote Power Controller Modules (RPCMs), Space Station Multiplexer/Demultiplexers (SSMDMs), MTL, LTL, shell heaters, Pressure Control Assembly (PCA), Advanced Control Devices (ACDs), C&W panel, CCAA, General Luminaire Assembly (GLA), ATUs, and IMV valves and fans. An overview of each procedure is provided in this section.

The first task is to activate and checkout all Node 3 DDCUs and RPCMs. All of the Node 3 DDCUs (four) and RPCMs (two) are enabled by uploading a Pre-Positioned Load (PPL) to the Power Management Controller Unit (PMCU). The DDCUs are then powered on and checked out. The DDCU converters are then activated, which powers

the RPCMs. The RPCMs that are controlled by the PMCU are checked out. The Node 3 MDM (HCZ)-1 MDM is activated and then transitioned to operational state. Lastly, all of the remaining RPCMs are checked out.

After checking out the DDCUs and RPCMs, the Node 3 SSMDM N3-1 is activated and checked out. Once the power has been applied to the MDM, an automatic initialization sequence takes place, then the MDM transitions itself to Operational state. Once this initialization is completed, HCZ-1 and the N3-1 MDM are communicating, and an essential checkout takes place. Finally, the Remote Terminal (RT) Fault Detection, Isolation, and Recovery (FDIR) is enabled. This procedure is repeated for SSMDM N3-2.

Node 3 MTL provides active cooling to both Node 3 avionic racks (N3O4 and N3O5), and once the MTL has been verified to be properly operating, all the thermal clocks associated to the avionics equipment being active with no active cooling end. Once activated, all Node 3 MTL components (Pump Package Assembly (PPA), System Flow Control Assembly (SFCA), and Cargo Transfer Bag (CTB) Three-Way Mixing Valve (TWMV)) are powered.

The Node 3 CCAA can be activated by the crew or the ground to supply cabin ventilation for Node 3 ingress as soon as the MTL is activated. The active Node 3 CCAA also enables smoke detection functionality for the Node 3 cabin Area Smoke Detectors (ASDs).

LTL provides active cooling to the Node 3 CCAA. The activation procedure includes the powering of all LTL components (SFCA Shutoff Valve (SOV), SFCA Flow Control Valve (FCV), Three-Way Mixing Valve (TWMV), LTL Pump Package Assembly (PPA), and LTL Nitrogen Interface Assembly (NIA)) and the activation of the LTL.

The Node 3 shell heater close loop control that runs within HCZ MDM should be activated so that the Node 1 to Node 3 LTA heaters are no longer needed. The temperature measurements that are relevant to the Node 3 shell zones are acquired by N3-1 and N3-2 MDMs. The temperature sensor data are passed from Node 3 MDMs to the HCZ MDM where they are then compared to the ON/OFF thresholds. Once the Node 3 shell heater control laws are enabled, the HCZ MDM automatically commands the RPCM switches to open/close in accordance with the shell heater control laws.

The activation of the CPA begins with the application of power to the Node 3 PCA. This action initiates an automated startup process to bring the Node 3 PCA up to the "Monitor" state. During startup, the PCA runs Power-On Built-In Test (PBIT) covering initialization of the Cabin Pressure Sensor (CPS), a check of the vent relief and introduction valve positions, and closure of the valves, if necessary. There is no checkout of the O2/N2 Introduction Valves (OIVs/NIVs). This activation occurs prior to crew ingress and Temperature and Humidity Control (THC) activation because the pressure inside the module must be known to meet minimum activation pressure constraints on some of the Node 3 hardware.

The two smoke detectors for Node 3 are activated by commanding the RPCM open, commanding the Node 3 MDM-1 and Node 3 MDM-2 to enable monitoring of the ASD1 and ASD2, respectively, and verifying both ASD1 and ASD2 are operating nominally. Following the activation of the two smoke detectors, Node 3 fire safing response can be enabled.

The Node 3 C&W panel is activated by closing RPCM N31B4A-2E switch 05, which allows power to be distributed to the N3-1 MDM Solenoid Driver Output (SDO) card. The panel is then checked out by depressing the C&W panel test button and verifying the illumination of five lights. This should be performed as soon as possible after the Node 3 ingress, or it may also be performed as soon as Node 3 is activated. The checkout of the C&W panel is only a checkout of the lights and not the C&W system.

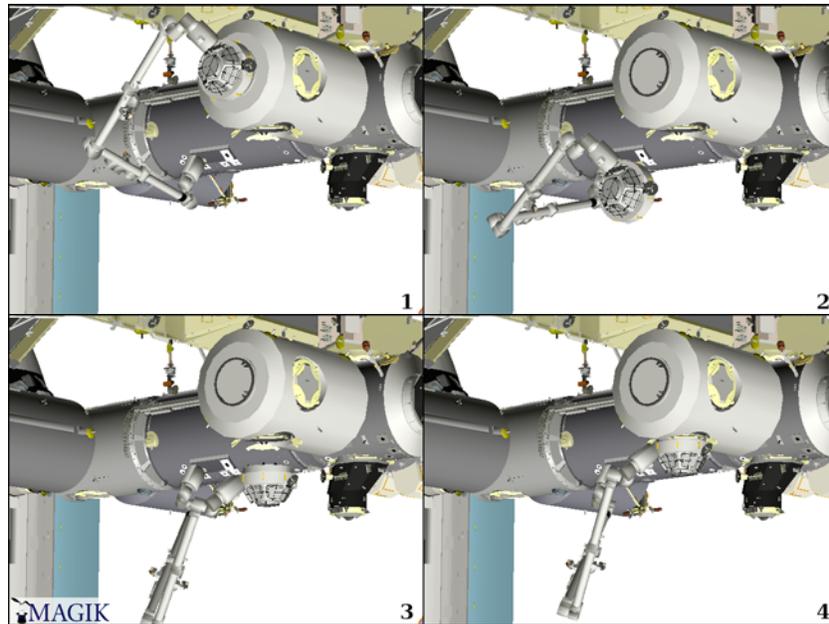
The Node 3 GLAs are activated by closing the RPCM switches and applying power. The GLAs are configured before launch and turn on as soon as power is applied. They are set on the “full bright” position. Once the power is applied, the crew visually verifies that the GLAs are illuminated.

Node 3 audio and video equipment is activated to prepare for crew ingress. Power is applied to Audio Bus Couplers (ABCs) 5 and 6. ATUs 16 and 17, Video Switch Unit (VSU) 5, and the Common Video Interface Unit (CVIU) 3 are all activated and checked out.

The Node 3 IMV is activated by the crew or the ground after the two STARBOARD IMV valves have been installed and connected to Node 3 THC ducting, the vestibule ducting has been installed connecting Node 1 to Node 3, and the Node 1 IMV modification kit is installed. Once activated, the IMV establishes intermodule ventilation with Node 1 and the U.S. Lab.

### **3.2.4 Cupola Relocation**

To facilitate transportation to the ISS, the Cupola was installed on Node 3 PORT ACBM. The desired location for the Cupola once Node 3 has been attached to Node 1 is on Node 3 NADIR ACBM. The SSRMS is used to grapple and relocate the Cupola (Figure 3-2).



**Figure 3-2. Cupola relocation**

Prior to the grappling of the Cupola by the SSRMS, the Cupola must be prepared for unberthing. This procedure consists of the deactivation and stowing of Cupola systems and the disconnection of utilities and lines. The Cupola Circuit Card Assembly (CCA), MLI, and ACBM are then installed prior to depressurization of the Cupola via Node 1 PORT Positive Pressure Relief Valve (PPRV)/Pressure Equalization Valve (PEV).

### **3.2.5 Cupola Activation**

Once the Cupola has been berthed to Node 3 NADIR ACBM, it is ready to be activated. The Cupola is initially pressurized via the PPRV/Manual Pressure Equalization Valve (MPEV). The Cupola MLI and CCA are then removed and stowed, and temporary air circulation and lighting are established. Utilities, heaters, ventilation, and Cupola systems are then activated. Once portable lighting and ventilation are functioning, the temporary air circulation and lighting can be deactivated.

### **3.3 EVA OPERATIONS SUMMARY**

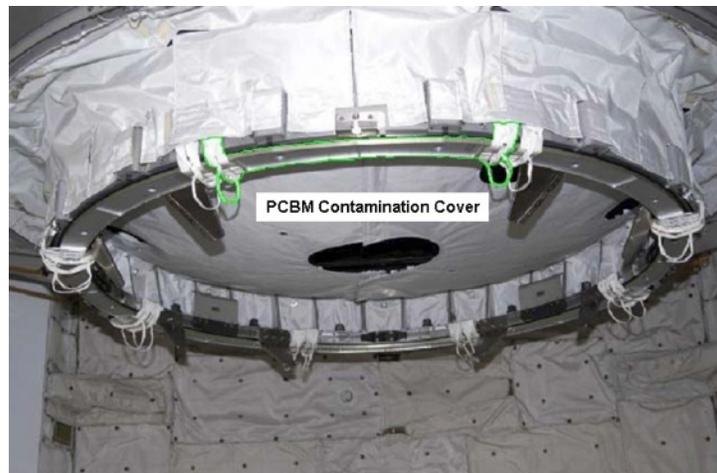
Details on each of the 20A EVA tasks are given in this section. An overview of the tasks for each EVA is given in Table 3-1. Reference the EVA checklist for the latest plan.

**Table 3-1. EVA task overview**

EVA	Tasks
1	<ul style="list-style-type: none"> <li>• Node 3 prep for unberth</li> <li>• Connect Node 3 LTA heaters to Node 1</li> <li>• Connect S0 umbilicals to Node 3</li> </ul>
2	<ul style="list-style-type: none"> <li>• Install Node 3 MLI keel and trunnion covers</li> <li>• Connect ammonia jumpers between Node 3 and U.S. Lab and open loop A QDs</li> <li>• Node 3 slidewires, handrails and WIF installations</li> <li>• Node 3 ACO NPV installation</li> </ul>
3	<ul style="list-style-type: none"> <li>• Cupola tasks post relocation</li> <li>• Open loop B QDs</li> <li>• Disconnect Node 3 LTA heaters to Node 1</li> </ul>

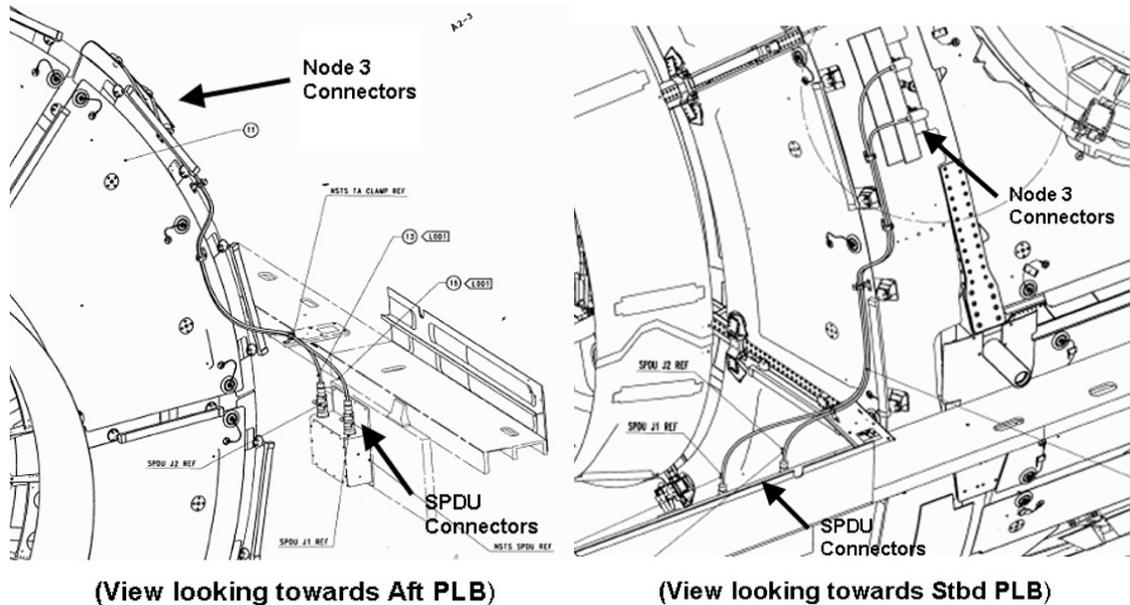
**3.3.1 Node 3 Prep for Unberth**

The first task to prepare Node 3 for unberthing is the removal of eight STARBOARD PCBM contamination covers (Figure 3-3). This EVA requires one Extravehicular (EV) crewmember to translate to bay 13 within the orbiter PLB. The crewmember has two trash bags used to stow the removed contamination covers.



**Figure 3-3. Typical PCBM contamination cover (U.S. Lab - Flight 5A)**

The LTA heater umbilicals (Figure 3-4) that provide heat to Node 3 while inside the orbiter PLB must be disconnected prior to the unberthing of Node 3. This task requires one EV crewmember and may be executed in parallel with the removal of the contamination covers.



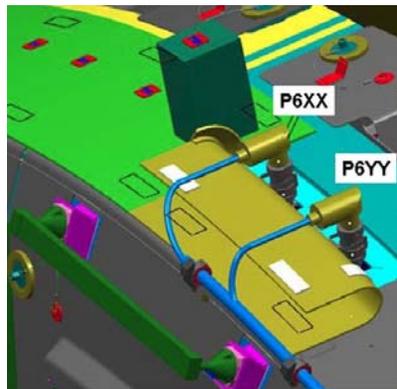
**Figure 3-4. Node 3 to orbiter LTA heater umbilicals (launch config)**

To disconnect the LTA heater umbilicals, the EV crewmember translates along orbiter PLB to orbiter port bay 7 and sets up an orbiter Portable Foot Restraint (PFR) and ingresses. Before the umbilicals are disconnected, orbiter APCUs 1 and 2 should be inhibited, and the LTA heaters should be deactivated. The LTA heater umbilicals can then be released from the EVA clamps on the orbiter, and the umbilicals from the orbiter SPDU connectors (W013P1, W014P1) can be disconnected from receptacles J1 and J2. Similarly, the LTA heater umbilicals from the three EVA clamps mounted on Node 3 STBD endcone can then be released. The crewmember then must temporarily remove the MLI cover (Figure 3-5) installed over the LTA heater connectors at the Node 3 STARBOARD stanchion to allow access to the Node 3 LTA heater connectors J6XX and J6YY.



**Figure 3-5. LTA heater connectors MLI cover**

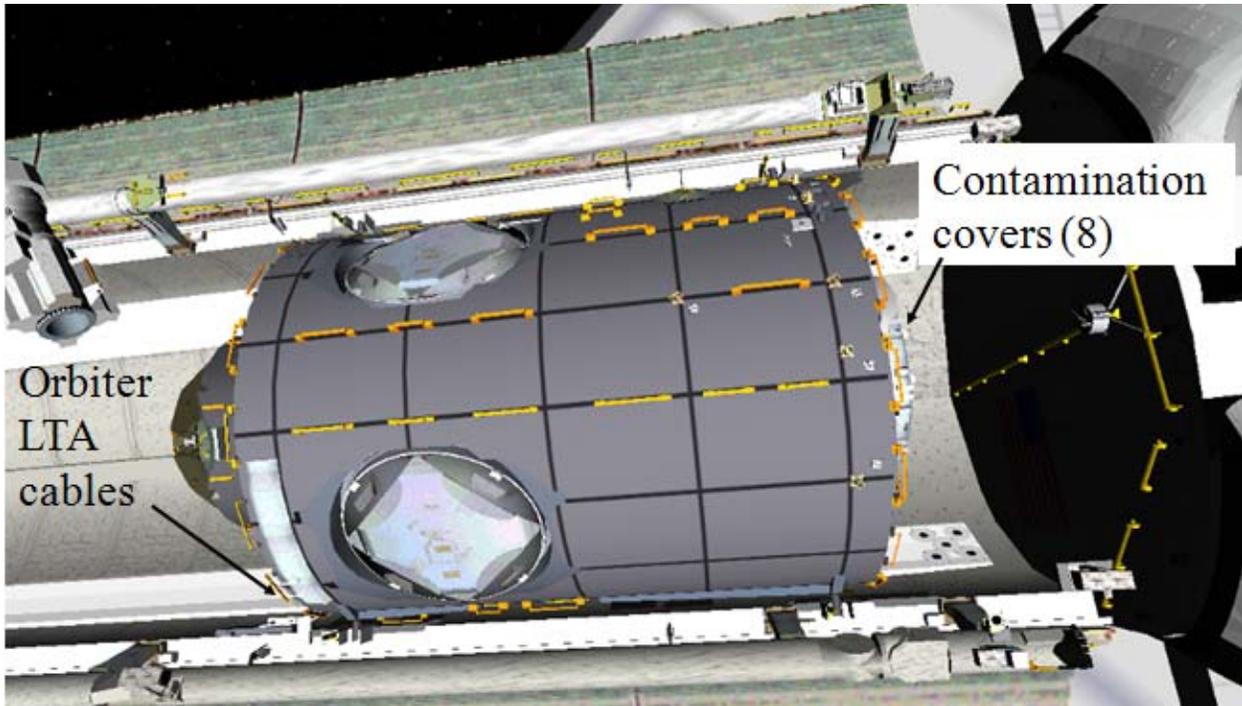
The EV crewmember then pulls back MLI booties over P6XX/W013P2, P6YY/W014P2 LTA heater umbilical connectors (Figure 3-6) and disconnects them from the Node 3 receptacles J6XX, J6YY.



**Figure 3-6. Heater connectors P6XX, P6YY**

The crewmember then installs dust caps on Node 3 receptacles J6XX and J6YY before reattaching and untethering the MLI cover over the Node 3 LTA heater connector stanchion. The crewmember then egresses the orbiter foot restraint (PFR) and temporarily stows the LTA heater umbilicals for disposal.

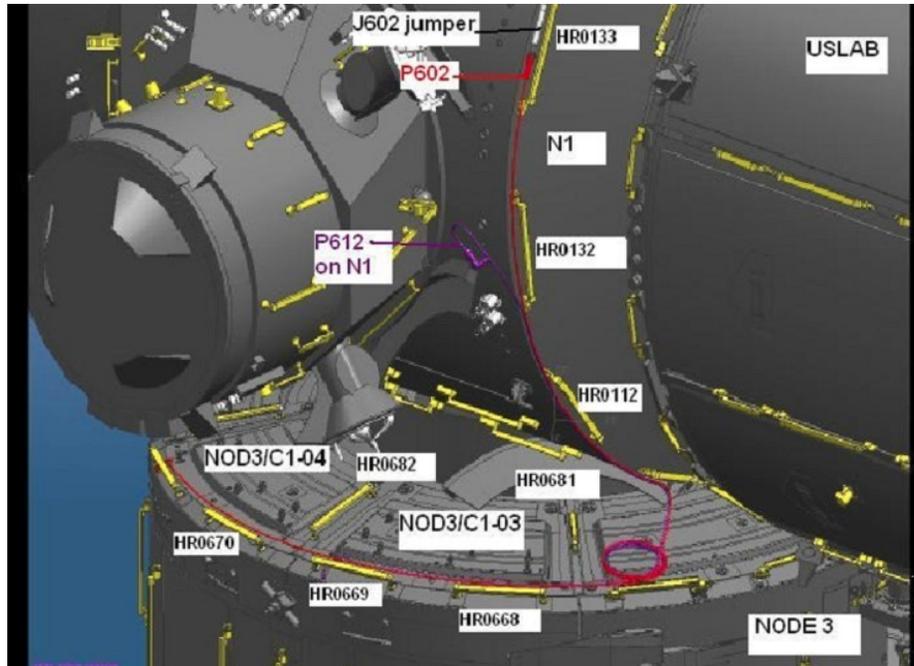
Figure 3-7 shows the locations of the contamination covers and heater cables in relation to the PLB.



**Figure 3-7. Contamination covers and heater cables**

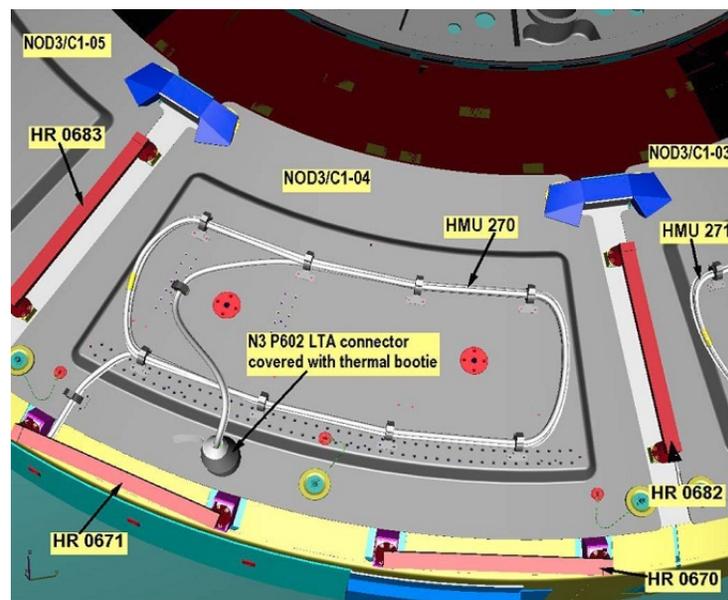
### **3.3.2 Connect Node 3 LTA Heaters to Node 1**

After berthing to the ISS, Node 3 LTA heaters must be temporarily connected to a power supply on Node 1 to prevent the capsule from freezing. Connectors J602 and J612 (Figure 3-8) provide the power source from Node 1 to Node 3. This EVA task requires two EV crewmembers (EV1 and EV2). Power to connectors J602 and J612 must be turned off prior to the following procedure.



**Figure 3-8. Node 3 LTA heater umbilicals overview**

The first task is to release the 10 Thruster Assist (TA) clamps securing LTA umbilical (HMU) 270 located on Node 3 Micrometeoroid/Orbital Debris (MMOD) shield NOD3/C1-04 (Figure 3-9). The crewmember then removes HMU 270 from the clamps and closes the clamps.



**Figure 3-9. LTA Umbilical HMU 270 P602 launch configuration**

**Verify that this is the correct version before use**

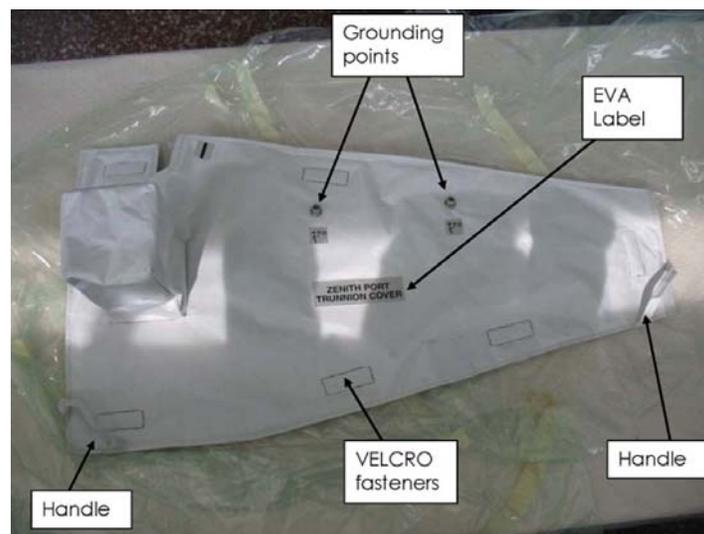
EV1 then demates P602 from the dummy receptacle and routes the LTA umbilical HMU 270 on Node 3. EV1 then translates with HMU 270 across to Node 1, as required to reach microjumper ESP2-W1 J602 connector at Node 1 HR 0133. P602 is then mated to Node 1 J602. Next, EV1 restrains HMU 270 on Node 1 and Node 3 before translating to Node 1 J612 worksite to demate the A/L power connector from Node 1. EV1 then translates to Node 3 WIF-07 and releases the LTA umbilical (HMU 271) EVA clamps on Node 3 before closing the clamps.

Likewise, the routing of HMU 217 and mating of P612 is also performed.

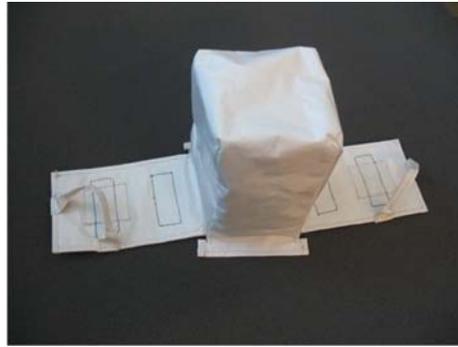
In a later EVA, the Node 3 P612 connector is demated from Node 1, and the airlock P612 connector is remated to Node 1.

### 3.3.3 Install Node 3 MLI Keel and Trunnion Covers

Four trunnions and one keel pin constitute the interface between Node 3 and the orbiter while Node 3 is installed in the PLB. After Node 3 has been berthed to Node 1, MLI covers must be installed on these structures to protect them from the thermal environment. The trunnion covers (Figure 3-10) are secured using Velcro fasteners and two electrical grounding fasteners. The keel pin cover (Figure 3-11) is essentially a box with flaps that covers the keel pin and is attached by two types of Velcro fasteners (HI-MEG and HI-AIR). The HI-MEG fasteners are protected prior to installation on the keel pin by two MLI flaps. These flaps must be opened prior to the installation of the keel pin cover. This EV requires a single crewmember to translate via SSRMS to the trunnion/keel pin worksites located on Node 3 and install the five covers.



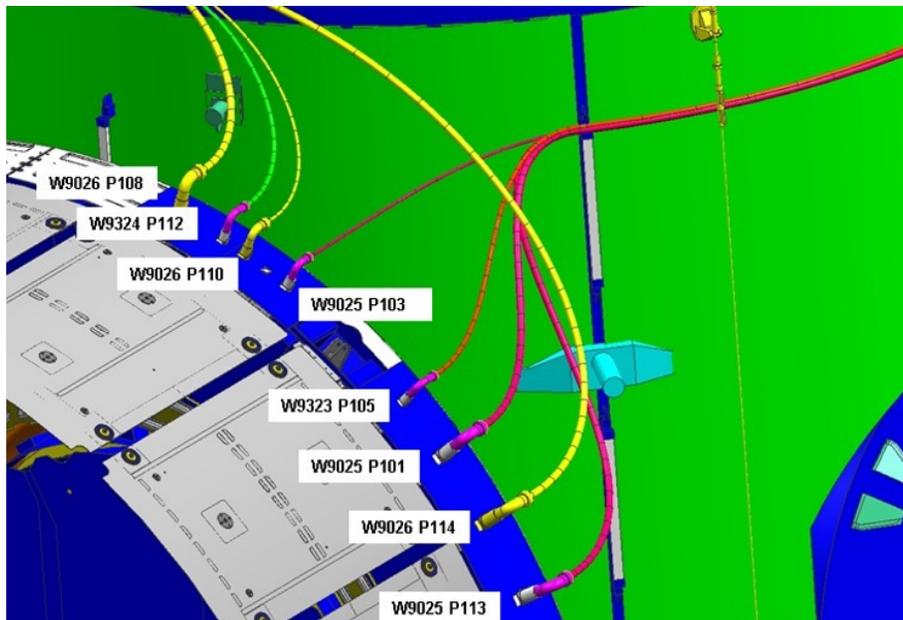
**Figure 3-10. Trunnion MLI cover**



**Figure 3-11. Keel pin MLI cover**

### 3.3.4 Connect S0 Umbilicals to Node 3

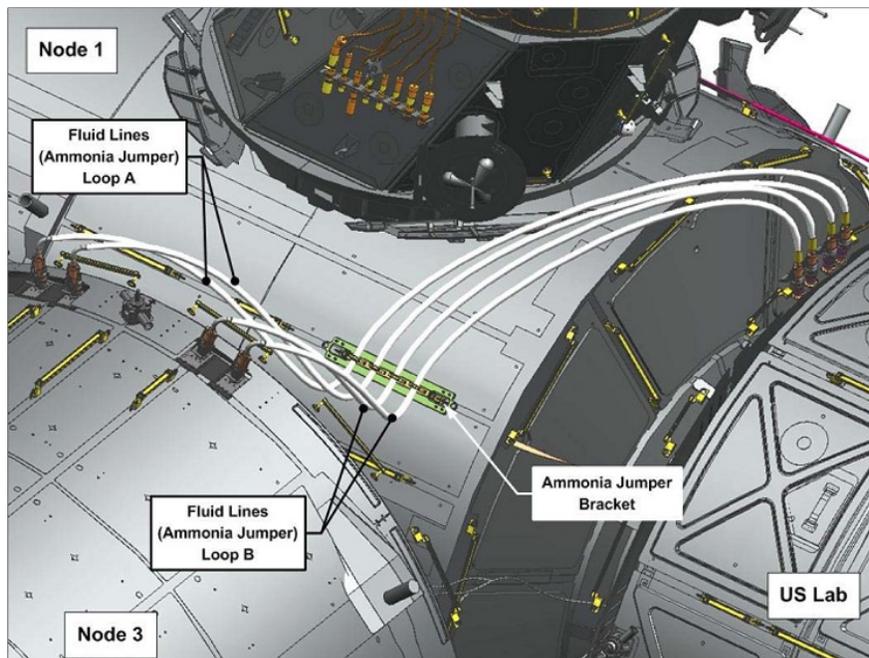
This EVA is performed by a single EV crewmember to mate avionics cables (Channel 2/3) and (Channel 1/4) to Node 3 (Figure 3-11). Both cables must be powered off prior to unstowing the cables from Node 1 and mating them to Node 3.



**Figure 3-12. Avionics cable connectors on Node 3  
(channel 2/3 - light, channel 1/4 - dark)**

### 3.3.5 Connect Ammonia Jumpers between Node 3 and Lab

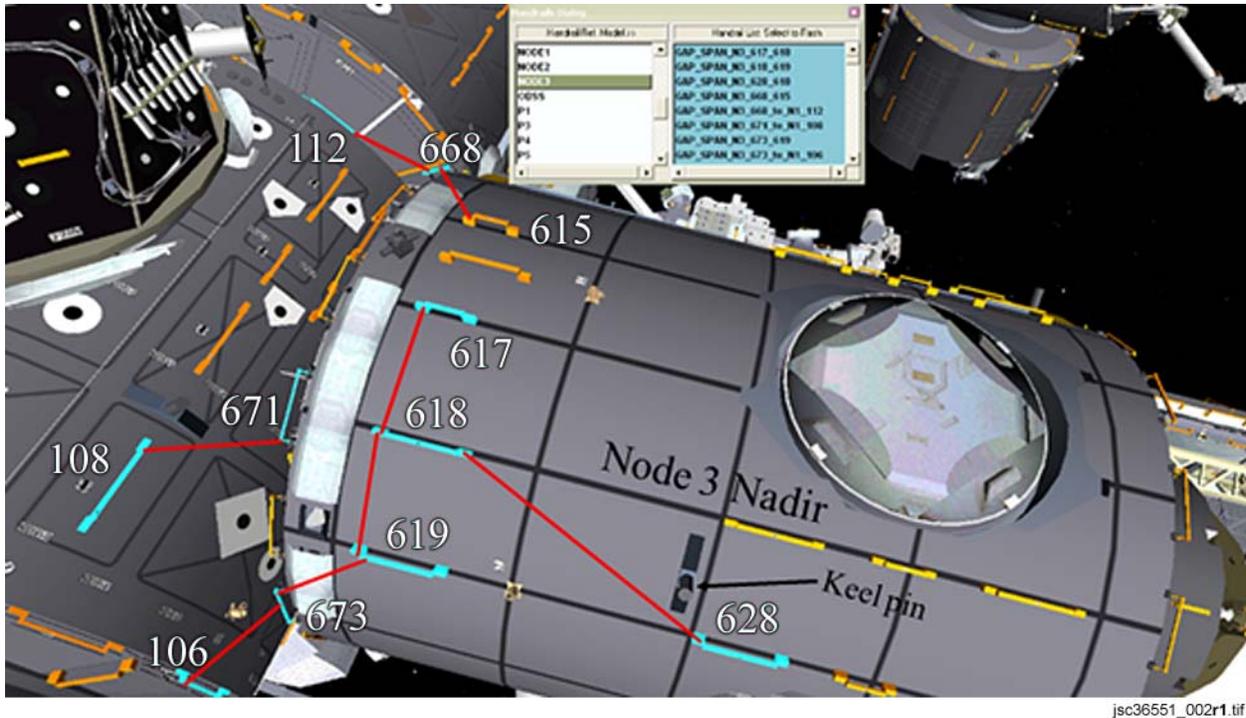
This EVA task is performed by two EV crewmembers to connect the U.S. Lab ammonia jumpers to Node 3. The jumpers (loops A and B) are mated to both the U.S. Lab and Node 3 (Figure 3-13) and are secured to a bracket located on Node 1. After mating, an insulating jacket is installed on the jumpers. Also, the U.S. Lab loop A QD is opened to allow NH<sub>3</sub> flow from the loop A ETCS to the Node 3 MT HX.



**Figure 3-13. Node 3 to U.S. Lab ammonia jumpers overview**

### 3.3.6 Node 3 Slidewires, Handrails, and WIF Installations

Two EV crewmembers are required to install Node 3 handrails (14), WIFs (3), and gap spanners (8). An additional IV crewmember is needed to operate the SSRMS during this EVA. (See Figure 3-14.)

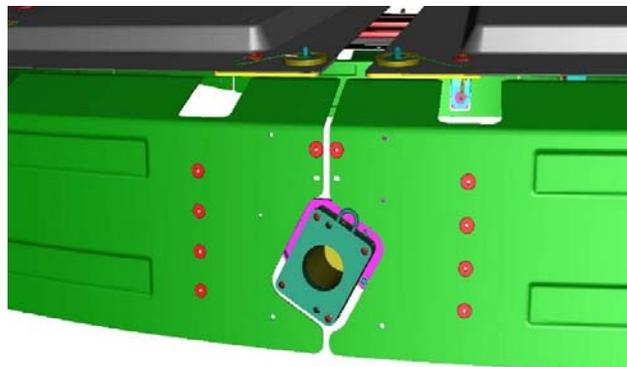


**Figure 3-14. Handrails and gap spanners**

### 3.3.7 Node 3 ACO NPV Installation

Once the Cupola has been berthed to Node 3 NADIR ACBM, the ACS Vent Relief Valve (VRV) can be installed by a single EV crewmember using the SSRMS. An IV crewmember is required to support the EVA by operating the SSRMS.

The procedure consists of releasing the four vent flange cover bolts and removing the vent flange cover (Figure 3-15) using a Pistol Grip Tool (PGT). The vent flange cover can be stowed on the fish stringer.



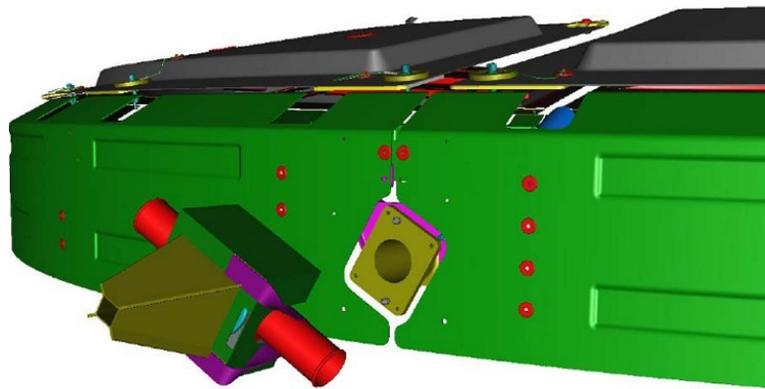
**Figure 3-15. Vent flange protective cover**

**Verify that this is the correct version before use**

### 3.3.8 Cupola Tasks Post Relocation

Following the relocation of the Cupola from Node 3 PORT CBM to Node 3 NADIR CBM via the SSRMS, a series of tasks are required to complete the installation of the Cupola. The Cupola is pressurized via Positive Pressure Relief Valve (PPRV)/Manual Pressure Equalization Valve (MPEV), and temporary air circulation and lighting is established. The bulkhead is then connected to the Cupola utilities, and the heaters are activated. Next, the Cupola HTL is filled with water, intermodule ventilation is established, and the portable light is turned on. The temporary air circulation and lighting can then be deactivated. The RWS and Portable Computer System (PCS) #2 are then activated.

The ACS Non-Propulsive Vent (NPV) (Figure 3-16) can then be installed by tightening four bolts. The EV crewmember then closes the ACS NPV thermal cover “pyramid” lid, securing the Velcro fasteners.



*Figure 3-16. ACS NPV*

### 3.3.9 U.S. Lab Loop B ETCS QDs Open

The EV crew opens the U.S. Lab loop B ETCS QDs to enable NH<sub>3</sub> flow from ETCS loop B to the Node 3 HX.

## 3.4 MIDDECK PAYLOADS

### 3.4.1 General Laboratory Active Cryogenic ISS Experiment Refrigerator

The General Laboratory Active Cryogenic ISS Experiment Refrigerator, also referred to as 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.

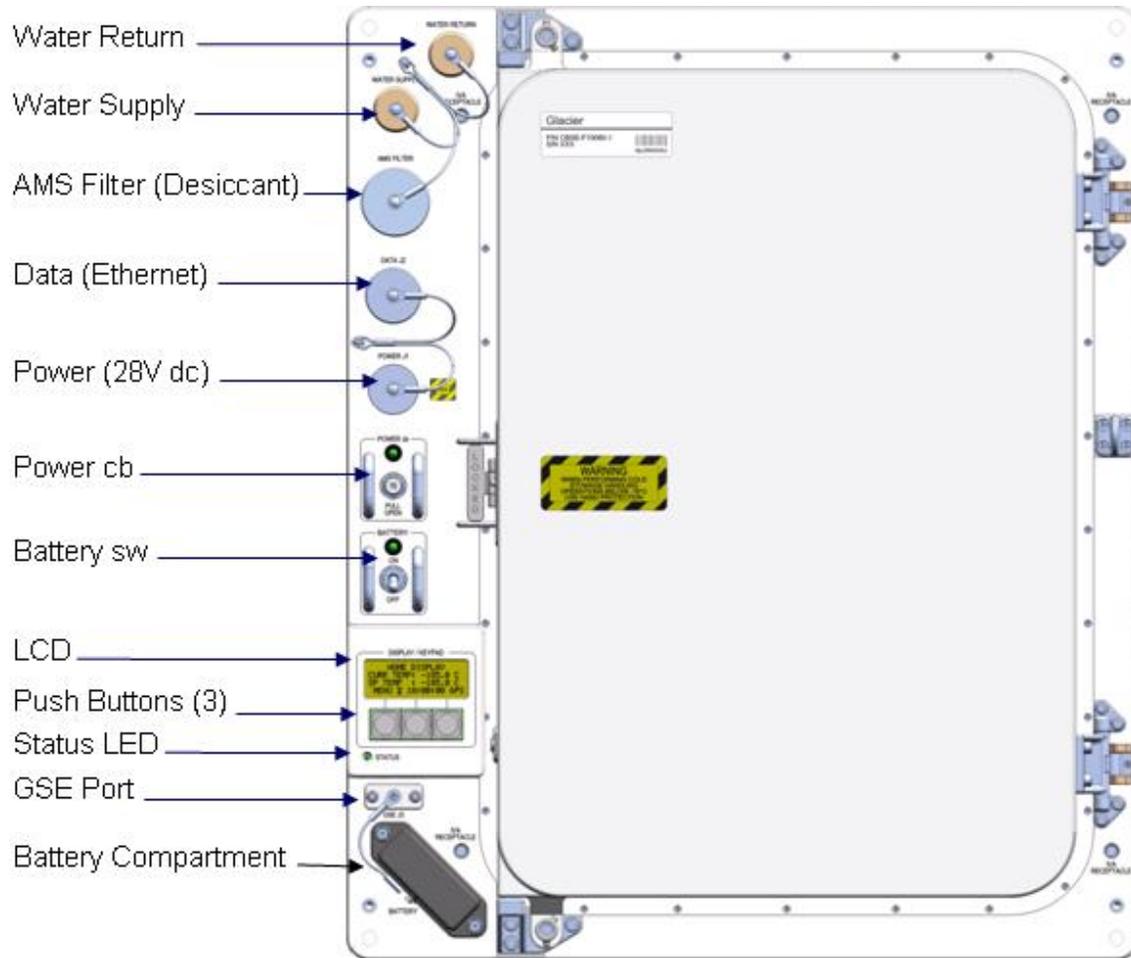
Glacier is designed to support experiments that require thermal control between +4° and -160° C.

Glacier is continuously powered by the nominal 28 V dc, 20-Amperes (A) source from Middeck Utility Panel (MUP) in the orbiter middeck. Power outage for preservation of samples should be limited to 30 minutes. Door openings for preservation of samples should be limited to the shortest time 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 starting on the day of launch, prior to crew sleep, then twice a day each day following. The desired separation of these status checks is 8 to 12 hours. A status check is required within 2 hours after the door opening to verify that the Glacier is ramping toward the set-point temperature.

Other nominal crew operations include hardware preparation for sample transfers, sample removal/insertion, swapping the middeck Glacier unit with the Glacier unit located in Express Rack 6 (ER6), and hardware configuration for landing.

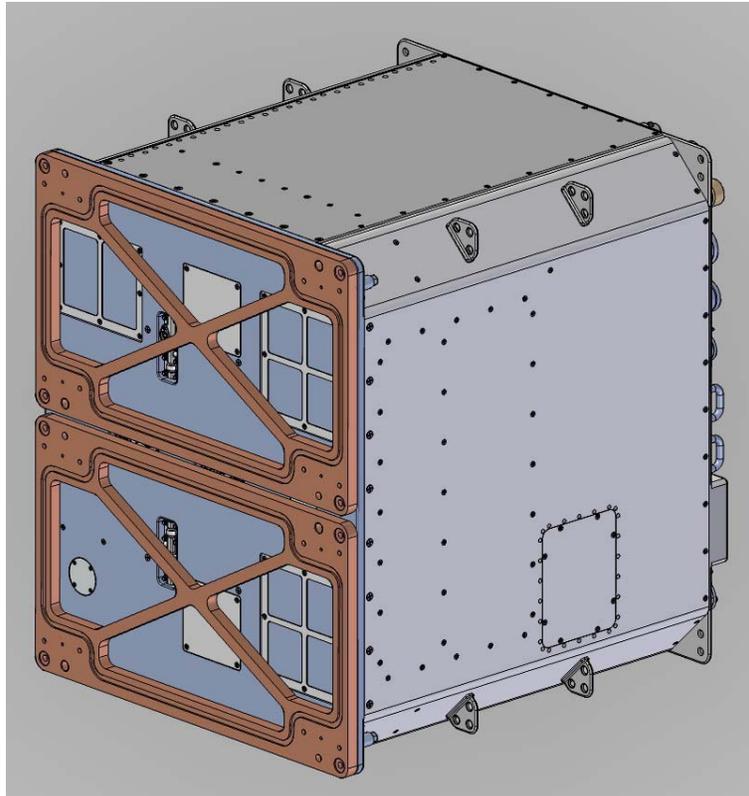
The Glacier front panel is shown in Figure 3-17.



**Figure 3-17. 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 3-18) but can be configured to use one VPMP and one Payload Mounting Panel (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.



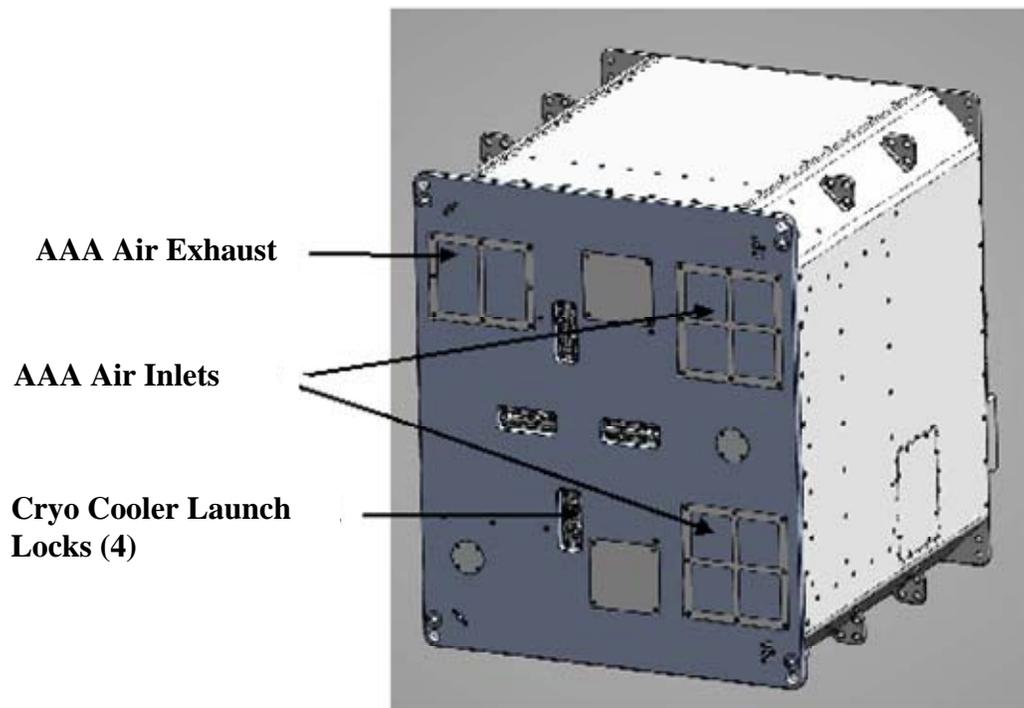
**Figure 3-18. Glacier with VPMP mounted**

Glacier is designed to accommodate 14.3 lb (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. Once Glacier is installed in the U.S. Lab 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 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 ER6 (LAB1O4). (See Figure 3-19.) 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 the 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 3-19. Glacier backplate**

### **3.4.1.3 Power Interface**

Glacier is powered by nominal 28 V dc, 20-A power resource from the orbiter middeck. Glacier has an estimated peak power consumption of 215 Watts (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. Once 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.

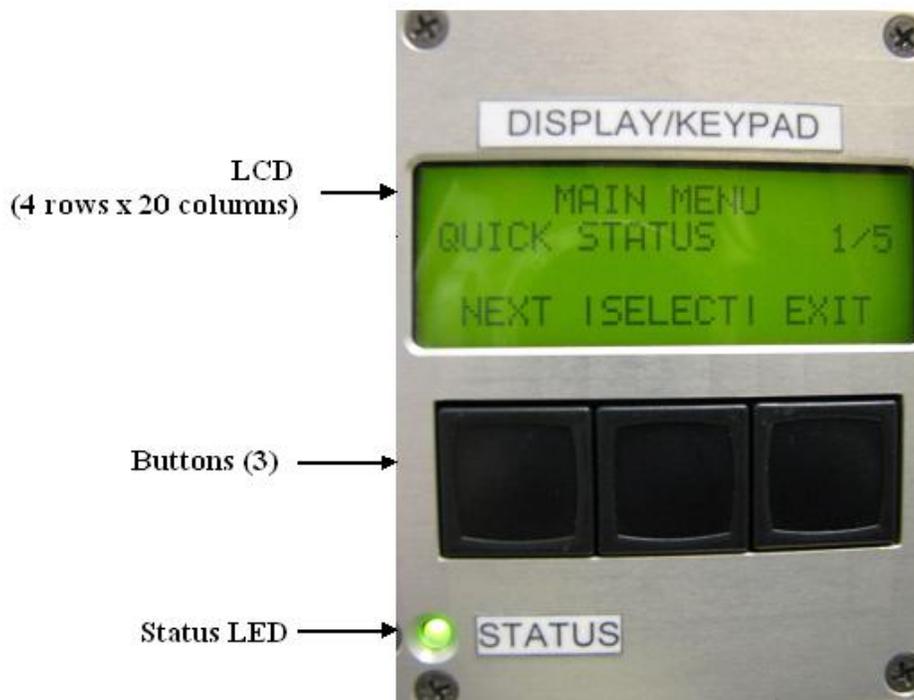
When 28 V dc power is interrupted, Glacier uses two disposable 9-V alkaline batteries to provide up to 96 hours of temperature data logging capability. The battery power circuit is fused at 1 A (1/2 A per battery). Battery logging backup is enabled by turning on the battery toggle switch on the front 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 3-20.)



**Figure 3-20. 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 a visual indication of the power status (main power and battery) and command activity. The STATUS LED blinks when there is an error detected.

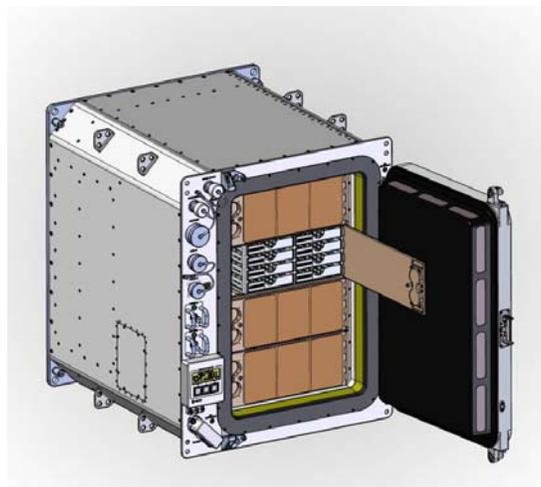
The main software functions of Glacier are thermal control, air management, health and status, communication, command, and control.

### 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 3-21 shows details of the outer door configuration and inner aperture doors.



**Figure 3-21. 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 contained within a canister with filter paper at the air entrance and exit. These filters trap particles down to the micron range to control the release into the crew environment. Since the Glacier is powered at turnover, 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 -18° C.

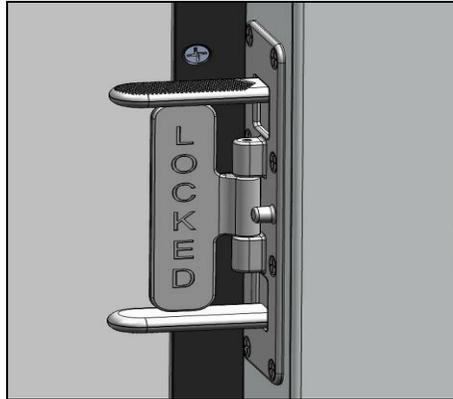
#### **3.4.1.7 Glacier Mechanisms**

Glacier uses five types of mechanisms, and 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; the cryocooler launch/landing locks are considered necessary for mission success.

The following descriptions provide an overview of the Glacier mechanisms:

##### **a. Door latch**

The Glacier door latch (see Figure 3-22) consists of the system necessary to gain access to the experiment volume contained within the Glacier and 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 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 3-22. 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 prior to landing.

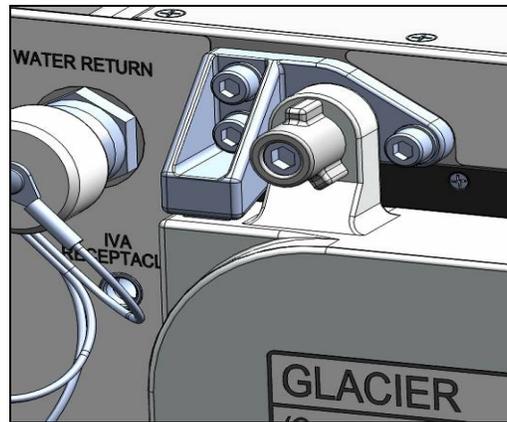
b. Door captive locks

The Glacier door also contains two captive locks or fasteners (see Figure 3-23) 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 required, the crew unlocks the door captive locks prior to sample transfer. The locks have a limited lifetime of five cycles, so once disengaged, the locks should not be reengaged until just prior to landing.

c. 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.

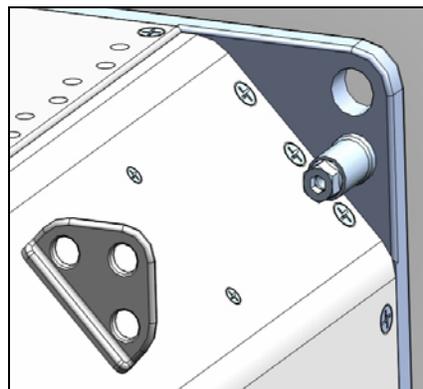


**Figure 3-23. Door captive lock (quantity of two)**

The door hinge mechanism is used to provide positive retention of the door in the open position during microgravity operations. The front panel incorporates a door retention spring and 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. Once the door goes past that point, it is prevented from returning to the closed position without active crew intervention.

d. VPMP/locker captive fasteners

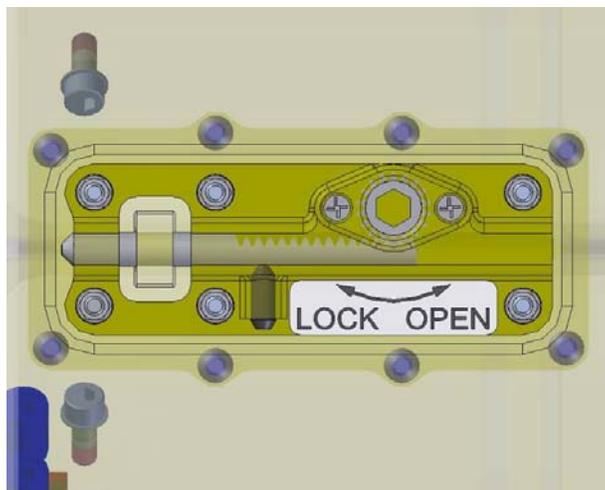
For launch and landing in the middeck, Glacier attaches to two mounting panels, in two places on each panel, by means of four captive fasteners, one in each corner (see Figure 3-24). Glacier uses these captive fasteners for all structural attachments, and they are required to be installed before launch or landing. The captive fasteners are replaced after each flight.



**Figure 3-24. Locker captive fasteners (quantity of four)**

e. Cryocooler launch/landing locks

Cryocooler launch/landing locks (see Figure 3-25) 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 of which 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.



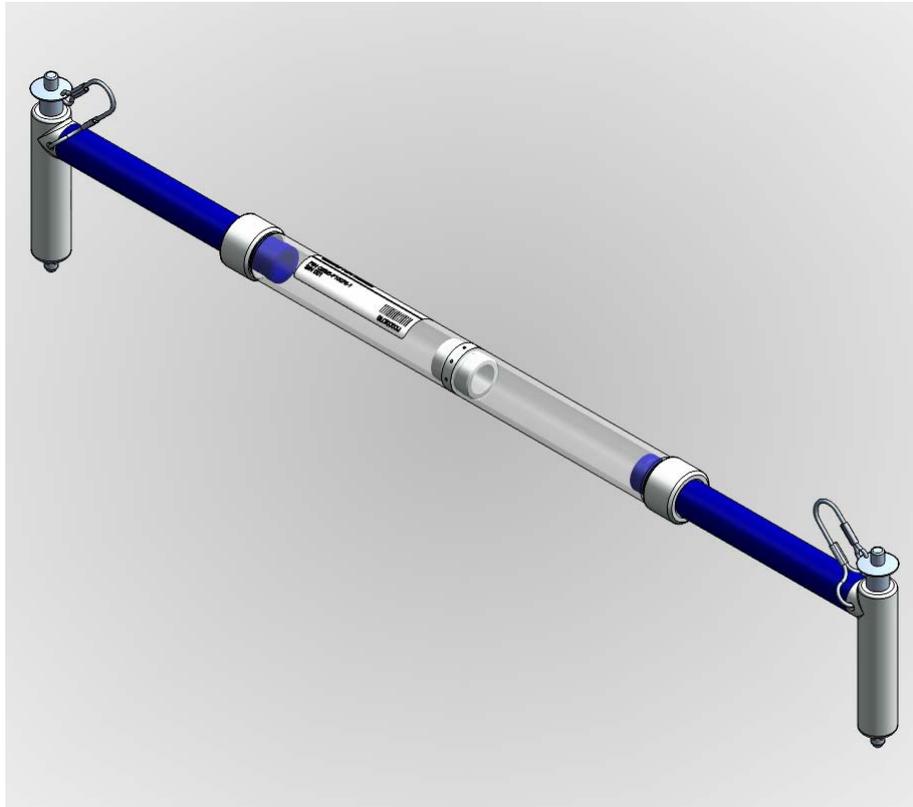
**Figure 3-25. Cryocooler launch/landing locks**

f. Glacier Intravehicular Activity handle assembly

A Glacier IVA handle, Figure 3-26, 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 3-26. IVA handle assembly**

#### **3.4.1.9 Flight History**

STS-127/2JA was 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 ER6 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 ER6. STS-127/2JA repeated the process; a new Glacier unit was launched in the middeck and swapped with the Mission-15A unit in ER6. Glacier is manifested on STS-127/2JA, STS-128/17A and STS-129/ULF-3.

#### **3.4.1.10 Flight-Specific Operations**

For STS-130/20A orbiter middeck operations, Glacier operates on air cooling with its thermal control system set to -95° C from prelaunch through postlanding.

### **3.4.2 Commercial Generic Bioprocessing Apparatus**

The Commercial Generic Bioprocessing Apparatus (CGBA) is used for the temperature-controlled stowage and computerized autonomous processing of biological samples in a microgravity environment. It has been designed as a generic research tool capable of supporting a wide variety of life science experiments. The objective of CGBA is to gather data on the effects of gravity on biological systems in the arena of applied life sciences research with commercial potential.

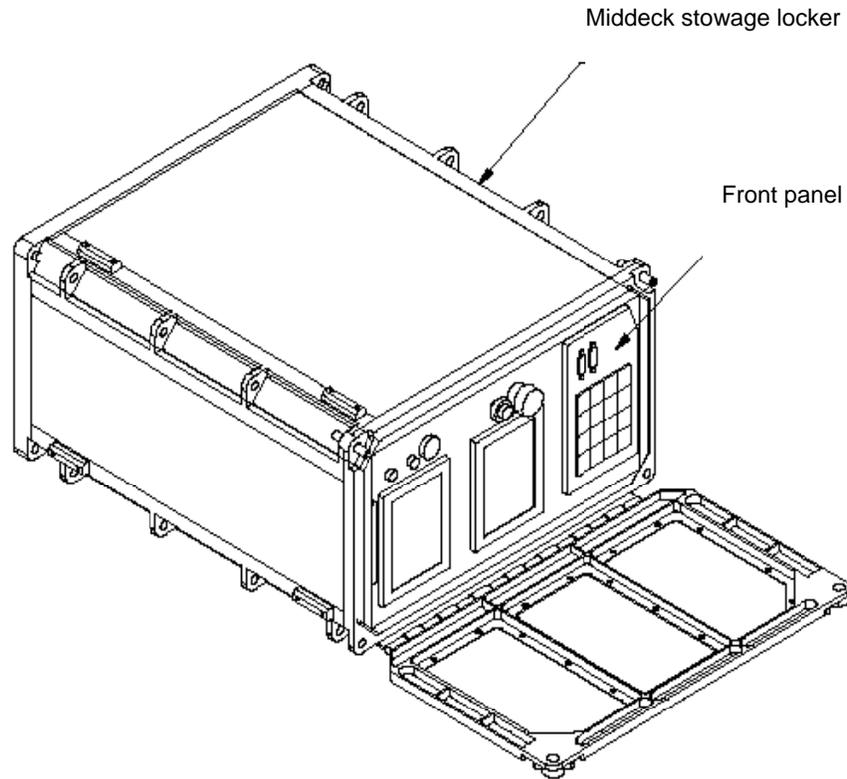
CGBA hardware has flown on STS-50, STS-57, STS-60, STS-62, STS-63, STS-69, STS-73, STS-77, STS-79/MIR/81, STS-86/MIR/89, STS-93, STS-95, STS-106, STS-100/Inc2/STS-105, STS-110, STS-111, STS-112, and STS-126. CGBA is manifested on STS-129.

#### **3.4.2.1 Hardware**

The CGBA is a self-contained incubation and refrigeration module used to stow and process several types of experiments in microgravity. The CGBA payload is housed in a single middeck locker while on the orbiter. (See Figure 3-27 and Figure 3-28.)

#### **3.4.2.2 Structural**

The CGBA housing is a lightweight aluminum/insulation clad box. Its dimensions are 20.3 by 10.75 by 18.13 in. Its weight varies, but, when fully loaded with samples, its mass and Center of Gravity (CG) can be accommodated by a single middeck locker. As it is a locker insert, the two latch mechanisms on the front of the program-provided modified locker door secure the CGBA in place. The modified locker door allows for air intake, air exhaust, and keypad access. Refer to Figure 3-27 for an overview of the CGBA locker insert.



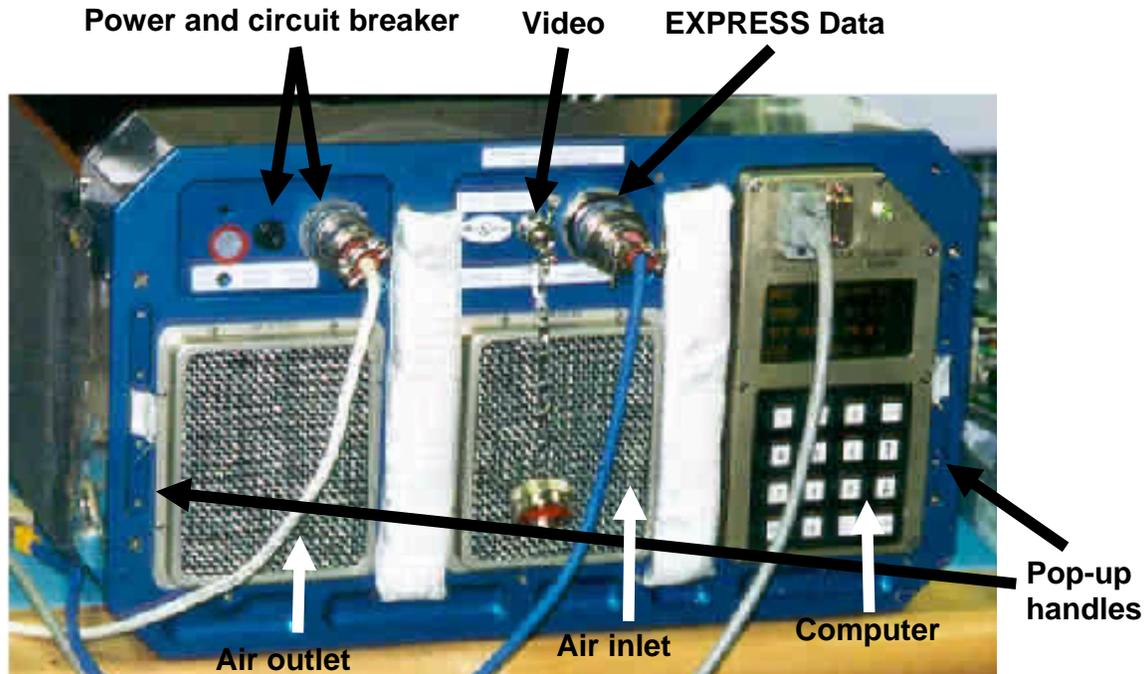
**Figure 3-27. Drawing of CGBA inside of a middeck locker**

The front portion of the housing (see Figure 3-28) contains the electronics and thermal and crew interfaces subsystems, while the back portion includes the temperature-controlled incubator volume with the experiment.



***Figure 3-28. View of sample volume versus subsystem volume***

The CGBA intakes and exhausts air from screens located on its front side.  
(See Figure 3-29.)



**Figure 3-29. Front of CGBA**

### 3.4.2.3 Electrical

The CGBA requires 28 V dc power from the orbiter, although supply variations from 24 to 32 V dc are tolerable. It has peak and steady state power consumption of 110 W and 55 W, respectively. (At full cooling capacity (-4° C), it can have a 130 W peak.) CGBA contains a small internal battery. This battery provides backup for computer memory, but it does not power the CGBA refrigerator hardware. If the CGBA is unpowered for more than 30 minutes, science may be adversely affected due to temperature increase or decrease. The CGBA uses wire gauge and connectors sized for an EXPRESS Rack. Therefore, a Direct Current (DC) jumper cable adapter is required to attach the orbiter power cable to the CGBA. Figure 3-30 is a CGBA electrical schematic.

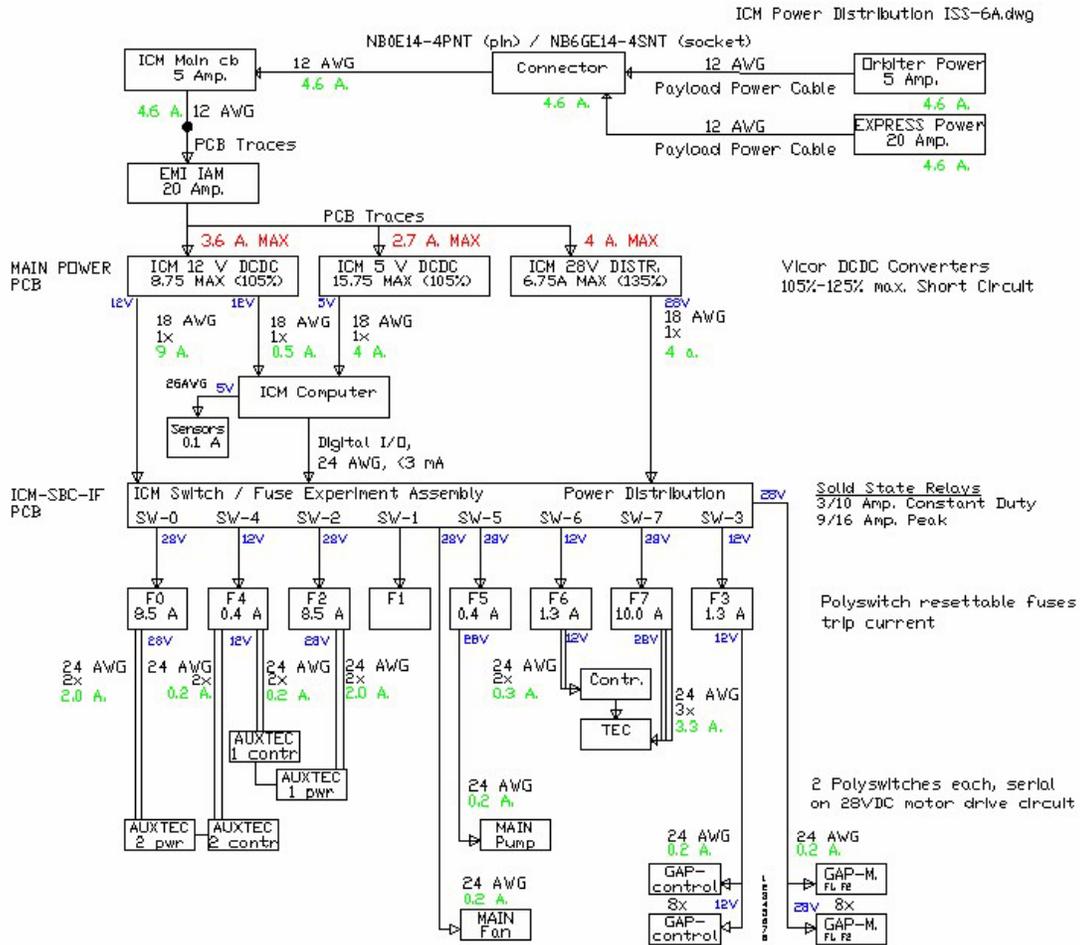
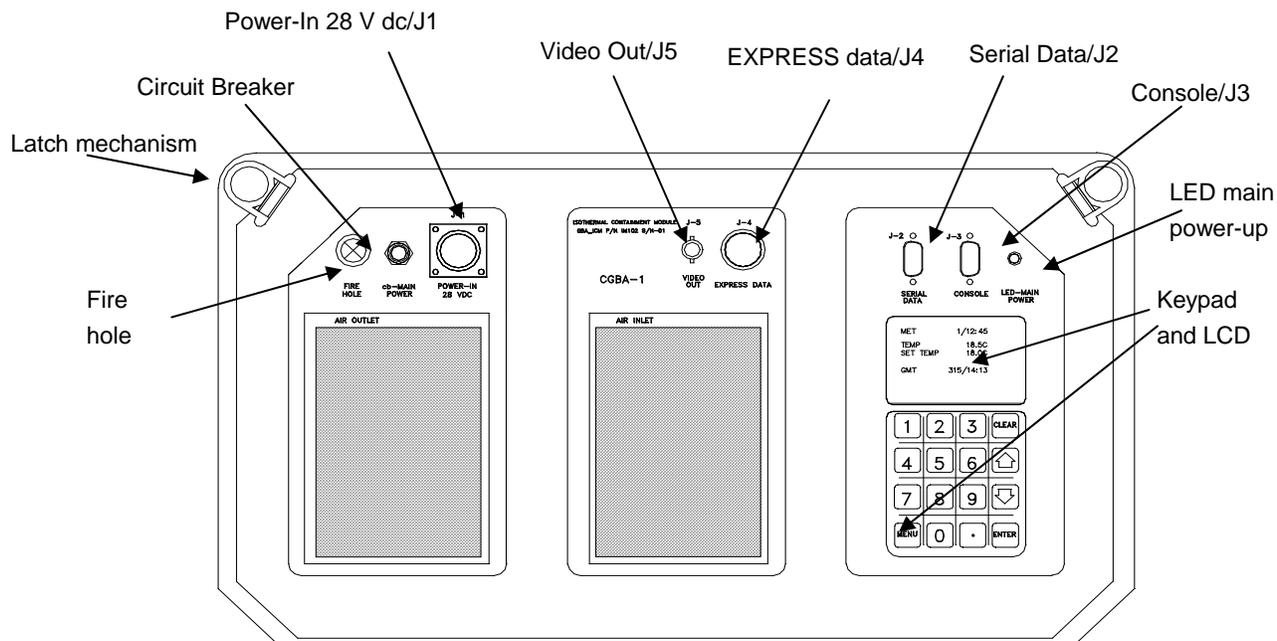


Figure 3-30. CGBA electrical schematic

### 3.4.2.4 Control/Command/Data/Display

The CGBA faceplate is shown in Figure 3-31. Table 3-2 defines the switch and connector functions.



**Figure 3-31. CGBA faceplate**

**Table 3-2. CGBA switches and connectors**

Switch/connector	Function
Power-in 28 V dc/J1	28 V dc power input from the orbiter (note: requires adaptor)
Serial data/J2	Data connection to ISS for data downloading to EXPRESS laptop (not used for this mission)
Console/J3	RS232 connection
EXPRESS data/J4	Ethernet and video connection to EXPRESS Rack (for ISS only)
Video out/J5	Analog output video signal from internal video cameras (not used for this mission)
cb - main power	Power on/off CGBA
Keypad and LCD	Main source of TLM from and crew input to CGBA computer
LED main powerup	Indicates whether or not the ICM is powered up
Fire hole	Port to insert fire extinguisher in case of internal fire

Note: The CGBA contains two popout handles, not included in Figure 3-31, on the middle of the right and left edges of the faceplate.

a. Command

The CGBA operates autonomously. Nominally, the only commands required from the orbiter crew are power on/off performed when the unit is installed and activated on the ISS. To turn the CGBA on/off, the Central Processing Unit (CPU) should be shut down through option 7 on the main menu display. After that, the on/off circuit breaker can be pulled. On the main screen of the CGBA, the date and time are displayed. If necessary, this date and time can be reset using the CGBA Set Greenwich Mean Time (GMT) procedure in the Assembly Operations Procedure (AOP).

b. Data

The CGBA requires no data connections while it is on the orbiter. All necessary data are recorded in the Assembly Operations Checklist during middeck status checks.

c. Display

Information is displayed on the LCD located on the front panel directly above the keypad. The CGBA has a built-in screen saver that simply blanks the screen when active. Touching any key recovers it and displays the main screen. (See Figure 3-32.) The main screen provides the information necessary for a status check. The parameters of the screen are tabulated in Table 3-3.



**Figure 3-32. CGBA main display screen**

**Table 3-3. Parameters of main display screen**

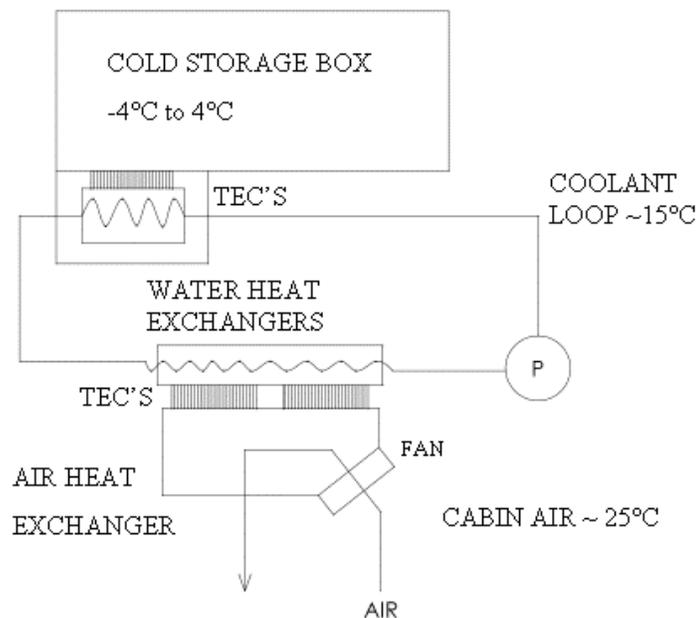
Parameter	Function
Experiment Elapsed Time (EET)	Displays time elapsed since internal accelerometers sensed launch
Temp	Actual internal volume temperature
Set temp	The desired temperature setpoint*
Date and time	Displays date and time in GMT

Note: \*The internal temperature is set to a uniform value; however, individual experiments within CGBA can be set to different temperatures.

### 3.4.2.5 Thermal

Figure 3-33 summarizes the CGBA cooling system. The equipment is air cooled. It intakes and exhausts air through two separate screens located on the front panel. The main heat exchanger dumps the heat from a closed fluid circulation system into this air. The Interim Control Module (ICM) internal incubator volume is normally maintained at a constant temperature using solid-state Peltier devices and a closed fluid circulation system. Redundant control and safety devices (active temperature control and passive bimetallic safety switches) ensure that temperature extremes do not exceed safe touch, exhaust, and operation limits. Specifically, the primary active temperature controller maintains the preset temperature of the liquid circulation loop and the incubator walls within limits. Three bimetallic switches (two on the liquid loop heat exchanger and one on the air heat exchanger) prevent the following:

- a. Overtemperature on the coolant loop (maintains  $< 45^{\circ}\text{C}$ )
- b. Freezing of the coolant loop (maintains  $> 0^{\circ}\text{C}$ )
- c. Overheating of the air heat exchanger (maintains  $< 49^{\circ}\text{C}$ ) air exhaust



**Figure 3-33. CGBA heat transfer system**

### 3.4.2.6 Interfaces with Shuttle

Table 3-4 provides a brief summary of the CGBA interfaces with the shuttle.

**Table 3-4. CGBA interfaces with orbiter**

Power interfaces	Thermal interfaces	Command/telemetry interfaces	Structural interfaces	Other interfaces
28 V dc orbiter power supply is connected to adaptor	Air cooled via middeck air exchange	None required on orbiter	None, CGBA has foam bonded to all six external sides. It is inserted, preflight, into a program-provided middeck locker (with modified door)	None
Adapter is plugged into connector J1				

### 3.4.2.7 Science Inserts

#### 3.4.2.7.1 NLP

The National Lab Pathfinder (NLP)-Vaccine-7 and NLP-Cells-3 Group Activation Packs (GAPs) are flown inside the experiment volume of CGBA on STS-130/20A. Each GAP contains sixteen Fluid Processing Apparatus (FPAs). Each FPA contains an experiment sample, a media solution, and a fixative solution of the principle investigator's choosing. The crew uses a hand crank to activate and later terminate each GAP.

#### Key Payload Operational Requirements and Constraints

The purpose of this section is to introduce and/or review key P/L requirements and constraints. The following constraints apply:

- a. CGBA requires continuous power. If it is powered down for more than 30 minutes, science may be affected.
- b. The MDL that houses the CGBA is modified. The three door panels of the locker are removed to allow air to flow in and out of the ducts and to allow access to the keypad.
- c. When powering down the CGBA, the CPU should be shut down first using the display menu and then with the on/off switch. However, in a contingency, the power switch can be flipped before CPU shutdown without harming the science.

- d. The main display shows “waiting for launch” under Experiment Elapse Time (EET) until built-in accelerometers sense liftoff. Once in orbit, if it still displays “waiting for launch,” it is an indication that the accelerometers did not work, and EET must be manually set.
- e. EET can be used by CGBA software to trigger various science operations.

**3.4.2.8 Safety**

Hazard reports have been developed for the electrical shock from the physiological test equipment and use of materials. These hazard reports can be found in Section 6 of the Phase III Preflight Safety Assessment.

**3.4.2.9 Operations**

Table 3-5 covers the Flight Rules that pertain to PL power and transfer.

***Table 3-5. Flight Rules pertaining to CGBA tests***

Flight Rule	Topic
20A_A19-1	Middeck Payload Power Constraints

Nominal Procedures

On the orbiter, status checks are required twice daily. Air inlet screen cleaning is required daily.

**3.4.2.10 Previous In-Flight Anomalies**

- a. STS-89

ICMv1: Stalled GAP motor: After crew intervention, progress of pressure plate was not recorded properly. Subsequently, the motor advanced the GAP pressure plate past the desired end plate. The software was changed to record location continuously (not after completion), a hardware stop was moved to stall the motor prior to exceeding desired end location, and GAP motor design was changed to change load path. This new design flew aboard STS-93 as the IM-GAP (Internal Motor GAP). Closed for STS-95 and obsolete due to redesign of Auto-GAP into IM-GAP as flown aboard STS-93.

- b. STS-95

Computer stalled due to conflict between two simultaneously running programs and a missing variable definition. Software was changed and has been tested continuously for about 18 months, including the flight of three computers aboard STS-93. Closed for STS-93.

c. STS-93

AUX-TEC circuit malfunction due to incompatibility between potentially excessive orbiter EMI noise and AUXTEC circuit board susceptibility, inrush current, and lack of appropriate ICM noise filter. New EMI filter with noise filter was installed, and inrush current was reduced through sequential powerup switching of circuit. New EMI test protocol developed for testing under realistic orbiter noise conditions. Closed for STS-106 and ISS.6A. Circuit performed flawlessly on STS-106.

d. STS-106

During deintegration postlanding, computer did not shut down properly due to hard disk error. The problem again occurred during EXPRESS interface testing at the ISS Building. The misbehaving spinning hard disk is replaced, and the replacement unit thoroughly tested to guarantee problem-free operations.

e. Increment 2

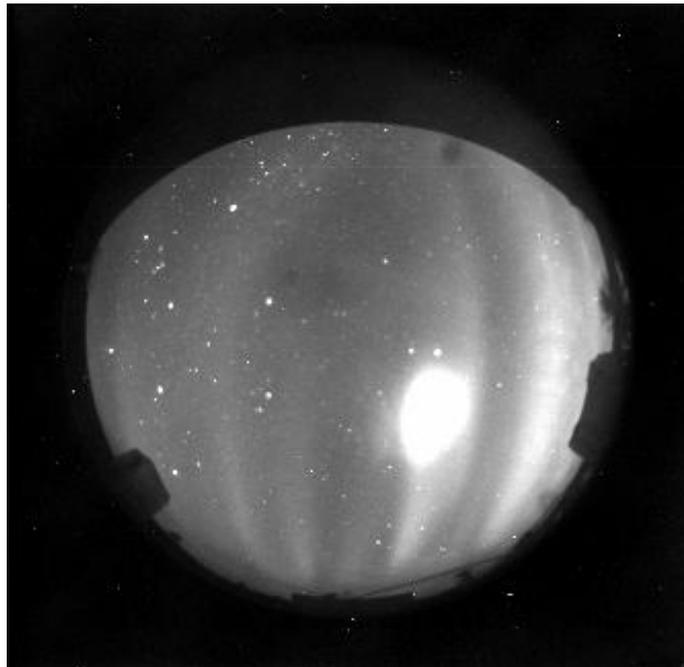
During the increment, a failure occurred in the CGBA. During a routine commanding session to change experiment parameters, the CGBA became hung up during the soft reboot used to reset the computer files and to remove log files that are no longer needed. The powerup sequence was not able to complete initialization due to the hangup. A control unit on the ground was running nominally at KSC after receiving all the same commands as the on-orbit CGBA. Troubleshooting began with two more reboots, and neither reboot was successful. The crew was able to read down the computer displays, allowing the Payload Operations Control Center (POCC) to determine how far the computer went into the normal powerup sequence. From these diagnostic tests, the POCC was able to characterize the failure, although they were still not absolutely sure about the cause. One theory (the most likely according to Kevin Gifford, Automation Engineer and Louis Stodieck, Bioserve Director) is that the third of six embedded processors had failed, preventing the main computer from functioning properly. The PL was turned off with all science lost.

### 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-130/20A: Maui Analysis of Upper-atmospheric Injections (MAUI), Shuttle Ionospheric Modification with Pulsed Localized Exhaust (SIMPLEX), and Shuttle Exhaust Ion Turbulence Experiments (SEITEs). All three are Department of Defense (DoD) experiments designed to analyze the orbiter's thruster firings for the 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

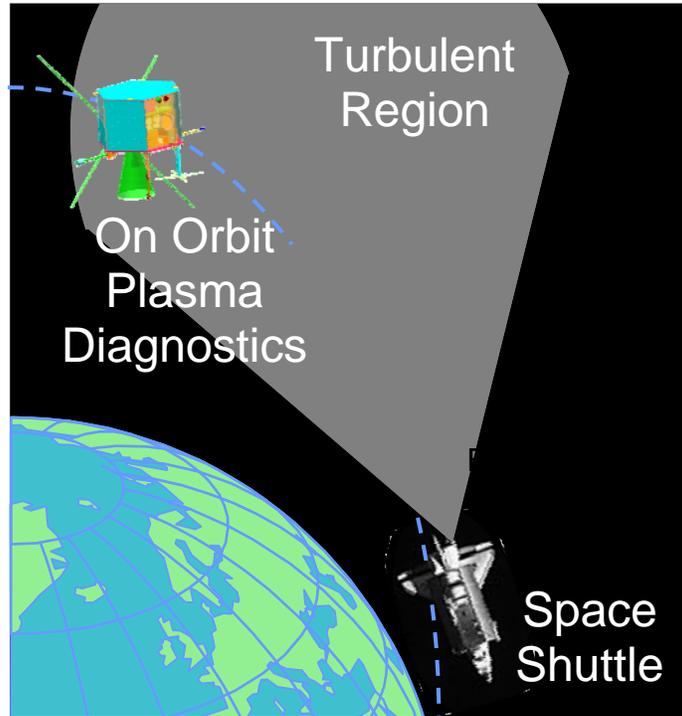
MAUI is designed to observe the orbiter exhaust plumes via the optical telescopes at the Air Force Maui Optical and Supercomputing Site (AMOS) located on Maui, Hawaii. An example of an Orbital Maneuvering System (OMS) burn viewed from the ground is shown in Figure 3-34. The images and data taken by the 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 3-34. Low-resolution all-sky imagery from OMS burn*

### 3.5.2 Shuttle Exhaust Ion Turbulence Experiments

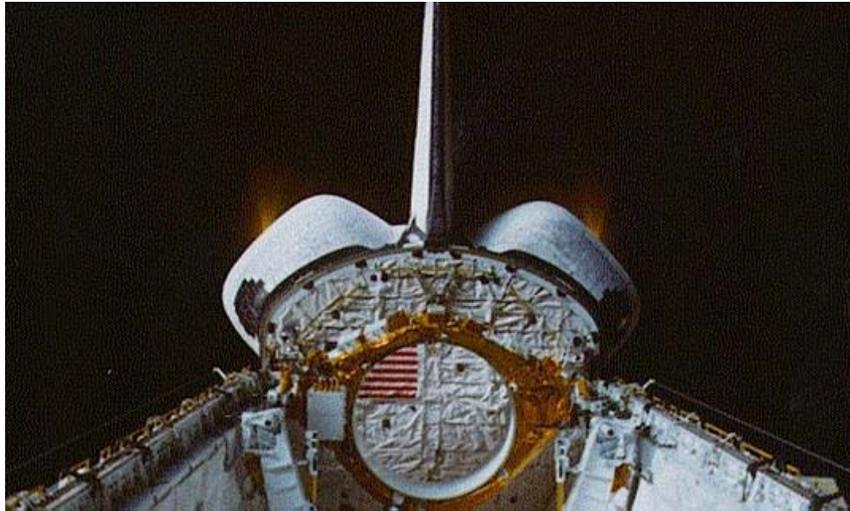
SEITE uses space-based sensors to investigate plasma turbulence in the ionosphere using the firing of the orbiter's OMS engines while within range of the available diagnostic satellite, as shown in Figure 3-35. Various sensors provide data on neutral flows, electron and ion distributions, electric fields, plasma waves, and radio scintillations. Furthermore, the data obtained through SEITE enables the development of quantitative models of the plasma disturbance, which degrades tracking and imaging radars.



**Figure 3-35. 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 3-36 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.

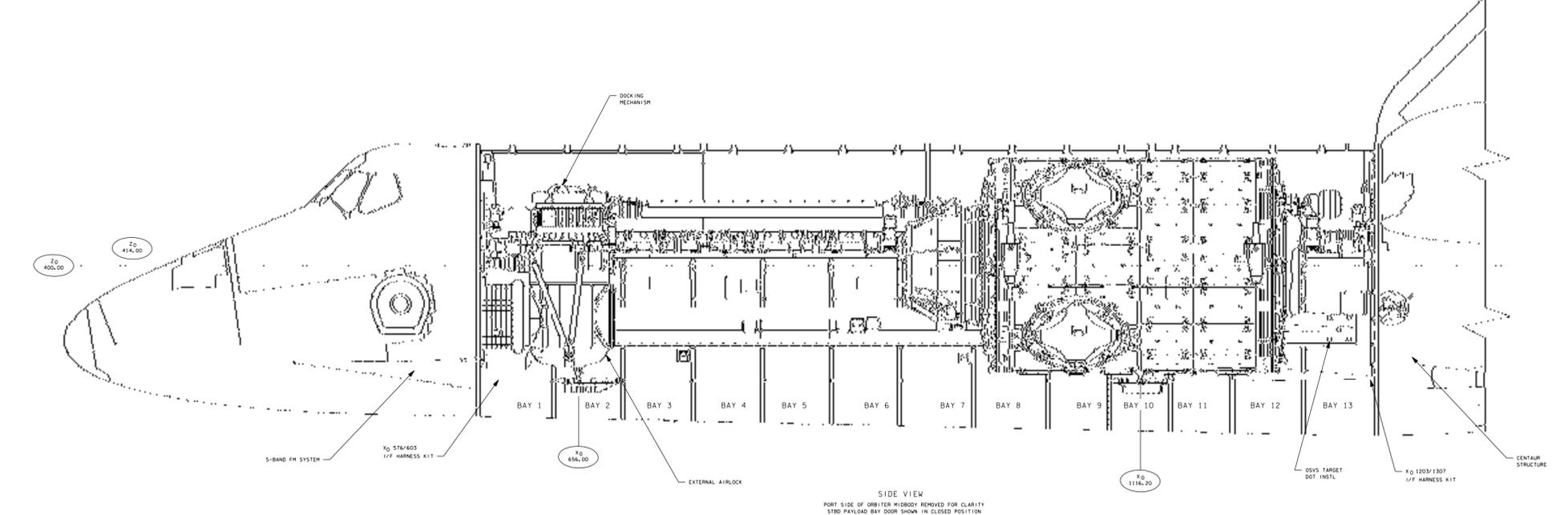
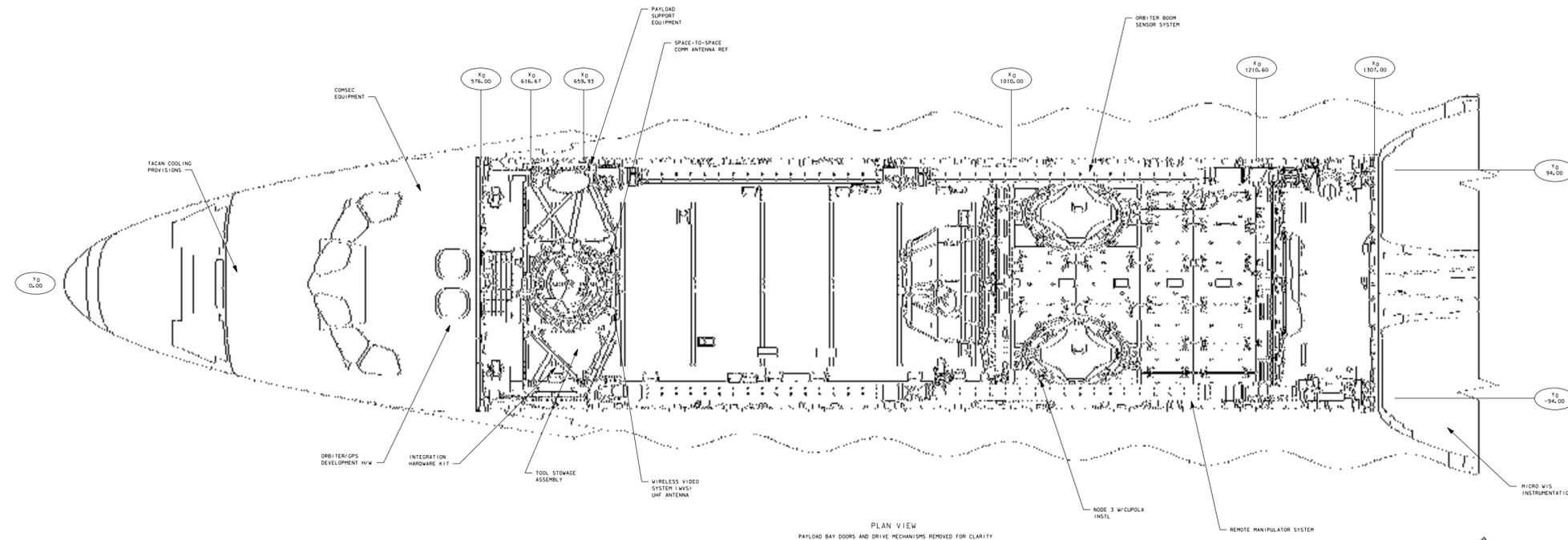
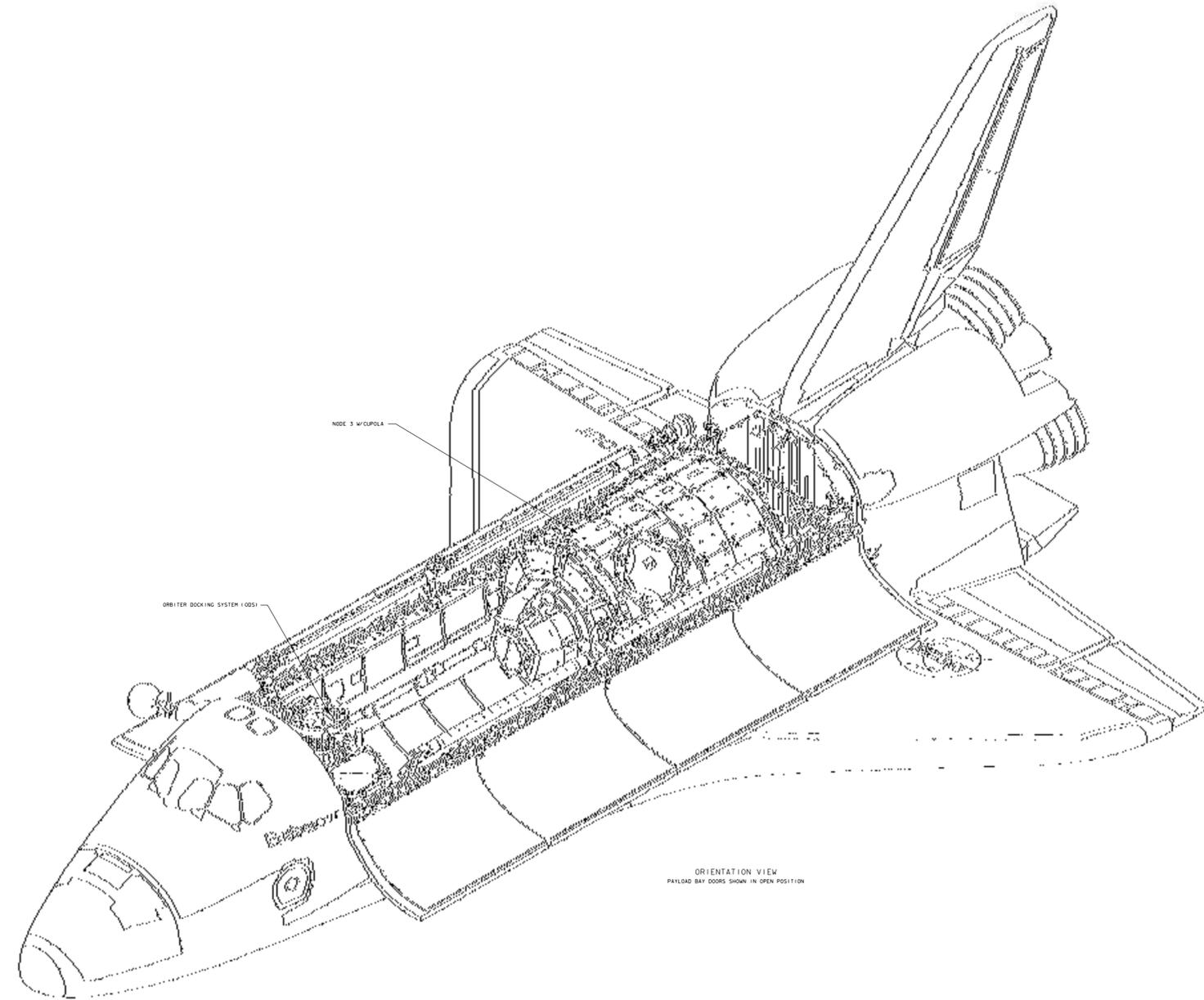


*Figure 3-36. Symmetrical dual-OMS burn during orbital daylight*

### 3.6 TRANSFER ACTIVITIES

TBD

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# 1 CARGO BAY L/O

SIGNATURE	DATE	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ENGR S. JAMES	04/22/09	LYNN B. JOHNSON SPACE CENTER HOUSTON, TEXAS
DR		
ENGR R. ADAMS		
ENGR		
APP		
APP	40H20A	DWG NO
CADS	S15-1307-20A	3.1
LTR	PCN	104.5 X 34

CARGO BAY LAYOUT

SHEET 2 OF 3

## 4.0 FLIGHT-SPECIFIC UNIQUE INTERFACES AND SYSTEMS

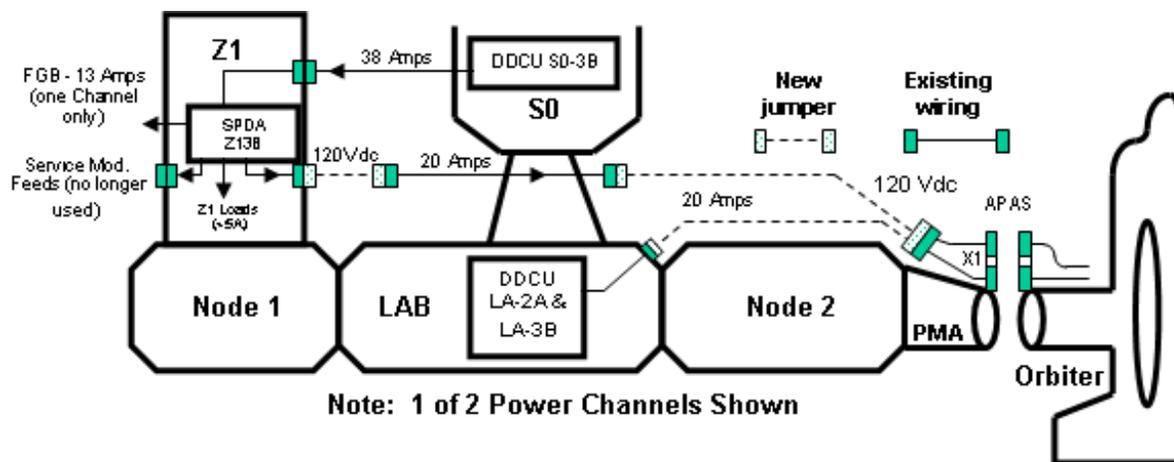
This section is intended to provide an overview of orbiter systems and capabilities that directly impact Mission 130/20A. A general description of the respective systems is provided, along with information on related orbiter interfaces and flight-specific configurations. The systems discussed in this section, as they pertain directly to the activities of Mission 130/20A, are the SSPTS, Payload Deployment and Retrieval System (PDRS), and crew interfaces.

### 4.1 ORBITER SYSTEMS

The following section describes the two unique orbiter configurations for Mission 130/20A: 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<sub>2</sub> and H<sub>2</sub> 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.



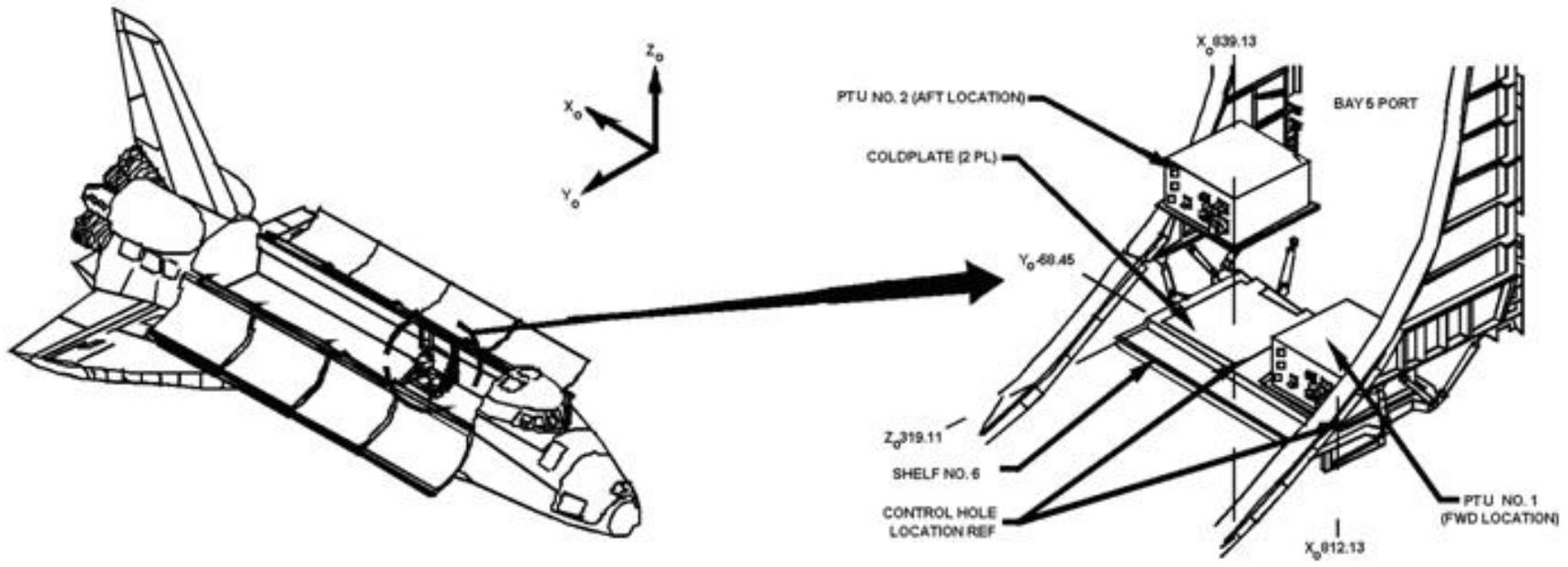
*Figure 4-1. SSPTS architecture (OV-103 and OV-105)*

##### 4.1.1.1 Hardware and Configuration

SSPTS has two principal components: two Power Transfer Units (PTUs), consisting of an APCU, Orbiter Power Converter Unit (OPCU), 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

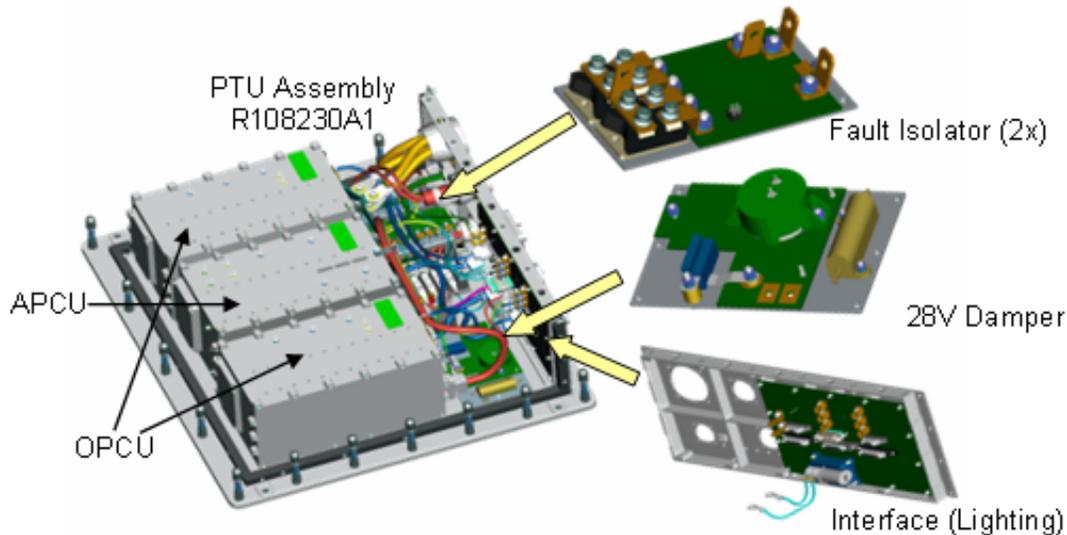
provide power to ISS has been eliminated due to the removal of return feeds through the X-connectors to the ISS.

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 130/20A.



**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).



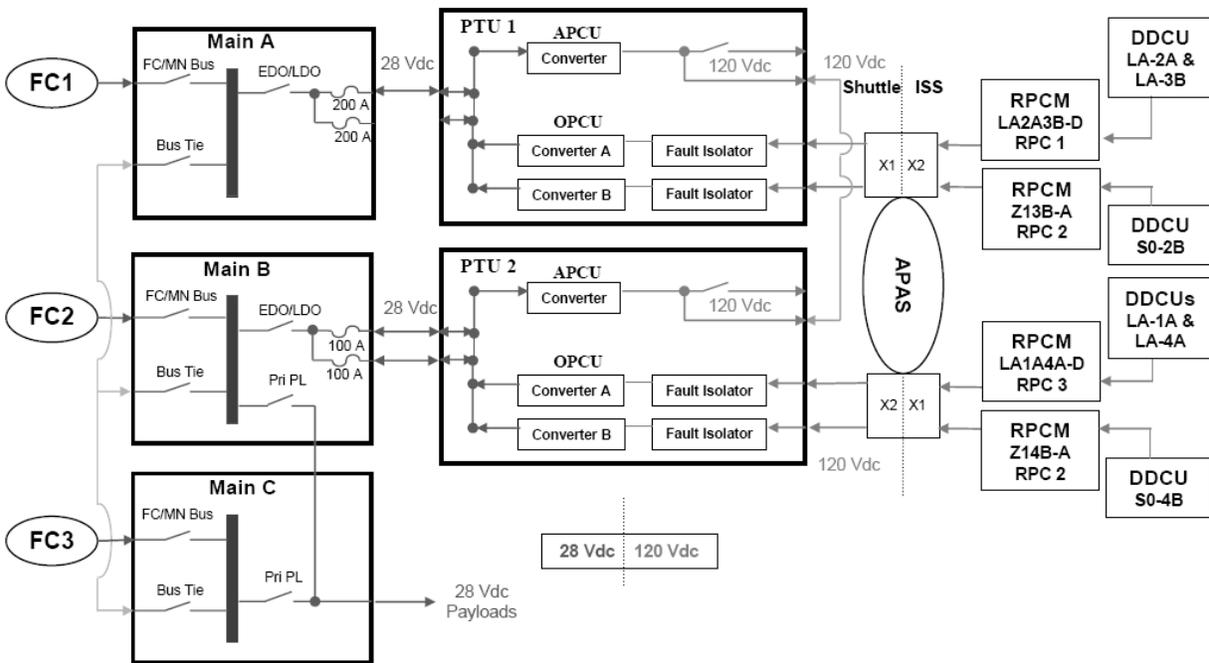
**Figure 4-3. Integrated PTU with additional hardware**

APCU1 and APCU2 each supply power to one string of redundant Node 3 shell heaters, as well as power inspection hardware on the OBSS.

The APCU configuration is shown in Figure 5-3.

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 Remote Power Controllers (RPCs) and converts it to 2 kW of 28 V dc orbiter-usable power (each PTU input power draw from the orbiter is 20 W maximum when the APCU is in the OFF state). There are four OPCU converters total (two per OPCU), designated 1a/1b and 2a/2b, capable of supplying a total of 8 kW should all four OPCU converters operate simultaneously. However, due to ISS power limitations, only three converters are likely to be on at any time. The orbiter fuel cells are certified to operate at a minimum power level of 2 kW.

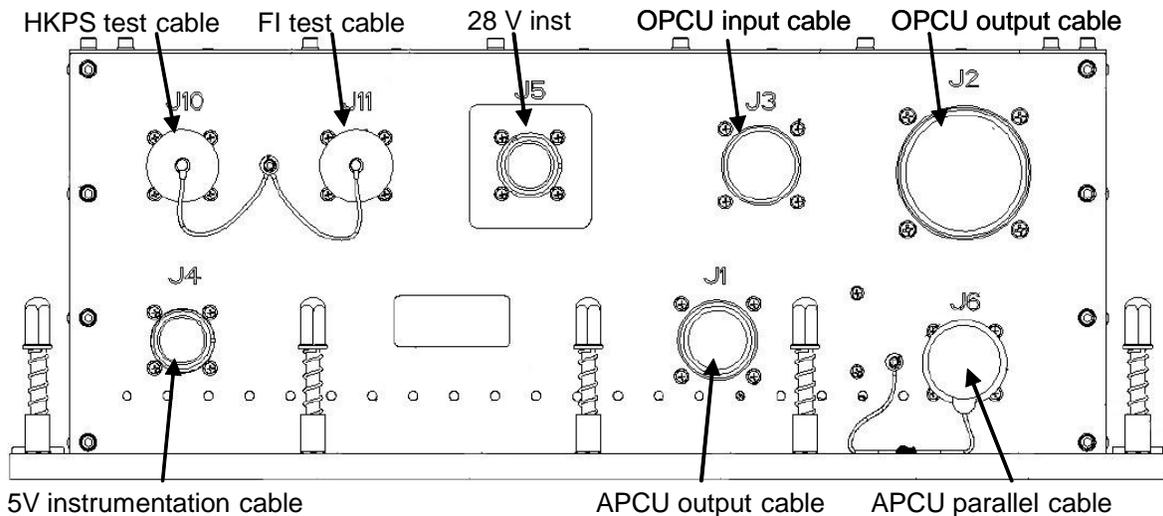
The system is controlled either manually by the flight crew or via command by ground personnel to achieve the desired fuel cell power level. The OPCU 1 converters are connected directly to the orbiter bus Main A (MNA) via Fuel Cell 1 (FC1) and OPCU 2 converters to Main B (MNB) via FC2 (see Figure 4-4). 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 the overall orbiter power usage.



**Figure 4-4. Bus wiring for return power to orbiter**

#### 4.1.1.2 Interface and Controls

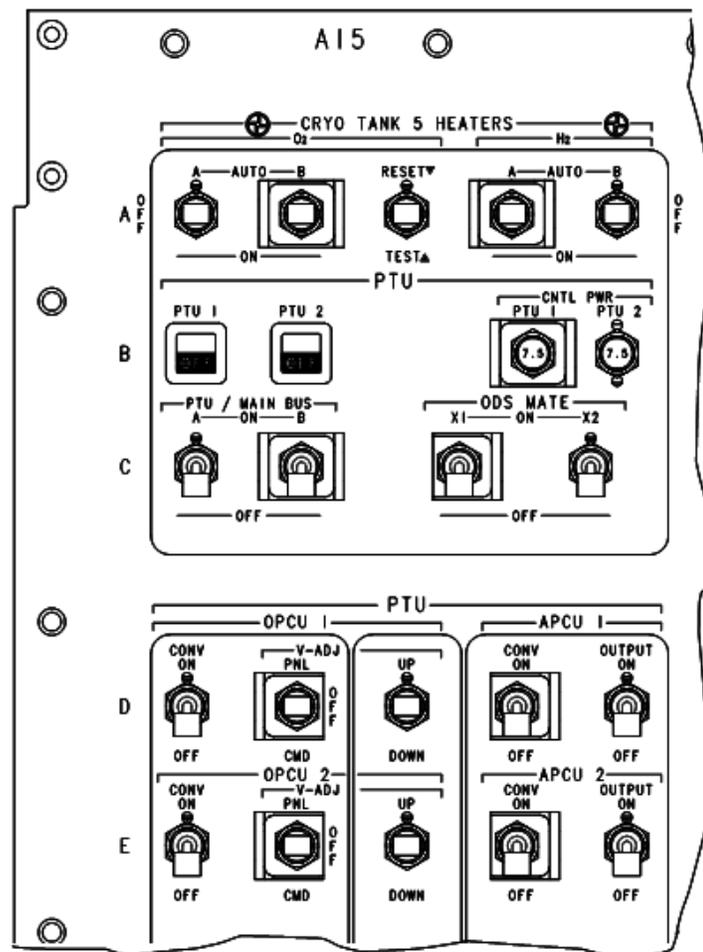
The front panel of the PTU (Figure 4-5) has input/output connectors for the OPCU and APCU, as well as connectors for control power and Ground Support Equipment (GSE) test equipment. Once installed, only the test cables are left disconnected.



**Figure 4-5. 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 Specialist Function (SPEC) display. The switches on panel A15 replace the APCU controls previously found on the SSPs. 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 4-6). OPCU power levels can be adjusted using ground commands or by the voltage-adjust switches on panel A15.



**Figure 4-6. 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 4-7).

	1									2									3									4									5								
	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
1	XXXX / XXX / 179									POWER TRANSFER									XX X									DDD / HH : MM : SS																	
2																												DDD / HH : MM : SS																	
3										1 / AXXXX									2 / BXXXX									3 / CXXXX																	
4	FC POWER (KW)									XX . XS									XX . XS									XX . XS																	
5	MAIN VOLTS									XX . XXS									XX . XXS									XX . XXS																	
6	PTU / MAIN BUS									XXX									XXX																										
7										PTU 1									PTU 2																										
8	OPCU									A									B									A									B								
9	OUT VOLTS									XX . XXS									XX . XXS									XX . XXS									XX . XXS								
10	AMPS									XX . XS									XX . XS									XX . XS									XX . XS								
1	TEMP									XXXS									XXXS									XXXS									XXXS								
2	TRIP									XX XX									XX XX									XX XX									XX XX								
3										XX XX									XX XX									XX XX									XX XX								
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6	APCU																																												
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8	AMPS									XX . XS									XX . XS									XX . XS																	
9	IN AMPS									XX . XS									XX . XS									XX . XS																	
20	TEMP									XXXS									XXXS									XXXS																	
1	OUTPUT									XXX									XXX									XXX																	
2	TRIP									XX XX									XXX XX									XX XX									XXX XX								
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Figure 4-7. SPEC 179 - Power Transfer

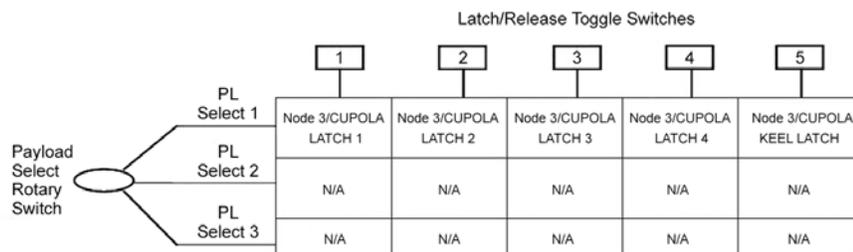
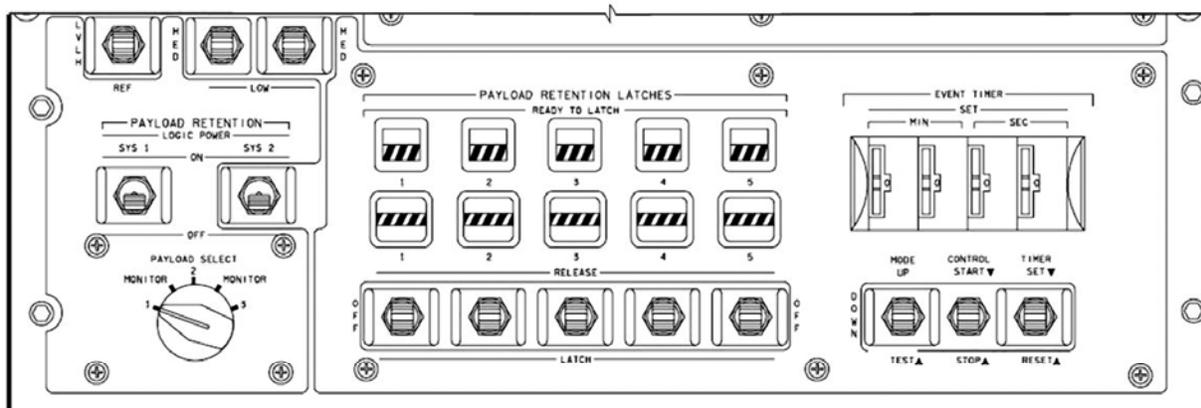
#### 4.1.2 Payload Deployment and Retrieval System

The orbiter PDRS is composed of the SRMS, the 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 130/20A. 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)).

The SRMS is the mechanical arm portion of the PDRS that maneuvers objects (ISS elements or EVA crew) to desired positions. The SRMS is 50 ft long and has six joints driven by electric motors. An End Effector (EE) on the end of the SRMS acts as the capturing device. The SRMS also has a separation system to provide jettison capability to the SRMS when it is unable to latch down or release the cargo it has in capture.

PRLAs secure the P/L in the orbiter PLB. The Node 3 element has four longeron trunnions and one keel trunnion secured with PRLAs. The motorized latches can be

opened and closed by the crew on orbit. The keel latches are used to take the side loads on a P/L and help center the P/L in the cargo bay. The keel latch does not have the force to overcome the longeron latches; therefore, the keel latch must be closed to center the P/L before closing the longeron latches. Dual redundant electrical motors drive all latches. Each latch has two microswitches that sense when the P/L trunnion is nested in the latch and is clear for the latch to close. Each latch has four additional microswitches that indicate the latch condition. Two switches indicate LATCH (closed), and two indicate RELEASE (open). Five switches on the A6 panel control the latches, as shown in Figure 4-8. Switches 1 to 5 on the Payload Select 1 control the four trunnion latches and the keel latch. The two AFT longeron latches are fixed, and the remaining latches are floating.



**Figure 4-8. Payload retention latches**

## 4.2 CREW INTERFACES

This section is devoted to the interfaces the crew has with the ISS and shuttle that are used in the assembly process. Displays for Mission 130/20A assembly activities are included in this section, with the exception of the standard switch panel descriptions, which are located in the Mission 130/20A Assembly Operations Procedures (AOPs).

### 4.2.1 Portable Computer System

There are no Node-3-specific PCS displays for Mission 20A.

#### **4.2.2 Station Support Computer**

There are no flight-specific Station Support Computer (SSC) applications for Mission 20A.

#### **4.2.3 System Laptop Terminal**

There are no flight-specific System Laptop Terminal (SLT) displays for Mission 20A.

#### **4.2.4 Payload Laptop Terminal**

There are no flight-specific Payload Laptop Terminal (PLT) displays for Mission 20A.

#### **4.2.5 Robotics Laptop Terminal**

There are no flight-specific Robotics Laptop Terminal (RLT) displays for Mission 20A.

#### **4.2.6 Multifunction CRT Display System**

The Multifunction CRT Display System (MCDS) displays provide a crew interface to some ISS systems and support hardware independent of the PCS units used on the AFT Flight Deck (AFD). The Payload Management Level C Flight Software Requirements for STS-130 has an extensive description of each relevant SPEC display used on the flight. Descriptions for the MCDS displays used during assembly missions can also be found in the Generic AOH (JSC-36517). There are no mission-specific assembly MCDS displays for Mission 20A.

## **5.0 20A SYSTEMS INFORMATION**

This section provides a description of assembly hardware, including Node 3 and Cupola elements, flown on Mission 20A. 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.

### **5.1 NODE 3**

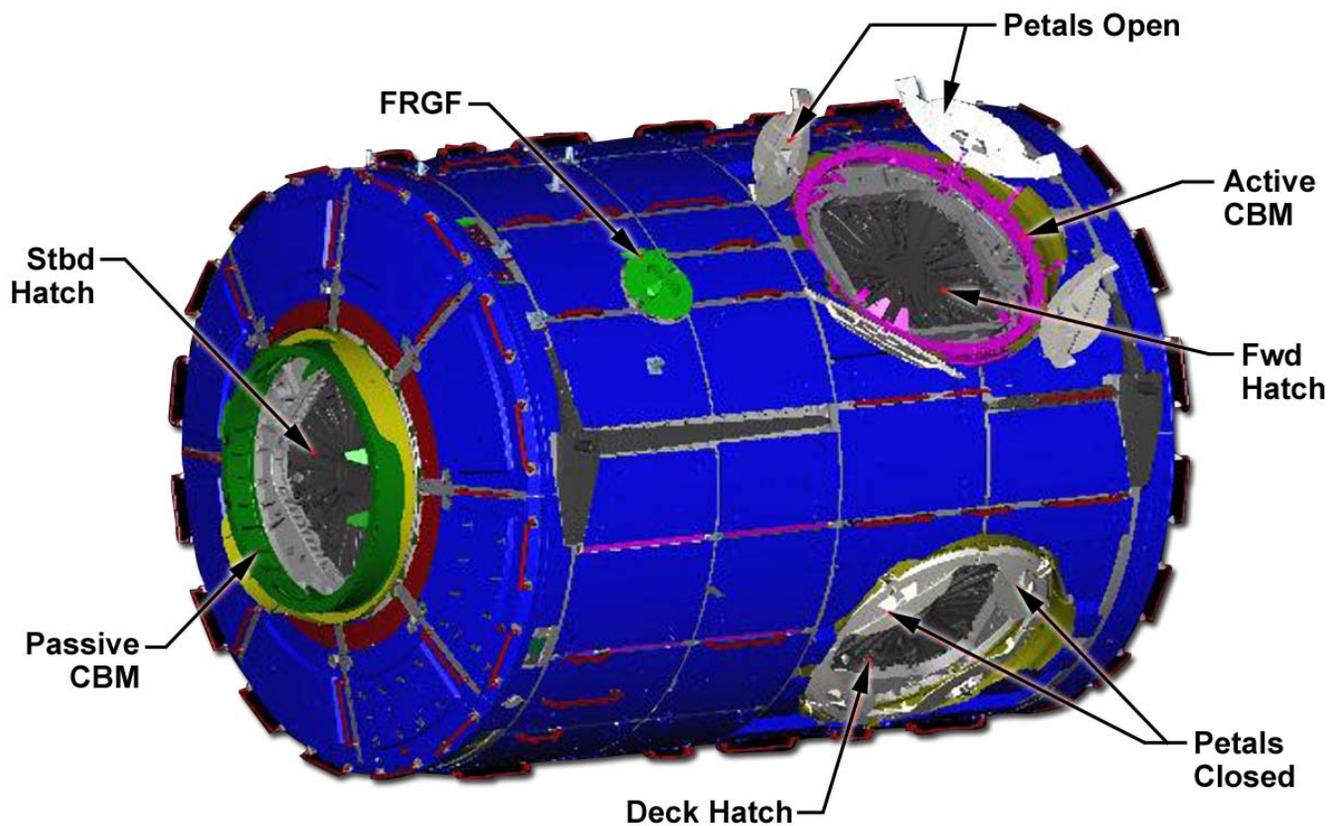
#### **5.1.1 Structures and Mechanisms**

The Node 3 element uses construction materials and methods common to the other USOS pressurized elements. The primary structure is constructed as a pressure vessel including a honeycomb web shell with ring-longeron reinforcements to increase structural integrity, with a support for connection to the secondary structural features. The secondary structure includes typical features, such as AFT endcones and alcoves, standard racks locations, and standoffs. It also includes midbay areas which are outfitted with essential powered hardware and transition to structural support for the CBMs.

##### **5.1.1.1 Common Berthing Mechanism**

The primary structure (final configuration) includes four radially arrayed (ZENITH, NADIR, FORWARD, and AFT) ACBMs and one axial ACBM (PORT). The Cupola is mated to the Node 3 NADIR ACBM via its passive CBM, and there are four additional CBMs to mate subsequent pressurized elements on downstream flights. Node 3 is berthed to Node 1 via Node 3's passive CBM installed on the STARBOARD axial bulkhead.

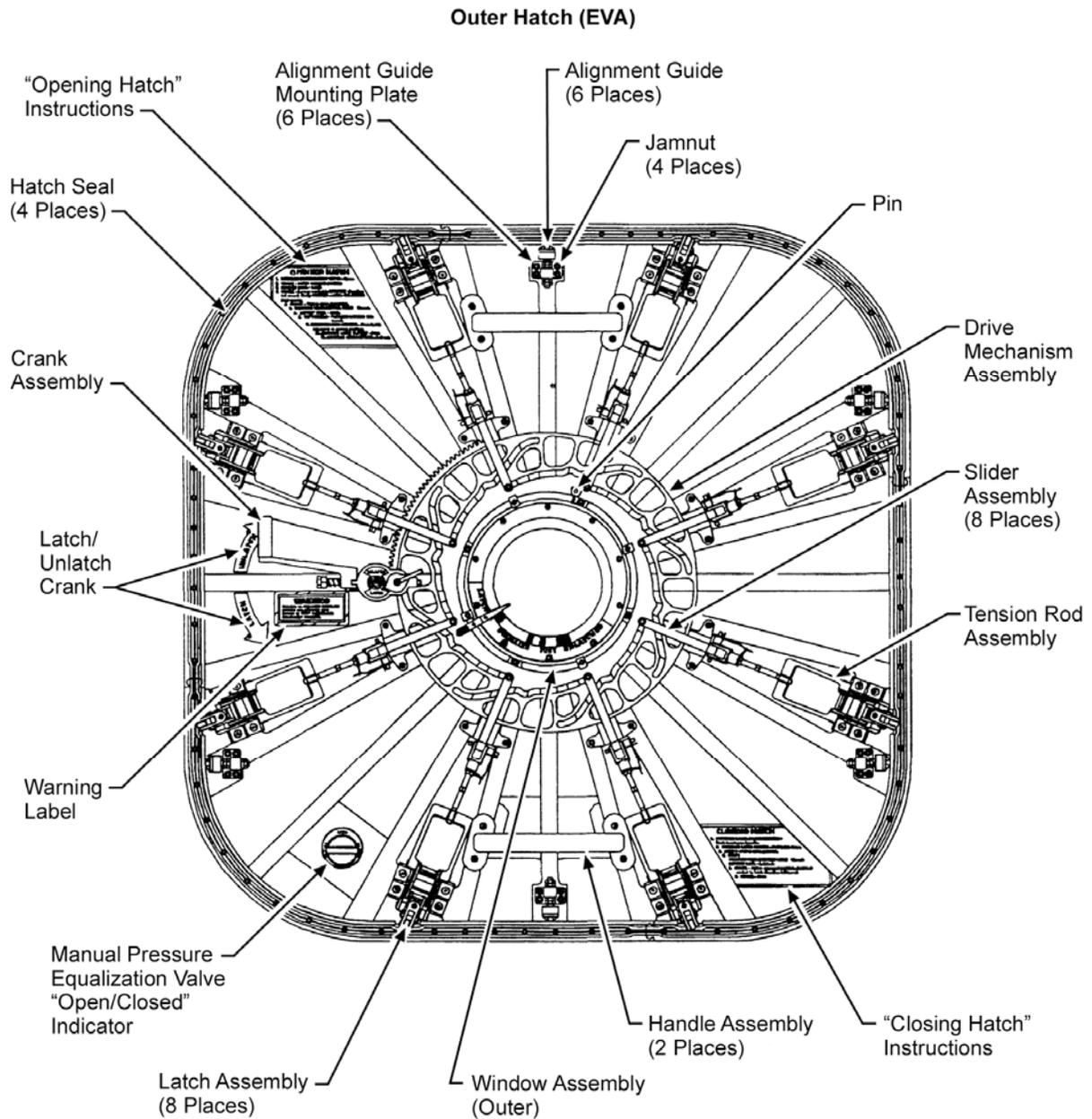
The PORT and radial ACBMs incorporate active motorized bolt assemblies, which are controlled by two sets of two CBM CPAs, which, in response to command authority from the MDMs, perform the control functions for their respective ACBM. The passive CBM features alignment guides that correspond to a matching set on the ACBM of the mating elements (Node 1) and are used to assist in coarse alignment during CBM mating. The PCBM ring structure features the integrated nuts into which the 16 bolts are driven and torqued to achieve an airtight mating interface. At launch, the CBM ring is protected to preclude damage to the mating surface. Each CBM interface includes penetrations for utilities, such as the IMV valves (outfitted with pressure relief valves at launch), and power and data jumpers. At the center of each CBM is a common hatch assembly, including a manual pressure equalization valve with a sample port. The CBM and hatch locations are shown in Figure 5-1. Hatch details are shown in Figure 5-2.



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**Figure 5-1. CBM and hatch locations**

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**Figure 5-2. USOS hatch**

### 5.1.1.2 Grapple Fixtures

Node 3 is equipped with one Flight Releasable Grapple Fixture (FRGF) that is used in Mission 20A assembly procedures to permit berthing of Node 3 directly to Node 1 PORT CBM using the SSRMS. The FRGF has no planned use after Node 3 has been berthed to Node 1.

### 5.1.2 Electrical Power System

Node 3 EPS hardware includes four DDCUs in parallel configuration, which convert primary power (133 to 170 V dc) from the Main Bus Switching Unit (MBSU) to secondary power (123 to 126 V dc). Two of the DDCUs are mounted inside Avionic Rack 04, and the other two are inside Avionic Rack 05. There are 23 RPCMs in Node 3.

Internally, Node 3 has four UOPs that may be used to power portable equipment, just as in the rest of the USOS. Each avionics rack in Node 3 is fitted with a Rack Power Switch (RPS) that allows the crew to remove power to an entire rack. There are 10 General Luminaire Assemblies (GLAs) throughout Node 3 and 3 Emergency Egress Lighting System (EELS) lights, located at the AFT port, Node 1 port, and PORT port to indicate exits. The GLAs are controlled by three Remote Control Assemblies (RCAs) that can simultaneously power on/off all the GLAs. Local switches on each GLA can override the RCA control.

The Node 3 EPS is illustrated in Drawing 5.1. Figure 5-3 illustrates the orbiter to Node 3 interface.

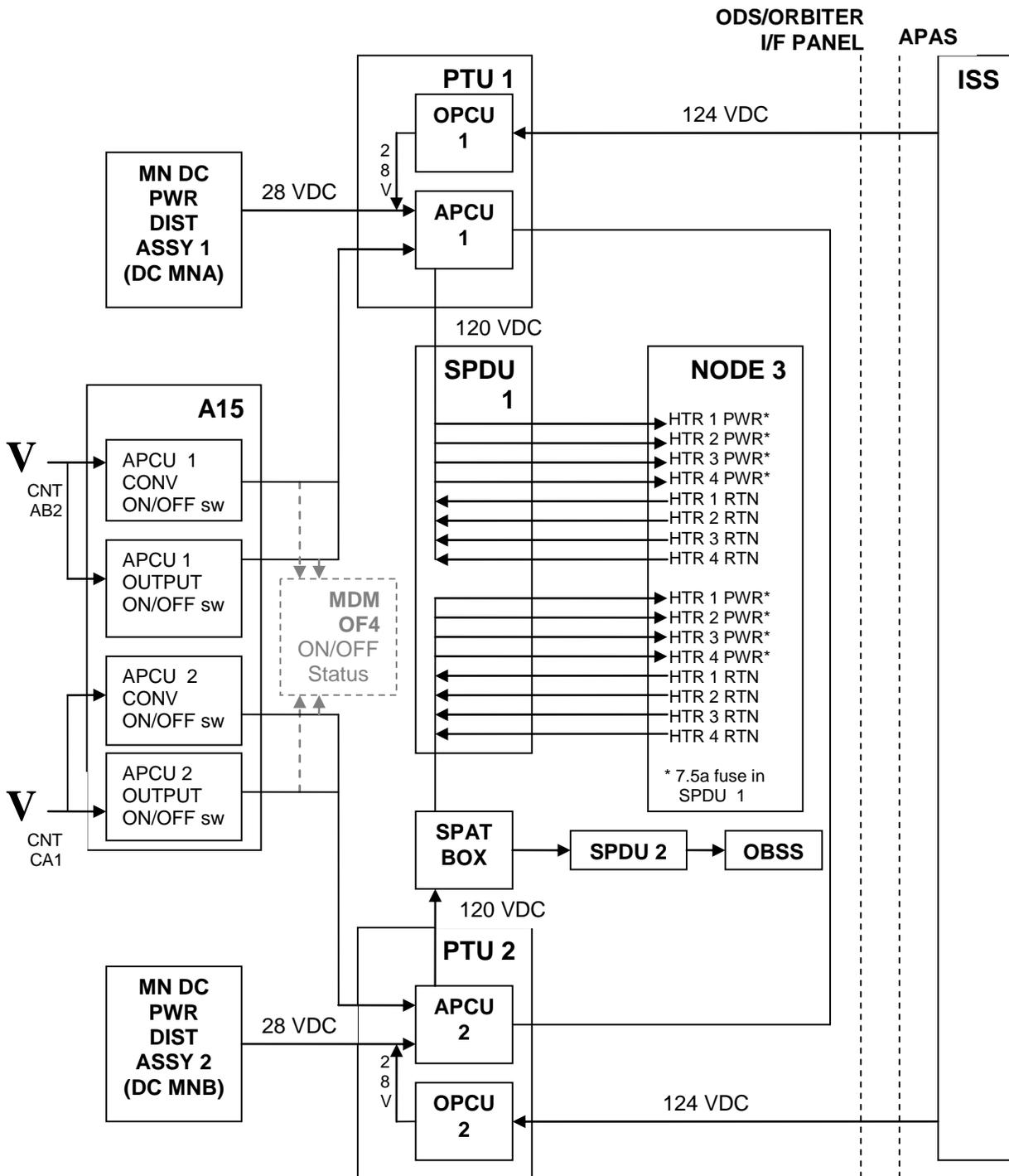


Figure 5-3. Orbiter to Node 3 EPS overview

### **5.1.2.1 General Luminaire Assemblies**

The Node 3 element is outfitted with 10 GLAs (five per lateral side) that provide interior light for the element. The GLA can be dimmed from 100 percent to 2 percent (or lower).

### **5.1.2.2 Emergency Egress Lighting System**

Node 3 is equipped with an EELS that provides a visual indication of the location of the emergency egress hatches in case of loss of power to the general purpose lighting. Whenever power is cut from both buses powering the general lights, the EELS at each exit hatch is activated automatically. The EELS on Node 3 consists of three Emergency Lighting Supplies (ELs) and three Emergency Lighting Strips (ELs). The strips are placed at the AFT port, Node 1 port, and PORT port in a suitable manner to indicate the Node 3 exits.

### **5.1.3 Command and Data Handling System**

The Node 3 C&DH architecture (Drawing 5.2) is based on two standard MDMs (N3-MDM-1 and N3-MDM-2), which are Tier III MDMs in the ISS C&DH hierarchy and two enhanced MDMs (HCZ-1 and HCZ-2), which are Tier II MDMs, all located internally to the Node 3 module.

### **5.1.4 Communications and Tracking**

The Node 3 element outfitting includes hardware supplemental to the internal audio subsystem and the video distribution subsystem.

#### **5.1.4.1 Audio Terminal Unit**

For Internal Communications (ICOM), Node 3 provides two ATUs that allow element-to-element communication for crewmembers, as well as ties to the air-to-ground audio channels for communicating with the Mission Control Center (MCC). It also distributes C&W alerts generated by other ISS systems to Integrated Audio System (IAS) crew terminals.

The Cupola has a single-channel human interface ATU supporting a Crew Headset Assembly (CHA) or a portable hardwired microphone. It interfaces to the IAS bus, to 120 V dc power, and, physically and thermally, to its coldplate.

#### **5.1.4.2 Audio Bus Coupler**

The ABC provides the distribution of Time Division Multiple Access (TDMA) to all the audio Orbital Replaceable Units (ORUs) on the IAS bus and has the capability to distribute audio and control data on the IAS bus. The ABC is capable of interconnecting with two other ABCs to enable intercom capability between ATUs.

The Node 3 hosts two ABCs, N3-ABC-5 and N3-ABC-6, that provide distribution of audio and control data between IAS and the ATUs and Video Tape Recorder (VTR)

(Signal Characterization and Recognition (SCAR) capability) in Node 3 and distributes the audio signals to PMA3 interfaces via Node 3 Docked Audio Interface Unit (DAIU). The two Node 3 ABCs are connected to different RPCMs to ensure redundancy constraints.

#### **5.1.4.3 Intravehicular Antenna Assembly**

The Intravehicular Antenna Assembly (IAA) is a part of the ISS UHF Communication Subsystem (UCS) and provides Radio Frequency (RF) distribution to/from the Space To Space Station Radio (SSSR) for communication with the EMU during wireless activity in the event of a depressurization event within the Node 3 element, which is only recoverable through EVA. Node 3 is outfitted with a single IAA, consisting of a single patch antenna, a UHF coupler, and four RF terminators to prevent line noise and unused connections.

#### **5.1.4.4 Video Switch Unit**

The VSU is part of the space station Internal Video Distribution and Control System (IVDS). The VSU is a single ORU design that supports the distribution of National Television Standard Committee (NTSC) video and RS-170 Synchronization (sync).

The VSU provides the following functions for the IVDS:

- a. Video image and sync signal distribution
- b. Data stripper
- c. ORU control and status
- d. Power distribution to video ports

The video image and sync signals are distributed over fiber optic lines connected at the two CVIUs in the element. The VSU control is via a 1553 data bus. The Node 3 is outfitted with one VSU.

#### **5.1.4.5 Common Video Interface Unit**

The CVIU provides video interfaces to the docked shuttle, video camera, and video monitor. The Node 3 is outfitted with three CVIUs, each a single ORU without redundant power. Each CVIU is able to transmit and receive fiber optic Pulse Frequency Modulated (PFM) video with a sync signal, as well as provide a power outlet for a Government Furnished Equipment (GFE) camera, typically a camcorder. The input/output video signal adheres to the NTSC standard.

#### **5.1.4.6 Video Camera Port**

The Video Camera Port (VCP) provides the actual power and video interface from the camera to the CVIU.

#### **5.1.4.7 Video Camera Support Assembly**

The Video Camera Support Assembly (VCSA) supports the single location for an External Television Camera Group (ETVCG) on the Node 3 element. The support structure consists of a mast, a mounting surface for the ETVCG and a baseplate fitting. The VCSA provides a single cable connection to the ETVCG for operating, lighting and heater power, fiber optic sync and control and video image data and camera light temperature data.

#### **5.1.4.8 Video Signal Converter**

The Video Signal Converter (VSC) is used in conjunction with the PDGF to support relocated SSRMS operations on the modules. Essentially, the VSC performs functions similar to the CVIU, converting between fiber digital and analog camera signals, but the functions are dedicated to PDGF video support.

#### **5.1.5 Motion Control System**

Mission 20A provides no additional capability for the MCS.

#### **5.1.6 Environmental Control and Life Support System**

One of the principle hardware deliveries accomplished for 20A is the delivery of the CCAA installed in Node 3. The CCAA has interfaces to the Node 3 major systems, including command and control through the N3-1 MDM. Additional Node 3 outfitting hardware includes typical USOS environmental control hardware, including IMV valves, manual pressure equalization valves, and supporting ductwork leading to attached elements. Refer to Drawing 5.4.

##### **5.1.6.1 Atmospheric Control System**

ACS components in Node 2 include the following:

- a. MPEVs are used to equalize pressure between isolated modules, allowing the opening of the closed hatches. The MPEV is installed on the hatch interface and is operable both from the internal and external sides of the hatch by means of a knob.
- b. Two NIAs are used for repressurization of accumulator assemblies for the ITCS MTL and LTL pump packages using N2 from the low pressure N2 lines. In the event of a loop water leak, the NIA is used to vent the N2 from the accumulator into the cabin.
- c. Four Negative Pressure Relief Valves (NPRVs) installed on the AFT and STBD bulkheads are used to limit the differential negative pressure across the Node 3 primary structure. Once Node 3 has been installed on Node 1, the STBD NPRVs are replaced with IMV valves.

- d. One Non-Propulsive Vent (NPV) assembly installed at the end of the cabin venting line is used to split the cabin venting flow in two equal and opposite parts to make the vent nonpropulsive.
- e. Two Portable Breathing Apparatus (PBA) interfaces installed in the AFT alcove and AFT STBD cone secondary structure of Node 3.
- f. The Pressure Control Panel (PCP) is used to monitor Node 3 cabin pressure and maintain the atmospheric pressure and the Oxygen and Nitrogen balance. The PCP is made up of a firmware controller, a cabin pressure sensor, Oxygen and Nitrogen pressure sensors, Oxygen and Nitrogen solenoid isolation valves and an Oxygen/Nitrogen diffuser.
- g. One Positive Pressure Relief Valve (PPRV) is used to limit the differential positive pressure across the Node 3 primary structure, allowing to the cabin air to exit the Node in the event of overpressurization.
- h. The VRV is used to perform the venting of the cabin atmosphere in the event of overpressurization or internal air contamination.

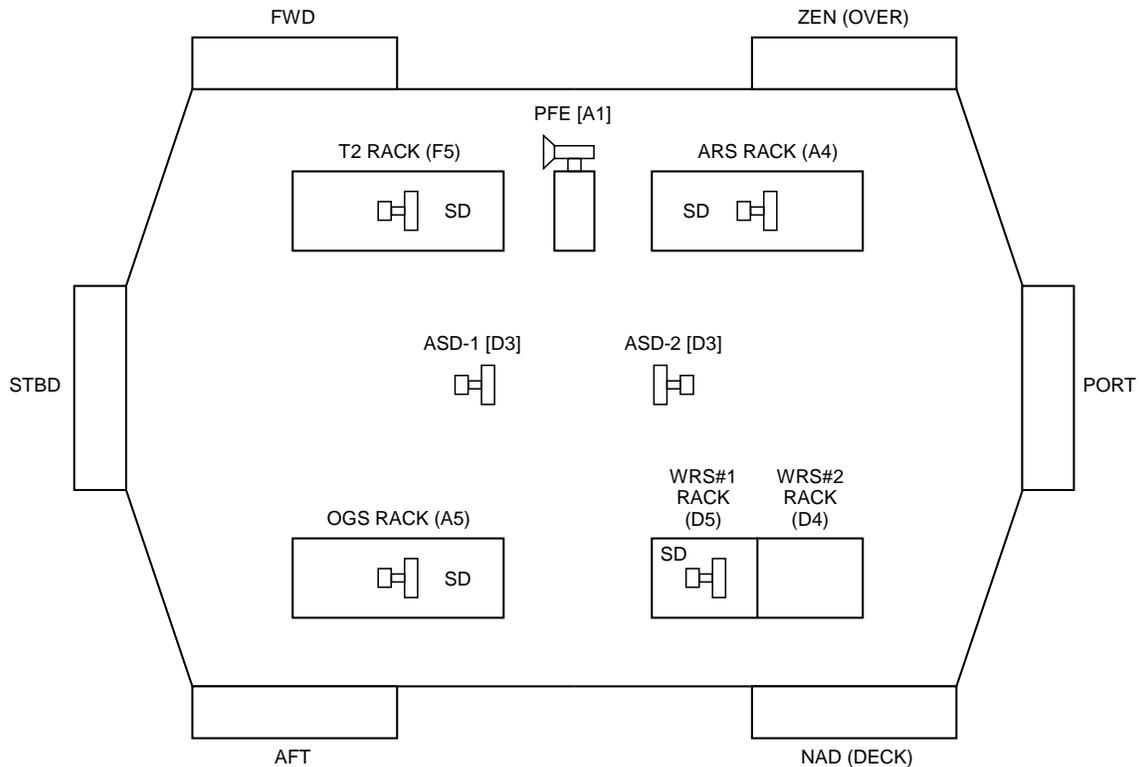
#### **5.1.6.2 Atmospheric Revitalization System**

The Node 3 ARS outfitting hardware includes subsystem hardware common to the USOS sample delivery system, including a single sample probe, air sampling valves, and atmosphere revitalization manual valves for isolating any single element from the Sample Distribution System (SDS).

#### **5.1.6.3 Fire Detection and Suppression**

Node 3 Fire Detection and Suppression (FDS) system hardware includes two Area Smoke Detectors (ASDs) installed downstream of the grid and upstream of the cabin air bacteria filter assembly, multiple fire ports, two PBAs, and common USOS extinguishers outfitted with nozzles to access fire ports at closeouts and standoffs. Fire control is performed manually by the crew in response to C&W annunciations through the use of the fire extinguishers. See Figure 5-4 for hardware location.

The Cupola design provides two fire holes for portable fire extinguisher application at the only enclosed volume that contains a potential fire source (the electrical power harness). The volume is bounded by the secondary and primary Cupola structure, passive and active CBMs, and the Node 3 bulkhead.



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**Figure 5-4. Node 3 smoke detection**

#### 5.1.6.4 Temperature and Humidity Control

The Node 3 element delivers an additional CCAA to support increased atmospheric ventilation requirements with the growth of the pressurized volume. The CCAA is installed in the midbay area of the Node and will assist in cooling and ventilation to future attached elements. The Node 3 CCAA is composed of a number of ORUs, most of which handle configuration functions for the subsystem, including the following:

- Inlet temperature sensor - The inlet temperature sensor is used in determining overall cabin air temperature.
- Inlet fan - The CCAA inlet fan is responsible for pulling cabin air into the CCAA and forcing mixing so that the principal components of the unit can perform their design function.
- Heat exchanger (HX) - The CCAA HX blows cabin air past a water-filled HX, cooling the air and carrying the heat to the ETCS ammonia HXs.
- Temperature Control Check Valve (TCCV) - The TCCV is contained within the Hx ORUs and is designed to maintain cabin temperature, proportioning airflow either through or around the condensing Hx. The TCCV uses an actuator for valve

positioning, which provides hard stops for end of travel, position feedback for fault detection, and a manual override.

- e. Liquid sensor - The liquid sensor is designed to verify the presence of water at the exit of the CCAA Hx.
- f. Water separator - The water separator collects condensate water from the cooled air and returns it to the Water Recovery and Management (WRM) system for recycling.
- g. Electrical interface box - The electrical interface box is designed to the conditioning of the nonstandard signal coming from the liquid sensors located in the water separator and on the AFT midbay THC pipeline. It also provides power to the solenoid valve in the water separator.

### **5.1.7 Thermal Control System**

The Node 3 element includes two independent loops for active internal cooling.

- a. Node 3 LTL
- b. Node 3 MTL

Some of the principle components of the ITCS delivered with the Node 3 element are as follows:

- a. The TWMV consists of a direct current, motor-driven, electromechanically actuated ball valve, which is used to control coolant flow from the direct and bypass legs of the system. The TWMV has two inlets and one outlet, allowing coolant at different temperatures to enter the inlet ports, mix the two incoming supplies of coolant in proportions that are continuously variable, and deliver the mixture to the single outlet. There are three TWMVs: two on the N3 MTL and one on the N3 LTL.
- b. Coldplates are used to actively cool equipment in the rack bays by conducting heat away from hardware surfaces. There are four different types of coldplates, varying in dimensions though not functionality. There are 17 coldplates in total in Node 3. Table 5-1 shows the coldplate designations, along with loop connectivity and the item being cooled.

**Table 5-1. Node 3 coldplate heat loads**

Location	Coldplate type	Electronic equipment
Avionics rack 1 (O4)	N3-O4_C/P_DASH_6-1	N3-O4_RPCM_1B4A-1A
		N3-O4_RPCM_1B4A-1B
		N3-O4_RPCM_1B4A-1C
		N3-O4_RPCM_1B4A-1D
		N3-O4_RPCM_1B4A-1E
		N3-O4_RPCM_1B4A-1F
	N3-O4_C/P_DASH_1-1	N3-O4_DDCU_1B
	N3-O4_C/P_DASH_1-2	N3-O4_DDCU_4A
	N3-O4_C/P_DASH_8-1	N3-DAIU-2
		N3-ABC-5
	N3-O4_C/P_DASH_8-2	N3-VSU-5
	N3-O4_C/P_DASH_8-3	N3-MDM_HCZ-1
		N3-MDM-1
	N3-O4_C/P_DASH_6-2	N3-O4_RPCM_1B4A-2A
		N3-O4_RPCM_1B4A-2B
N3-O4_RPCM_1B4A-2C		
N3-O4_RPCM_1B4A-2D		
N3-O4_RPCM_1B4A-2E		
N3-O4_RPCM_1B4A-2F		
AFT STBD cone (S6)	N3-A6_C/P_DASH_8-1	N3-VTR-3
		N3-VTR-4
	N3-A6_C/P_DASH_4-1	N3-ATU-16
Avionics rack 2 (O5)	N3-O5_C/P_DASH_6-1	N3-O5_RPCM_2A2B-1C
		N3-O5_RPCM_2A2B-1E
		N3-O5_RPCM_2A2B-1F
		N3-O5_RPCM_2A2B-1A
		N3-O5_RPCM_2A2B-1B
	N3-O5_C/P_DASH_1-1	N3-O5_DDCU_2B
	N3-O5_C/P_DASH_1-2	N3-O5_DDCU_2A
	N3-O5_C/P_DASH_8-1	N3-ABC-6
		N3-RAIU-3
	N3-O5_C/P_DASH_8-2	N3-CVIU-1
		N3-CVIU-2
		N3-CVIU-3
	N3-O5_C/P_DASH_8-3	N3-MDM_HCZ-2
		N3-MDM-2
	N3-O5_C/P_DASH_6-2	N3-O5_RPCM_2A2B-2A
N3-O5_RPCM_2A2B-2B		
N3-O5_RPCM_2A2B-2C		
N3-O5_RPCM_2A2B-2D		
N3-O5_RPCM_2A2B-2E		
N3-O5_RPCM_2A2B-2F		
AFT alcove (S1)	N3-A1_C/P_DASH_4-1	N3-ATU-17

- c. A PPA for each independent loop (LTL, MTL), which consists of a motor driven water pump, motor controller, accumulator with quantity sensor, filter with isolation valves, noncondensable gas trap with isolation valves, flow meter, pump inlet pressure sensor, pump differential pressure sensor, gas trap differential pressure sensor, pump outlet temperature sensor, and filter differential pressure sensor. The filter and gas trap are considered ORUs, and the PPA is designed so that these two items may be removed and replaced without interruption of pump operation.
- d. The Manual Flow Control Valve (MFCV) is a manually operated ball valve that controls the flow of coolant through each loop. There are eight total MFCVs in Node 2 located throughout the MTL and LTL loops.
- e. The SFCA controls and monitors coolant that flows through the ITCS. The SFCA includes a flow control valve, a shutoff valve, and a differential pressure sensor. A constant differential pressure is maintained across the high (supply) and low (return) headers using a flow bypass technique. The SFCA also provides isolation capability for the PPA. There is one SFCA on each loop (MTL and LTL).
- f. The ammonia/water Hx is designed to transfer heat from internal cooling lines and coldplates to the external ammonia TCS. The Hx (two) are located on the STBD cone external shell of Node 3. The HX ORU is composed of an Hx, a bypass valve on the ammonia side, an isolation relief valve at the ammonia outlet, and two temperature sensors located at each water or ammonia outlet. The external plumbing connecting the NH<sub>3</sub>/H<sub>2</sub>O Hxs in the unpressurized volume consists of 1.0-in. diameter metal flex lines.
- g. The Rack Flow Control Assembly (RFCA) is a motor-driven valve that provides for remote modulation of coolant flow rate and temperature. The RFCA includes a flow-modulating valve, a flow sensor, and a temperature sensor. Node 3 requires five RFCAs.
- h. The Regenerative Heat Exchanger (RHX) is used to warm the ITCS coolant when operating in single mode if the water exiting the central thermal bus interface Hx is too cold (i.e., below the cabin dew point).
- i. ITCS temperature sensors monitor and transmit operating fluid temperature to the MDMs. Node 3 implements two rack temperature sensors, one for each Avionics Rack, located in the rack output branch used to monitor the rack MTL water output temperature.

In addition to the active internal cooling system, heaters and MLI are used to control heat transfer.

### **5.1.7.1 Node 3 Low Temperature Loop**

The LTL collects and removes waste heat from the attached MPLM (when attached) and Node 1 LTLs and from the coldplate of avionics rack N3O4. The heat is rejected through the dedicated NH<sub>3</sub>/H<sub>2</sub>O HX. The Node 3 LTL is controlled by the N3-2 MDM.

### **5.1.7.2 Node 3 Moderate Temperature Loop**

The MTL collects and removes waste heat from the attached MPLM (when attached), and Node 1 MT loops and from coldplate-cooled electronic equipment located in the racks of Node 3. The heat is rejected through the dedicated NH<sub>3</sub>/H<sub>2</sub>O HX located on the ZENITH cone shell. The Node 3 MTL is controlled by the N3-1 MDM.

### **5.1.8 Robotics**

Mission 20A provides no additional robotics capability.

## **5.2 CUPOLA**

The Cupola serves as an observation and worksite area for space station crewmembers. It provides a pressurized command/control workstation and space for hardware used to observe Earth, celestial objects, and space station external surfaces. Two crewmembers can be accommodated at any time. Since eye level is 39 in. from the CBM interface plane, crewmembers partially intrude into Node 3. The Cupola is attached following a sequence of transfers: from cargo bay to Node 1 while attached to Node 3 PORT port, then from Node 3 PORT port to Node 3 NADIR port.

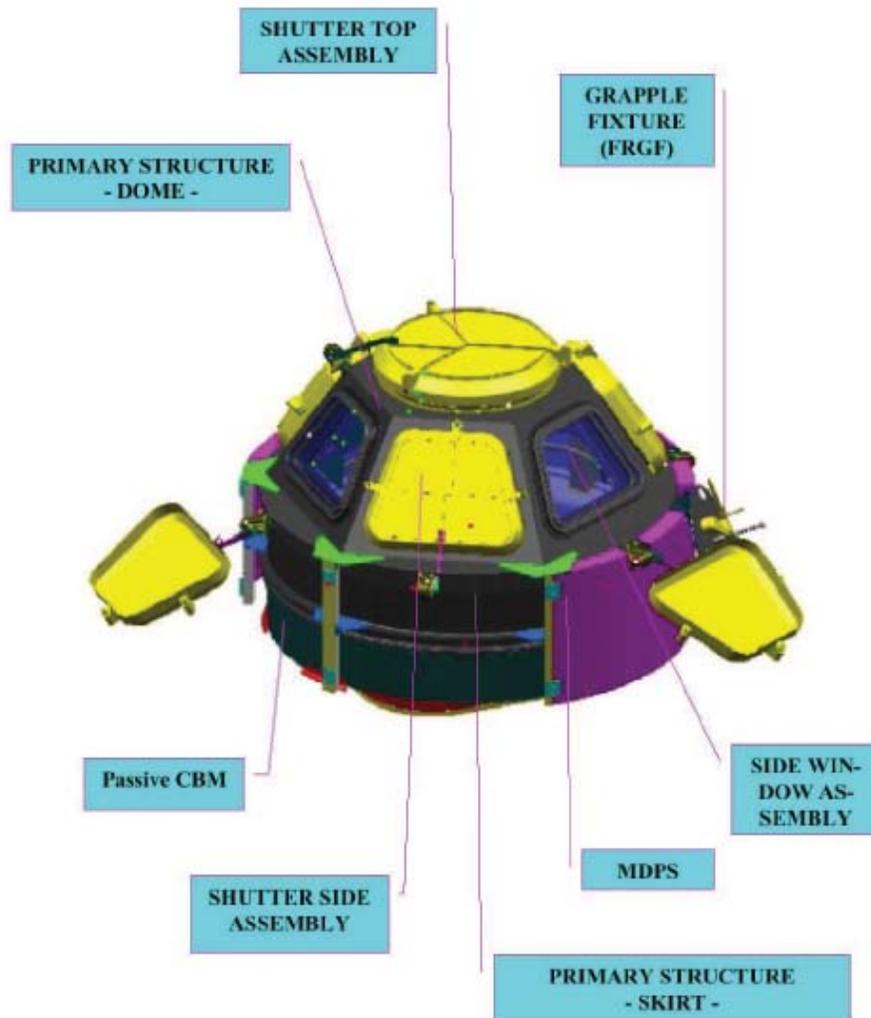
### **5.2.1 Structure and Mechanisms**

The Cupola is a pressurized space station element geometrically shaped like a truncated hexagonal pyramid mounted above a cylinder. The Cupola's total pressurized volume is 3.5 cubic meters. The Cupola primary structure consists of two major items, the dome and the skirt, which are welded together. The primary structure is attached to the PCBM, which interfaces to an ACBM located at the Node 3 NADIR port.

The two main components of the Cupola are the dome and skirt. The dome is shaped like a truncated hexagonal pyramid with six trapezoidal windows around the sides and one circular window on the top. The skirt is plasma welded to the dome. Figure 5-5 shows the main components of the Cupola.

#### **5.2.1.1 Flight Releasable Grapple Fixture**

The Cupola provides two identical FRGFs with dedicated support brackets on the Cupola primary structure. The FRGFs allow Cupola installation on the ISS Node 3 and its relocation from Node 3 PORT to Node 3 NADIR.



**Figure 5-5. Cupola components**

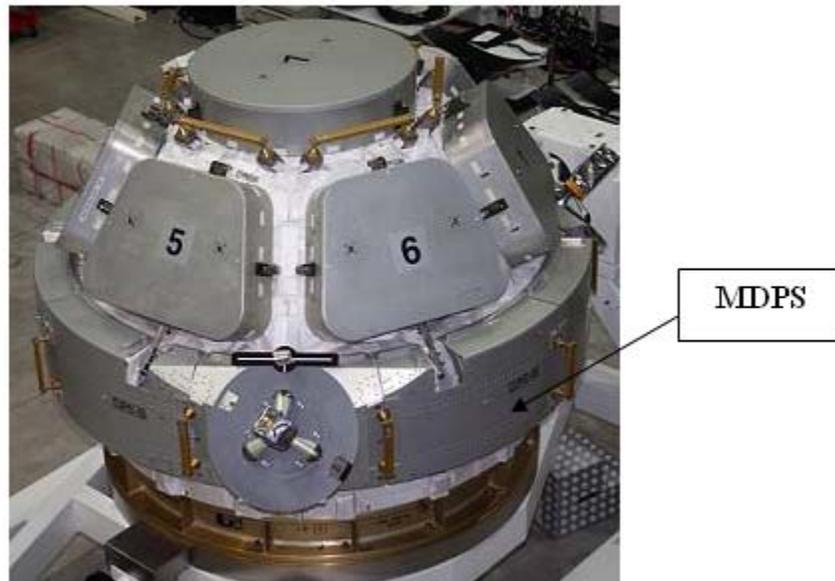
### 5.2.1.2 Windows

Each window assembly is fixed to the primary structure by a bolted flange and is designed to be completely removable and replaceable on orbit, if necessary. All windows are equipped with a shutter, which provides a thermal barrier and debris protection. Each window is composed of four assemblies: a pressure assembly, a debris assembly, a scratch assembly, and a flex hose assembly. The pressure assembly is composed of primary and redundant glass pressure panes and pressure seals. The debris assembly provides residual protection for the pressure assembly from micrometeoroid and space debris impacts when the window shutter is open. The scratch assembly protects the primary pressure pane from damage resulting from crew or equipment impacts, provides heater power to prevent condensation forming on the window, and provides Ultraviolet (UV) absorption. The flex hose assembly provides a connection between Self Sealing Quick Disconnect (SSQD)-1 and SSQD-2, which

allows air enclosed between the primary and redundant pressure panes to be released to the external environment prior to pressurization of the Cupola internal volume.

### 5.2.1.3 Meteoroid Debris Protection System

The Meteoroid Debris Protection System (MDPS) consists of a single aluminum bumper structure that protects the primary structure from meteoroid and debris impact. The bumper consists of eight panels, each covering a section of the Cupola. Each panel is attached to the primary structure on a titanium bracket with four quick-locking fasteners. Refer to Figure 5-6 for the Cupola with MDPS installed.



**Figure 5-6. Cupola with MDPS installed**

The Cupola harness provides the connection between the Node bulkhead and all electrical equipment installed in the Cupola. This system provides power, analog and digital signals, commands, and fiber optics. The harness is compliant with the electrical constraints imposed by the ATU, Mobile Service System Robotic Work Station (MMS RWS), and the UOP. The Cupola provides three dual redundant MIL-STD-1553 data buses between the Node, the UOP, and the RWS port: HC-LB-2, BCU-LB-2, and CB-INT-2.

### 5.2.2 Electrical Power System

The Cupola receives power from Node 3 to the audio ATU, UOPs, and Cupola heaters via RPCM N32A2B, as shown in Drawing 5.1.

### **5.2.3 Command and Data Handling System**

The Cupola has no C&DH capability for 20A. Refer to Drawing 5.2 for 20A C&DH capabilities.

### **5.2.4 Communications and Tracking System**

An audio ATU is located in the Cupola. There is no video capability. Refer to Drawing 5.3 for the details.

### **5.2.5 Motion Control System**

The Cupola has no MCS capability.

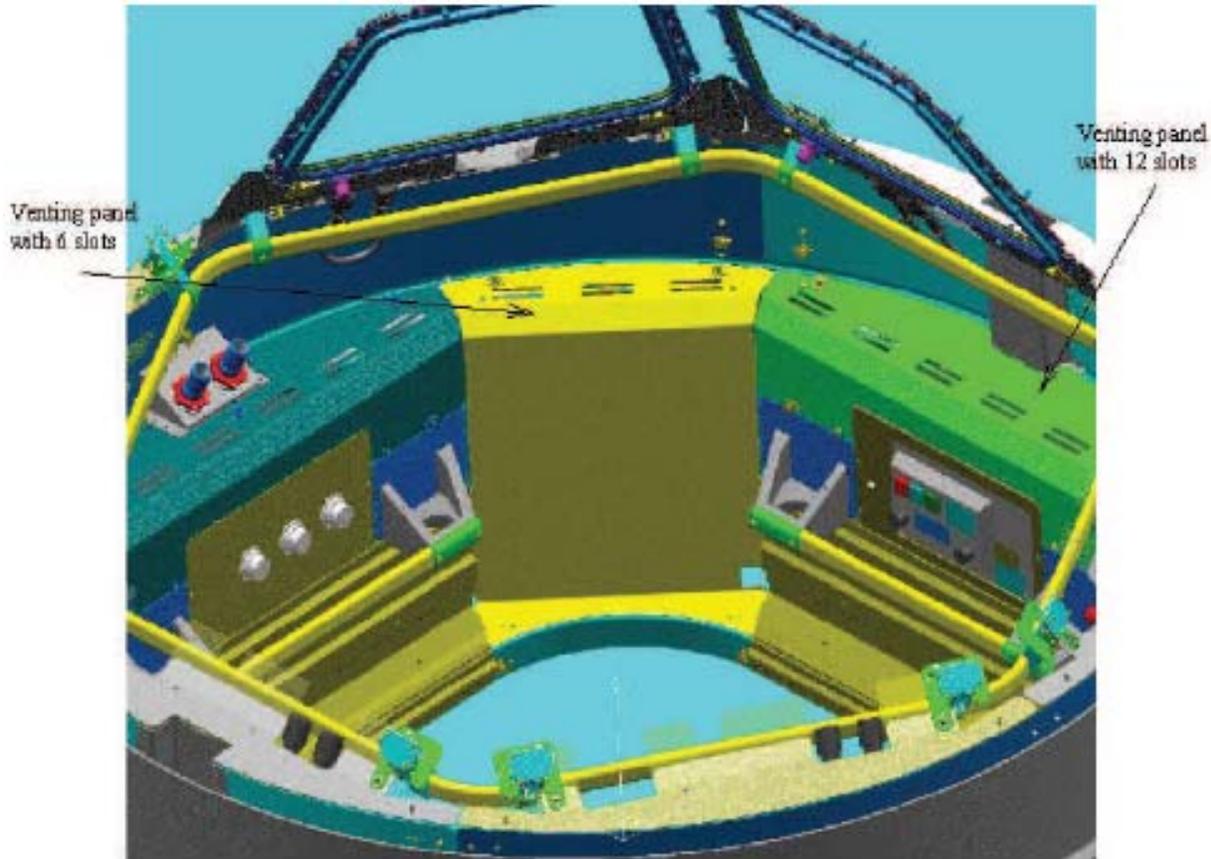
### **5.2.6 Environmental Control and Life Support**

The cupola receives air from Node 1 via a dedicated IMV line. Air delivered from the Node flows directly into the Cupola plenum, an enclosed volume bounded by the Node bulkhead, the CBM, part of the primary structure skirt, and lower secondary structure closeout panels. A deflector plate is installed inside the plenum close to the IMV interface to deflect the main air flux and to guarantee a balanced air distribution inside the volume. The air is then discharged into the Cupola cabin via dedicated slots cut in the closeout panels of the secondary structure in the barrel zone. These slots have the same function as a traditional air diffuser. The air flow returns to the Node via the Node open hatch.

The Cupola is launched as a nonpressurized item, making it subject to shuttle cargo bay pressure trends. When attached, the Cupola is considered part of Node 3, so it will follow pressure trends of Node 3. The Cupola has no dedicated hardware for control and monitoring of internal pressure; this information is obtained from existing ISS hardware.

Air from Node 3 flows into the Cupola via an IMV line and then is distributed evenly with a deflector plate located close to the IMV interface. Air is discharged inside the cabin with the use of slots arranged in groups of 6 or 12 (see Figure 5-7). Crewmembers can adjust the IMV inlet temperature using a rheostat located in Node 3.

ECLSS details are shown in Drawing 5.4.



**Figure 5-7. Cupola ventilation panels**

### **5.2.7 Cupola Thermal Control System**

The Cupola TCS is composed of the ITCS and the Passive Thermal Control System (PTCS). The primary purpose of the Cupola TCS is to control the primary and secondary structure temperatures, to control the temperatures of the structural walls using the HTL, to prevent condensate formation inside the Cupola, and to actively control the ATU equipment during the on-orbit manned phases.

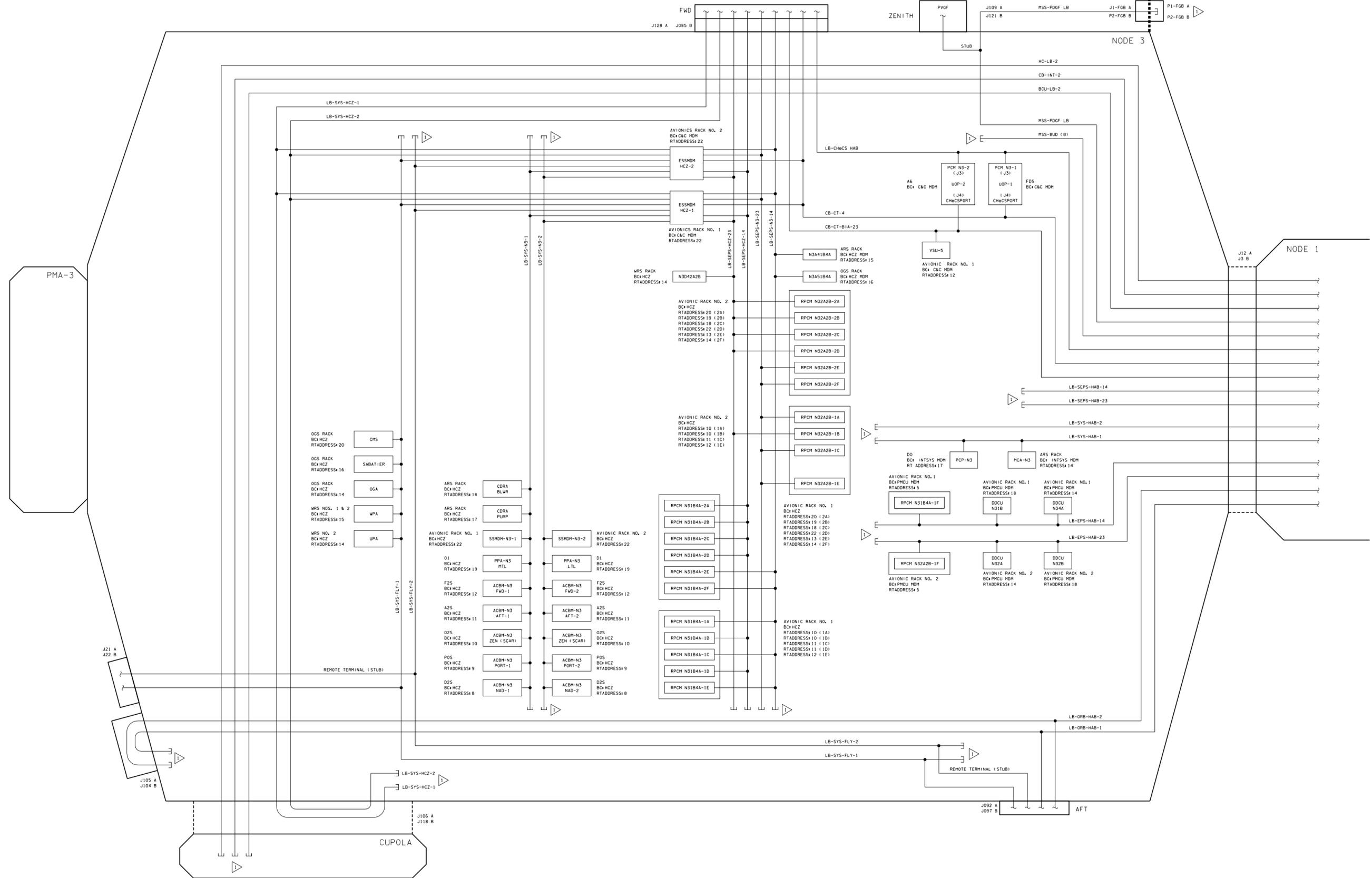
The ITCS consists of a central loop and a dome loop. The central loop is dedicated to the thermal conditioning of the ATU when installed in one of its two possible mounting locations. The dome loop serves to thermally condition the Cupola dome structure and the window assemblies, limiting the temperature gradients and excursions to preclude condensation on the walls and windows. The ITCS heat rejection system uses a heat transfer water-piping loop around the windows in the dome. The water is charged, pressurized, and circulated by the ISS U.S. Lab water accumulator/pump package.

The PTCS protects the Cupola from the external environment by minimizing heat leak/gain, promoting the primary structure cooling via the heat transfer loop, and avoiding water freezing and vapor condensation on the internal surfaces of the Cupola. The PTCS is composed of MLI blankets throughout the Cupola.

The Cupola TCS is integrated in Drawing 5.5, NODE 3 THERMAL CONTROL SYSTEM.

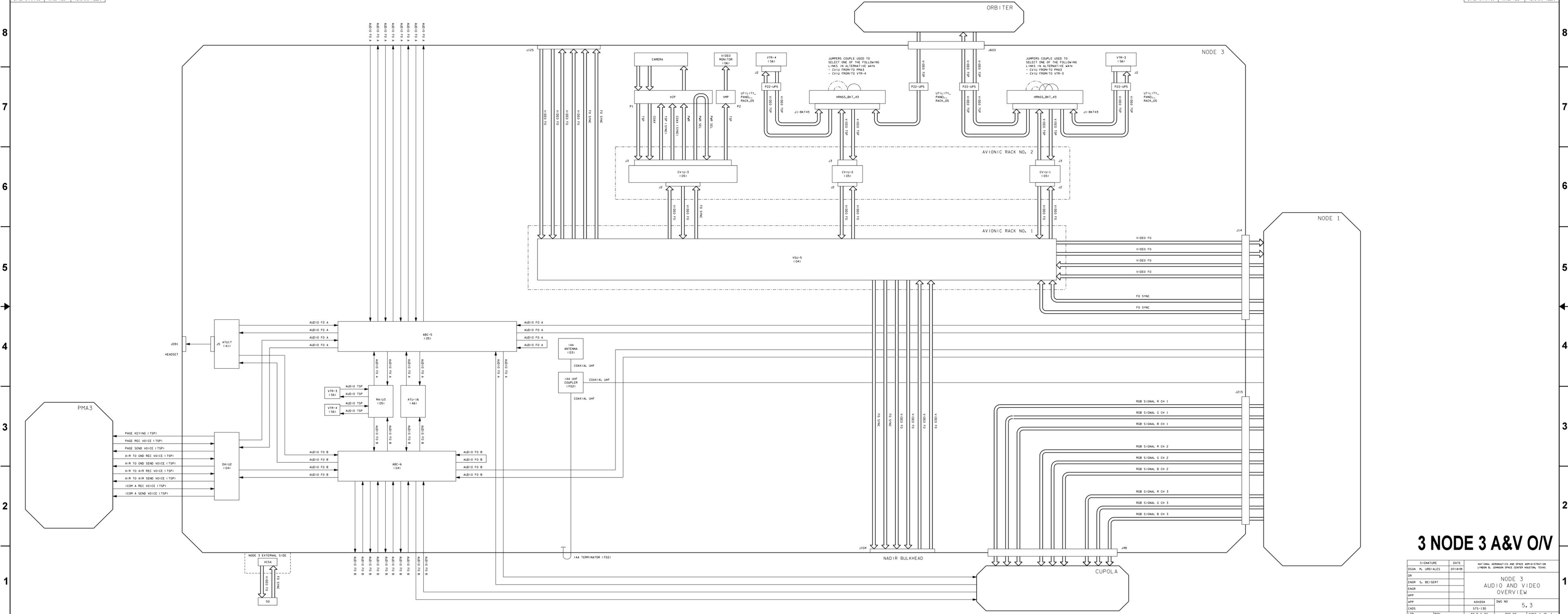
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## 2 NODE 3 C&DH SYS O/V

SIGNATURE	DATE	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER HOUSTON, TEXAS	
DSGN M. URDI/ALES	07/01/09	NODE 3 COMMAND & DATA HANDLING SYSTEM OVERVIEW	
ENGR S. BEISERT			
APP			
APP		ADH20A	DWG NO. 5-2
CADS		STS-130	66 X 34
LTR	PCN		SHEET 1 OF 1



SIGNATURE	DATE	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
DSGN: KL URD/ALES	07/14/09	LINDOR BL JOHNSON SPACE CENTER HOUSTON, TEXAS
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## APPENDIX A ACRONYMS AND ABBREVIATIONS

A	Amperes
A/L	Airlock
AA	Antenna Assembly
AAA	Avionics Air Assembly
ABC	Audio Bus Coupler
ACBM	Active Common Berthing Mechanism
ACD	Advanced Control Device
ACO	Assembly Checkout Officer
ACS	Atmospheric Control and Resupply System
AFD	Aft Flight Deck
AMOS	Air Force Maui Optical and Supercomputing Site
AOH	Assembly Operations Handbook
AOP	Assembly Operations Procedure
APAS	Androgynous Peripheral Attachment System
APCU	Assembly Power Converter Unit
ARCU	American-to-Russian Converter Unit
ARS	Atmospheric Revitalization System
ASD	Area Smoke Detector
ATA	Ammonia Tank Assembly
ATCS	Active Thermal Control System
ATU	Audio Terminal Unit
BCDU	Battery Charge/Discharge Unit
BCP	Instrumentation jumper
BDS	Backup Drive System
BGA	Beta Gimbal Assembly
C&C	Command and Control
C&DH	Command and Data Handling
C&T	Communication and Tracking
C&W	Caution and Warning
C/L	Crew Lock
cb	circuit breaker
CBCS	Centerline Berthing Camera System
CBM	Common Berthing Mechanism
CCA	Circuit Card Assembly
CCAA	Common Cabin Air Assembly
CCTV	Closed-Circuit Television
CDRA	Carbon Dioxide Removal Assembly
CETA	Crew and Equipment Translation Aid
CFM	Cubic Feet per Minute
CG	Center of Gravity
CGBA	Commercial Generic Bioprocessing Apparatus

CHA	Crew Headset Assembly
CHT	Russian designation for Voltage and Current Stabilizer
CHX	Cabin Heat Exchanger
Cmd	Command
CMG	Control Moment Gyro
COL	Columbus
Comm	Communication
Config	Configuration
CPA	Controller Power Assembly
CPS	Cabin Pressure Sensor
CPU	Central Processing Unit
CRT	Cathode-Ray Tube
CTB	Cargo Transfer Bag
CVIU	Common Video Interface Unit
DAIU	Docked Audio Interface Unit
DC	Direct Current
	Docking Compartment
DC-1	Docking Compartment-1
DCSU	Direct Current Switching Unit
DDCU	DC-to-DC Converter Unit
DIU	Data Interface Unit
DMC	Data Management Computer
DMS	Data Management System
DoD	Department of Defense
DRTS	Japanese Data Relay Satellite
E/L	Equipment Lock
EATCS	External Active Thermal Control System
ECLSS	Environmental Control and Life Support System
ECU	Electronic Control Unit
EE	End Effector
EELS	Emergency Egress Lighting System
EET	Experiment Elapsed Time
EF	Exposed Facility
EFHX	Exposed Facility Heat Exchanger
ELS	Emergency Lighting Strip
	Emergency Lighting Supply
EMI	Electromagnetic Interference
EMU	Extravehicular Mobility Unit
EPDS	Electrical Power Distribution System
EPS	Electrical Power System
ER6	Express Rack 6
ESA	European Space Agency
ESC	JEF System Computer
ETCS	External Thermal Control System

ETRS	ISS Temporary Rail Stop
ETVCG	External Television Camera Group
EV	Extravehicular
EVA	Extravehicular Activity
EXT	Exterior
FA	Fluid Accumulators
FC	Fuel Cell
FCV	Flow Control Valve
FD	Flight Day
FDIR	Fault Detection, Isolation, and Recovery
FDS	Fire Detection and Suppression
FGB	Functional Cargo Block
FPA	Fluid Processing Apparatus
FPP	Fluid Pum Packages
FRD	Flight Requirements Document
FRGF	Flight Releasable Grapple Fixture
GAP	Group Activation Pack
GFE	Government Furnished Equipment
GLA	General Luminaire Assembly
Glacier	General Laboratory Active Cryogenic ISS Experiment Refrigerator
GLONASS	Global Navigational Satellite System
GMT	Greenwich Mean Time
GNC	Guidance, Navigation, and Control
GPC	General Purpose Computer
GPS	Global Positioning System
GSE	Ground Support Equipment
HCE	Heater Control Equipment
HCZ	ISS Tier II MDM
HEPA	High Efficiency Particulate Acquisition
HI-AIR	Flame-resistant hook-and-loop fastener made of Nomex
HI-MEG	Silver-coated hook-and-loop fastener for an electrically conductive tape
HMU	Umbilical
HTL	High Temperature Loop
HX	Heat Exchanger
IAA	Intravehicular Antenna Assembly
IAS	Integrated Audio System
IATCS	Internal Active Thermal Control System
ICM	Interim Control Module
ICOM	Internal Communications
ICS	Interorbit Communication System
IFHX	Interface Heat Exchanger
IM	Internal Motor
IMCS	Integrated Mission Control System

IMV	Intermodule Ventilation
INT	Internal
IP	International Partner
ISL	Integrated Station LAN
ISS	International Space Station
ISSH	International Space Station Systems Handbook
ITCS	Internal Thermal Control System
ITS	Integrated Truss Segment
IVA	Intravehicular Activity
IVDS	Internal Video Distribution and Control System
JAXA	Japanese Aerospace Exploration Agency
JCP	JEM Control Processor
JEF	JEM Exposed Facility
JEM	Japanese Experiment Module
JEMRMS	Japanese Experiment Module Remote Manipulator System
JLE	Japanese Experiment Logistics Module - Exposed Section
JLP	JEM Experiment Logistics Module - Pressurized Section
JPM	Japanese Pressurized Module
Lab	Laboratory module
LCA	Lab Cradle Assembly
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LEE	Latching End Effectors
LRU	Line Replacement Unit
LT	Low Temperature
LTA	Launch-to-Activation
LTL	Low Temperature Loop
M-RTAS	Modified Rocketdyne Truss Attachment System
MAUI	Maui Analysis of Upper-atmospheric Injections
MBS	Mobile Base System
MBSU	Main Bus Switching Unit
MCA	Major Constituent Analyzer
MCC	Mission Control Center
MCC-H	Mission Control Center-Houston
MCC-M	Mission Control Center-Moscow
MCD	Multifunction CRT Display System
MCS	Motion Control System
MDCU	Main Bus Switching Unit
MDL	Middeck Locker
MDM	Multiplexer/Demultiplexer
MDP	Management Data Processor
MDPS	Meteoroid Debris Protection System
MFCV	Manual Flow Control Valve

MKAM	Minimum Keep Alive Monitor
MLE	Middeck Locker Equivalent
MLI	Multilayer Insulation
MMC	Mission Management Computer
MMOD	Micrometeoroid/Orbital Debris
MMS RWS	Mobile Service System Robotic Work Station
MNA	Main A
MNB	Main B
MNC	Main C
MPEV	Manual Pressure Equalization Valve
MPLM	Multipurpose Logistics Module
MPM	Manipulator Positioning Mechanism
MRL	Manipulator Retention Latch
MSS	Mobile Servicing System
MT	Mobile Transport
MTL	Moderate Temperature Loop
MUP	Middeck Utility Panel
NIA	Nitrogen Interface Assembly
NIV	N2 Introduction Valve
NLP	National Lab Pathfinder
NPRV	Negative Pressure Relief Valve
NPV	Non-Propulsive Vent
NSTS	National Space Transportation System
NTA	Nitrogen Tank Assembly
NTSC	National Television Standard Committee
OBSS	Orbiter Boom Sensor System
OCA	Orbital Communications Adapter
ODS	Orbiter Docking System
OGS	Oxygen Generator System
OIV	O2 Introduction Valve
OMS	Orbital Maneuvering System
OPCU	Orbiter Power Converter Unit
Ops	Operations
ORCA	Oxygen Recharge Compressor Assembly
ORU	Orbital Replaceable Unit
OSA	Orbiter-Based Station Avionics
OV	Orbiter Vehicle
P/L	Payload
PAS	Payload Attach System
PBA	Portable Breathing Apparatus
PBIT	Power-On Built-In Test
PCA	Pressure Control Assembly
PCBM	Passive Common Berthing Mechanism

PCP	Pressure Control Panel
PCS	Portable Computer System
PCU	Power Control Unit
PDB	Power Distribution Box
PDGF	Power and Data Grapple Fixture
PDH	Payload Data Handling Unit
PDRS	Payload Deployment and Retrieval System
PDU	Power Distribution Unit
PEV	Pressure Equalization Valve
PFM	Pulse Frequency Modulated
PFR	Portable Foot Restraint
PGT	Pistol Grip Tool
PIB	Power Interface Box
PIP	Push-In-Pull out
PLB	Payload Bay
PLCU	P/L Command Unit
PLT	Payload Laptop Terminal
PM	Pump Module
PMA	Pressurized Mating Adapter
PMCU	Power Management Control Unit
PMP	Payload Mounting Panel
PO	Port Outboard
POA	Payload/ORU Accommodation
POCC	Payload Operations Control Center
PPA	Pump Package Assembly
PPL	Pre-Positioned Load
PPRV	Positive Pressure Relief Valve
PRLA	Payload Retention Latch Assemblies
PTCS	Passive Thermal Control System
PTR	Port Thermal Radiator
PTU	Pan/Tilt Unit
PVCU	Photovoltaic Controller Unit
PVM	Photovoltaic Module
PVR	Photovoltaic Radiator
PVTCS	Photovoltaic Thermal Control System
QD	Quick-Disconnect
RACU	Russian-to-American Converter Unit
RBVM	Radiator Beam Valve Module
RCA	Remote Control Assembly
RCS	Reaction Control System
RF	Radio Frequency
RFCA	Rack Flow Control Assembly
RGA	Rate Gyro Assemblies
RHX	Regenerative Heat Exchanger

RLT	Robotics Laptop Terminal
ROS	Russian Orbital Segment
RPC	Remote Power Controller
RPCM	Remote Power Controller Module
RPDA	Remote Power Distribution Assembly
RPS	Rack Power Switch
RS	Russian Segment
RT	Remote Terminal
RTAS	Rocketdyne Truss Attachment System
RWS	Robotic Workstation
SARJ	Solar Alpha Rotary Joint
SCAR	Signal Characterization and Recognition
SDO	Solenoid Driver Output
SDS	Sample Distribution System
SEITE	Shuttle Exhaust Ion Turbulence Experiment
SFCA	System Flow Control Assembly
SIMPLEX	Shuttle Ionospheric Modification with Pulsed Localized Exhaust
SLT	Station Laptop Terminal
SM	Service Module
SOV	Shutoff Valve
SPC	Standard Portable Computer
SPDA	Secondary Power Distribution Assembly
SPDM	Special Purpose Dexterous Manipulator
SPDU	Secondary Power Distribution Unit
SPEC	Specialist Function
SRMS	Shuttle Remote Manipulator System
SSAS	Segment-to-Segment Attach System
SSC	Station Support Computer
SSCN	Space Station Change Notice
SSIPC	Space Station Integration and Promotion Center
SSMDM	Space Station Multiplexer/Demultiplexer
SSPTS	Station/Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
SSSH	Space Shuttle Systems Handbook
SSSR	Space to Space Station Radio
STBD	Starboard
STR	Starboard Thermal Radiator
STS	Space Transportation System
Sync	Synchronization
TA	Thruster Assist
TCCS	Trace Contaminant Control System
TCCV	Temperature Control and Check Valve
TCS	Thermal Control System
TDMA	Time Division Multiple Access

THC	Temperature and Humidity Control
TLM	Telemetry
TMA	Russian vehicle designation
TOCA	Total Organic Carbon Analyzer
TRRJ	Thermal Radiator Rotary Joint
TUS	Trailing Umbilical System
TWMV	Three-Way Mixing Valve
U.S.	United States
UCCAS	Unpressurized Cargo Carrier Attach System
UCS	UHF Communication Subsystem
UHF	Ultrahigh Frequency
ULF3	Utilization Logistics Flight 3
UMA	Umbilical Mechanism Assembly
UOP	Utility Outlet Panel
USOS	United States On-Orbit Segment
UV	Ultraviolet
VCP	Video Camera Port
VCSA	Video Camera Support Assembly
VDS	Video Distribution System
VHF	Very High Frequency
VPMP	Vented Payload Mounting Panel
VRV	Vent Relief Valve
VSC	Video Signal Converter
VSU	Video Switch Unit
VTR	Video Tape Recorder
W	Watts
WHC	Waste and Hygiene Compartment
WIF	Worksite Interface
WMV	Water Modulating Valves
WOOV	Water On-Off
WPA	Water Pump Assembly
WRM	Water Recovery and Management
WRS	Water Recovery System
WS	Water Separator
	Work Site
	Work Station
WVA	Water Vent Assembly

**APPENDIX B  
SUPPLEMENTARY DATA**

There are currently no supplementary data identified.

## **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.

### **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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