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PRESSURIZED CARRIERS GROUP

EXPORT ADMINISTRATION
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Multi Purpose Logistics Module Interface Definition Document

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DOCUMENT HISTORY LOG

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Revision	D	2/11/03	ECR FD24-0014 to add changes submitted by JSC & KSC Cargo Integration
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1.0 INTRODUCTION

The MPLM is a pressurized logistics module designed to supply and return cargo requiring a pressurized storage environment to and from the International Space Station (ISS) via the National Space Transportation System (NSTS).

Three Flight Units are available, each reconfigurable from Active to Passive. The MPLM is designed for 10 years (or 25 missions) operational life per Flight Unit.

MPLM missions will be conducted to support the Assembly Phase of the ISS and to guarantee the resupply and refurbishment of the Station during the Utilization Phase.

The manifested cargo can either be passive (dry cargo) or include refrigerated cargo. Refrigerated cargo will be accommodated in active Refrigerators/Freezers (R/Fs).

1.1 PURPOSE OF DOCUMENT

The purpose of this document is to describe the main characteristics of the MPLM and to provide design, capabilities, performance characteristics and constraints data, to enable the User Community to determine how their payloads can be accommodated and transported by the MPLM.

This document reflects the MPLM baseline and contains the controlled data set concerning the MPLM capabilities, constraints, and cargo interfaces. The document covers all the MPLM mission phases, including ground processing at the Launch and Landing Site (LLS).

The scope of this Interface Definition Document (IDD) is limited to the MPLM cargo accommodation capabilities and constraints. Specific data related to the MPLM operations are as a rule reported in the document MLM-HB-AI-0002 and are noted in the IDD only for aspects strictly linked to the cargo accommodation. MPLM ground processing procedures are detailed in K-SS-09.5.1.

1.2 PRECEDENCE

The integration of the MPLM into the Orbiter payload bay and to Space Station is defined in ICD-A-21350 and SSP 42007 respectively.

The integration of cargo (payload plus payload accommodation provisions) to the MPLM is driven by this IDD in conjunction with SSP 41017, SSP 41155, SSP 42007, SSP 57000, SSP 57007, and JSC 28169. In the event of conflict between this document and SSP 41017, SSP 41155, SSP 42007, or JSC 28169 those documents will take precedence.

SSP 57000, SSP 57007, and Mission Level ICDs drive the integration of science payloads and equipment for transportation in the MPLM. In the event of conflict between this document and SSP 57000, SSP 57007, or Mission Level ICDs for science payload and equipment level requirements, these documents will take precedence.

1.3 GENERAL MPLM SYSTEM DESCRIPTION

Transportation of pressurized payloads (including supplies and products) to and from ISS primarily occurs in the MPLM. The MPLM provides 16 rack positions. Volume available to payloads varies by flight. Five of the rack locations are active (powered) positions and the remaining 11 locations are passive. Six of the 11 passive locations can accommodate Active Rack Isolation System (ARIS) equipped racks. While the ARIS equipped racks are in the MPLM, the ARIS is not activated.

The MPLM will support two mission types, Active and Passive. Note that during Passive Flights and Active Flights, the MPLM requires resources from both the NSTS and from the ISS. The terms "active" and "passive" refer to cargo characteristics: during any mission phase of passive flights the cargo requires no power, data or cooling resources (dry cargo), while during active flights the R/F racks require MPLM resources (refrigerated cargo) in terms of power, data and cooling capabilities. In Passive Flights the NSTS resources are needed for heater power supply, and the ISS resources for module illumination, heating, atmosphere control, etc.

The majority of the Utilization Flights (UFs) will fall into the Active Flight category. Active Flights (AFs) will carry up to 16 racks, of which up to 5 can be active racks (R/F racks). It will return to earth with mission dependent download mass.

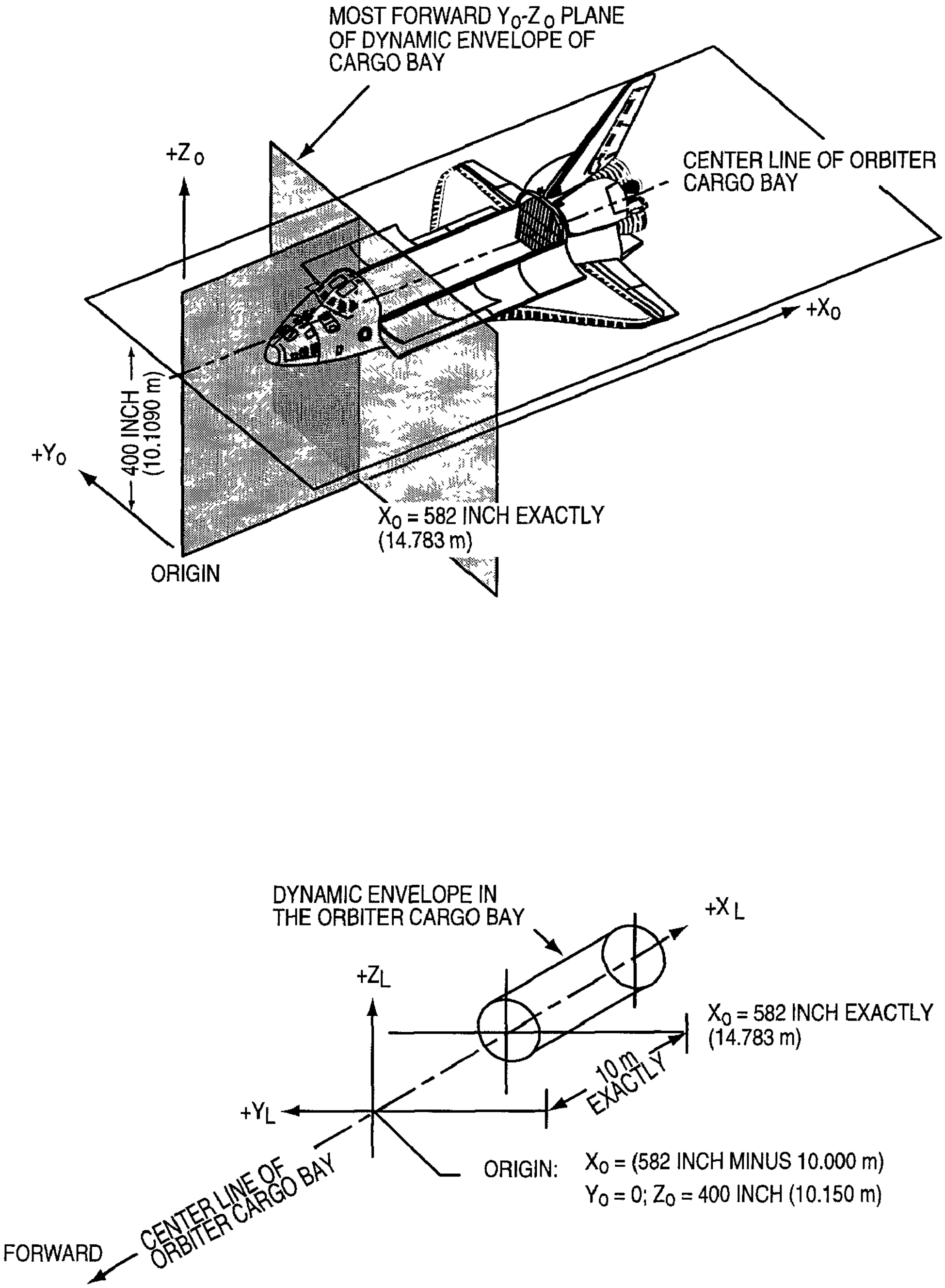
Passive Flights (PFs) will primarily support the ISS outfitting, though passive Utilization Flights are not excluded. The MPLM will carry up to 16 passive racks to be transferred to the ISS and it may return to earth with a different rack manifest comprising 16 to zero racks (typical outfitting mission). Passive flights are considered both during Human Tended Configuration (HTC) and during Permanent Human Configuration (PHC).

2.0 ORBITER/MPLM PERFORMANCE AND CONSTRAINTS

2.1 COORDINATE SYSTEMS

2.1.1 Orbiter Reference Coordinate System (RCS)

The Orbiter coordinate system is defined in Figure 2.1-1.



Origin:	In the Orbiter plane of symmetry, 400 inches below the centerline of the payload bay and at Orbiter X Station = 0.
Orientation:	The X_O axis is the vehicle plane of symmetry, parallel to and 400 inches below the payload bay centerline. Positive sense is from the nose of the vehicle toward the tail.
	The Z_O axis is in the vehicle plane of symmetry, perpendicular to the X_O axis, and positive upward in the landing attitude.
	The Y_O axis completes a right-handed system.
Characteristics:	Right Handed cartesian coordinate system. The standard coordinate designation is $_O$ (e.g., X_O, Y_O, Z_O)

Figure 2.1-1. Orbiter Coordinate System

2.1.2 MPLM Directional Orientation and Reference Coordinate System (RCS)

The MPLM coordinate system corresponds with the Orbiter coordinate system.

The MPLM Reference Coordinate System (RCS) is shown in Figure 2.1-2. It is a (X,Y,Z) right-handed orthogonal coordinate system, with the origin located on the MPLM centerline, such that the primary fitting trunnion attachment points are at 1000 in. (25400 mm).

The orientation of the coordinate system axes is defined as follows:

- the (X) axis is coincident with the MPLM centerline; positive sense is from the forward to the aft of the MPLM
- the (Y) axis is directed from the port to the starboard side
- the (Z) axis is directed from the lower to the upper side

The relationship between the MPLM directional orientation and the Space Station general orientation (defined on the basis of the Space Station plus velocity vector) is depicted in Figure 2.1-3.

The link between the MPLM Flight System RCS and the Orbiter RCS is defined by the following:

$X_{Shuttle} = X_{MPLM} + 202.73$ in. (5149.3 mm);

$Y_{Shuttle} = Y_{MPLM}$;

$Z_{Shuttle} = Z_{MPLM} + 400$ in. (10160 mm)

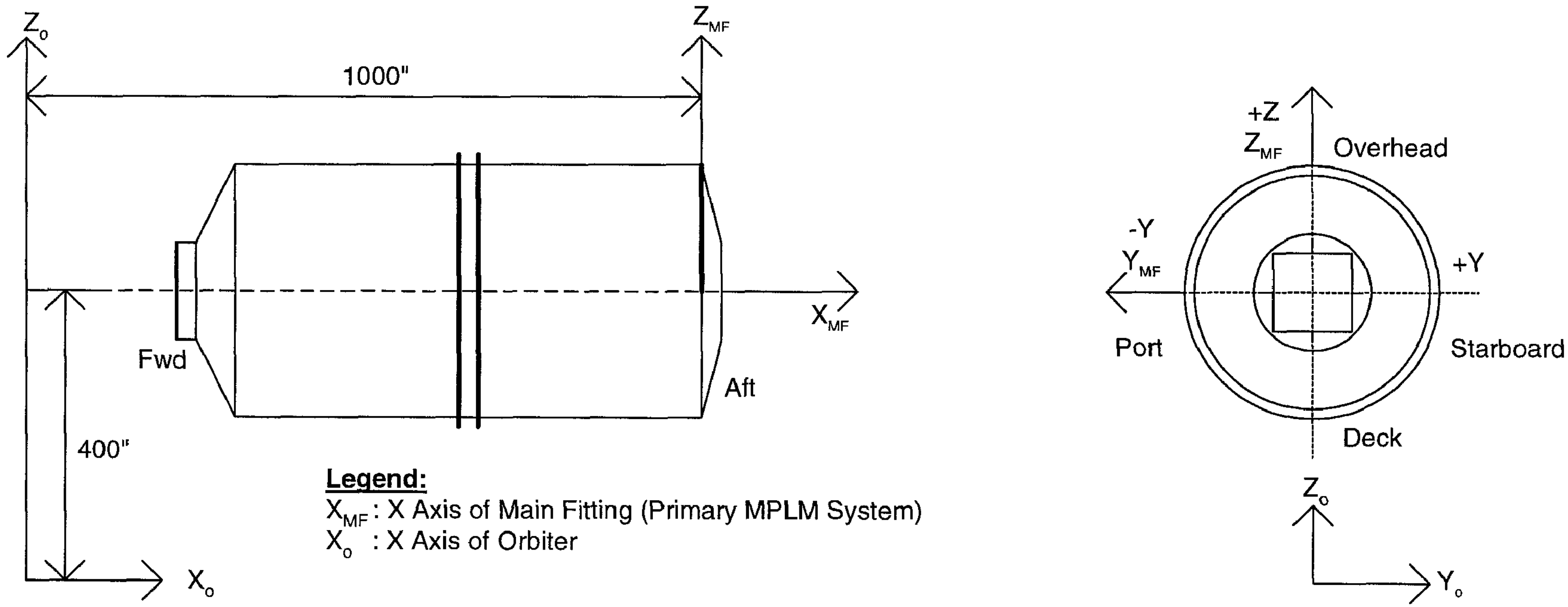


Figure 2.1-2. MPLM Flight System Reference Coordinate System

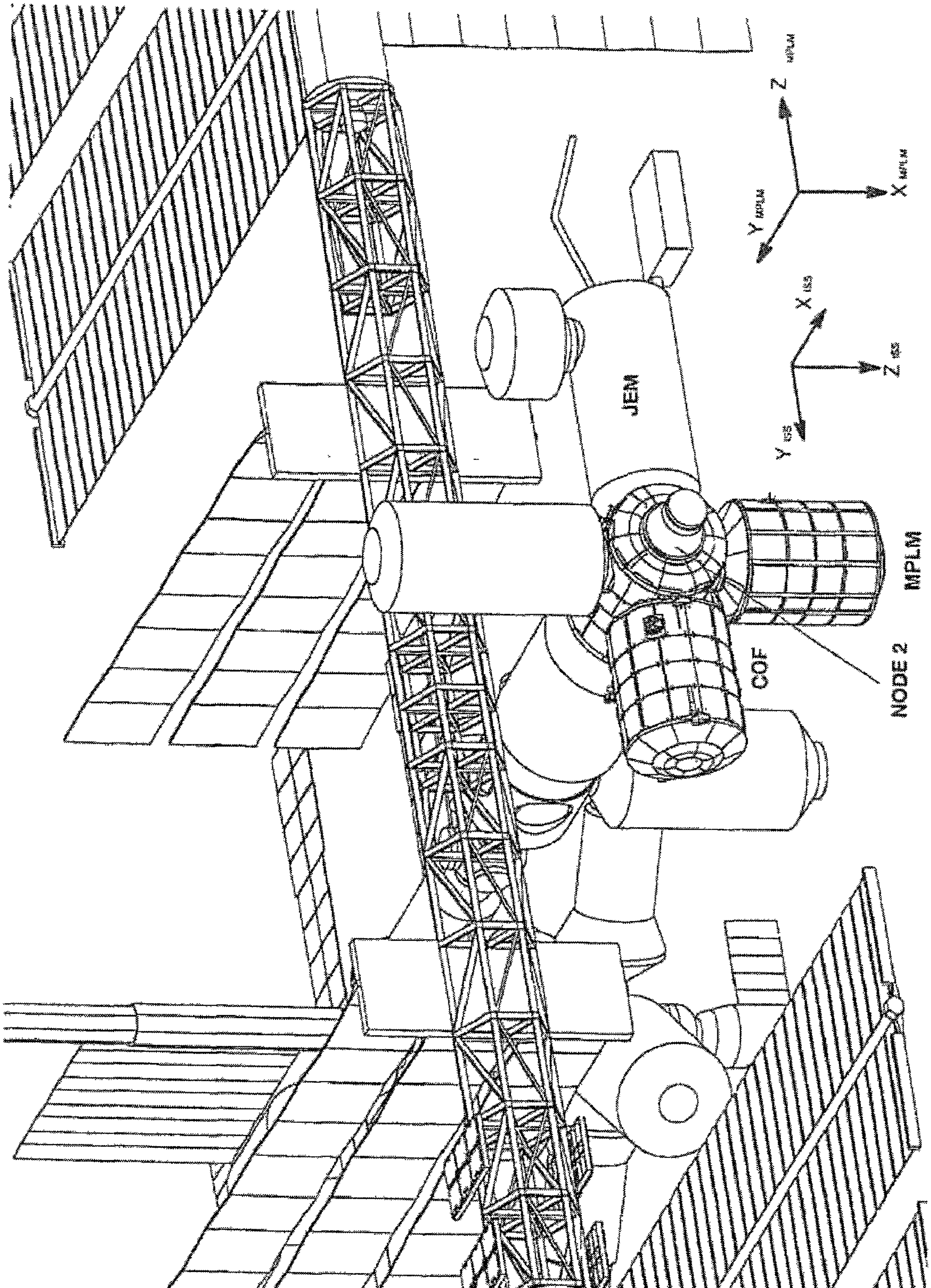


Figure 2.1-3. Relationship between the MPLM Reference Coordinate System and the Space Station Orientation

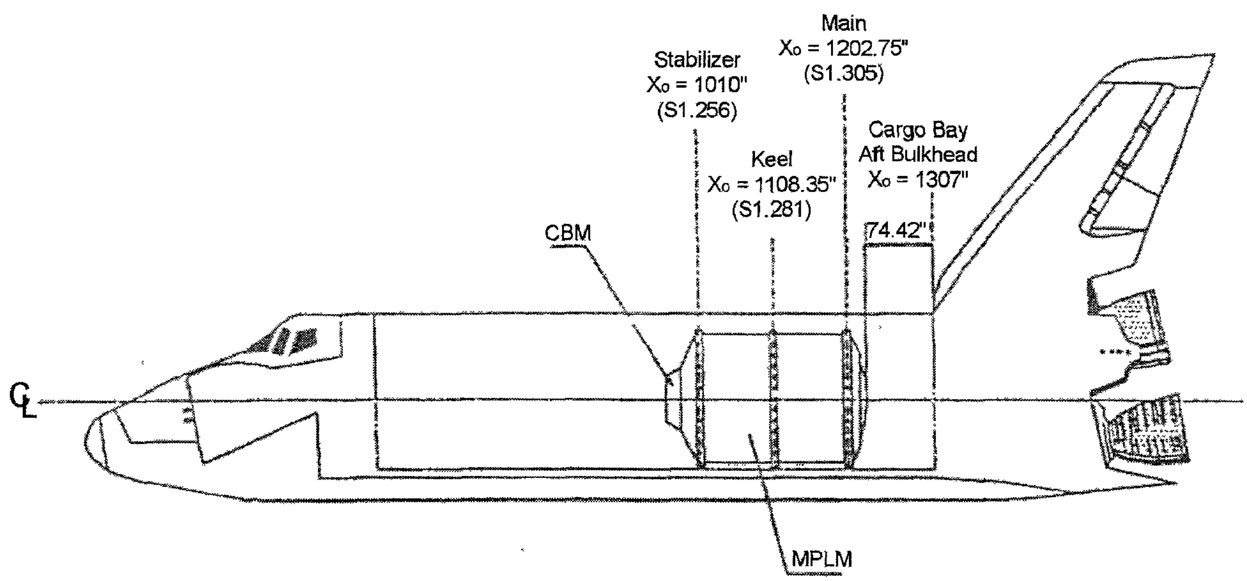
2.2 DIMENSIONAL AND PHYSICAL DATA

To ensure that the Orbiter aerodynamic stability is maintained during the nominal re-entry and landing phases and during a landing event following a mission abort, and to prevent overloading of the MPLM structure both at the cargo-to-MPLM and MPLM-to-Orbiter interfaces, the Center of Gravity (CG) of all cargo accommodated in the Orbiter bay must comply with the envelope requirements defined in ICD-A-21350.

The MPLM location in the Orbiter bay is depicted in Figure 2.2-1. The location shown in this figure is the only allowed location for an integrated MPLM weight up to 31,000 lb (14061 kg). This means that the entire cargo complement CG mass properties depend on the following factors:

- lay-out and mass properties of the MPLM accommodated cargo
- location and mass properties of the other payload accommodated in the Orbiter bay (e.g. Spacelab pallet)

Note that the data needed for the integration of the MPLM into the Orbiter are out of the scope of this IDD. Such data will be captured in the Mission Integration Plans (MIPs) and associated annexes.



Refer to Figure 2.1-1 for Orbiter Coordinate System

Figure 2.2-1. MPLM Location in the Orbiter Cargo Bay

2.2.1 Maximum Weights

The MPLM up-mass is 31,000 lb (14061 kg) of which 20,000 lb (9072 kg) is dedicated to MPLM cargo. This cargo capability includes the mass of payloads (including internal fluids) and payload accommodation provisions.

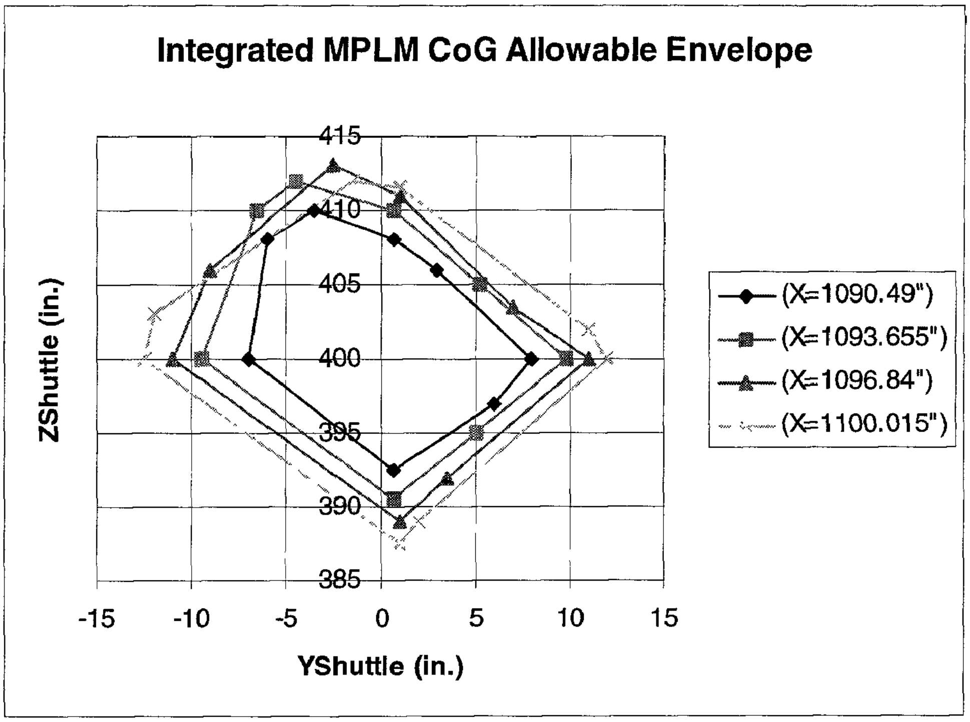
Specific constraints apply to MPLM cargo loading such that overloading of the MPLM structure both at the cargo-to-MPLM and MPLM-to-Orbiter interfaces is precluded. Consequently, the overall cargo manifest and the cargo lay-out inside the MPLM shall be defined by ensuring the compliance of the overall cargo mass with the MPLM cargo carrying capability requirement and the compatibility of the overall cargo CG with a predefined allowable envelope resulting from the MPLM carrying capabilities. The cargo layout definition is also driven by functional, grouping and operational constraints, which are strictly cargo - manifest dependent and must be evaluated on a mission-by-mission basis.

2.2.2 Center of Gravity (CG) Constraints

The current MPLM allowable CG envelope is based on the MPLM mass properties (reported in MLM-RP-AI-0013) and on Coupled Loads Analyses (CLA) performed by Alenia Aerospazio; and an additional set of CLA carried out by NASA (UOTAT-49, "MPLM Structures Task - Vol. 1: Analysis Archival Documentation"). The results of these CLA (considering different manifest configurations with the cargo weight limit of 20,000 lb [9072 kg]) indicate that the X-direction CG allowable envelope shall be within the range:

$$1087.7 \text{ in.} < X_o < 1117.9 \text{ in.}$$

with respect to the Orbiter coordinate system. The allowable Y and Z coordinates are illustrated in Figure 2.2-2 as a function of the X coordinate. In the subject figures, the CG allowable area is contained inside the polygon resulting from sectioning of the CG allowable envelope at the indicated X coordinate.



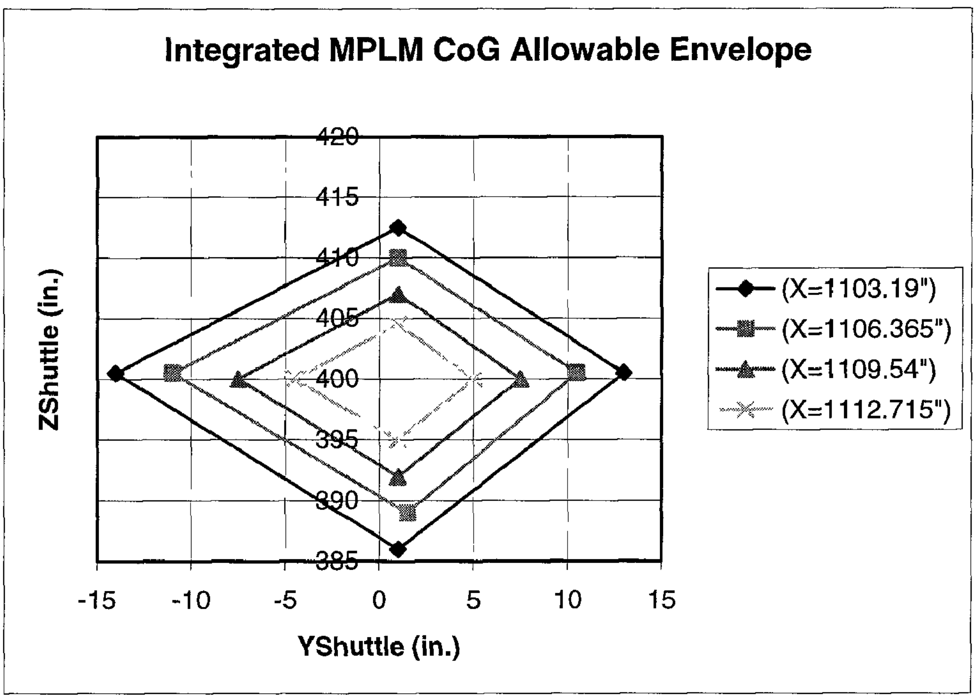


Figure 2.2-2. CG Allowable Envelope

2.2.3 MPLM Tare Mass Properties

To be supplied.

2.3 FLIGHT OPERATIONS OVERVIEW

2.3.1 Ascent/Descent MPLM Monitoring

During launch/ascent as well as during descent/landing no MPLM active operations are required. During launch the MPLM provides and maintains the following functions:

- Negative pressure relief function
- Positive pressure relief function
- Passive Thermal Protection
- Water loop within nominal pressure range (Active Flight only)
- Structural and physical interface (I/F) with NSTS (sustain in general the launch environment)

No procedures are needed during this phase for MPLM.

2.3.2 MPLM Berthing and Unberthing

To interface with the Active Common Berthing Mechanism (ACBM) mounted on the Space Station Node 1 and Node 2 nadir ports, the MPLM is provided with the Passive Common Berthing Mechanism (PCBM).

The PCBM, together with the ACBM, performs the following functions:

- reception and guidance
- capture and locking
- structural connection
- pressurized passageway
- jumper accommodation
- electrical bonding between the MPLM and the Space Station

The PCBM is an Aluminum cylinder, 82 in. (2082.8 mm) in diameter and 10.89 in. (276.6 mm) in length, interfacing with the Bulkhead. The PCBM is thermally protected by Multi-Layer Insulation (MLI) on both the external and the internal surfaces.

2.3.3 MPLM On-Orbit Activation

Upon power on of the Multiplexer-Demultiplexer (MDM), initialization of communications with the Orbiter Interface Unit (OIU), activation of the Power Distribution Box (PDB) Auxiliary Power Supply (APS) and verification of correct MPLM status, the MPLM activation in NSTS can be commanded by the crew or from the ground. The procedure can be carried out manually or automatically.

2.3.4 Cargo Loading/Unloading

2.3.4.1 Rack Removal

A major feature of the MPLM is the ability to easily remove/reinstall racks to/from ISS. Procedures are in place to remove International Standard Payload Racks (ISPRs), Express Racks, Resupply Stowage Racks (RSRs), and NASDA Racks. Other rack types (or rack-like structures) can also be removed provided they use standard rack mounting provisions and meet the requirements specified in this IDD.

2.3.4.2 Payload Removal

Procedures are similar for the removal of an individual payload item from the MPLM. Because this operation involves a payload unconnected to any MPLM structure, the payload developer shall comply with the Intra-Vehicular Activity (IVA) requirements and shall limit payloads to sizes that can be readily moved through Common Berthing Mechanism (CBM) hatches as defined in SSP 50005.

2.3.4.3 General Removal Considerations

Rack transfer operations (one-way rack transfer only) are performed at a rate of one rack per hour using a team of two crewmembers and at a rate of two racks per hour using a team of five crewmembers. The transfer time can be higher in cases where different subunits (rack or R/F drawers/content) have to be moved separately. All 16 racks can be removed.

For Active Rack changeout, the rack transfer operations should be optimized so that R/Fs are unpowered for the minimum amount of time.

Prior to MPLM rack translation, all MPLM aisle contents and auxiliary bracing are removed and stowed.

A suitable distribution of interfaces for restraints and mobility aids is provided.

2.3.5 Rack Installation

This activity is simply the reverse of the rack unloading process. The same considerations and limitations apply.

2.3.6 Resupply Stowage Platform (RSP) Cargo Installation for Return

The face plates (front & back) of the RSP provide accommodations for (78) ¼ inch fasteners to attach cargo provided mounting plates. All cargo not stowed in soft stowage bags must utilize mounting plates and these accommodations. Mounting Panel Provisions are shown in JSC 28169, Figures 3.3.2-1, 3.3.2-2, and 3.3.2-3.

2.3.7 On-Orbit Deactivation

The MPLM configuration and functionalities before Deactivation are the same as after On-Station Activation. After deactivation the configuration is as described in Tables 6.3.4.1-1 and 6.3.4.1-2 of MLM-HB-AI-0002. The activity starts when the hatch is closed and latched and the R/F's already deactivated.

The R/F's are deactivated when the MPLM is still active.

The deactivation of all MPLM equipment except for the MDM will be either automatically or step-by-step performed upon crew or ground commands.

Prior to starting MPLM deactivation (in particular prior to complete module isolation), on Active Flights the United States On-Orbit Segment (USOS) will assure a reduced MPLM internal air dew point of 50°F (10°C), to avoid condensation during subsequent MPLM mission phases.

During Fire Detection deactivation, the Smoke Detector is deactivated after deactivating the Fan, in order to detect possible smoke produced by the Fan.

When the MPLM is attached to ISS the shell heaters [and Payload Disconnect Assembly (PDA) heaters for active flights] deactivation is performed just before PDB deactivation by means of a command to deactivate the relevant PDB outlet.

During On-Station Operations, when the MPLM Hatch and/or Inter-Module Ventilation (IMV) are opened, the MPLM relies on Station Positive Pressure Relief (PPR) capability. During MPLM On-Station activation, the MPLM PPR is disabled after IMV and Hatch opening and re-enabled before IMV and Hatch closure in order to guarantee the PPR function.

In order to avoid simultaneous utilization of the same MPLM PDB resource (i.e., the converter #2) by different end-items, the R/F Delta Pressure (dP) control capability will not be active during Sample Line Shutoff Valve (SSOV), Water On/Off Valve (WOV) and IMV operations. During nominal operations, this is ensured by the activation and deactivation sequence. During off-nominal IMV closure by means of external [USOS Command and Data Handling (C&DH) MDM] autonomous command or autonomous MPLM internal recoveries, the MPLM will ensure that the Water Modulating Valve (WMV) will not be operated by the R/F dP control capability (applicable to Active Flights only).

During MPLM AF On-Station deactivation, the MPLM Thermal Control Subsystem (TCS) is reconfigured for Shuttle operations, so that in case the WOV fails to open it is still possible to manually open the WOV via the valve manual override.

The step-by-step procedure is detailed in MLM-RP-AI-0177.

2.4 ORBITER SUPPORT TO MPLM

2.4.1 Summary of Support

The Orbiter provides orbital maneuvering, attitude control, crew accommodations, and a number of other services and items which are available for use by MPLM and its payload.

2.4.1.1 Orbiter Avionics

The Orbiter avionics provides for:

- reception, transmission, and distribution of voice
- transmission of operational telemetry
- reception and transmission of MPLM data (including payload data)
- transmission of commands from the ground or Orbiter to MPLM C&DH System
- transmission and distribution of television signals
- landing site facilities of the Orbiter

2.4.1.2 Orbiter/ISS Support of MPLM Environmental Control Subsystem (ECS)

When on ISS, the MPLM Environmental Control and Life Support System (ECLSS) Temperature and Humidity Control (THC) exchanges air with the ISS via the Inter-Module Ventilation Shutoff Valve (ISOV) and via the hatch (when open).

The MPLM Active Thermal Control Subsystem (ATCS) exchanges coolant fluid (H_2O) with the ISS via the bulkhead connectors or with the NSTS via the Remote Operated Fluid Umbilical (ROFU) for heat transfer. There is no ECLSS interaction between the MPLM and NSTS.

ISS provides one Portable Fire Extinguisher (PFE) and one Portable Breathing Apparatus (PBA) after MPLM berths to the ISS to support fire suppression and crew breathable atmosphere.

2.5 REMOTE MANIPULATOR SYSTEM (RMS)

The MPLM interfaces with the Space Station Remote Manipulator System (SSRMS) or Shuttle Remote Manipulator System (SRMS) during transfer to/from the Station by means of the two Flight Releasable Grapple Fixtures (FRGFs).

3.0 MPLM SYSTEM CAPABILITIES

3.1 FLIGHT CONFIGURATION DESCRIPTION

The MPLM configuration, briefly described below, is depicted in Figures 3.1-1 (External Configuration) and 3.1-2 (Internal Configuration).

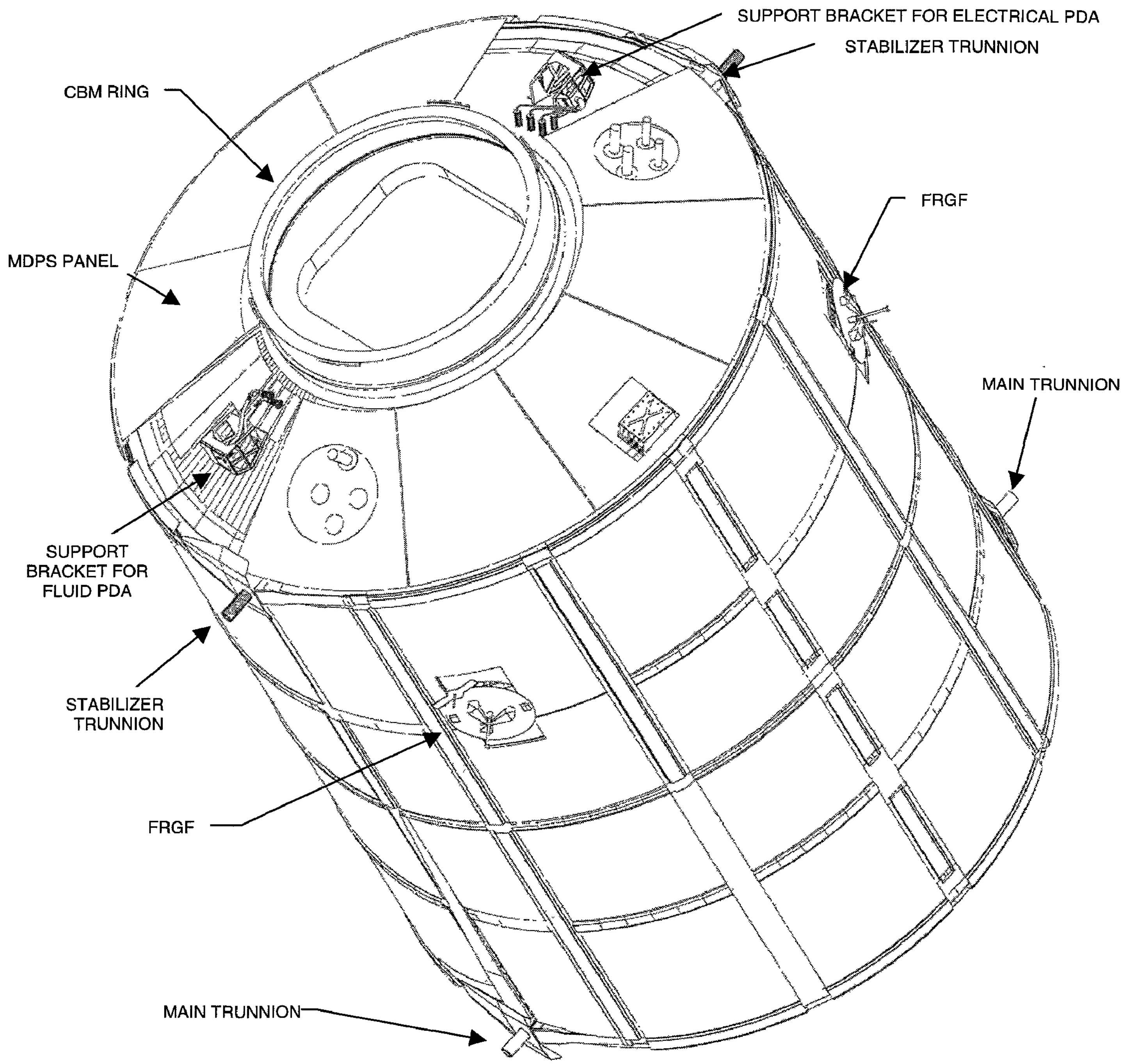


Figure 3.1-1. MPLM External Configuration

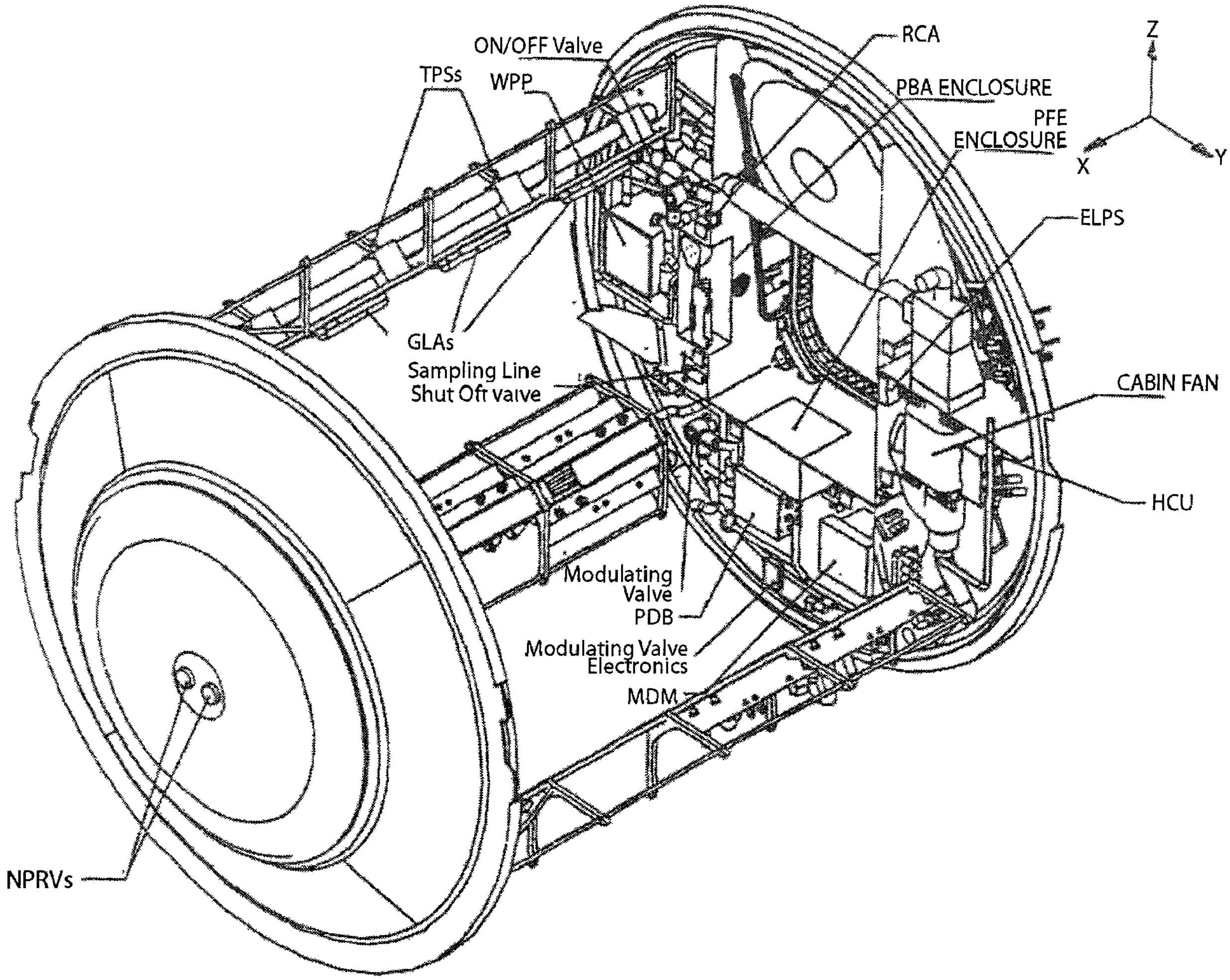


Figure 3.1-2. MPLM Internal Configuration (Aft Isometric View)

3.1.1 Structure and Mechanism

The MPLM structure consists of the following elements:

- primary structure
- secondary structure
- mechanisms

3.1.1.1 Primary Structure

The MPLM primary structure is designed to transport a maximum of 20,000 lb (9072 kg) of cargo and equipment. The main components of the primary structure are:

- the cylindrical shell, consisting of two sections interfacing through a central ring
- three forged rings (two end rings and one central ring) and two machined rings (intermediate rings)
- sixteen box-shaped longeron assemblies

- the forward cone shell, consisting of aluminum alloy waffle panels welded together and one Feed-through (F/T) plate
- the bulkhead, including the penetration for the utility lines to/from the ISS
- the hatch
- the aft cone shell, formed by waffle panels welded together and one forged ring
- the AAC
- the flight fittings (two main fittings, two stabilizing fittings and one keel fitting)
- the Rack Attachment Blocks (RABs) connecting the racks to the cylindrical shell longerons

3.1.1.2 Secondary Structure

The MPLM secondary structure includes:

- the Meteoroid and Debris Protection System (MDPS), consisting of a single bumper shield, provided with openings in proximity of the grapple fixtures, the atmosphere control valves and in general any equipment arranged externally on the module shell
- the forward cone support structure, including three independent honeycomb panels connected to the primary structure, used to support most of the MPLM equipment
- four stand-offs which mainly provide support for diffusers, grids, lights, ducting, piping and electrical harness; and allowing on-orbit rack tilting by insertion of dedicated hinge mechanisms
- close-out panels, to meet human factor requirements, and lightweight panel for fire suppressant containment
- bracketry

3.1.1.3 Mechanisms

The MPLM includes the following external mechanisms:

- the PCBM, providing interface with the ACBM installed on the ISS Node 1 and Node 2 nadir ports
- two FRGFs, to allow the MPLM on-orbit deployment and berthing to the ISS, and the retrieval and the re-insertion into the Orbiter cargo-bay
- PDA half of Remote Operated Fluid Umbilical (ROFU)/Remote Operated Electrical Umbilical (ROEU)
- Hatch
- Pressure relief valves, depress valves, pressure equalization valves

3.1.2 Dynamic Envelope

Dynamic envelopes for different rack types are defined in SSP 41017 and JSC 28169 for the RSP.

3.1.2.1 Rack

Figure 3.1-3 depicts the basic rack geometry. Each rack shall not exceed the static envelope defined in SSP 41017. In addition, each rack shall not exceed the dynamic envelope defined in SSP 41017.

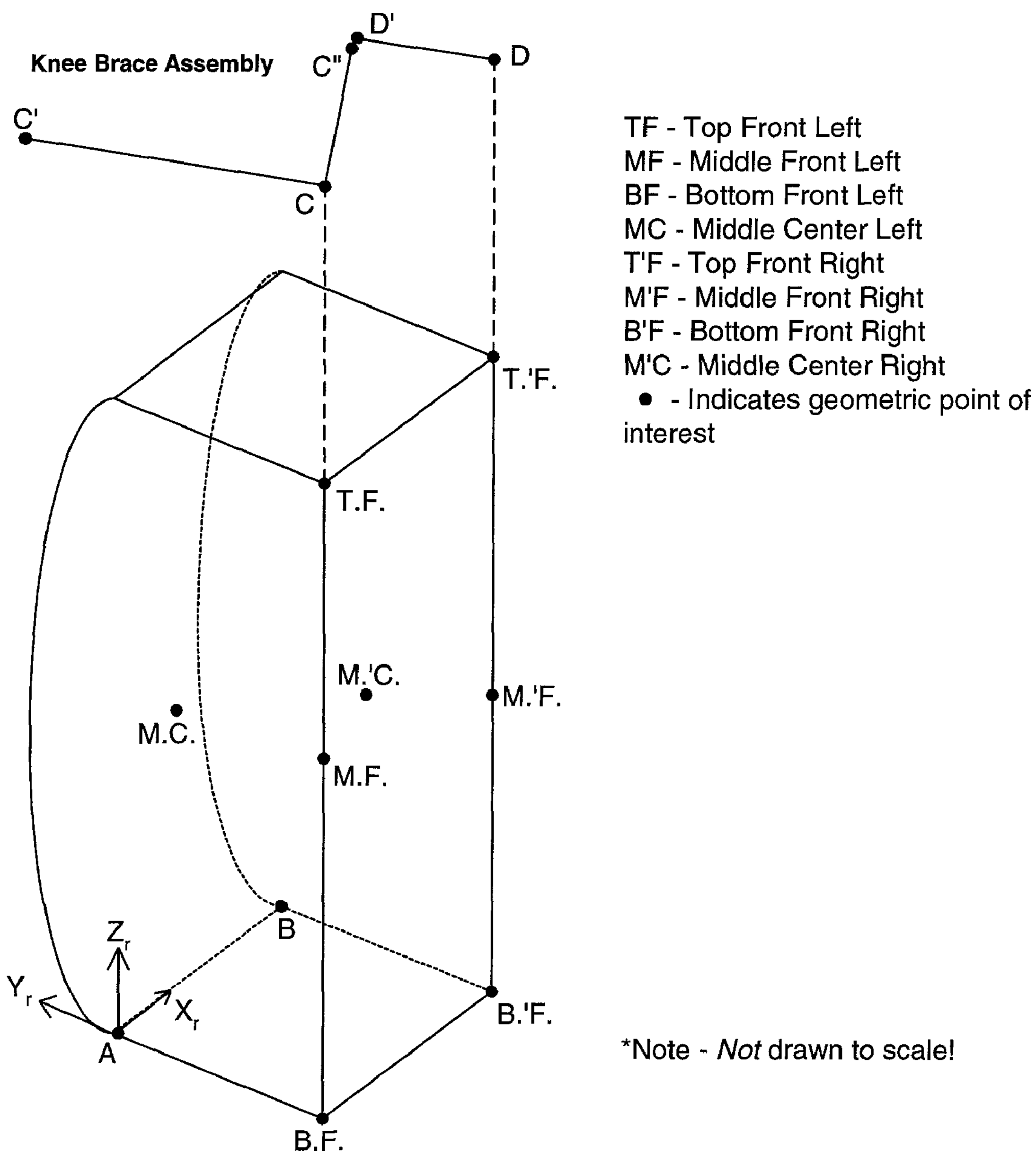


Figure 3.1-3. Basic Rack Geometry with Point Identifiers

3.1.2.2 ARIS Rack

ARIS Racks shall not exceed the static envelope defined in SSP 41017. In addition, each ARIS rack shall not exceed the dynamic envelope defined in SSP 41017.

3.1.2.3 Resupply Stowage Platform (RSP)

RSPs shall not exceed the static envelope defined in JSC 28169. In addition, each RSP shall not exceed the dynamic envelope defined in JSC 28169.

3.2 MPLM SUBSYSTEM EQUIPMENT

3.2.1 Basic MPLM Equipment

The following is a list of basic MPLM Flight Equipment. MPLM Mechanical Ground Support Equipment (MGSE) is listed in Section 6.2; Electrical Ground Support Equipment (EGSE) is listed in Section 6.3.

Structural/Mechanical

Primary Structure

- Cylindrical Shell
- Forged Rings
- Longeron Assemblies
- Forward Cone Shell
- Bulkhead
- Aft Cone Shell
- Aft Access Closure (AAC)
- Flight Fittings (two main fittings, two stabilizing fittings, one keel fitting)
- Rack Attachment Blocks (RAB) connecting the racks to the cylindrical shell

Secondary Structure

- Meteoroid and Debris Protection System (MDPS)
- Forward Cone Support Structure
- Stand-offs
- Rack Lower Attachment
- Knee Brace
- Close-out Panels
- Bracketry

Mechanism

- Passive Common Berthing Mechanism (PCBM)
- Flight Releasable Grapple Fixture (FRGF)
- Remote Operated Electrical Umbilical (ROEU) Payload Disconnect Assembly (PDA)
- Remote Operated Fluid Umbilical (ROFU) Payload Disconnect Assembly (PDA)
- Knee Brace Locking Clip
- Knee Brace Alignment Clip
- Utility Interface Panel (UIP) (fluid and electrical)

Active Rack Isolation System (ARIS)

Environmental Control System

Environmental Control and Life Support Subsystem (ECLSS)

Atmosphere Control System (ACS)

- Manual Pressure Equalization Valve (MPEV)
- Cabin Depressurization Assembly (CDA)
- Positive Pressure Relief Assembly (PPRA)
- Negative Pressure Relief Assembly (NPRA)
- Total Pressure Sensor (TPS)

Atmosphere Revitalization System (ARS)

- Atmosphere Sampling Line (ASL)
- Sample Line Filter (SLF)
- Sample Line Shutoff Valve (SSOV)
- Fluid Connector, male side, for I/F with station ARS

Temperature and Humidity Control (THC)/Module Ventilation

- Cabin Loop Air Distribution System
- Inter-Module Ventilation Shutoff Valves (ISOV)
- Cabin Fan Assembly (CFA)

Fire Detection and Suppression (FDS)

- Duct Smoke Detector (DSD)
- Portable Fire Extinguisher (PFE) – Drag on ISS equipment
- Portable Breathing Apparatus (PBA) – Drag on ISS equipment

Thermal Control Subsystem (TCS)

Active Thermal Control Subsystem (ATCS)

- Water Pump Package (WPP)
- Water On/Off Valve (WOV)
- Water Modulating Valve (WMV)
- Differential Pressure Sensor
- Plumbing

Passive Thermal Control Subsystem (PTCS)

- Thermal Control Coatings
- Multi-Layer Insulation (MLI)
- Other insulation material
- Shell Heaters
- PDA Heaters
- Thermal conductive material

Avionics

Electrical Power Distribution and Conditioning (EPDC)

- Power Distribution Box (PDB)
- Heater Control Unit (HCU)
- Battery (BAT)
- General Luminary Assemblies (GLA)
- Emergency Lighting Power Supply (ELPS)
- Emergency Lighting Strip (ELS)
- Electrical Harnesses

Command and Data Handling System (C&DH)

- Multiplexer/Demultiplexer (MDM)
- Electrical Harnesses

Crew Habitability

Seat Tracks

Intravehicular Activity Restraints and Mobility Aids (R&MA)

- Hand Rails – Drag on ISS equipment
- Foot Restraints – Drag on ISS equipment

3.2.2 Mission Dependent Equipment (MDE)

The following equipment is carried on Active Flights, but not on Passive Flights:

- Water On/Off Valve (WOV)
- Water Pump Package (WPP)
- ROFU PDA
- Battery
- Flex Hoses between the ROFU PDA and Water Modulation Valve (WMV)
- Flex Hoses and Connectors between the UIP and Racks
- Active Rack Grounding Straps

The following equipment is used on Active Flights and flown on Passive Flights, unused:

- Water Modulation Valve (WMV)
- Utility Interface Panel (UIP)
- Flex and Hard Lines between the WMV and UIP
- Wiring between the MDM and XXX and the UIP

The following equipment is flown on Passive Flights and not on Active Flights:

- Quick Disconnect Caps for all exposed QDs

3.2.3 Racks

MPLM can transport up to 16 racks provided the total cargo weight remains below the 20,000 lb (9072 kg) limit.

During the flight operations phases, the activities for the MPLM cargo mainly consists of the loading and unloading of:

- Various passive racks
  - ISPRs (up to 1773 lb each)
  - Express racks (up to 1550 lb each)
  - Outfitting racks (up to 1550 lb each)
  - Resupply/Return racks (up to 1550 lb each)
  - Resupply Stowage Platform (RSP) (up to 500 lb each)
- R/F racks (maximum of 5 racks, up to 1350 lb each)
- ARIS (up to 1773 lb each)

The number and type of manifested racks depends on the specific mission requirements.

3.2.3.1 Rack Location Coding

For on-orbit operation purposes, each MPLM rack location is identified by an alphanumeric string, defined as follows (according to SSP 30575):

$MPLn_1X_1n_2\_X_2X_3$

where:

n_1 identifies the MPLM Flight Model (1, 2 or 3)

X_1 identifies the rack location directional orientation inside the module, according to the ISS directional orientation

n_2 identifies the module bay (1, 2, 3 or 4 going from the forward end to the aft end)

X_2 and X_3 (following an underscore) are reserved to define a location within the rack space

The rack location labels installed on the MPLM stand-offs are based on this coding system.

An overview of the rack locations is depicted in Figure 3.2-1.

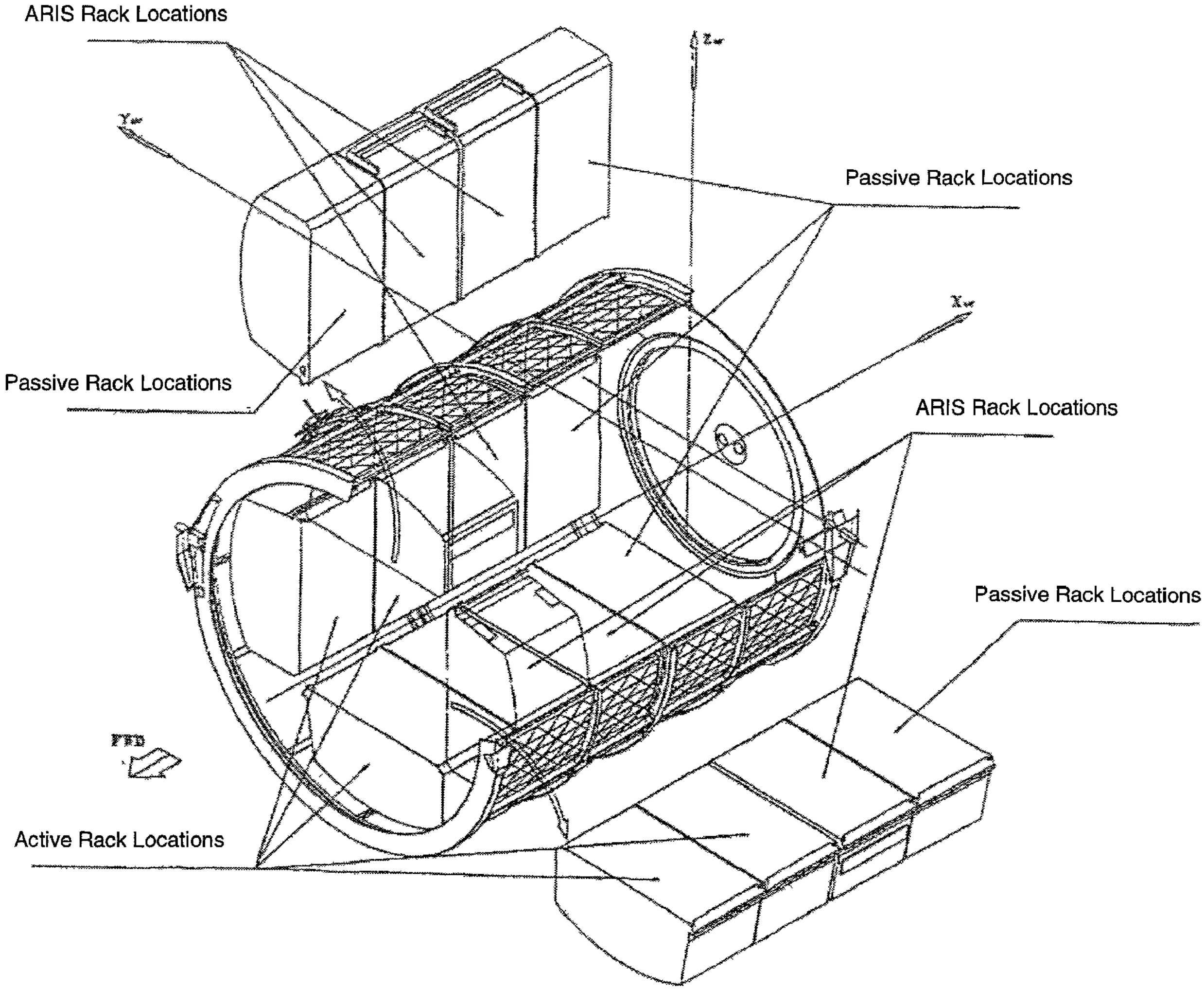


Figure 3.2-1. Rack Locations

3.2.3.2 Passive Racks

All the MPLM cargo locations are able to support the accommodation of a passive rack.

3.2.3.2.1 International Standard Payload Racks (ISPRs)

The ISPR provides basic payload connection interfaces. The connections for major secondary structure interface are through the rack posts. The NASA ISPR structure is primarily a graphite-epoxy composite with some sub-structural elements made of aluminum. The NASA ISPR is available in four to six post configurations. The front posts of the rack include seat tracks for restraints and mobility aids for hardware attachment. The standard ISS restraints and mobility aids that are available for attaching to the seat tracks are defined in Section 4.4.1.3.

The ISPR is delivered in a six post configuration which can be easily converted into a four post rack. The six post configuration supports integration of Standard Interface Rack (SIR) drawer payloads and as well as payloads which are less than 18.2 inches in width. The

ISPR center posts can be removed to obtain a rack with a four post configuration. In this configuration, the graphite post with aluminum ground planes is positioned on the exterior sidewalls of the rack. The four post configuration allows for wider payloads (37.5 inches post to post) to be installed. One center post can be removed creating a five post configuration if desirable. Holes on the front face of the forward posts provide for attachment of user provided front panel(s). A riveted nutplate with thread specification .1900x32 UNJF-3B is behind each hole. A pattern of .261/.257 diameter holes backed by floating .2500x28 UNJF-3B removable/replaceable floating nutplates are located on the post inside faces (parallel to rack sides). These attachments provide the primary load path for launch and landing loads. Detailed structural information needed by a payload developer to integrate into a NASA ISPR as well as CG and weight limitations can be found in SSP 57000 and SSP 57007.

3.2.3.2.2 Resupply Stowage Racks (RSRs)

The RSR locker is subdivided into 10 locker bays as shown in Envelope Drawing 683-60581 Stowage System Locker Assembly and Figure 3.2-2.

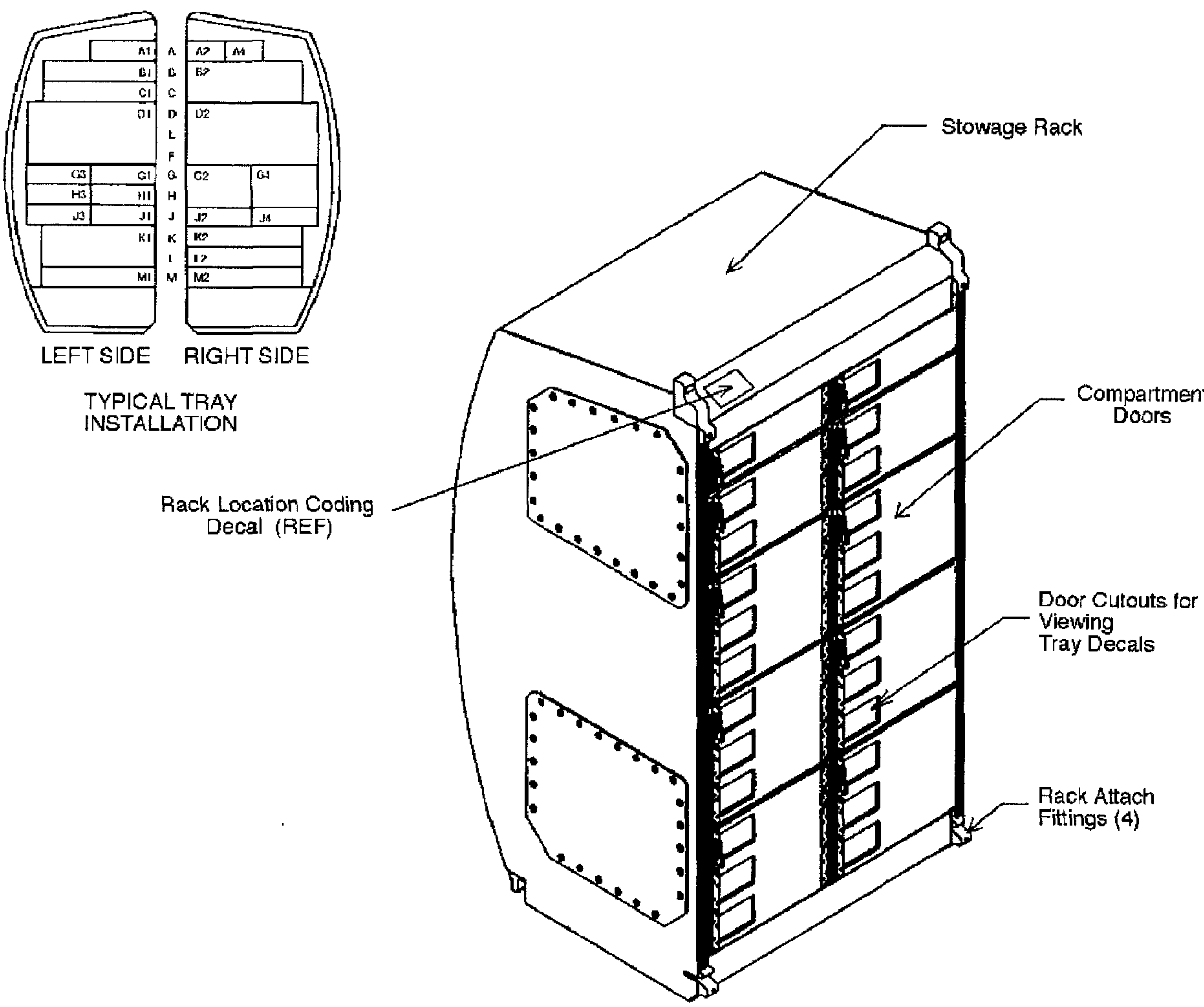


Figure 3.2-2. Resupply Stowage Rack with Typical Tray Installation

3.2.3.2.3 Resupply Stowage Platforms (RSPs)

Each MPLM rack location can support an RSP, the RSP utilizes the same mechanical interfaces with the rack lower rear attachments and with the rack upper attachment interfacing knee-brace assembly. The RSP maximum allowable envelope dimensions can support up to two RSPs for each MPLM bay, with the constraint that the RSPs must be placed in opposite (i.e. facing) rack locations. Based on this constraint, during active missions including cargo requiring late access, only the two aft bays can be used for RSP, since the first and second bays are dedicated to the active cargo. During passive missions, or active flight manifests which do not require late access, two opposite rack locations for each bay can accommodate RSPs. RSPs are shown in Figure 3.2-3 in opposite rack locations with M-Bags installed.

If RSPs block air ventilation diffusers, refer to Section 4.8.1.1.3 for details of crew activities to increase ventilation in the MPLM.

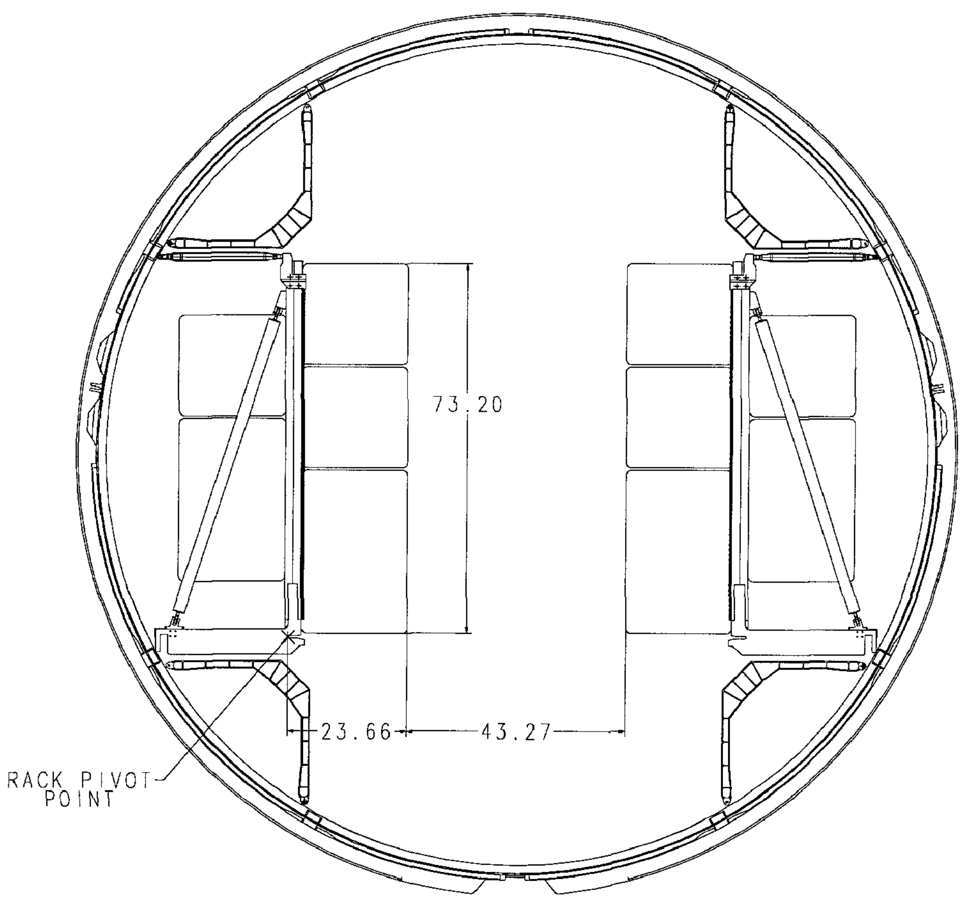
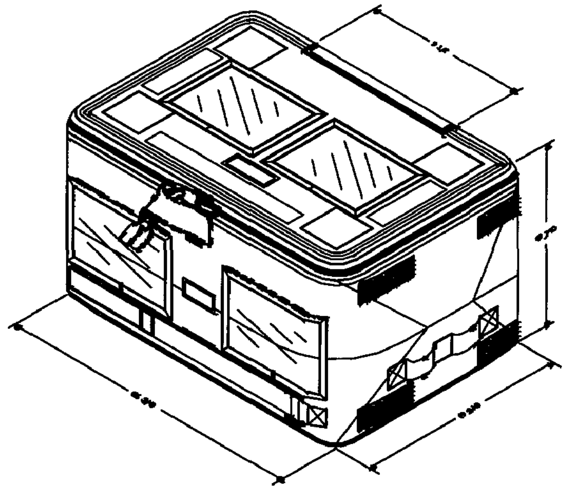


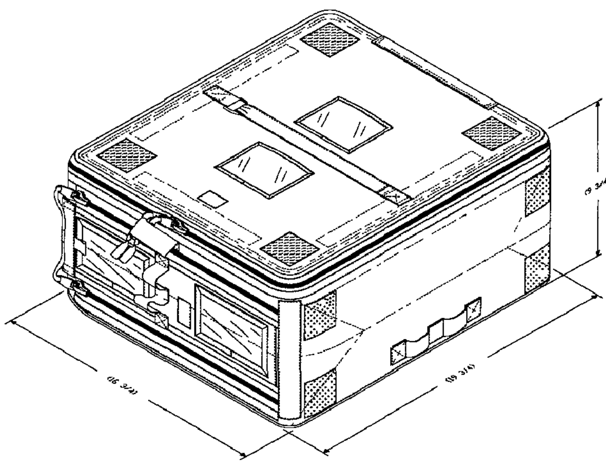
Figure 3.2-3. RSPs in the MPLM Bay with M-Bags Installed

3.2.3.2.4 Cargo Bags and Trays

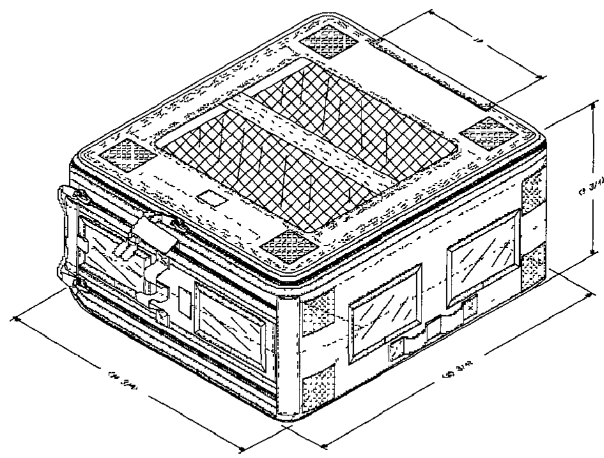
Individual payload hardware items which will be stowed for the transportation phase or while not in use on–orbit are to be packed in Cargo Transfer Bags (CTB), ISS Stowage Trays, or M–bags. The CTB is a fabric transport enclosure which is designed to fit into a Middeck locker, or M–bag. The CTB is equipped with configurable dividers to provide separation and cushioning between individual hardware items. In general, CTBs are not unpacked by the transfer crew but are just transferred from the shuttle to ISS. The CTB is depicted in Figure 3.2-4. ISS Stowage Trays are designed to be modular and interchangeable. There are 11 different sizes of trays to support a variety of cargo types. The ISS Stowage Trays are depicted in Figure 3.2-5. The M–bags are designed to contain CTBs or odd/large size payload items. There are 2 types of M–Bags, M1 and M2. The M1–bag will contain up to 6 Cargo Transfer Bag Equivalent (CTBE) of cargo, the M2–bag will contain up to 4 CTBE of cargo. The contents of these bags are removed and transferred to the ISS; the bags remain in the MPLM. The M–bags are depicted in Figure 3.2-6. Payload hardware packed in CTBs, ISS Stowage Trays, or M–bags is transported to the ISS in either a Resupply Stowage Platform or Resupply Stowage Rack.



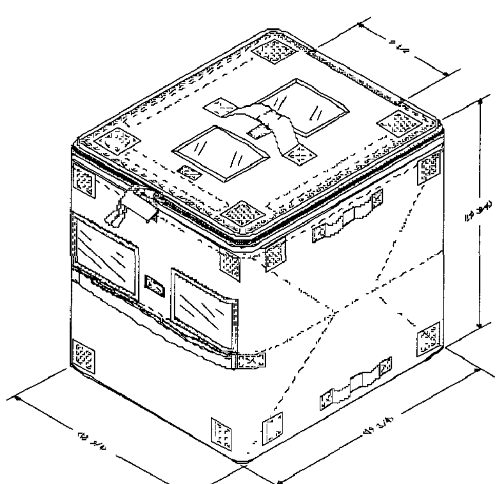
Half Size (P/N SEG33111836)



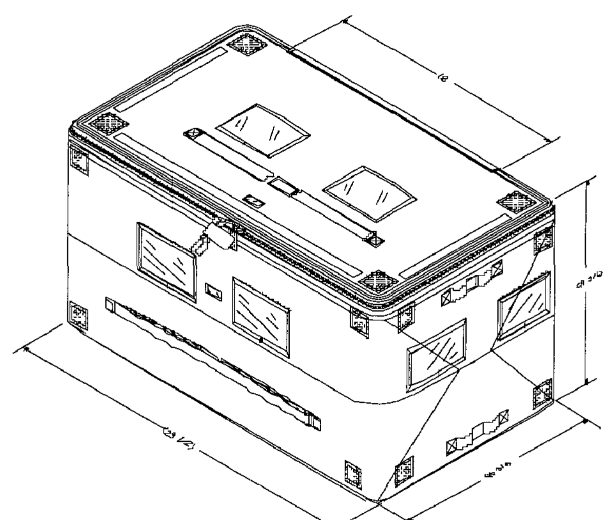
Full Size without Windows
(P/N SEG33111838)



Full Size with Windows (P/N SEG33111837)



Double Size (P/N SEG33111839)



Triple Size (P/N SEG33111840)

Figure 3.2-4. Cargo Transfer Bags

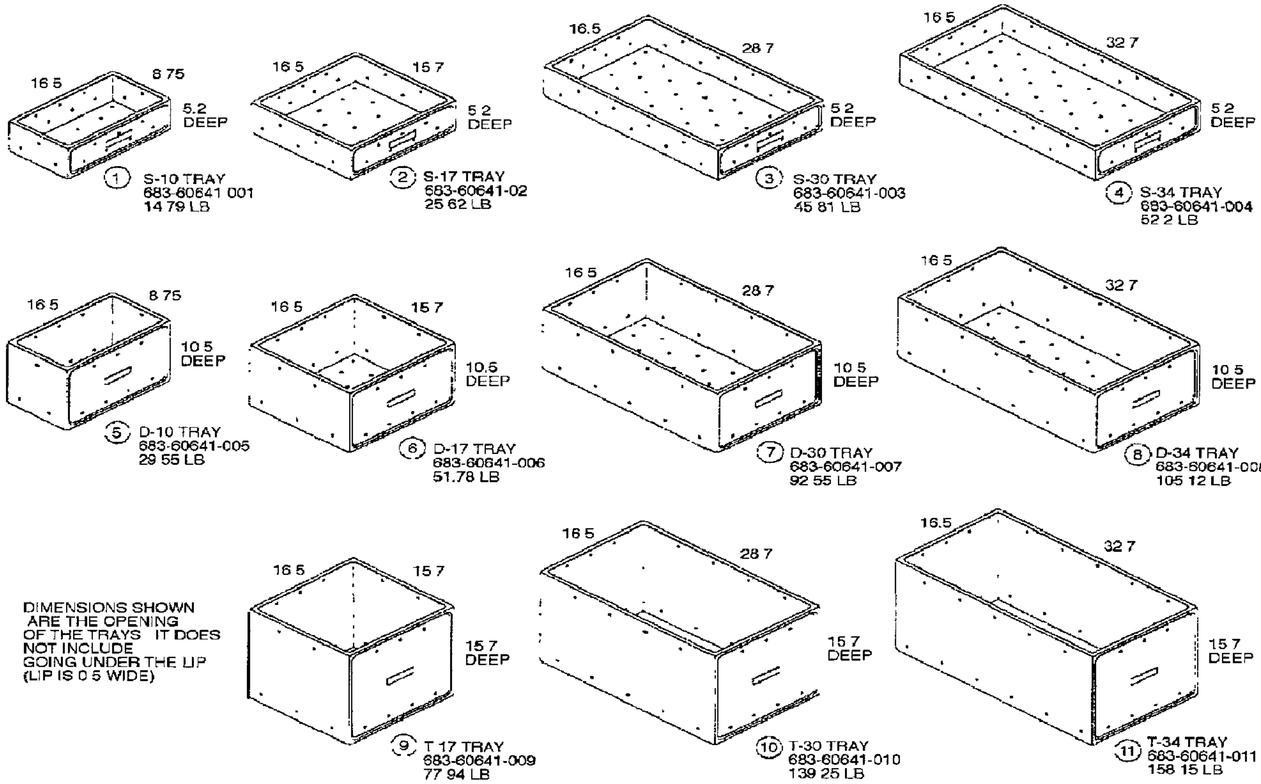
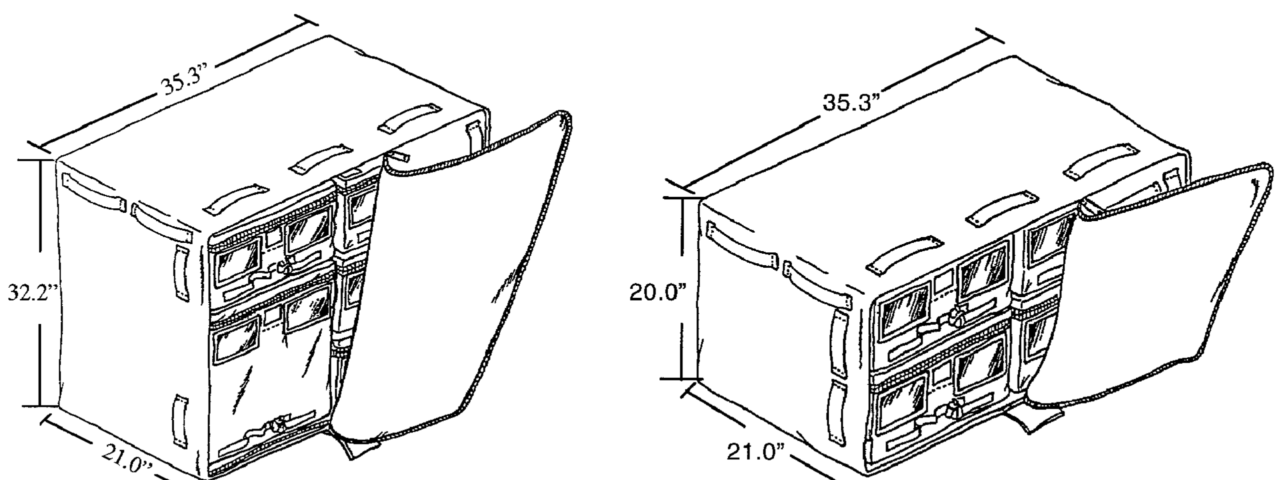


Figure 3.2-5. Stowage Trays



M01 Bag with ONE Double and FOUR Single Cargo Transfer Bags

M02 Bag with FOUR Single Cargo Transfer Bags

Figure 3.2-6. M-Bags

3.2.3.3 Active Racks

The MPLM is capable of accommodating up to five active racks. The active rack available locations are depicted in Figure 3.2-1.

3.2.3.4 Active Rack Isolation System (ARIS)

Payloads having strict payload microgravity requirements may wish to be integrated into an ARIS equipped NASA ISPR. The ARIS is used on-orbit to isolate the rack from structural vibrations. An ARIS-equipped rack is suspended by eight actuator pushrods. Vibrations are sensed by three rack-mounted accelerometers and these measurements are used to create and transmit appropriate reactive control signals to specific actuators to attenuate the disturbances. It should be noted that the volume available to payloads in ARIS equipped NASA ISPRs is less than that in non-ARIS equipped NASA ISPR due to the ARIS subsystems. For detailed information about the ARIS equipped ISPR refer to SSP 57006, SSP 57005, and SSP 50251.

The MPLM cargo locations which can accommodate ARIS equipped racks are defined in Figure 3.2-1.

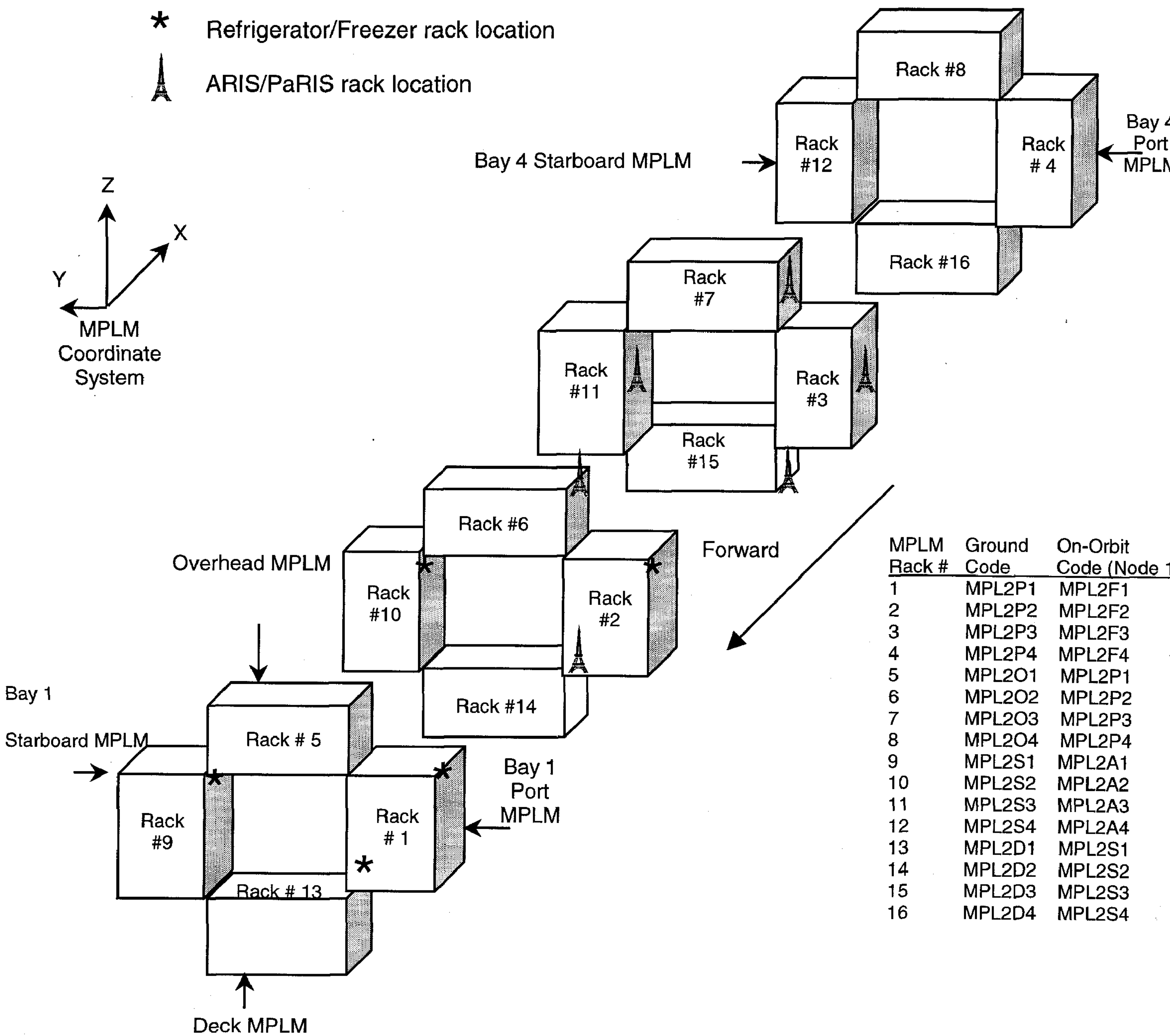
While the ARIS-equipped racks are in the MPLM, the ARIS is not activated.

3.2.3.5 MPLM Rack Constraints and Guidelines

The following are constraints and guidelines for positioning racks in the MPLM.
Constraints are limitations that cannot be violated. Guidelines are general recommendations. The constraints and guidelines are listed in order of priority generically, however they shall be reviewed on a mission-to-mission basis and shall be customized to suit the needs of a particular mission.

3.2.3.5.1 Rack Nomenclature

The nomenclature used for rack location in subsequent paragraphs is in the 1G ground coordinate system and shown below. (Note: rRack number 1 through 16 is rack number assignment for structural analysis used in the MPLM structural math model).



MPLM Rack #	Ground Code	On-Orbit Code (Node 1)
1	MPL2P1	MPL2F1
2	MPL2P2	MPL2F2
3	MPL2P3	MPL2F3
4	MPL2P4	MPL2F4
5	MPL2O1	MPL2P1
6	MPL2O2	MPL2P2
7	MPL2O3	MPL2P3
8	MPL2O4	MPL2P4
9	MPL2S1	MPL2A1
10	MPL2S2	MPL2A2
11	MPL2S3	MPL2A3
12	MPL2S4	MPL2A4
13	MPL2D1	MPL2S1
14	MPL2D2	MPL2S2
15	MPL2D3	MPL2S3
16	MPL2D4	MPL2S4

3.2.3.5.2 MPLM Constraints and Guidelines

3.2.3.5.2.1 MPLM Constraints

a. MPLM Center of Gravity (CG).
The integrated MPLM CG must be within the design box documented in paragraph 2.2.2.
Rationale: Module design constraint.

b. Active Rack Isolation System (ARIS) and Passive Rack Isolation System (PaRIS) Rack Placement.
Position ARIS and PaRIS type rack in Bay 2 or 3 Overhead, Bay 3 Port, Bay 2 or 3 Deck, Bay 3 Starboard location.
Rationale: Module design constraint.

c. Refrigerator/Freezer Rack Placement.
Position Refrigerator/Freezer rack in Bay 1 Port or Starboard, Bay 2 Port or Starboard, Bay 1 Deck location.
Rationale: Module design constraint.

d. Minus Eighty Degree Laboratory Freezer for ISS (MELFI) Rack Placement.
Position MELFI rack in Bay 2 Port or Starboard location.
Rationale: Module design constraint for high power locations.

e. Zero G Stowage Rack (ZSR) Placement.
   - Do not position ZSRs in radially adjacent racks in the same bay.
     Rationale: ZSRs in radially adjacent racks violate each other static envelope.
   - Do not position ZSRs in Bay 1.
     Rationale: ZSRs in bay 1 interfere with the MPLM forward endcone closeout panels.
   - Deployed RSP fences next to a ZSR mounted location may need to be folded down prior to ZSR installation or removal.
     Rationale: Folded RSP fences next to a ZSR location permit access to ball-lock pins on the ZSR for installation or removal.

3.2.3.5.2.2 MPLM Guidelines

a. Core Module Guidelines.
Position racks in the MPLM so that the integrated MPLM CG is as close to the module geometric center as possible.
Rationale: Provides maximum flexibility for emergency safe return assessments and limits the number of rapid safing instructions for the crew.

b. Zero G Stowage Rack (ZSR) Placement.
Do not place ZSR in Bay 4 if possible.
Rationale: ZSRs FSE in Bay 4 interfere with bungee jail studs.

3.2.3.5.3 Rack Constraints and Guidelines

3.2.3.5.3.1 Rack Constraints

a. Physical Interference

- Do not position RSPs radially adjacent to each other in any given bay.
  Rationale: Adjacent RSPs in a bay violate each other static envelope.
- Position Waste Management Rack (WMR) and Crew Hygene Rack (CHR) in Bay 4 Port and Starboard locations or in Bay 4 Overhead and Deck locations with the 0.5 inch extension adjacent to the MPLM endcone area.
  Rationale: Allow 0.5 inch rack extension to extend to the MPLM endcone area.
- Position Waste Management Rack (WMR) and Crew Hygene Rack (CHR) adjacent to an empty rack location with the 0.5 inch extension adjacent to the empty rack location.
  Rationale: Allow 0.5 inch rack extension to extend to the empty rack location.

b. Late Access Integration at the Pad.
- RSP front-side stowage in Bay 1 cannot protrude more than 17" from the RSP plate.
  Rationale: Required for PLAK clearance.
- RSP front-side stowage is not permitted on RSP in Bay 2, and fences must be folded.
  Rationale: RSP front-side stowage and deployed fences in Bay 2 interfere with PLAK operations.
- Handrails are not allowed on the aft seat tracks of RSRs in Bay 2.
  Rationale: Handrails on the aft seat tracks of RSRs in Bay 2 interfere with PLAK operations.

c. Intra Vehicular Activities
- The minimum cross sectional dimensions of microgravity translation paths for one crewmember in light clothing shall be 32"X32" for passthrough and 72"X32" for standard passageway.
  Rationale: Requirement per SSP 50005 paragraph 8.8.3.1.
- The minimum interior cross section dimensions of 50" shall be maintained to support equipment translation.
  Rationale: Requirement per SSP 50005 paragraph 8.8.3.2.

3.2.3.5.3.2 Rack Guidelines

a. Space Station Processing Facility Integration.
- Element Rotation Stand (ERS) Operations.
  1. Position RSRs and RSPs in Port or Starboard locations.
     Rationale: RSRs and RSPs in Port and Starboard locations provide easy access in the ERS and Launch Package Integration Stand (LPIS).
  2. Limit RSPs with front-side bags in the Overhead location.
     Rationale: RSPs with front-side bags in the Overhead location may require additional MPLM rotations in the ERS resulting in increased MPLM physical integration timeline.
  3. Limit RSPs with front-side bags in the Deck location.
     Rationale: RSPs with front-side bags in the Deck location decrease ability of cargo late stowage, decrease use of artificial floor and may require additional MPLM rotations in the ERS resulting in increased MPLM physical processing timeline.
  4. Position RSRs in Bay 1 and 2 Deck locations.
     Rationale: RSRs in Bay 1 and Bay 2 Deck locations provide support for artificial floor.
  5. Minimize RSR location changes from previously flown flight module.

Rationale: Minimizing RSR location changes from previously flown flight module reduce impact to KSC ground processing by minimizing the number of RSR installations/de-installations.

b. Late Access Integration at the Pad
- Do not position RSRs intended for late access operations in Bay 1 Overhead or Bay 2 Overhead location.
  Rationale: Pressurized Module Late Access Kit (PLAK) ladder blocks access to a majority of the RSRs lockers in the Bay 1 Overhead and Bay 2 Overhead locations.
- Position Late access RSRs in Bay 2.
  Rationale: Bay 2 provides easier access than Bay 1.
  Avoid late access to RSR lockers closest to an adjacent RSP when an RSP is positioned adjacent to the RSR is the same bay.
  Rationale: Front side M bags of RSPs adjacent to RSRs limit access to RSR locker location in the same bay (i.e. Front side M bags of RSP in Bay 1 Starboard location limits access to some RSRs locker in Bay 1 Deck location).
- Minimize handrail installation in Bay 1 and 2 Aft to allow for more clearance of the PLAK.
  Rationale: Allow more clearance with PLAK.

c. Intra Vehicular Activities.
- Position RSPs such that the crew can access the rear from an empty bay or from the aft end cone.
  Rationale: Accessing the rear of the RSPs from an empty bay minimize maximizes crew transfer time for transfer activities.
- RSPs in opposing location within a bay is acceptable, however all front-side bags have to be removed prior to rack translation.
  Rationale: All front-side bags of opposing RSPs within a bay will have to be removed to satisfy the minimum cross sectional standard passageway.

d. Payload Rack Placement.
- Position payload racks in Port or Starboard location when possible.
  Rationale: Payload racks positioned in Port or Starboard location provide easier late loading capability.

e. Illumination and Ventilation
- Stagger RSPs between bays.
  Rationale: Staggered RSPs between bays improve illumination and ventilation within the MPLM.
  The generic MPLM flight rule C20-12, "MPLM Ventilation Configuration Ingress" (MPLM Flight Rules, Volume C) to remove bags that block diffusers will typically satisfy illumination and ventilation concerns. Therefore, other RSP constraints usually take precedence over the illumination study guidelines listed below and the guideline for the ventilation stay-out zone shown in Figure 4.8-2.Other RSPs constraints and guidelines take precedence over the illumination study guidelines listed below. To satisfy the illumination study guidelines, a generic MPLM flight rule is in place to remove cargo items that block the diffusers and/or General Luminary Assemblies (GLAs).
  1. Illumination study guidelines.
     Position RSPs in the following order from aft to forward bays: Deck, Port/ Starboard and Overhead. Adjacent RSPs position for Deck location is acceptable; avoid adjacent RSPs position for Port, Starboard and Overhead location if feasible.

Rationale: RSPs in Deck location allow most absolute illumination across entire module. Spacing between RSPs in Port, Starboard and Deck locations minimizes high and low illumination difference.

2. For RSPs in Port and Starboard locations, avoid mounting uppermost M02 bag on the front-side of the RSP.
   Rationale: Front-side M02 bag on RSPs reduce absolute light level.
3. For RSPs in Overhead bay location, recommend only one M01 bag or one M02 bag mounted at mid position.
   Rationale: Multiple bags mounted on RSPs front-side in the Overhead bay location reduce absolute light level.

3.2.3.6 Stowage Constraints and Guidelines

3.2.3.6.1 Stowage Constraints

a. RSP Cargo Placement
Position cargo as close to the RSP plate as possible.
Rationale: To comply with RSP Y-CG design requirement (i.e. within 10.5 " from RSP plate).

b. Late Access Integration at the Pad
RSP front-side stowage in Bay 1 cannot protrude more than 17" from RSP plate
Rationale: Required for PLAK clearance.

c. Hazardous Cargo/Waste and Cargo Containing Fluid/Liquid
Double bag leaky hazardous cargo/waste and leaky cargo containing fluid/liquid in the appropriate bag.
Rationale: Contain contents leakage.

d. Return items containing liquid.
Do not use Spacehab trash liners for return items containing liquid.
Rationale: Size limitation.

e. Bungee Retention Net
Do not use bungee retention net to hold cargo for launch or return.
Rationale: Bungee retention net is not designed to hold cargo for launch or return.

3.2.3.6.2 Stowage Guidelines

a. Early Delivered Hardware
Locate early delivered hardware on the backside of RSPs and in Overhead RSRs locations.
Rationale: Optimize KSC ground processing time.

b. Hazardous Cargo/Waste Return
- Do not stow hazardous cargo/waste in Overhead rack location.
  Rationale: Mitigate potential damage due to leaky container.
- Stow hazardous cargo/waste in Starboard or Port rack location with Deck location as secondary option.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow hazardous cargo/waste on the backside of RSP.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.

c. Return EDV (Russian Urine Containers)
- Do not stow EDV in Bay 1 location.

Rationale: Bay 1 location is adjacent to the forward end cone, which contains MPLM electronics.

- Do not stow EDV in Overhead rack location. If unavoidable, EDV can be stowed in Overhead rack location, in an upright orientation (i.e. EDV lid facing locker rear wall) and surrounded with foam/clothing.
  Rationale: Mitigate potential damage due to leaky container.

- Stow EDV in Port and Starboard rack locations, in sideway orientation (i.e. EDV lid facing locker rear wall) and surround with foam/clothing.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return; avoid potential spill.
- Stow EDV in Deck rack location, in an upright orientation (i.e. EDV lid facing locker door) and surround with foam/clothing.
  Rationale: Avoid potential spill.
- Do not stow EDV on the backside of RSPs.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Stow EDV in an easily accessible location, i.e. stow toward front side of RSR.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow EDV in the same location as LIOH.
  Rationale: Avoid chemical reaction.

d. Return KBO (Russian Soft Trash bag)
- Do not stow KBO in Overhead rack location.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow KBO on the backside of RSPs.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.

e. Return KTO (Russian Solid Waste Container).
- Do not stow KTO in Overhead rack location.
  Rationale: Mitigate potential damage due to leaky container.
- Stow KTO in Port and Starboard rack locations.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow KTO on the backside of RSPs.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Stow KTO in an easily accessible location, i.e. stow toward front side of RSR.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.

f. Return CWC (Contingency Water Container).
- Do not stow CWC in Bay 1 location.
  Rationale: Bay 1 location is adjacent to the forward end cone, which contains MPLM electronics.
- Do not stow CWC in Overhead rack location.
  Rationale: Mitigate potential damage due to leaky container.
- Stow CWC in Port and Starboard rack locations.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow CWC on the backside of RSPs.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Stow full CWC with soft stow around it.
  Rationale: Reduce load to the CWC.
- Do not stow CWC with other cargo items that can puncture the CWC.
  Rationale: Avoid potential leakage.
- Do not stow CWC in the same location as LIOH.
  Rationale: Avoid chemical reaction.

g. Return PWR (Payload Water Reservoir).
- Do not stow PWR in Bay 1 location.

Rationale: Bay 1 location is adjacent to the forward end cone, which contains MPLM electronics.

- Do not stow PWR in Overhead rack location.
  Rationale: Mitigate potential damage due to leaky container.
- Stow PWR in Port and Starboard rack locations.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow PWR on the backside of RSPs.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow PWR in the same location as LIOH.
  Rationale: Avoid chemical reaction.

h. Return IRED (Interim Resistive Exercise Device) canisters.
- Do not stow IRED canisters on the backside of RSPs.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow IRED canisters in Overhead rack location.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Stow IRED canisters in an easily accessible location, i.e. stow toward front side of RSR.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.

i. Return HRF (Human Research Facility) equipment containing fluid.
- Do not stow HRF equipment containing fluid in Bay 1 location.
  Rationale: Bay 1 location is adjacent to the forward end cone, which contains MPLM electronics.
- Do not stow HRF equipment containing fluid in Overhead location.
  Rationale: Mitigate damage due to leaky container.
- Stow HRF equipment in Port and Starboard rack locations.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow HRF equipment containing fluid on the backside of RSPs.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Stow HRF equipment with fluid in an easily accessible location, i.e. stow toward front side of RSR.
  Rationale: Allow timely removal of cargo and ease KSC ground processing upon return.
- Do not stow HRF equipment containing fluid in the same location with LIOH.
  Rationale: Avoid chemical reaction.

j. Return Lithium Hydroxide (LiOH) Cartridge
- Stow LiOH cartridges in vertical position with little to no side loading and in area not susceptible heavy top loading. Preferable stow on top rack location.
  Rationale: LiOH cartridge shell is made of aluminum and is susceptible to dents, punctures and tears in outer shell.
- Stow LiOH cartridges away from payloads containing liquid.
  Rationale: Avoid chemical reaction.
- Stow LiOH cartridges in area not susceptible to exposure to the following items containing one or in combination any of these acid gases: Trichloroethylene, Chloroform, Methyl Chloroform, Vinylidine Chloride, Tetrachloroethane.
  Rationale: Avoid chemical reaction.

k. Size of cargo stowed on the back side of RSP in bay 4
- Stow cargo with dimensions not exceeding the standard triple CTB dimensions (19.75", 29.50" or 16.75") on the back side of RSP in bay 4. Cargo that has a dimension exceeding the standard triple CTB dimensions shall be identified.
  Rationale: Lack of space required to transfer cargo larger than a standard triple CTB through the aft end cone area without rotating the RSP.

l. Late Access Integration at the Pad

- Stow late stow items for pad integration in a stowage bag such as CTB or M-bag.
  Rationale: Prevent hardware damage and minimize packing/integration time at the pad.

3.2.3.7 Structural Stowage Constraints and Guidelines

3.2.3.7.1 Structural Stowage Constraints

3.2.3.7.1.1 Launch

a. Design Requirement
   - RSR, RSP and bag design capabilities shall not be exceeded (reference SSP 41017 and JSC 28169).
     Rationale: Design requirement per SSP 41017 and JSC 28169.
   - Do not plan to stow late access cargo into RSPs that are near their design capability.
     Rationale: Insure that RSP design capability is not exceeded.

b. VLA requirement
   - Overall Final as-measured integrated rack weights must remain within ± 50 lbs and CG must remain within a ± 1" RSS envelope of final VLA input.
     Rationale: VLA requirement per NSTS 37329. Overall Final as-measured integrated
   - MPLM weight must remain within ± 200 lbs and CG must remain within ± 1" RSS envelope of final VLA input.
     *Rationale: VLA requirement per NSTS 37329.*Schedule constraints
     Do not plan to stow late access cargo into RSPs that are near their design capability.
     Rationale: Assure that RSP design capability is not exceeded.

3.2.3.7.1.2 Return

a. Design Requirement
b. RSR, RSP and bag design capabilities shall not be exceeded (reference SSP 41017, JSC and 28169).
   Rationale: Design requirement per SSP 41017, and JSC 28169.
c. RSP foam shall be returned per stowage plan only.
   Rationale: Assure that RSP design capability is not exceeded.
d. VLA requirement
   - Overall rack weights must remain within ± 50 lbs and CG must remain within a ± 1" RSS envelope of final VLA input.
     Rationale: VLA requirement per NSTS 37329.
   - Overall integrated MPLM weight must remain within ± 200 lbs and CG must remain within ± 1" RSS envelope of final VLA input.
     Rationale: VLA requirement per NSTS 37329.
e. Foam Plan
   RSP foam shall be returned per stowage plan only.
   Rationale: Assure that RSP design capability is not exceeded.

3.2.3.7.2 Structural Stowage Guidelines

3.2.3.7.2.1 Return

a. Total RSP weight should not be over 655 lbs.

Rationale: Assure that RSP design capability is not exceeded.

b. Cargo Distribution
c. Stowage should be distributed evenly throughout the RSRs For RSRs, cargo should be evenly distributed and cargo should be placed in locker location so that CG will be toward the center of the rack.
Rationale: Allow for manifest growth and provide flexibility. .

d.Foam Plan
Excess RSR foam should be equally distributed as much as possible among all RSRs locker location.
Rationale: Allow rack to be homogeneous.

3.2.4 Knee Brace Assembly

The MPLM internal mechanisms include the rack knee brace assemblies for rack-to-MPLM primary structure mechanical connection and non-fixed rack pivot mechanisms for on-orbit rack installation and removal.

Each knee brace assembly (depicted in Figure 3.2-7) includes three adjustable length braces, arranged according to an N-shaped scheme, connecting the rack upper attachments to the RABs installed on the cylindrical shell.

Each knee brace is attached to the MPLM shell by means of a pin, removable on the ground or on-orbit as shown in Figure 3.2-8. When the knee braces are mounted on the MPLM but no rack is installed, a clip is clamped to the braces (as shown in Figure 3.2-9) in order to tighten the interface to the MPLM structure and prevent unwanted brace vibrations.

When a rack is not flown in a space, the knee brace is secured against the stand-off by the locking clips (as shown in Figure 3.2-9) in order to tighten the interface to the MPLM structure and prevent unwanted vibrations. When a rack is flown in a space, the knee brace is mounted in the alignment clips (as shown in Figure 3.2-10) to hold the knee brace in position to interface with the rack structure. The alignment clips may be readjusted by the flight crew as well as the ground operations personnel.

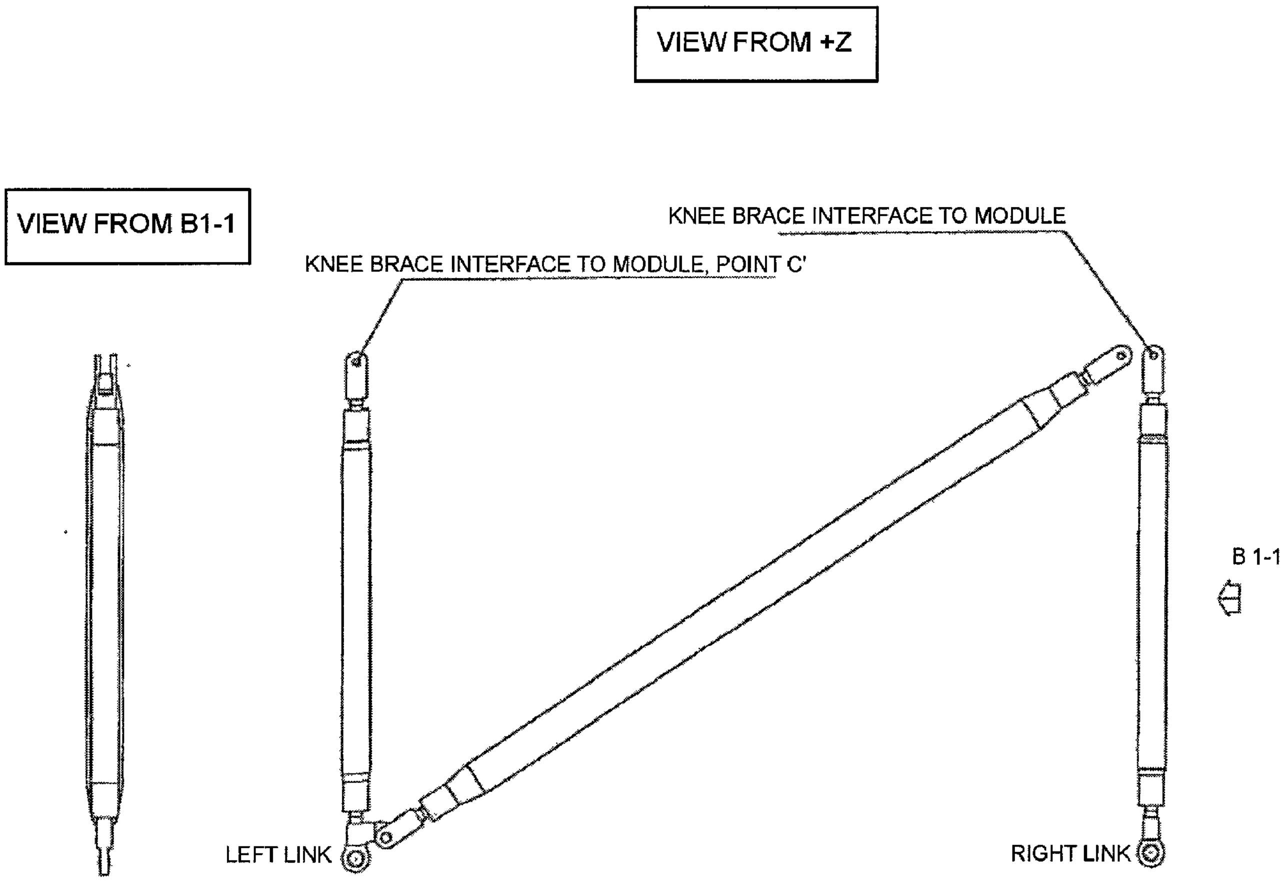


Figure 3.2-7. Knee Brace Assembly

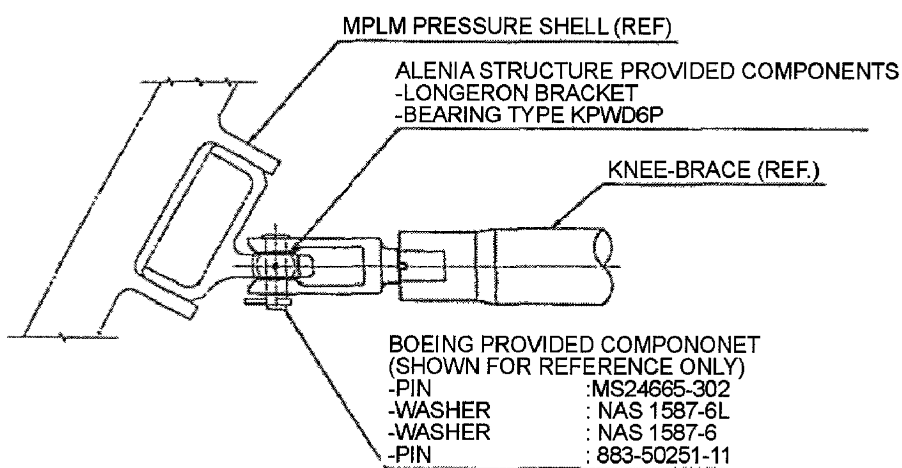


Figure 3.2-8. Knee Brace to Longeron Interface

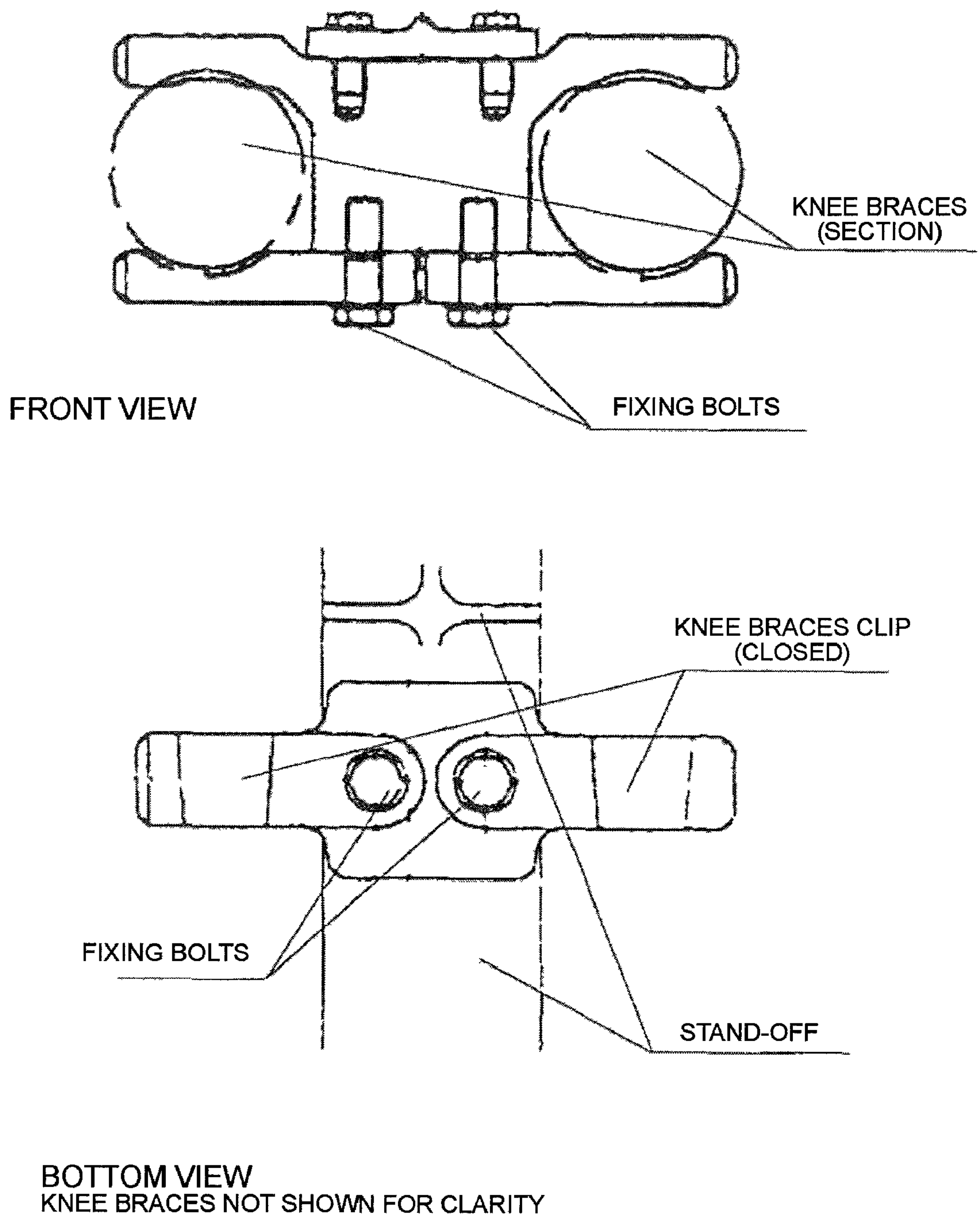


Figure 3.2-9. Knee Brace Retention Device

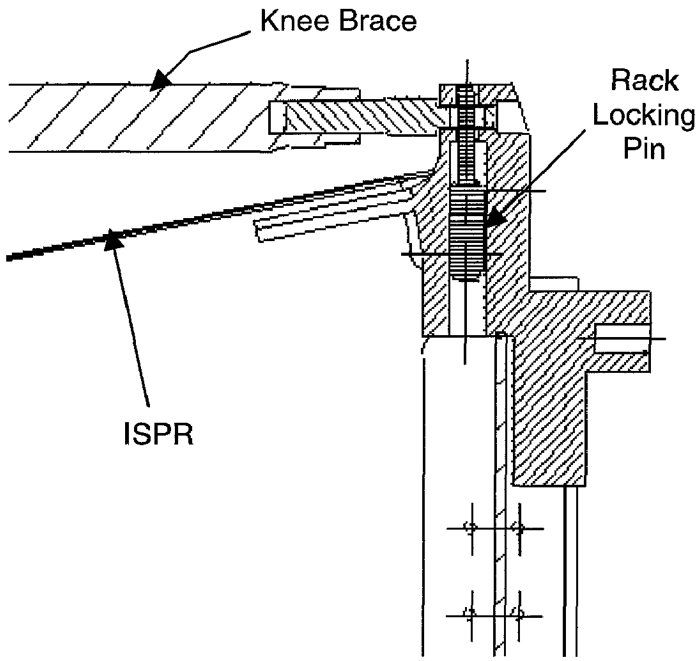


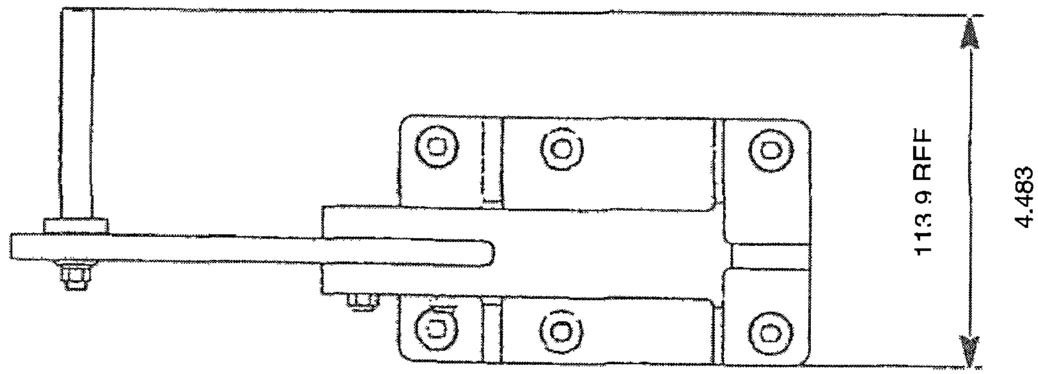
Figure 3.2-10. Forward Rack to Knee Brace Interface

3.2.5 Rack Pivot Mechanism

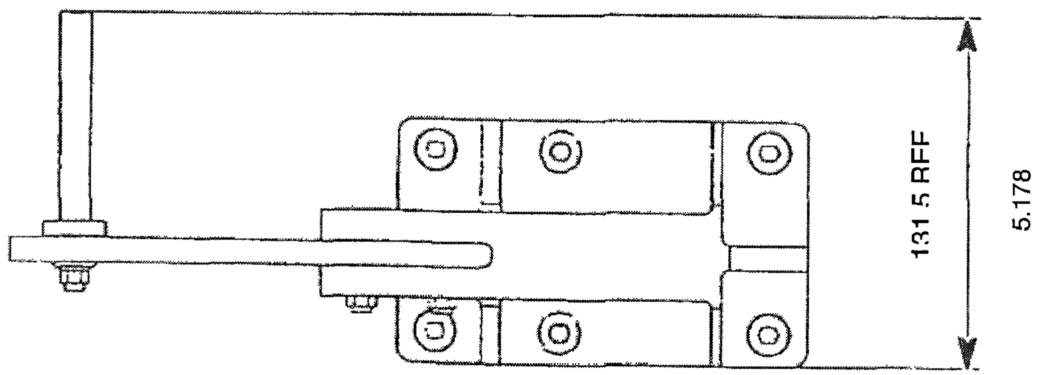
The rack pivot mechanisms (see Figure 3.2-11) are non-fixed mechanical devices, mounted on the stand-offs for on-orbit rack installation and removal. Each pivot mechanism includes an integral pin, to interface with the rack pivot slot.

After berthing to the USOS, the racks still remain attached to the primary structure, until initiation of the rack tilt-out and removal operations; when a rack has to be transported to the adjacent pressurized element, both the upper and lower rear attachments are disengaged and the rack is tilted using the rack pivot mechanisms installed on the stand-off structure.

There are two different types of pivot mechanisms, which differ in pin length; the appropriate pivot pin must be chosen according to the rack bay width.



Short Bracket (left), P/N 1600P051-401



Long Bracket (left), P/N 1600P061-401

Figure 3.2-11. Pivot Pin Brackets

3.2.6 Brace Locking System Assembly

The Brace Locking System Assembly (BLSA) is a device designed to facilitate the installation of either ISPR, NASA and NASDA racks inside the MPLM while it is attached to the Space Station. The BLSA is installed on the ground and interfaces with the MPLM stand-off structure. The interface with the knee brace is performed through a seat and a velcro closure.

The BLSA main components are:

- A stand–off interface structure
- A sustaining structure
- A vertical sliding structure
- A knee brace locking structure with horizontal sliding capability

The structure allows manual adjustments during rack installation without transferring loads either to the stand-offs or to the knee braces. The BLSA mechanical configuration in shown in Figure 3.2-12. Additional details of the BLSA are documented in MLM-HB-AI-0002.

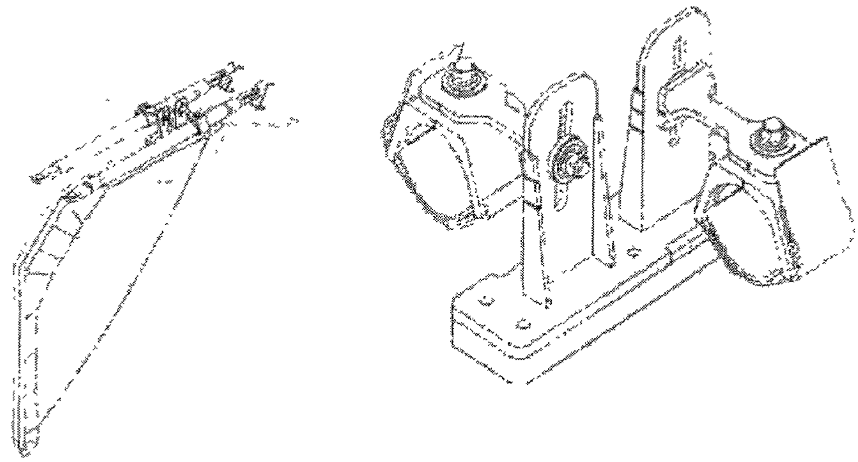


Figure 3.2-12. BLSA Mechanical Configuration

3.2.7 Removal/Installation of Racks During Ground Operations

The Personnel Access Floor (PAF)/Lightweight Personnel Floor (LWPF) will be removed, the MPLM rotated 90 degrees (keel starboard) for floor and ceiling rack installation and the PAF/LWPF re-installed. The Rack Insertion Device (RID) and Weight and CG End Effector (W&CG EE) will be configured to remove racks from the Rack Handling Adapter (RHA), perform rack weight and CG determination and install racks into the MPLM. After all floor and ceiling racks are installed, the PAF will be removed, the MPLM rotated back to keel down and the PAF re-installed. The RID and end effector will then be used to remove racks from RHA's, perform weight and CG and install port and starboard racks.

The following Ground Support Equipment (GSE) is required:

- Element Rotation Stand (ERS)
- Hatch Access Structure (HAS)
- Lightweight Personnel Floor (Unique Items)
- Personnel Access Floor (PAF)
- Rack Insertion Device (RID)
- Aft Access Closure (AAC)

The MPLM is configured as follows:

- MPLM installed in the ERS
- MPLM powered off
- Hatch open
- AAC removed
- PAF and LWPF installed

The Rack installation activity requires MPLM rotation around the X-axis. To minimize loads on MPLM during its rotation the sequence will be as follows:

1. 90° counterclockwise (CCW) rotation of the module (empty).
2. Installation of Ceiling and Floor racks.
3. 90° clockwise (CW) rotation of the module (half loaded).
4. Installation of Port and Starboard racks.

The RID has the capability to insert a full rack inside MPLM and rotate it in position in both right and left rows. Therefore, only two rotations of the module during rack installation and removal are required.

After the racks have been installed in the MPLM, relevant power and data interfaces are connected (active racks only).

For unused R/F locations, the proper protection caps are installed for flight at the Utility Interface Panels (UIPs) of the unused R/Fs.

For rack deintegration the MPLM is configured as for Rack Integration and the same constraints apply. After Rack deintegration, the protective caps at the electrical/fluid interfaces are installed.

3.2.8 Rack Services

At each active rack available location, the MPLM is able to provide electrical power. For the two second-bay active rack locations, the MPLM can provide up to 1050 W each of electrical power. For the other three active rack locations, up to 598 W each of electrical power are available.

The total maximum continuous power available for the MPLM active cargo is 2400 W during the transportation phases (i.e. while in the Orbiter cargo bay) and 2200 W during on-ground processing and during the on-station phase.

Each MPLM accommodated active cargo shall provide a bonding receptacle, according to guidelines specified in Figure 3.2-13.

At each active rack available location, the MPLM is able to provide water cooling as described in Section 3.5.2.1.

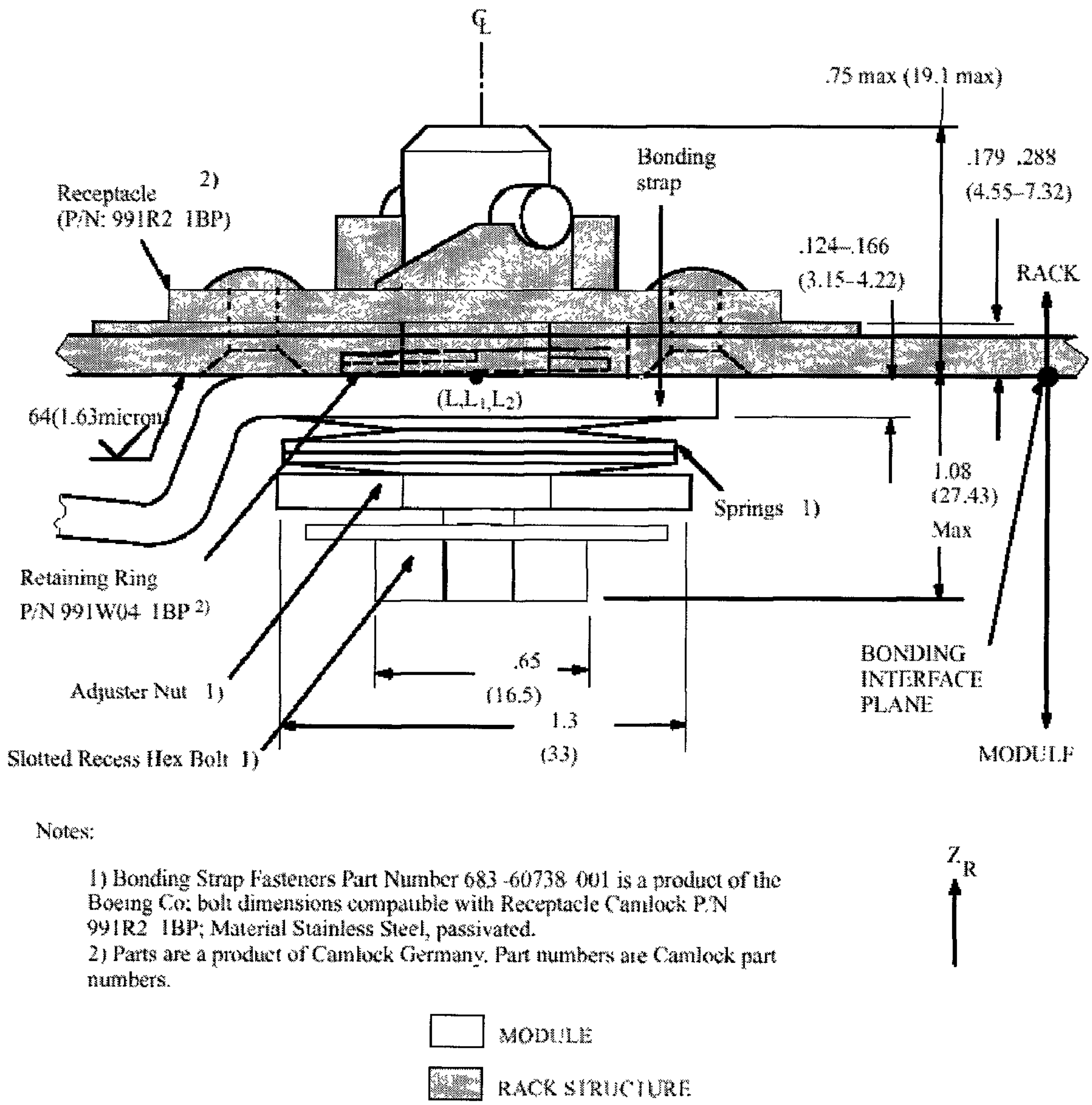


Figure 3.2-13. Bonding Receptacle

3.3 POWER AND SIGNAL HARNESSES

The interface cable set provides cables that connect to MPLM flight interfaces. These cables will breakout the power and data paths to unique support equipment connections. They are of minimum length and are provided with strain relief to protect the flight interface from unnecessary loads. The active rack cable and wire interface shall be compliant with SSP 30242.

3.4 UTILITIES

3.4.1 Utility Interface Panel (UIP)

UIPs are available at the active cargo locations. UIPs support the interface connectors for fluid coolant, electrical power and data transfer to/from the active rack. The active cargo support resources are currently planned to be available during the MPLM missions to ISS Node 2.

The UIP location and dimensions are shown in Figure 3.4-1. The layout of the UIP is shown in Figure 3.4-2.

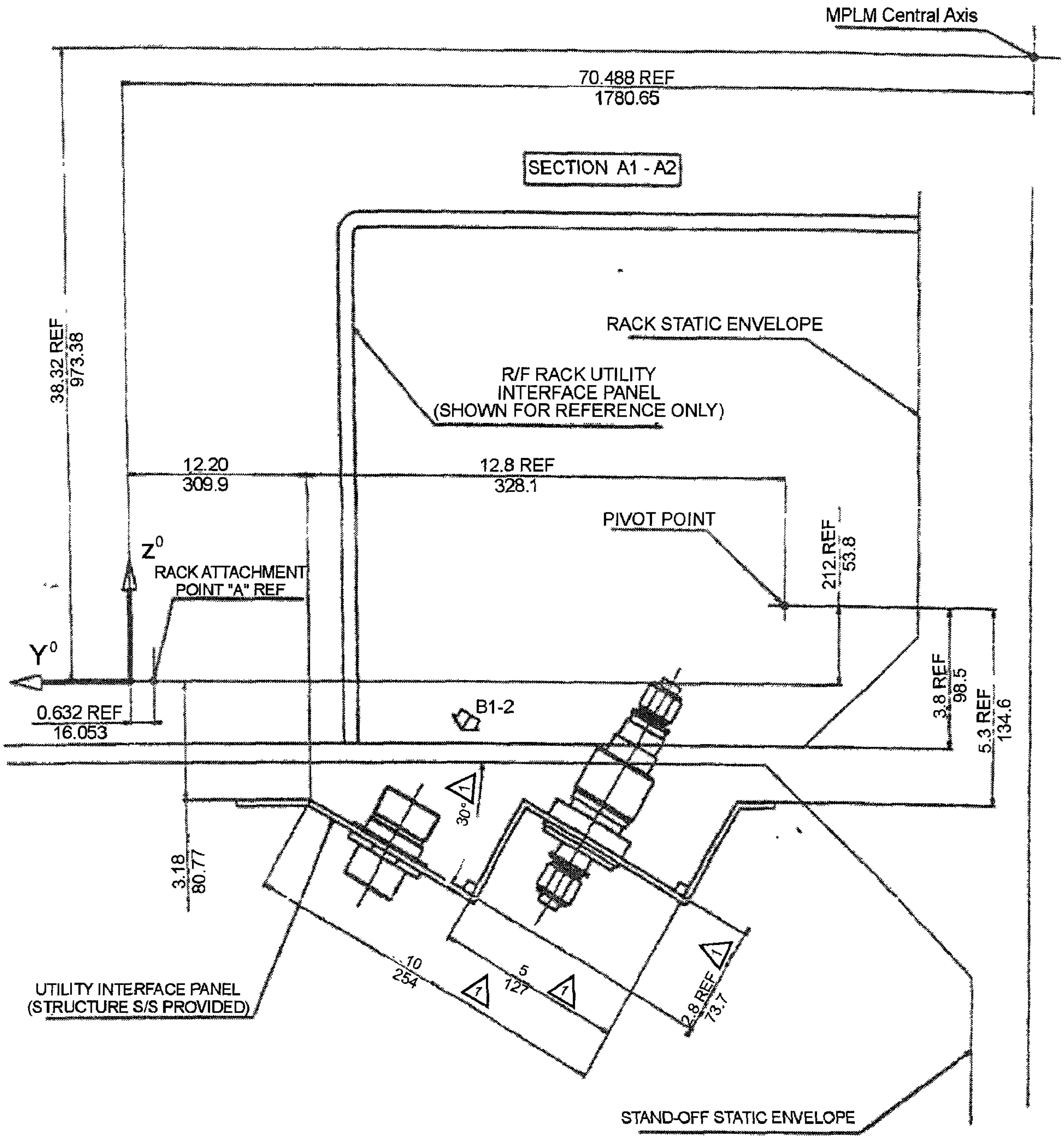


Figure 3.4-1. Utility Interface Panel Location and Dimensions

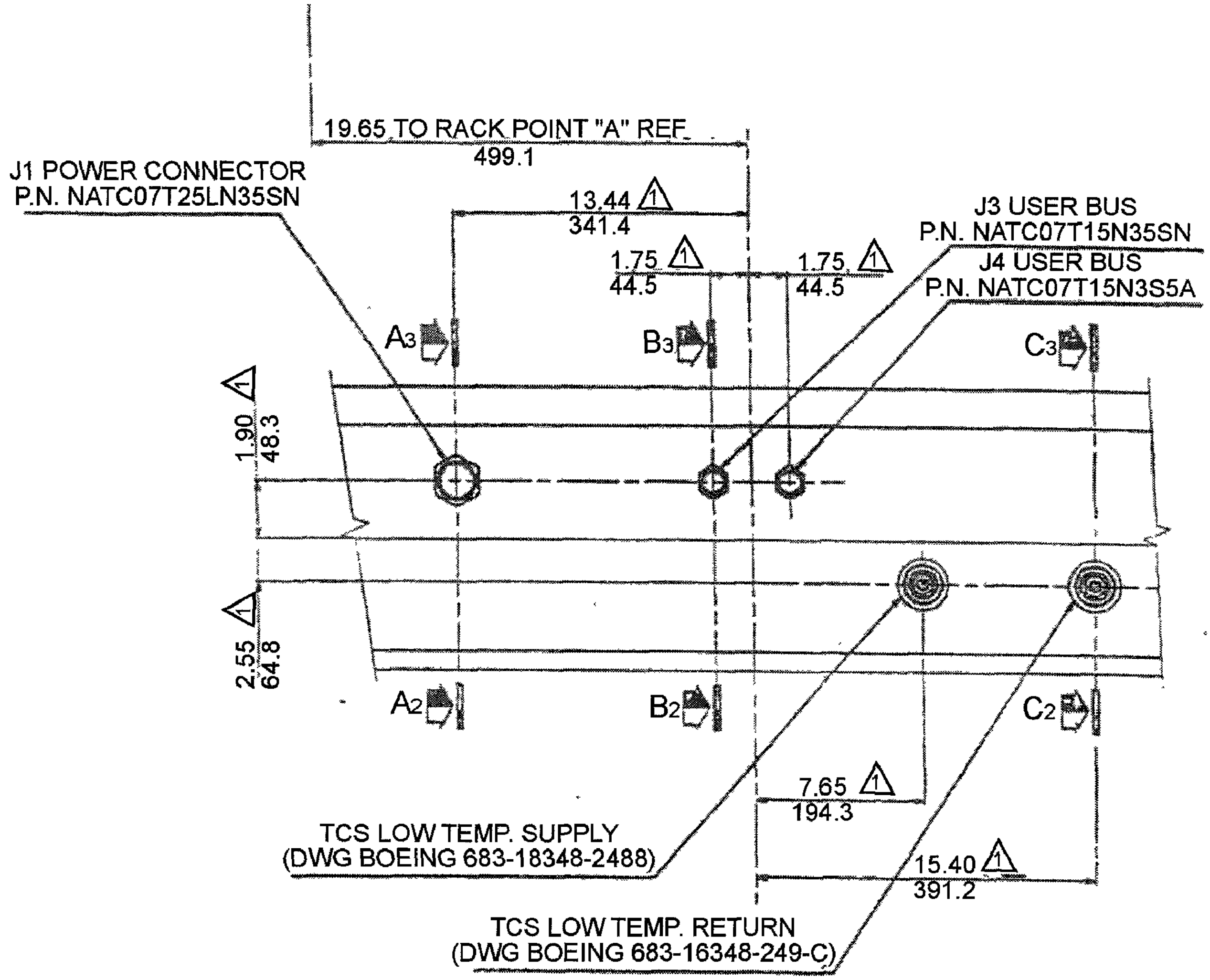


Figure 3.4-2. Utility Interface Panel Layout

3.4.1.1 Fluid Connectors

The active rack fluid coolant connectors interface with the following MPLM installed connectors:

- P/N 683-16348-248/B, at the coolant supply interface
- P/N 683-16348-249/C, at the coolant return interface

3.4.1.2 Electrical Power Connectors

The active cargo P01 electrical power interface connector interfaces with the MPLM installed J01 connector P/N NATC07T25LN3SN. Tables 3.4-1 through 3.4-5 provide the J01 connector pin assignment for each active cargo location.

Table 3.4-1. P1 Active Cargo Location J01 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
A	R	ACTIVE RACK 3 PWR	PIPW	EO	
B		Not Used	-	-	
C	R	ACTIVE RACK 3 PWR RTN	RTN		

Table 3.4-2. L1 Active Cargo Location J01 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
A	R	ACTIVE RACK 2 PWR	PIPW	EO	
B		Not Used	-	-	
C	R	ACTIVE RACK 2 PWR RTN	RTN		

Table 3.4-3. S1 Active Cargo Location J01 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
A	R	ACTIVE RACK 4 PWR	PIPW	EO	
B		Not Used	-	-	
C	R	ACTIVE RACK 4 PWR RTN	RTN		

Table 3.4-4. P2 Active Cargo Location J01 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
A	R	ACTIVE RACK 1 PWR	PIPW	EO	
B		Not Used	-	-	
C	R	ACTIVE RACK 1 PWR RTN	RTN		

Table 3.4-5. S2 Active Cargo Location J01 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
A	R	ACTIVE RACK 5 PWR	PIPW	EO	
B		Not Used	-	-	
C	R	ACTIVE RACK 5 PWR RTN	RTN		

3.4.1.3 Data Connectors

The active cargo P03 and P04 data connectors interface with the following MPLM installed J03 and J04 connectors at the dual redundant MIL-STD-1553B User Bus:

- J03: P/N NATC07T15N35SN
- J04: P/N NATC07T15N35SA

Tables 3.4-6 through 3.4-15 provide the J03 and J04 connector pin assignment for each active cargo location.

Table 3.4-6. P1 Active Cargo Location J03 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1	S	R/F 3(A) BUS BIT 0 ADDRESS	1553	RF	Jumper
2	S	R/F 3(A) BUS BIT 1 ADDRESS			
3	S	R/F 3(A) BUS BIT 2 ADDRESS			
4	S	R/F 3(A) BUS BIT 3 ADDRESS	1553	RF	Jumper
5	S	R/F 3(A) BUS BIT 4 ADDRESS	1553	RF	Jumper
6	S	R/F 3(A) BUS PARITY	1553	RF	Jumper
7	S	R/F 3(A) BUS LOGIC GROUND	1553	RF	Jumper
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Spare	-	-	
18		Spare	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 3 STUB A COMPLEMENT	RTN		
37	S	R/F 3 STUB A TRUE	1553	RF	
BSH	S	R/F 3 STUB A SHIELD			

Table 3.4-7. P1 Active Cargo Location J04 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1		Spare	-	-	
2		Spare	-	-	
3		Spare	-	-	
4		Spare	-	-	
5		Spare	-	-	
6		Spare	-	-	
7		Spare	-	-	
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Not Used	-	-	
18		Not Used	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 3 STUB B COMPLEMENT	RTN		
37	S	R/F 3 STUB B TRUE	1553	RF	
BSH	S	R/F 3 STUB B SHIELD			

Table 3.4-8. L1 Active Cargo Location J03 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1	S	R/F 2(A) BUS BIT 0 ADDRESS	1553	RF	Jumper
2	S	R/F 2(A) BUS BIT 1 ADDRESS			
3	S	R/F 2(A) BUS BIT 2 ADDRESS			
4	S	R/F 2(A) BUS BIT 3 ADDRESS	1553	RF	Jumper
5	S	R/F 2(A) BUS BIT 4 ADDRESS	1553	RF	Jumper
6	S	R/F 2(A) BUS PARITY	1553	RF	Jumper
7	S	R/F 2(A) BUS LOGIC GROUND	1553	RF	Jumper
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Spare	-	-	
18		Spare	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 2 STUB A COMPLEMENT	RTN		
37	S	R/F 2 STUB A TRUE	1553	RF	
BSH	S	R/F 2 STUB A SHIELD			

Table 3.4-9. L1 Active Cargo Location J04 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1		Spare	-	-	
2		Spare	-	-	
3		Spare	-	-	
4		Spare	-	-	
5		Spare	-	-	
6		Spare	-	-	
7		Spare	-	-	
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Not Used	-	-	
18		Not Used	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 2 STUB B COMPLEMENT	RTN		
37	S	R/F 2 STUB B TRUE	1553	RF	
BSH	S	R/F 2 STUB B SHIELD			

Table 3.4-10. S1 Active Cargo Location J03 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1	S	R/F 4(A) BUS BIT 0 ADDRESS	1553	RF	Jumper
2	S	R/F 4(A) BUS BIT 1 ADDRESS			
3	S	R/F 4(A) BUS BIT 2 ADDRESS			
4	S	R/F 4(A) BUS BIT 3 ADDRESS	1553	RF	Jumper
5	S	R/F 4(A) BUS BIT 4 ADDRESS	1553	RF	Jumper
6	S	R/F 4(A) BUS PARITY	1553	RF	Jumper
7	S	R/F 4(A) BUS LOGIC GROUND	1553	RF	Jumper
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Spare	-	-	
18		Spare	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 4 STUB A COMPLEMENT	RTN		
37	S	R/F 4 STUB A TRUE	1553	RF	
BSH	S	R/F 4 STUB A SHIELD			

Table 3.4-11. S1 Active Cargo Location J04 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1		Spare	-	-	
2		Spare	-	-	
3		Spare	-	-	
4		Spare	-	-	
5		Spare	-	-	
6		Spare	-	-	
7		Spare	-	-	
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Not Used	-	-	
18		Not Used	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 4 STUB B COMPLEMENT	RTN		
37	S	R/F 4 STUB B TRUE	1553	RF	
BSH	S	R/F 4 STUB B SHIELD			

Table 3.4-12. P2 Active Cargo Location J03 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1	S	R/F 1(A) BUS BIT 0 ADDRESS	1553	RF	Jumper
2	S	R/F 1(A) BUS BIT 1 ADDRESS			
3	S	R/F 1(A) BUS BIT 2 ADDRESS			
4	S	R/F 1(A) BUS BIT 3 ADDRESS	1553	RF	Jumper
5	S	R/F 1(A) BUS BIT 4 ADDRESS	1553	RF	Jumper
6	S	R/F 1(A) BUS PARITY	1553	RF	Jumper
7	S	R/F 1(A) BUS LOGIC GROUND	1553	RF	Jumper
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Spare	-	-	
18		Spare	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 1 STUB A COMPLEMENT	RTN		
37	S	R/F 1 STUB A TRUE	1553	RF	
BSH	S	R/F 1 STUB A SHIELD			

Table 3.4-13. P2 Active Cargo Location J04 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1		Spare	-	-	
2		Spare	-	-	
3		Spare	-	-	
4		Spare	-	-	
5		Spare	-	-	
6		Spare	-	-	
7		Spare	-	-	
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Not Used	-	-	
18		Not Used	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 1 STUB B COMPLEMENT	RTN		
37	S	R/F 1 STUB B TRUE	1553	RF	
BSH	S	R/F 1 STUB B SHIELD			

Table 3.4-14. S2 Active Cargo Location J03 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1	S	R/F 5(A) BUS BIT 0 ADDRESS	1553	RF	Jumper
2	S	R/F 5(A) BUS BIT 1 ADDRESS			
3	S	R/F 5(A) BUS BIT 2 ADDRESS			
4	S	R/F 5(A) BUS BIT 3 ADDRESS	1553	RF	Jumper
5	S	R/F 5(A) BUS BIT 4 ADDRESS	1553	RF	Jumper
6	S	R/F 5(A) BUS PARITY	1553	RF	Jumper
7	S	R/F 5(A) BUS LOGIC GROUND	1553	RF	Jumper
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Spare	-	-	
18		Spare	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 5 STUB A COMPLEMENT	RTN		
37	S	R/F 5 STUB A TRUE	1553	RF	
BSH	S	R/F 5 STUB A SHIELD			

Table 3.4-15. S2 Active Cargo Location J04 Connector Pin Assignment

PIN	S/R	SIGNAL NAME	TYPE	EMC	REMARKS
1		Spare	-	-	
2		Spare	-	-	
3		Spare	-	-	
4		Spare	-	-	
5		Spare	-	-	
6		Spare	-	-	
7		Spare	-	-	
8		Spare	-	-	
9		Not Used	-	-	
10		Not Used	-	-	
11		Not Used	-	-	
12		Not Used	-	-	
13		Not Used	-	-	
14		Not Used	-	-	
15		Not Used	-	-	
16		Spare	-	-	
17		Not Used	-	-	
18		Not Used	-	-	
19		Not Used	-	-	
20		Not Used	-	-	
21		Not Used	-	-	
22		Not Used	-	-	
23		Not Used	-	-	
24		Spare	-	-	
25		Spare	-	-	
26		Spare	-	-	
27		Not Used	-	-	
28		Not Used	-	-	
29		Not Used	-	-	
30		Not Used	-	-	
31		Spare	-	-	
32		Not Used	-	-	
33		Not Used	-	-	
34		Not Used	-	-	
35		Not Used	-	-	
36	S	R/F 5 STUB B COMPLEMENT	RTN		
37	S	R/F 5 STUB B TRUE	1553	RF	
BSH	S	R/F 5 STUB B SHIELD			

3.5 PAYLOAD ACCOMMODATION CAPABILITIES

Table 3.5-1 reports the cargo types that are currently planned to be transported by the MPLM. To accommodate these cargo types, the MPLM offers a unique interface design, both from the mechanical viewpoint (interface design in compliance with SSP 41017) and from the active cargo available utility viewpoint (interface design according to SSP 41155).

MPLM cargo consists of ISS Systems racks, International Standard Payload Racks (ISPR) containing experiments, Resupply Stowage Racks (RSR) and their contents, and Resupply Stowage Platforms carrying soft stowage containers, and on Active missions, Refrigerator/Freezer Racks (RFR) carrying cold storage items. No experiment operations are planned in the MPLM. Rack and platform items include Crew items, experiment equipment and samples, and replacement systems and facility items (ORUs).

MPLM ballast may be carried up and/or down to maintain the rack CG and mass within specification.

Table 3.5-1. Cargo Types

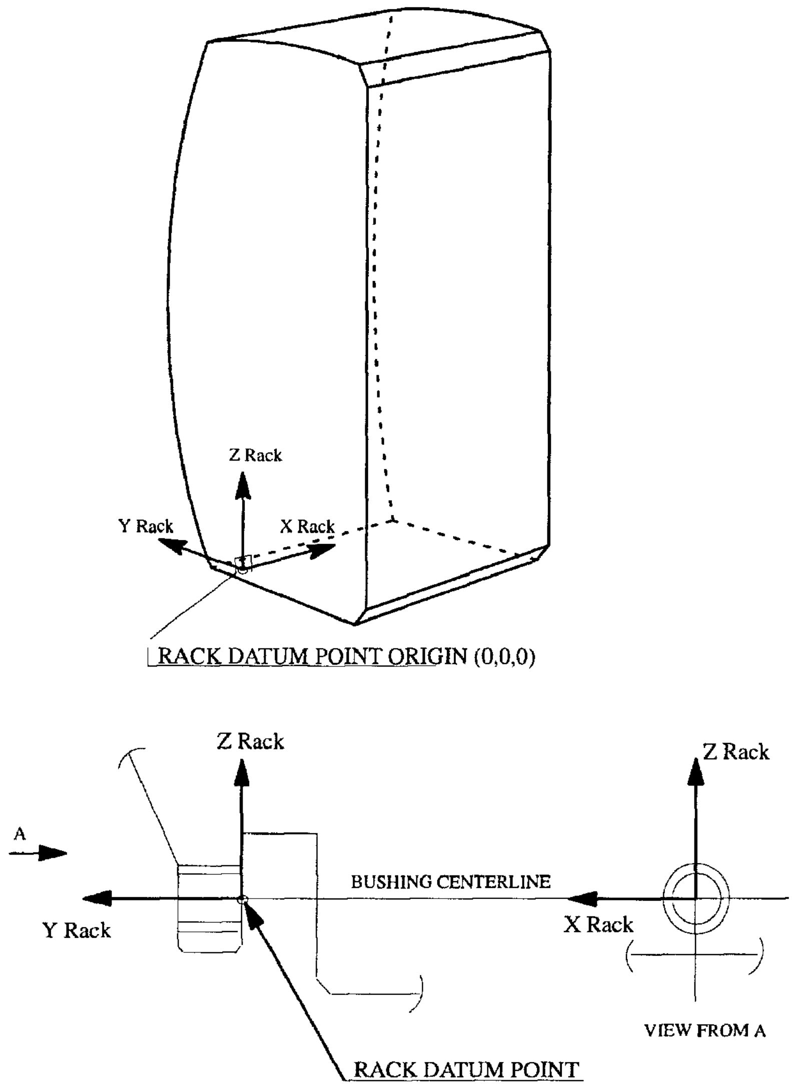
Cargo Type	Payload (P/L) Accommodation System	P/L	Remarks
Cryo Rack (-183°C R/FR)	Dewars	Science samples	Active
Express Rack	Drawers, Lockers	Experiments and small payloads	Passive
International Standard Payload Rack	Facility Racks	Payload and experiment equipment	Passive
MELFI Rack (-80°C R/FR)	Dewars, Trays	Science samples	Active
+4/-26°C Refrigerator/Freezer Rack	Trays	Food and supplies	Active
Resupply Stowage Platform	Hardmount capability, Bags, CTBs	Crew rotation hardware and supplies	Passive
Resupply Stowage Rack	Trays, CTBs	Hardware and supplies	Passive

3.5.1 Volume and Mounting Area Available to MPLM Cargo

The volume available and interface definition for cargo/payload are defined in SSP 57007 for ISPRs; SSP 57005 and SSP 57006 for ARIS racks; JSC 28169, SEG33111805 and SEG33111806 for RSPs; and 683-60581 for RSRs.

3.5.2 Racks

The MPLM is capable of accommodating and transporting up to sixteen racks. The rack RCS is defined in Figure 3.5-1.



Note: The physical reference is the Rack Datum Point at the interface of the center line bushing attachment to the rear side of the lower module bearing behind point A.

Figure 3.5-1. Rack Reference Coordinate System

3.5.2.1 Active Cargo Support Resources

Each of the active rack available locations is provided with a UIP, which supports the interface connectors for fluid coolant, electrical power and data transfer to/from the active rack. The active cargo support resources are currently planned to be available during the MPLM missions to the ISS Node 2.

At each active rack position, the MPLM is able to provide fluid coolant flow.

Water cooling is provided by the MPLM to the active cargo only during the following phases:

- pre-launch
- on-orbit (except for the Orbiter-to-ISS and ISS-to-Orbiter transfer phases)
- post-landing

For detailed requirements for the design of active payloads see SSP 41155.

3.5.2.1.1 Coolant Specification

The payload cooling loop plumbing shall be compatible with SSP 30573 Table 4.1-1.9.2 (Heat Transport Fluid, IATC).

3.5.2.1.2 Air Heat Load

The total airborne heat load from the payload complement to the MPLM shall not exceed the values of Table 3.5-2 with linear interpolation for ambient temperatures between those specified.

Table 3.5-2. Heat Loads

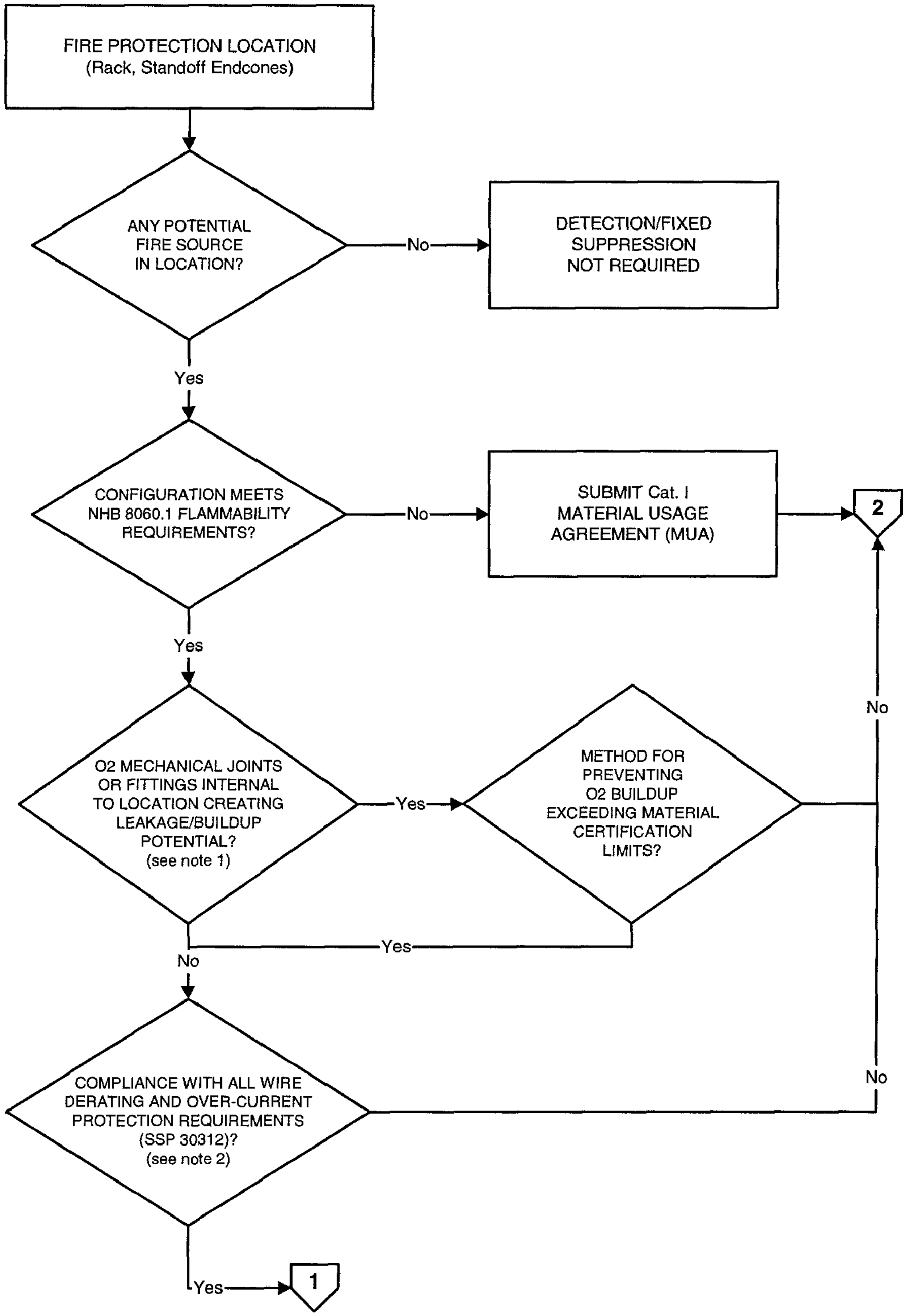
Ambient Temperature	Heat Load
60°F 15.5°C	-254 W
85°F 29.4°C	-317 W
120°F 48.9°C	-526 W

3.5.2.1.3 Fire Detection and Suppression

3.5.2.1.3.1 Fire Protection

The active cargo shall comply with the fire protection and selection criteria as defined in Figure 3.5-2.

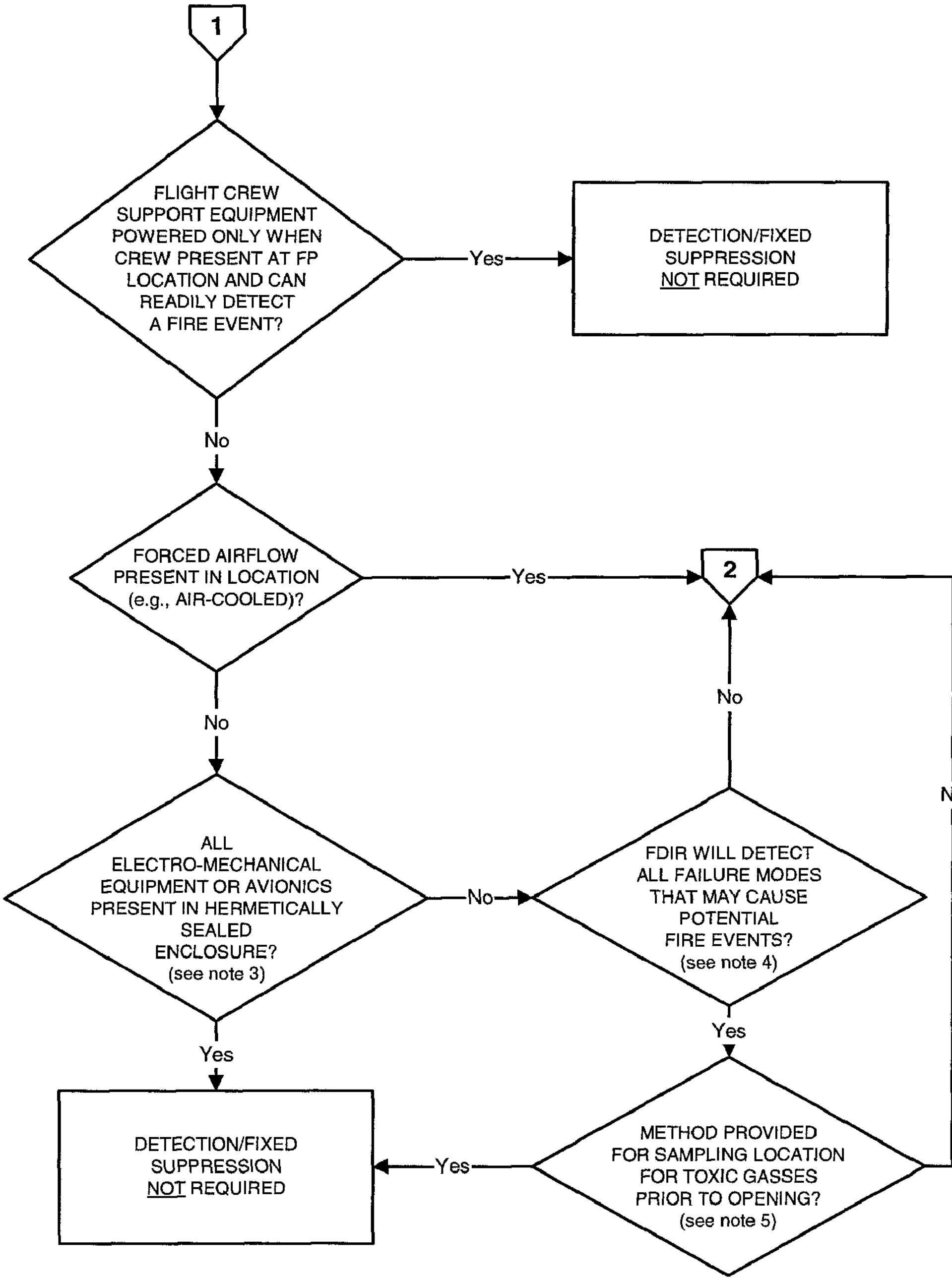
If smoke detectors are embedded, the related data shall be provided through the User Bus.



Notes:

1. An O2 line running through a location, with no fittings, fittings with redundant seals, metal seals or only welded fittings internal to the location would be a “no”. Also assumes worst case credible failure for determining leakage/buildup potential.
2. Compliance with SSP 30312 is determined by Parts Control Board for any deviations.

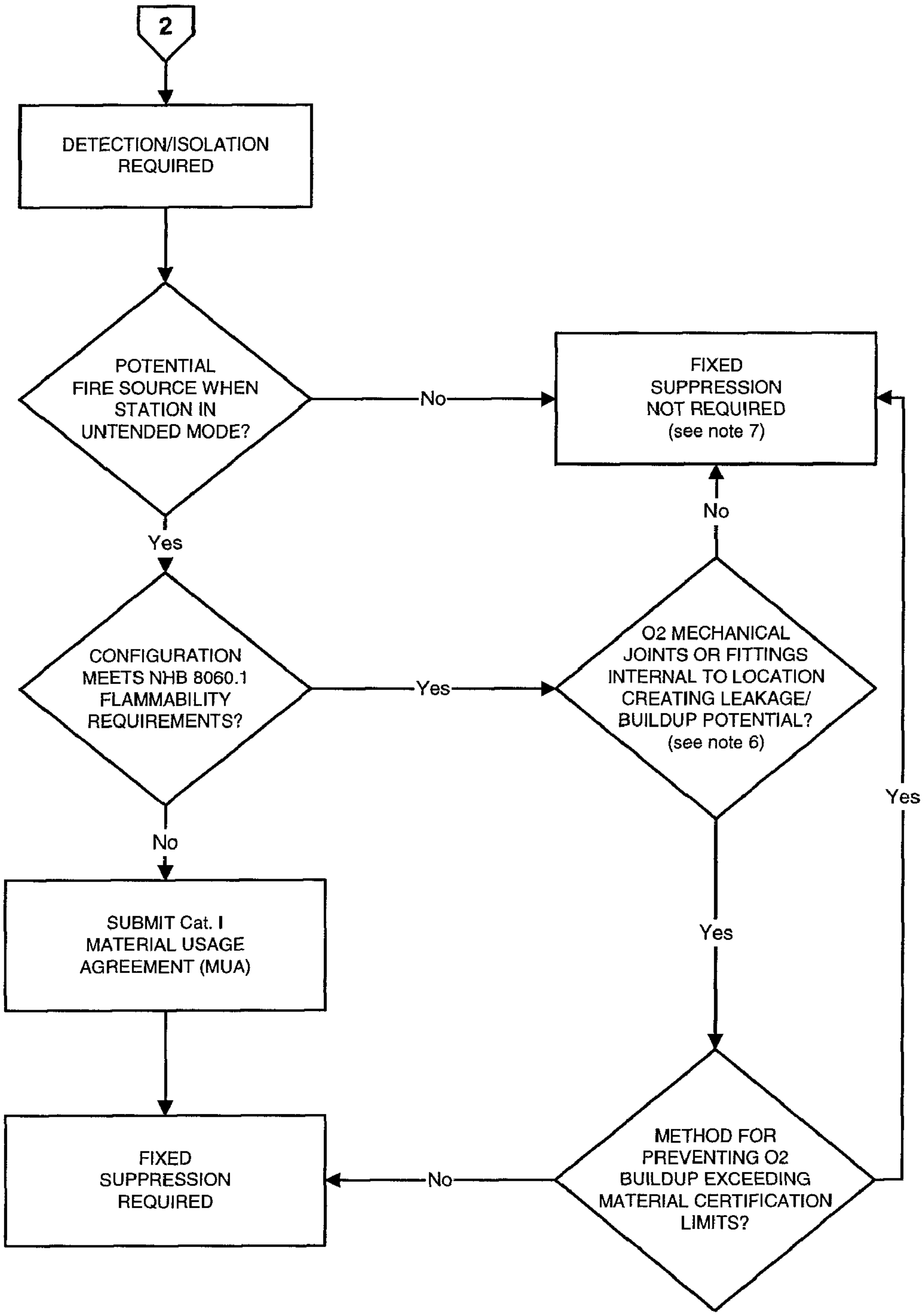
Figure 3.5-2. Fire Protection and Selection Criteria (Sheet 1 of 3)



Notes:

3. Avionics refers to any electrical equipment, or components other than power/data connectors, cables, lines, or wires (e.g., card mounted electronic components). Electro-mechanical equipment refers to any motors, pumps, etc.
4. FDIR must be sufficient to alert the crew to failure modes of the equipment, not in hermetically sealed enclosures, which could cause a fire event. Notification of loss of function satisfies the FDIR requirement. Electrical equipment and wiring having two upstream devices to detect and isolate overcurrent and short circuit conditions meet the FDIR requirements.
5. Sampling is intended to allow the crew to avoid opening a location which may contain buildup of hazardous offgassing. Sampling through a PFE suppression port using the GFE (NASA) Manual Sampling Equipment satisfies this requirement.

Figure 3.5-2. Fire Protection and Selection Criteria (Sheet 2 of 3)



Notes:

6. An O2 line running through a location with no fittings, fittings with redundant seals, metal seals or only welded fitting internal to the location would be a “no”. Assumes worst case credible failure for determining leakage/buildup potential.
7. Based on capability of crew to perform suppression via PFEs for locations which will be powered only when station is tended. When the station is untended for material control and no O2 leakage/buildup potential will prevent a fire from propagating.

Figure 3.5-2. Fire Protection and Selection Criteria (Sheet 3 of 3)

3.5.2.1.3.2 Fire Suppression

Each rack which contains a potential fire source shall provide a dedicated interface for the PFE to permit fire suppression by the crew by inserting the PFE nozzle into the PFE port. This port will be 0.5 in. (12.7 mm) to 1.0 in. (25.4 mm) in diameter if the rack panel thickness is less than or equal to 0.125 in. (3.175 mm). Racks with a panel thickness greater than 0.125 in. (3.175 mm) will provide a port with a diameter of 1.0 in. (25.4 mm).

3.5.2.2 Avionics System (AVS)

The AVS performs electrical power distribution and conditioning, module illumination, and Command and Data Handling (C&DH).

The electrical power distribution equipment includes:

- one PDB, which distributes electrical power to all subsystem equipment (except for the shell heaters) depending on the user interface characteristics
- one Heater Control Unit (HCU), which distributes electrical power to the shell heaters
- one Battery, which supplies the ROFU PDA heaters during the transfer phases (when the MPLM is manifested with active cargo)

The module general illumination is accomplished by means of eight General Luminary Assemblies (GLAs), switched on/off by one Remote Control Assembly (RCA). The emergency illumination, which ensures lighting for an emergency egress in the event of loss of power, is provided by the Emergency Egress Lighting (EEL) System, which consists of one Emergency Lighting Strip (ELS) and one Emergency Lighting Power Supply (ELPS). The ELPS is re-charged on-ground during each turnaround.

The C&DH provides the capability to monitor and control the MPLM equipment and the active cargo (when included in the flight manifest). The hardware dedicated to this function is the MDM. Electrical harness (cabling, connectors, backshells, MIL-STD-1553B components) is provided to support power distribution and data transfer.

The AVS overall functional schematic is depicted in Figure 3.5-3. The bulkhead connectors are provided with tethered caps to be installed when the MPLM is not connected to the ISS. The R/F connectors located on the stand-offs are provided with caps to be installed when no rack is connected.

The MPLM receives Orbiter avionics services via Remote Operated Electrical Umbilical (ROEU). MPLM receives 28 vdc via the Orbiter primary payload bus for shell heater power. MPLM receives 120 vdc from the Orbiter Assembly Power Converter Unit(s) (APCUs) to power subsystems and active racks, as required. The MPLM can also receive GSE power via T-0 umbilical through the ROEU for ground checkout and active rack conditioning. The MPLM command and data interface with the Orbiter is via MIL-STD-1553B bus interface between the MPLM MDM and Orbiter OIU. For ground checkout, EGSE can be used to communicate with MPLM MDM via 1553 data bus through the T-0 umbilical. Refer to ICD-A-21350 for more details regarding Orbiter avionics interfaces.

The capabilities of the power interfaces allocated to payloads are defined in ICD-A-21350, Sections 7.3.2 and 7.3.3. The total electrical power available to payloads during each mission phase shall be as defined in ICD-A-21350, Sections 7.1.1.1 and 7.1.1.2.

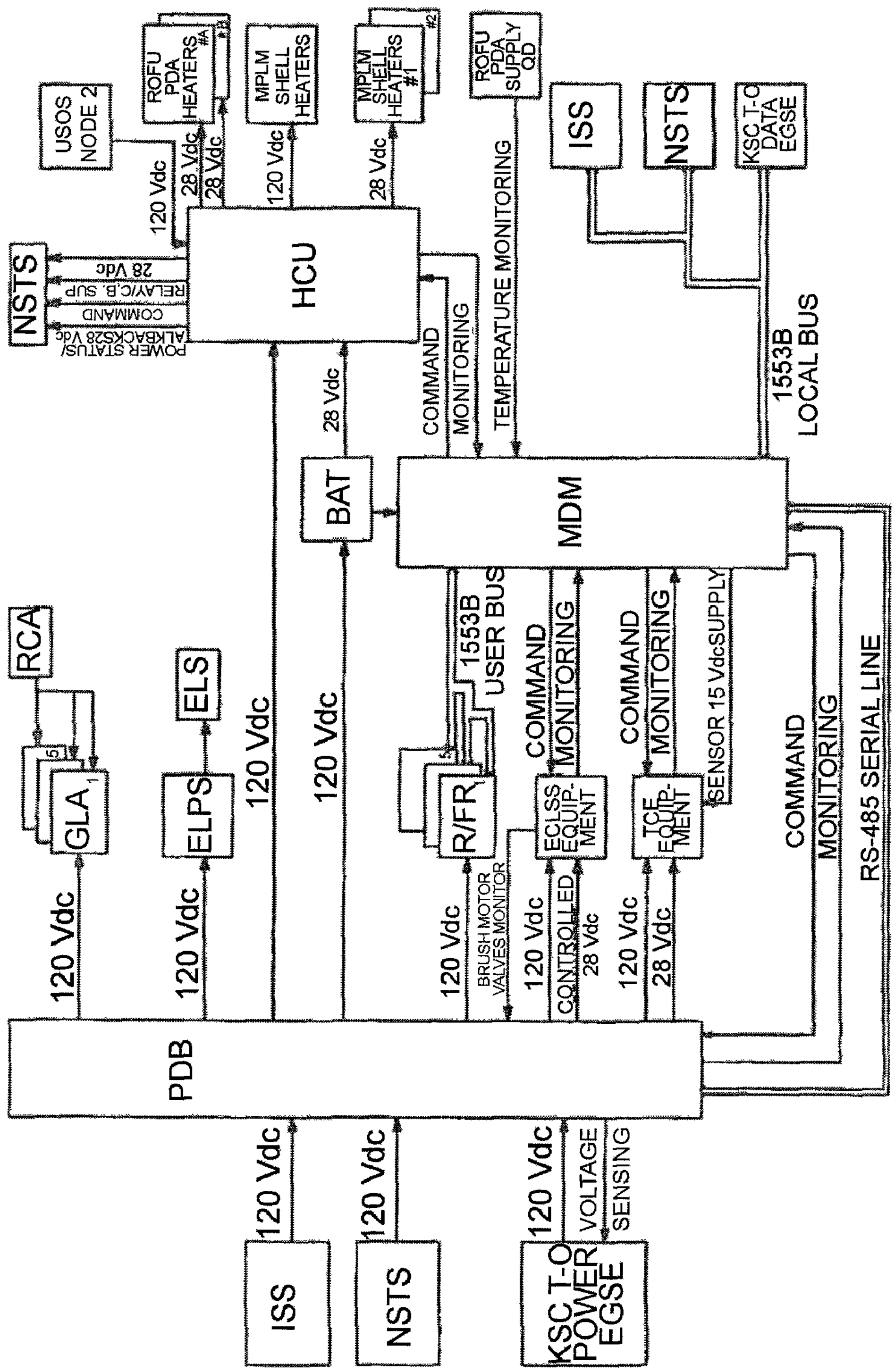


Figure 3.5-3. Avionics System (AVS) Configuration

3.5.2.2.1 Electrical Power and Voltage

Electrical power is provided by the MPLM to the active cargo during the following phases:

- pre-launch
- on-orbit (except for the Orbiter-to-ISS and ISS-to-Orbiter transfer phases)
- post-landing

Electrical power can be provided at each active rack position. The total maximum continuous power available for the MPLM active cargo is 2400 W during the transportation phases (i.e. while in the Orbiter cargo-bay), and 2200 W during on-ground processing and while on-station. The integrated active payload shall not exceed the defined integrated maximum power levels.

The maximum continuous power allocated to each high-power active rack location is 1050 W at 113 – 126 vdc; the maximum continuous power allocated to each low-power active rack location is 598 W at 113 - 126 vdc. The power allocated to the active cargo is summarized in Table 3.5-3.

Table 3.5-3. Power Allocation for Active Cargo

Rack Location		Power Level	Power Available (W)
Bay	Quadrant		
1	Port	Low	598
1	Starboard	Low	598
1	Floor	Low	598
2	Port	High	1050
2	Starboard	High	1050

3.5.2.2.2 T-0 Ground Support Equipment (GSE) Power

For a passive MPLM, the requirements with T-0 high power is not applicable. At pre-launch and post-landing, T-0 GSE power is 3000 W at maximum continuous and 3000 W at peak. The voltage is at the ROEU [Orbiter Disconnect Assembly (ODA)/PDA] interface. The MPLM T-0 power source provides power to R/Fs installed in the MPLM. The interface to flight hardware is through the T-0 system.

3.5.2.2.3 Payload Ground Support Equipment (GSE) Power and Signals

GSE power via the T-0 umbilical is independent of Orbiter power distribution subsystems. Utilization of T-0 wires for commands and signals requires that these functions meet the Electromagnetic Compatibility (EMC) criteria (including voltage limits) specified in ICD-A-21350, Section 10.7.1.

The power source for T-0 power, whether cargo element or Orbiter provided, will meet the EMC requirements specified for cargo equipment level (crew compartment) in ICD-A-21350, Sections 10.7.3.1.1 and 10.7.3.1.2.

3.5.2.2.4 Contingency Orbiter Rollback

Power will be removed from the Orbiter vehicle 11 hours prior to rollback to the Vehicle Assembly Building (VAB) and nominally remains off until return to the Launch Pad. Payload customers must plan on not having power-on capability for up to three days while at VAB. For anticipated stays of more than three days, the required interfaces will be connected and power will be applied to the Orbiter for health status checks only. The payload bus may be powered at this point.

If the decision to rollback occurs prior to L-7 days active cargo samples will not be loaded. Between L-7 days and L-88 hours the GSE remains at the pad and samples will be removed prior to rollback. After L-88 hours the procedure is not yet defined.

3.5.2.2.5 Power Quality

The power quality is quality C, as defined in SSP 30482, Volume 1 (113 to 126 vdc voltage range), except for inrush current, which is defined in SSP 41155.

3.5.2.2.6 MPLM Reverse Energy/Current

The MPLM reverse energy/current shall be as defined in SSP 41155.

3.5.2.2.7 MPLM Soft Start/Stop Compatibility

The MPLM power interface shall have soft start/stop characteristics as defined in SSP 41155.

3.5.2.3 Data

At each active rack available location, the MPLM provides one stub interface on the MPLM dual redundant MIL-STD-1553B User Bus (stub A and stub B), via two receptacle connectors, available at the UIP. The 1553 User Bus is provided through the MDM SPD1553 card.

3.5.3 Heat Rejection

The maximum allowable continuous heat rejection at the Orbiter Payload Bay Heat Exchanger for MPLM configuration is 3000 W in accordance with ICD-A-21350, Section 6.0.

The maximum allowable MPLM heat load transferred to the USOS is 3250 W in accordance with SSP 42007, Section 3.2.2.3. This total includes the low temperature heat transfer fluid interface heat load and intermodule ventilation, but excludes metabolic heat loads.

The cargo integrator shall ensure that these levels are not exceeded.

4.0 CARGO ACCOMMODATION CONSTRAINTS

Figure 4.1-1 illustrates the various integration levels to be addressed on a mission-by-mission basis. Each level must be appropriately considered for a specific mission, in order to determine the MPLM manifest.

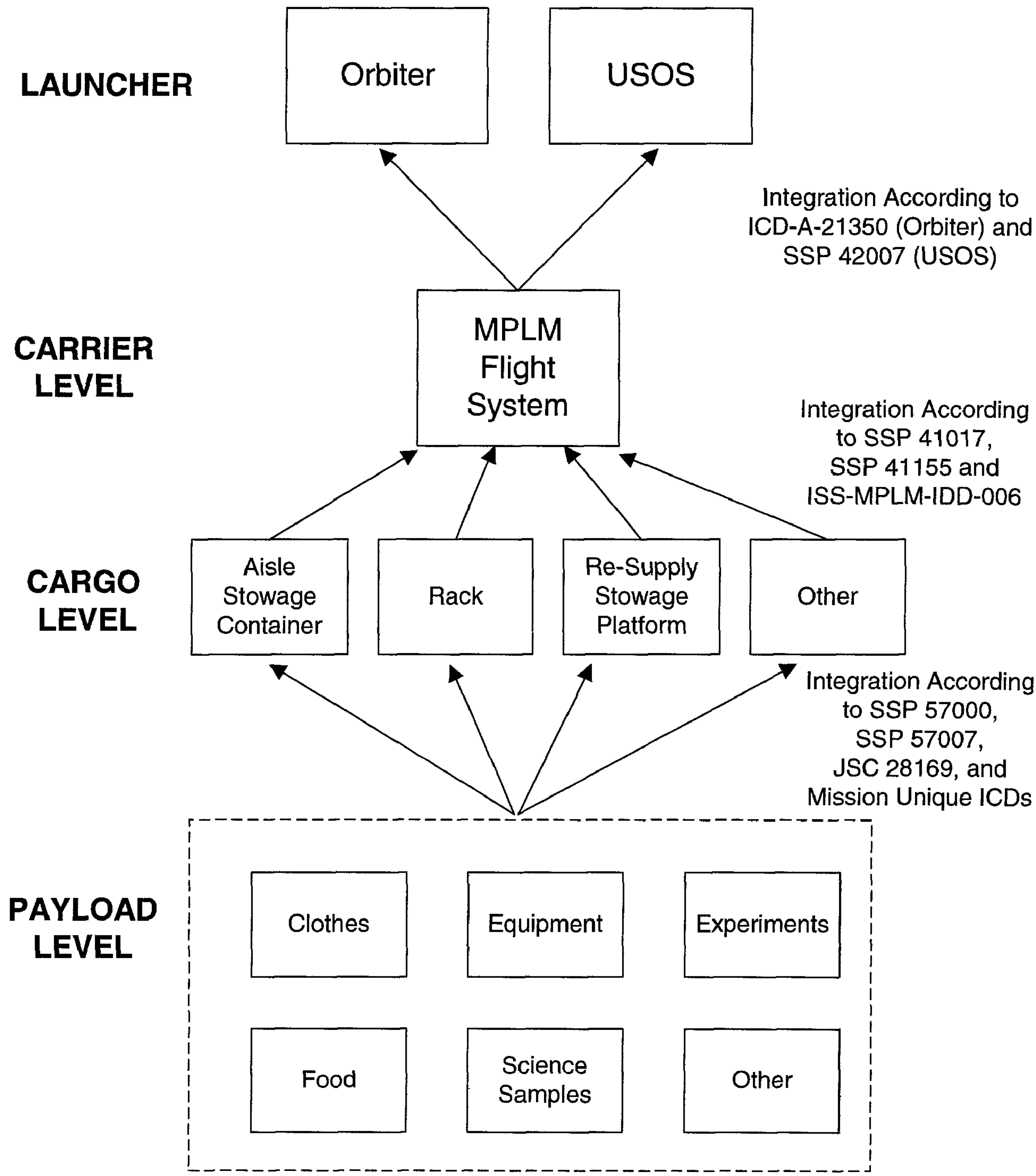


Figure 4.1-1. Integration Levels and Applicable Documentation

4.1 RACK ATTACHMENT PROVISIONS

The cargo to be accommodated and transported by the MPLM will use the following mechanical interfaces:

- knee brace interface at the top of the rack, during the launch, ascent, descent and landing phases
- lower rear attachment interfaces, during the launch, ascent, descent and landing phases
- pivot attachment interfaces, during the on-orbit phase
- ground handling interfaces, during on-ground processing

The launch/ascent, on-orbit and descent/landing mechanical interfaces are depicted in Figure 4.1-2.

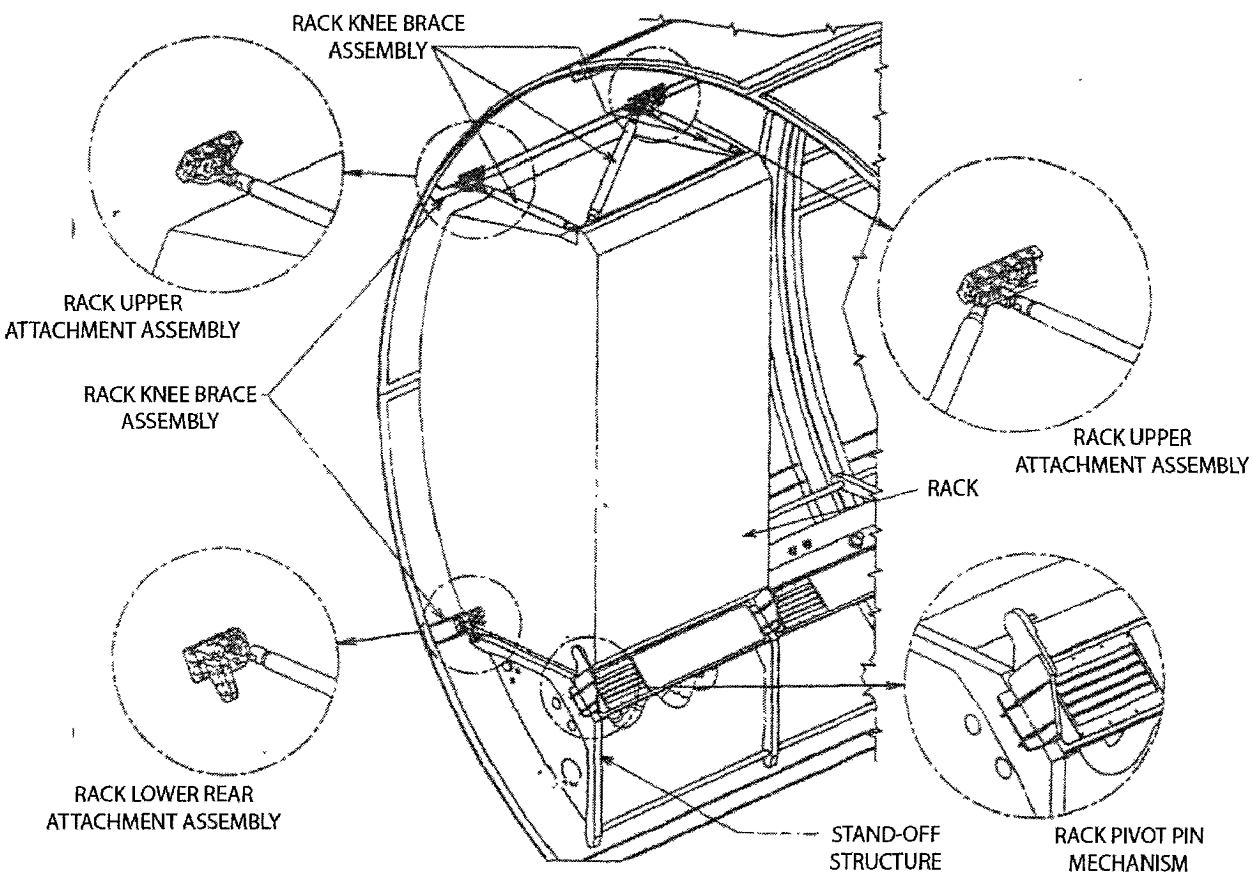


Figure 4.1-2. MPLM-to-Cargo Mechanical Interfaces

4.1.1 Upper Attachments

The MPLM-to-cargo upper attachment to the knee brace is defined in Figure 4.1-3.

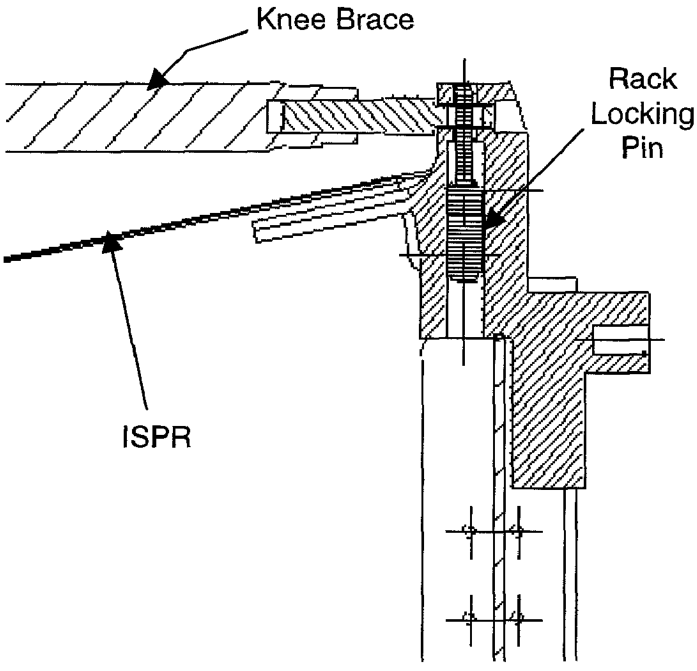
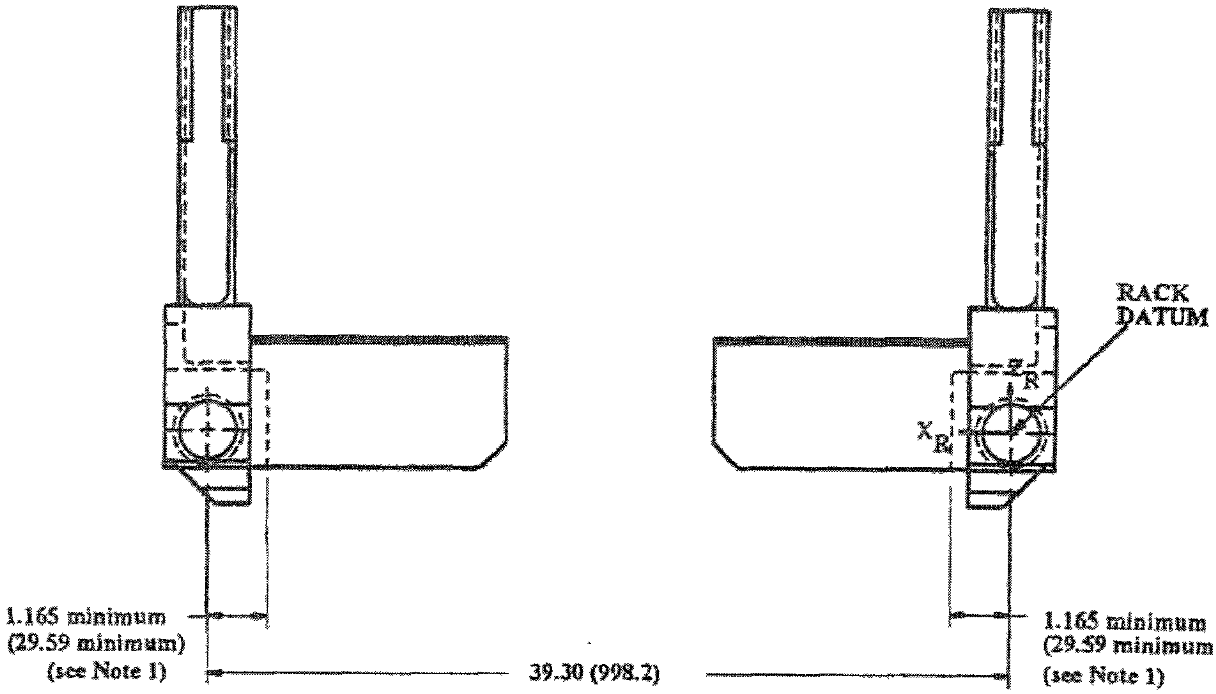


Figure 4.1-3. Upper Attachment Interface

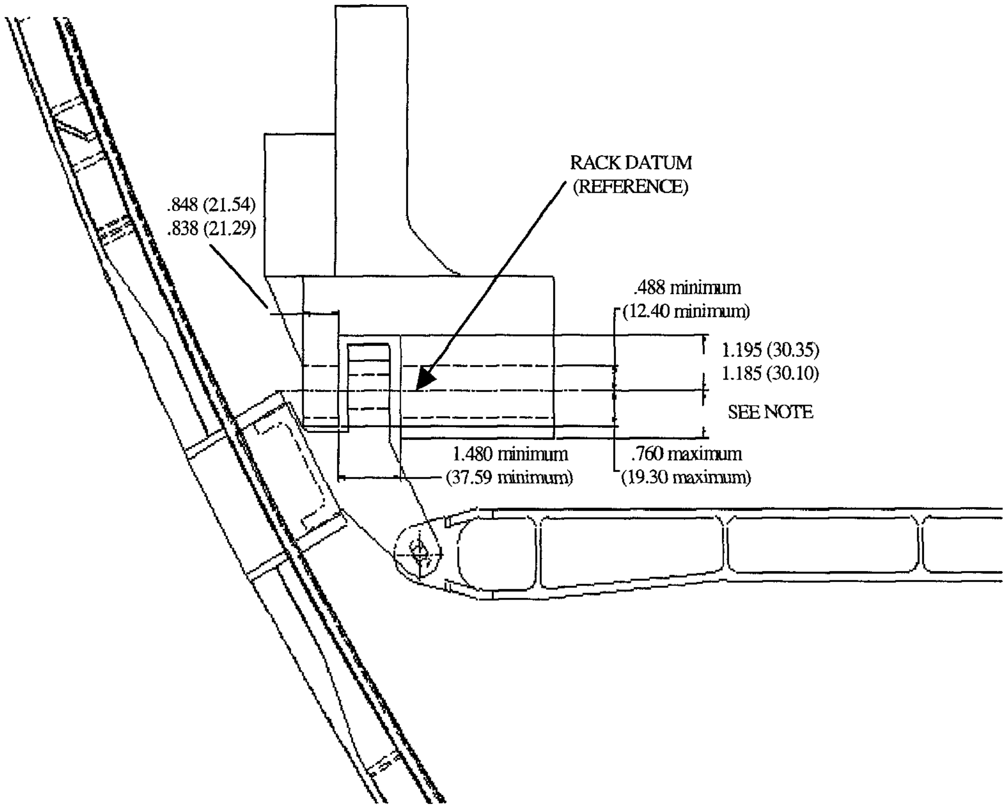
4.1.2 Lower Rear Attachments

The MPLM-to-cargo lower rear attachment interface is defined in Figure 4.1-4.



NOTES: (1) Width of opening in rack to accommodate longeron fitting. Dimension is from centerline of spherical bearing.
(2) Sliding capability in B not shown for clarity

Figure 4.1-4. Lower Rear Attachment Interface (Sheet 1 of 2)



Note: This dimension is applicable only to rack lower rear attachment fitting.
NASA Rack: maximum static envelope dimensions as specified by SSP 41017 Part 1 Figure 3.2.1.1.2-1
NASDA Rack: 1.303 in. (33.10 mm) maximum.

Figure 4.1-4. Lower Rear Attachment Interface (Sheet 2 of 2)

4.1.3 Rack Pivot Attachments

The MPLM provides two rack pivot mechanisms (Orbital Support Equipment) for rack on-orbit tilt-out. These pivot mechanisms are purposely designed to be utilized at every rack location. The rack pivot pin interface dimensions are shown in Figure 4.1-5.

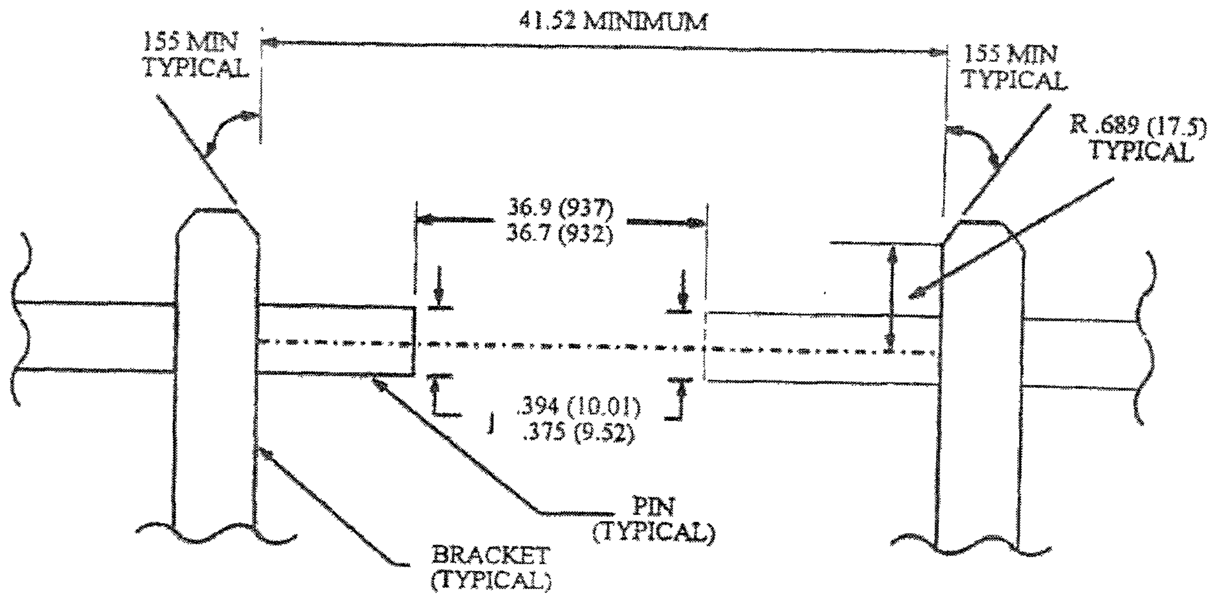


Figure 4.1-5. Rack Pivot Mechanism

4.2 MPLM CARGO LAY-OUT AND MASS PROPERTIES

Specific constraints apply to MPLM cargo loading, basically to preclude overloading of the MPLM structure both at the cargo-to-MPLM and MPLM-to-Orbiter interfaces. Consequently, the overall cargo manifest and the cargo lay-out inside the MPLM will be defined by ensuring the compliance of the overall cargo mass with the MPLM Cargo carrying capability requirement and the compatibility of the overall cargo CG with a pre-defined allowable envelope resulting from the MPLM carrying capabilities.

Ballast can be used to manipulate the weight and CG of a Cargo Transfer Bag, Stowage Tray, Resupply Stowage Platform, and Resupply Stowage Rack for transportation within a pressurized environment.

4.3 MPLM CLOSE-OUT PANELS

To reduce the risk of injury to the crew members and to avoid drifting tools in zones of difficult access, close-out panels in beta cloth or Kapton are provided in the forward cone area vestibule, close to the Bulkhead (see Figure 4.3-1) and on the stand-offs. The vestibule panels are also required for fire containment in the fire compartments defined between the -Y, +Y and -Z tilting panels and the forward cone shell. In some locations, the panels need to be easily removed for ground or flight operations involving access to the enclosed volumes. In this case the panels are fixed with Velcro. The non-removable panels are attached with Kapton tape and bi-adhesive layers.

The panels are provided with cut-outs for line penetration and for accessibility purposes. In particular, the PBA and PFE lockers and the GLA RCA cut-outs are provided with dedicated closures for crew operations. In addition, the -Y and +Y vestibule panels are designed to be easily removed during flight operations to allow easy access to the forward cone equipment, in particular the valve manual override interfaces. These panels are in b-cloth and are fixed by means of Velcro.

Grounding of removable panels is of pin/socket type for ground operations requiring complete removal. During flight operations no grounding strap removal is required.

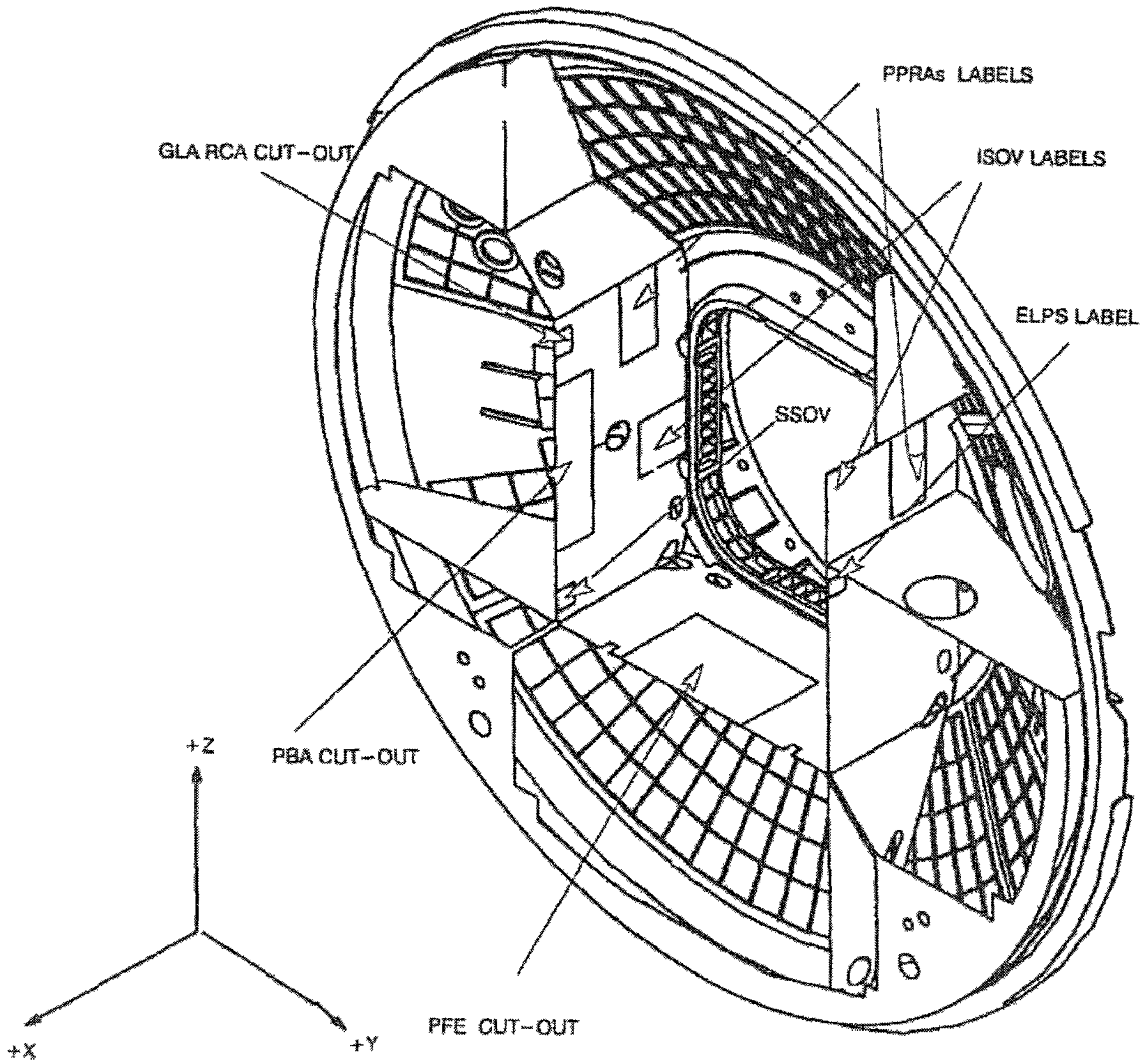


Figure 4.3-1. FWD Cone Close-Out Panels (harness and fluid line penetration cut-outs shown)

4.4 CREW HABITABILITY

4.4.1 Drag-on Equipment

The equipment moved into the MPLM after berthing to the ISS and removed prior to unberthing is called drag-on equipment. The drag-on equipment includes:

- one PFE, used as the manual fire suppression system
- one PBA, to provide the crew with breathable air in the event of a hazardous atmosphere condition
- Intra-Vehicular Activity Restraints and Mobility Aids, to assist crew member operations and work activities

4.4.1.1 Portable Fire Extinguisher (PFE)

The PFE is placed in the forward cone lower area in a tailored betacloth enclosure. A close-out panel door allows quick accessibility to this item in a potential emergency situation.

The PFE consists of a carbon dioxide tank, equipped with valves, a pressure gauge and a discharge nozzle.

4.4.1.2 Portable Breathing Apparatus (PBA)

In order to provide breathable atmosphere to the crew members in the event of a hazardous atmosphere condition, one PBA is transferred from ISS to MPLM.

The PBA is housed in the forward cone port area, in a tailored betacloth enclosure, within 12 ft (3658 mm) of the MPLM entrance. A dedicated opening in the nearby close-out panel allows quick accessibility to this item in a potential emergency situation. The PBA mainly consists of an oxygen tank and a face mask.

The PFE and the PBA are located within 3 ft (914 mm) from each other.

4.4.1.3 Intra-Vehicular Activity (IVA) Restraints and Mobility Aids (R&MAs)

Intra-Vehicular Activity (IVA) Restraints and Mobility Aids (R&MAs) are installed inside the MPLM to assist crew member operations and work activities.

The seat tracks are properly located to provide the necessary translation paths to support the crew mobility inside MPLM. Seat tracks are installed in the cabin aisle, to support rack transport operations, and in the forward cone area, to allow Hatch operations and to permit easy access to the PBA and PFE. Seat track locations are depicted in Figure 4.4-1. When ISPR are manifested, they provide two 69 in. seat track portions mounted along the lateral pillars of the rack front panels (with a pitch of 40 in.). These seat track portions allow the installation of one 41.5 in. handrail.

Note that the usage of pitch throughout this section refers to the distance between the seat track portions where a handrail is installed. There is 1.5 in. separating the length of the handrail specified and the pitch (0.75 is devoted to each seat track portion).

The MPLM seat track configuration includes:

- four pairs of 1.62 in. seat track portions are installed with a pitch of 7 in. on each (-Z) frame surface of both starboard and port upper stand-offs, except the ones closest to the forward cone which allow the installation of one 8.5 in. handrail for each pair
- four pairs of 1.62 in. seat track portions are mounted on each 45 degree plate, included between two frames, of both port and starboard lower stand-offs, with a pitch of 20 in. These seat tracks allow the installation of one 21.5 in. handrail (parallel to the MPLM X-axis) for each pair
- two 57.8 in. seat track portions are mounted along the internal edge, onto the (+X) surface, of the (+Y) and (-Y) structural panels of forward cone. These seat tracks allow the installation of one 41.5 in. handrail for each portion
- two 1.62 in. seat track portions, with a pitch of 40 in., are installed on the (-Z) close out panels on each side of the PFE. These seat tracks allow the installation of one 41.5 in. handrail
- two 69 in. seat tracks are mounted along each edge of ISPR front panel, with a pitch of 40 in. These seat tracks allow the installation of one 41.5 in. handrail on each seat track or one on both seat tracks

The seat tracks allow accommodation of the following types of R&MA:

- Handrails: three sizes of handrails can be used inside MPLM: 8.5 in., 21.5 in., and 41.5 in. These also serve as the primary foot and torso restraint system.

  Note: The handrail has been tested and verified to be able to withstand 42 launch/landings when installed in any MPLM location. 42 MPLM launch/landings is a conservative estimate based on the MPLM schedule and is equivalent to the life of the station (15 years). This testing was performed at JSC as part of the closure for SSCN 6664.

  The handrail is installed to seat track by inserting the handrail base into the seat track and depressing the handrail levers to engage the soft dock mechanism. The handrail is secured to the seat rail track by rotating each nut assembly until the ratcheting mechanism is engaged.

- Foot restraint with both Seat Track Equipment Anchors (STEA) and Handrail Equipment Anchors (HEA). Used in place of handrails where two hand operations that require more than a few minutes are required.

- Torso restraint, used where handrails or foot restraints provide insufficient restraint
  - .

Refer to SSP 30257 and D683-43437–1–3 for additional R&MA details.

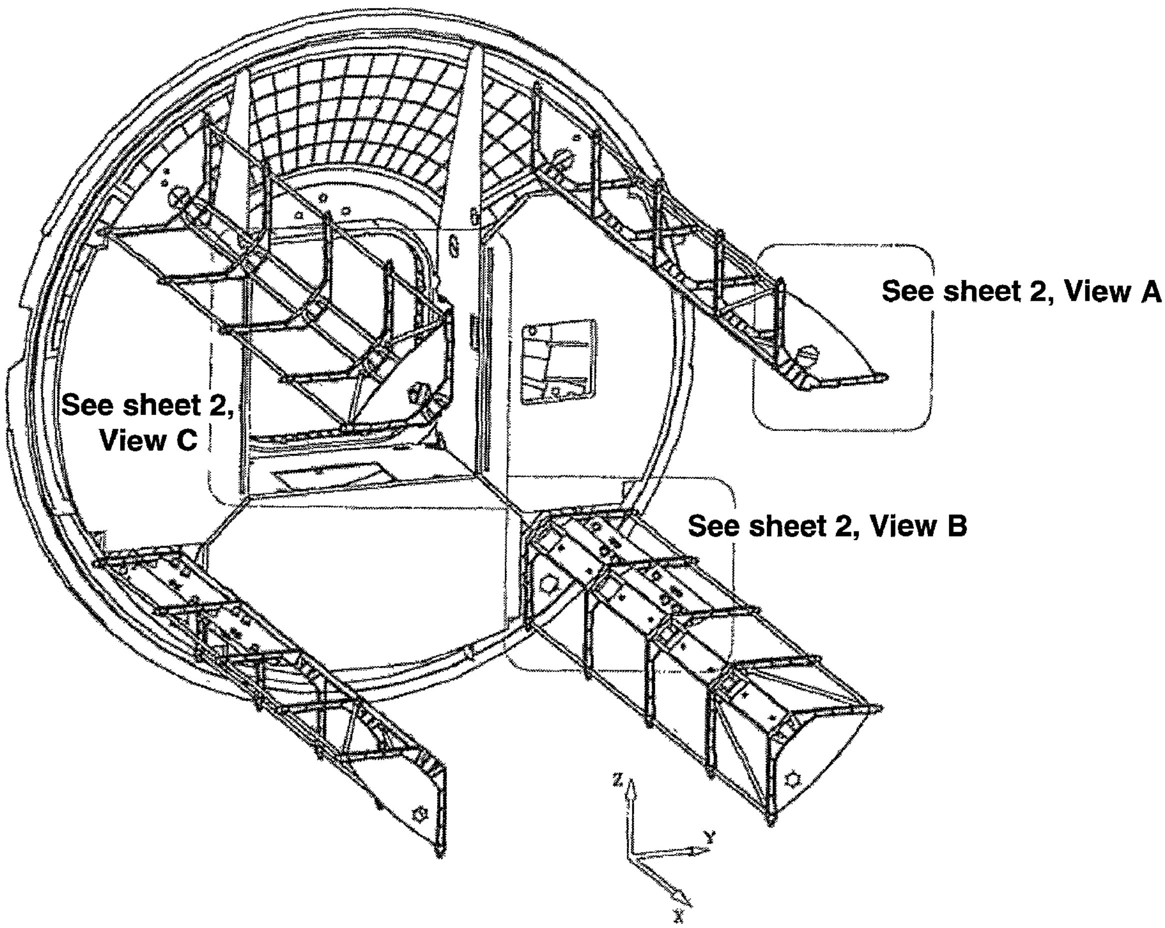


Figure 4.4-1. Seat Track Locations
(Sheet 1 of 2)

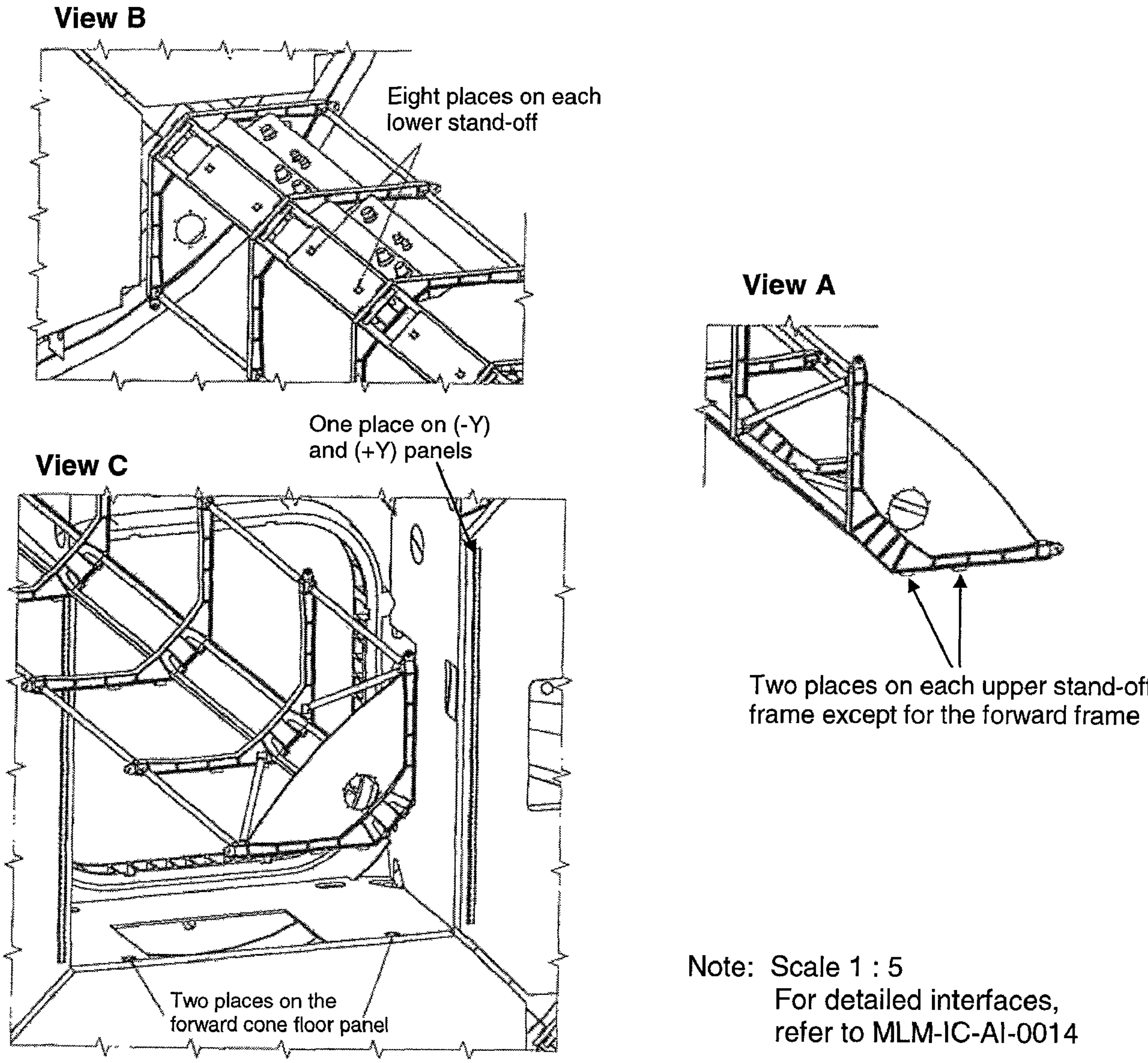


Figure 4.4-1. Seat Track Locations (Sheet 2 of 2)

4.5 ELECTRICAL POWER DISTRIBUTION AND CONDITIONING

This system controls, distributes, and conditions the electrical power received from the MPLM external sources to all MPLM users requiring electrical power. Namely, MPLM subsystems (AVS, ECLSS and TCS) equipment and the five locations established for accommodation of R/Fs. Power distribution in this context excludes dedicated power for the operation of MPLM shell heaters.

It is designed to be available to support MPLM nominal and contingency functions during:

- on-ground operations at the processing facilities for MPLM functional performance and interface checkout, and for MPLM active flight operations at Launch Pad
- on-orbit operations in the NSTS for both MPLM passive and active flights
- on-station operations at ISS for both MPLM passive and active flights

It distributes the 120 vdc electrical power and performs the voltage conditioning where 28 vdc is needed by the MPLM subsystem equipment. The 28 vdc is generated internally to the PDB and is required by ECLSS and TCS hardware.

It is implemented via one PDB and power harness, designed to distribute up to 3000 W of nominal maximum continuous power at 120 vdc voltage, 25 A, in nominal conditions, to all users in all phases, and based on a star distribution to supply each load/end-user independently from the others.

The MPLM electrical power distribution system relies on independent power feeds from each of the following sources:

- KSC T-0 POWER EGSE, via NSTS T-0 interface, during on-ground operations during pre-launch and post-landing phases
- NSTS 120 vdc power, via APCU, during on-orbit phase
- NSTS 28 vdc power for MPLM shell heaters while in orbiter payload bay during on-orbit phase
- ISS, via APCU and DC-to-DC Converter Unit (DDCU) (Node 1) or Secondary Power Distribution Assembly (SPDA) (Node 2), during on-station phase

No power is provided from NSTS during ascent and descent phases.

Power EGSE at the on-ground processing facilities can be connected to the NSTS/ISS flight interfaces to perform checkout activities.

The maximum total continuous power available to the five R/Fs locations is 2200 W. Hence, the allowed manifested R/Fs configurations are such that the total R/Fs power requirement does not exceed the limit of 2200 W.

The power is provided through outlets controlled by standard Remote Power Controllers (RPCs), which provide power on/off switching and protection capability. Control of PDB electronic circuits, internal converters, RPCs and drivers is performed by the MPLM flight software via MDM interfaces.

All the 120 vdc users are supplied and controlled independently. Specifically, one PDB power outlet with one RPC has been assigned to each load to prevent failure propagation between loads and outside the PDB. Each RPC is designed according to its load maximum current draw and surge current value. Therefore, each RPC has its own fixed thresholds that can not be changed via software.

Users of 28 vdc power are subdivided in two groups; each supplied by a dedicated 120/28 vdc converter in the PDB. The first group is composed of the ECLSS Atmosphere Control System (ACS) functions hardware [Depressurization Assemblies (DAs) and Positive Pressure Relief Assemblies (PPRAs)], which imply three levels of inhibit required for safety critical functions to preclude unwanted activation. The second group is composed of the ECLSS Atmosphere Revitalization System (ARS) functions hardware (SSOV), the ECLSS THC functions hardware (ISOVs) and the TCS ATCS functions hardware (WOV and WMV), which imply only two levels of inhibit against unwanted activation.

4.5.1 Power Distribution Box (PDB)

The PDB is designed to perform the following functions:

- switching, conditioning and distribution to MPLM Subsystems and R/Fs of 120 vdc electrical power received from either T-0, NSTS or ISS
- ensuring compatibility between the MPLM external power sources and the end users
- source and wiring protection against load or load-induced short circuit
- loads and wiring protection against load overcurrent absorption
- independent power on/off control of loads
- dedicated control of electrical power as required by special loads (i.e. brush motors driven valves)
- report to MPLM flight software of power supply and configuration status

The PDB is active both in Active and Passive Flights on NSTS and on ISS. The PDB is activated as soon as the MPLM is powered, after the MDM Built-in Test (BIT)/Health Data and Scenario checks and is deactivated immediately before MPLM power down. The PDB is off during launch, ascent, descent and deployment phases.

The PDB receives 120 vdc electrical power from T-0, NSTS and ISS by means of three independent feeds, and distributes this power to the MPLM users through individual dedicated power outlets. The ISS and NSTS input power lines are the same size and reside on a single AWG # 8 cable. The two T-0 input power lines are accommodated on a dedicated AWG # 12/16 cable, together with the voltage sense line provided at the PDB input to allow the T-0 source voltage regulation.

The PDB is designed to control and distribute up to 3000 W of nominal maximum continuous power, which corresponds to an input current of 25 A at the nominal voltage of 120 vdc, and to provide the full nominal performances when supplied with an input voltage in the range 113 to 126 vdc.

The PDB distributes 120 vdc and 28 vdc power, depending on the user's need, through thirty-six power outlets (twenty-three at 120 vdc, thirteen at 28 vdc), controlled by thirty-one RPCs. The PDB generates internally the 28 vdc needed to supply the ECLSS and TCS hardware by means of two dedicated converters which also implement protection and control functions. The PDB also internally generates, by means of the APS, all the DC secondary voltages needed to supply its internal logic. Each RPC is self-powered by its input line. The PDB functional block diagram is depicted in Figure 4.5-1.

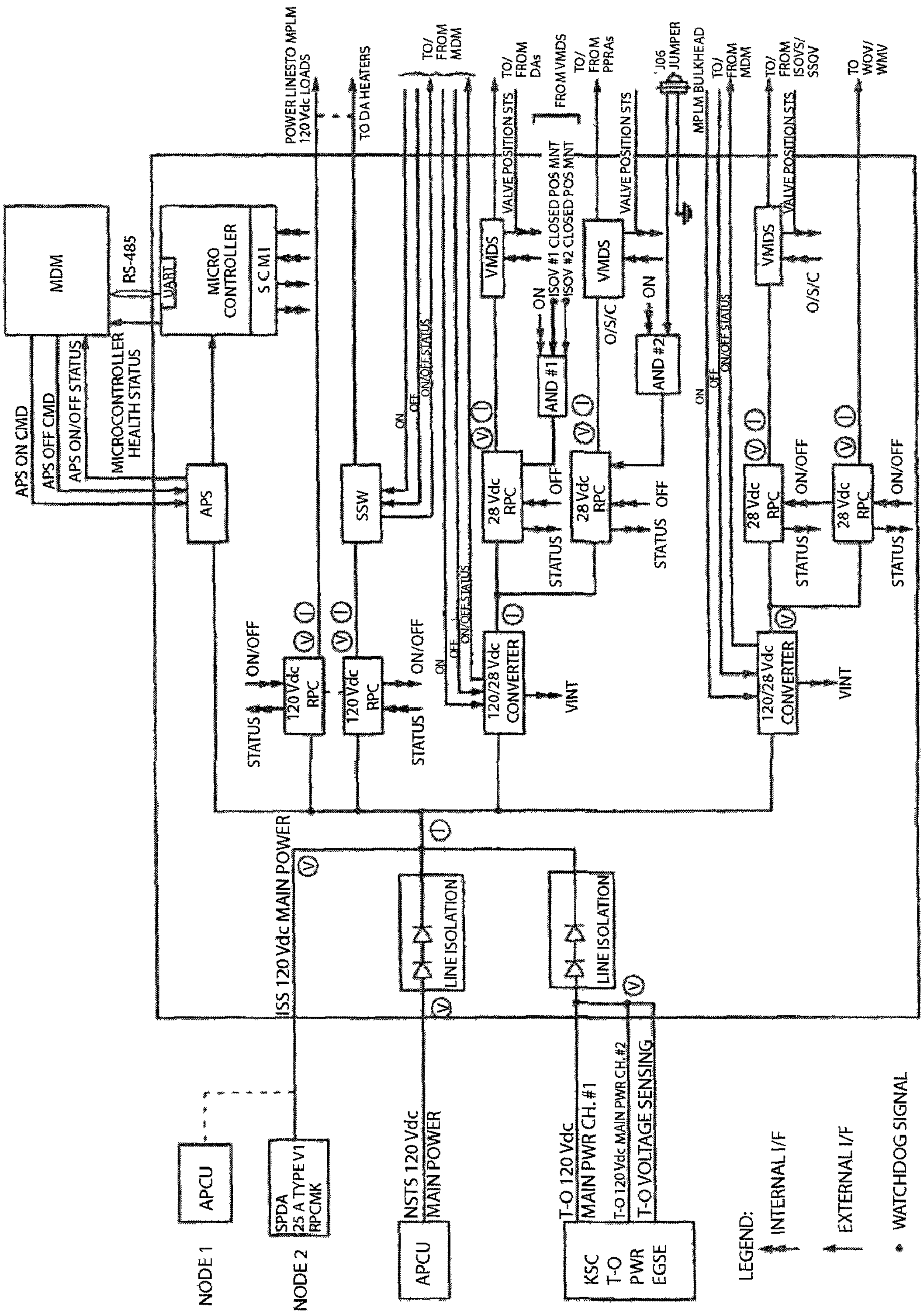


Figure 4.5-1. PDB Functional Block Diagram

4.5.2 Heater Control Unit (HCU)

The HCU performs the following functions:

- distribution of electrical power received from NSTS, ISS, PDB and Battery (BAT) to the ROFU PDA and MPLM shell heaters
- interfacing with NSTS Standard Switch Panel (SSP) to receive relay/circuit breaker configuration commands and to provide power status and relay/circuit breaker on/off status
- conditioning of electrical power from 120 vdc to 28 vdc
- protection of input and output power lines to preclude propagation of externally-induced short-circuits inside the HCU, between heater chains and outside the HCU
- enable/disable of BAT power supply to the load
- acquisition, conditioning and transmission to MDM of analog current and voltage monitoring data
- execution of relay/circuit breaker configuration commands received from and provision of relevant on/off status to MDM

The HCU interfaces with the MPLM MDM to receive circuit breaker reset commands and to transmit analog sensors monitoring data relevant to the heater chains. It interfaces also with the NSTS to receive commands from the SSP switches to enable power supply of either shell heaters or ROFU PDA heaters, and to provide to SSP indicators power supply status.

The HCU block diagram is depicted in Figure 4.5-2.

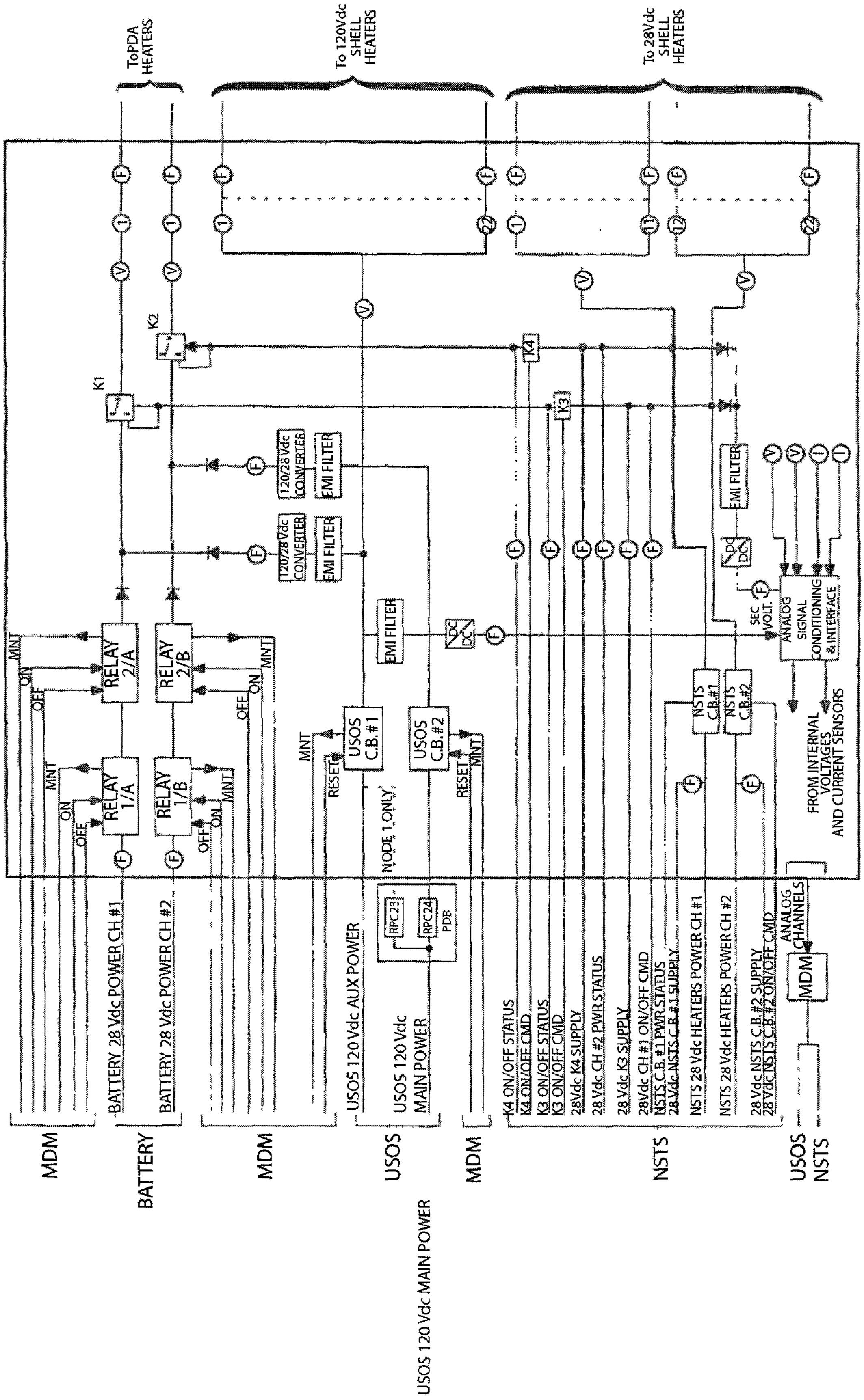


Figure 4.5-2. HCU Block Diagram

CHECK THE MASTER LIST-
VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

The HCU receives electrical power from:

- Orbiter, via two (Ch. #1 and Ch. #2) 28 vdc power lines in the range 24 to 32 vdc
- BAT, via two (Ch. #1 and Ch. #2) 28 vdc power lines in the range 25.5 to 35.5 vdc
- ISS, via one 120 vdc power line in the range 108 to 126 vdc
- PDB, via two 120 vdc power lines in the range 108 to 126 vdc

The power received from the two Orbiter power lines is distributed to the MPLM shell heaters, providing 750 W of total power at 24 vdc through 22 fused outlets (11 outlets for each line) and, upon request, also to the ROFU PDA heaters, which require a total power of 32 W at 24 vdc.

The power received from the ISS power line is distributed to the MPLM shell heaters, providing 732 W of total power at 110 vdc through 19 fused outlets (3 power outlets are kept as spares), and to ROFU PDA heaters supply, when installed. The same power line received from ISS (ISS Node 2) or PDB (ISS Node 1) to supply the MPLM shell heaters distributes (through a DC/DC converter) power at 28 vdc also to one of the two PDA heater lines (ROFU PDA HTR # A).

The other ROFU PDA heater chain (ROFU PDA HTR # A) is powered by a dedicated PDB outlet and the HCU through a DC/DC converter.

The power received from the BAT power lines is distributed to the PDA heaters providing 24 W total power (including HCU and cabling losses) at 28 vdc.

The HCU is required to support the heater chains power demand as required by the heaters resistance, which has been defined in front of:

- a minimum voltage of 24 vdc at the input of any ROFU PDA heater chain and 28 vdc shell heater chain
- a minimum voltage of 110 vdc at the input of any 120 vdc shell heater chain

4.5.3 General Luminary Assemblies (GLAs)

General illumination is accomplished by means of eight fixed GLAs located in the cabin. The GLAs are mounted four per lateral side (port: GLA #1 through GLA #4; starboard: GLA #5 through GLA #8) on the upper stand-off panels, such that required illumination levels are assured. One RCA is also included to switch on/off all GLAs simultaneously from inside the MPLM. Each GLA includes a fluorescent tube with the associated supply and control electronic circuitry, and can be switched on/off remotely via MDM commands to activate or deactivate the relevant PDB outlet. The command is generated outside the MPLM by the RCA before the crew goes in.

The RCA is a centralized switch located at the entrance to the MPLM. It is used to turn on/off simultaneously all eight GLAs using two independent push-buttons, after the GLAs have been powered from the PDB. Local on/off switching capability is also provided for manual control by the crew, as well as dimming to regulate the light intensity from maximum to off. The default position of this switch is "on" to allow GLA start-up upon receiving power from PDB. The default dimmer position corresponds to the maximum intensity. The RCA, as well as the local on/off switches, remain in the same "on" or "off" status when power is restored following a power removal.

4.5.4 Emergency Lighting System

Emergency egress illumination is implemented by means of a self-energizing Emergency Egress Lighting (EEL) system to provide sufficient illumination of the module exit. The EEL system is independent from the MPLM general illumination system. It is activated automatically in the event of loss of general illumination within the MPLM. The EEL system relies on the same design established for the ISS and is comprised of one Emergency Lighting Power Supply (ELPS), and one Emergency Lighting Strip (ELS), placed in the forward cone in a suitable manner to illuminate the MPLM exit.

The ELPS includes all the electronic circuitry for EEL activation and checkout and a rechargeable 9.6 vdc Nickel Cadmium (Ni/Cd) battery to supply the ELS upon detection of loss of input power. The ELPS is provided with a switch (on/off/push-to-test positions) to enable/disable the ELPS functions. The ELPS needs to be enabled at first crew ingress in the MPLM in order to be ready to supply the ELS with power in case of MPLM power off. To prevent unwanted battery activation, and consequently battery discharge, the ELPS needs to be disabled before MPLM power off and at last crew egress before the MPLM closeout.

4.6 COMMAND AND DATA HANDLING (C&DH)

The C&DH implements data management and processing functions via one MDM. The MDM block diagram is depicted in Figure 4.6-1.

The MDM provides processing capability to support the MPLM flight software for management and process control of MPLM internal items. To store programs and data, both volatile and nonvolatile memory is provided.

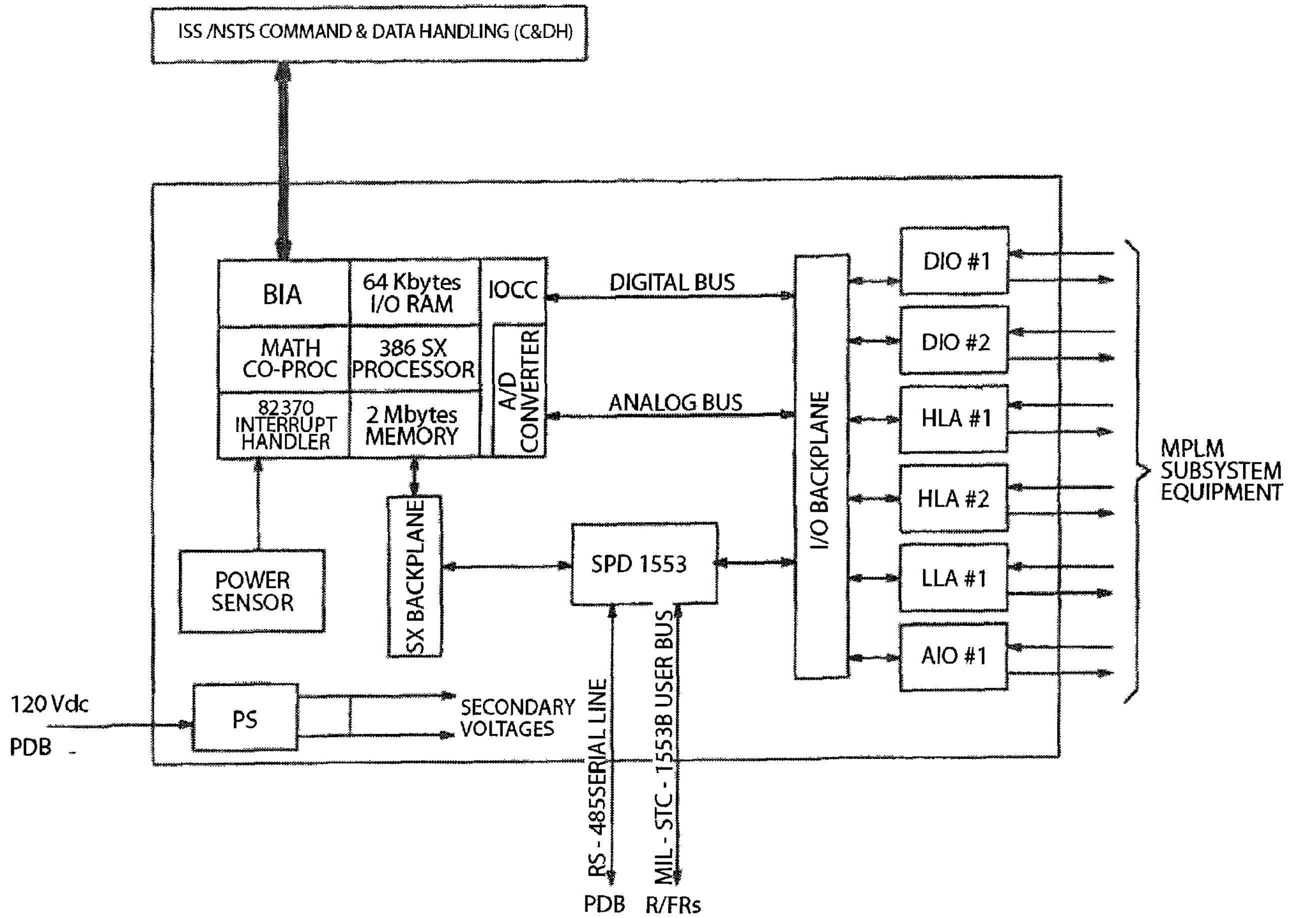


Figure 4.6-1. MDM Block Diagram

4.6.1 Multiplexer-Demultiplexer (MDM) Description

The MPLM MDM basically consists of:

- Input/Output Control Unit (IOCU)
- I/O and SX backplanes
- Seven Standard Input/Output and High-Performance User cards
  - one Low Level Analog (LLA)
  - two High Level Analog (HLA)
  - one Analog Input/Output (AIO)
  - two Discrete Input/Output (DIO)
  - one Serial/Parallel/Digital/1553B (SPD1553)
- Power supply
- Chassis

No user-unique cards have been adopted.

The internal operation of the MDM is controlled by a separate circuit card called Input/Output Control Unit (IOCU), that handles all communications, controls and processes all I/O operations, provides all MDM computing capabilities, controls all internal MDM operations management (including built-in-test) and performs all analog-to-digital conversions. When connected to a 1553B Local Bus interface the IOCU can be configured only as a Remote Terminal and it requires a MIL-STD-1553B dual redundant transformer coupled connection.

The IOCU receives commands/data from the KSC EGSE Command and Monitoring Unit (CMU), the NSTS OIUs and from the ISS MDMs via the 1553B Local Bus and executes embedded user application software. It commands standard and high performance I/O cards and monitors health and status of the MDM. I/O cards are accommodated on the I/O backplane (standard I/O cards) and the SX backplane (high speed interface).

The **I/O backplane** provides accommodations for the standard I/O cards. The IOCU controls these cards via a separate 5-wire low-power serial link to each I/O slot. Each card slot compatible with this backplane provides connections for power and ground, I/O backplane signals and 64 wires connected to the external connectors for access to sensors/effectors.

The **SX backplane** provides a high-speed interface between IOCU and up to 6 SX card slots in order to accommodate IOCU control and communication via a memory-mapped interface. The SX backplane supports 10 Mbytes memory addressing and 48 Kbytes I/O addressing. The SX card can interrupt the IOCU.

The **LLA card** provides 32 input channels to convert low-power analog inputs from sensors to standard analog bus voltage levels and provides this signal to the IOCU upon demand. The LLA is preset by the IOCU to one of the four voltage ranges: full scale sensitivities of +/- 50 mV (gain = 100), +/- 200 mV (gain = 25), +/- 500 mV (gain = 10) or +/- 5 V (gain = 1); default configuration corresponds to the voltage input mode with gain = 1.

Each LLA channel is configurable to two modes of operation: current loop (LLA 1) or voltage input (LLA 2). In the current loop mode, the LLA provides a current source of 1 mA (accuracy is less than +/- 0.3%) for RTD excitation and measures the voltage drop across an internal precision resistor and the external device resistance. In the analog voltage input mode, the LLA measures the balanced differential voltage levels across the input pins; the current source is disconnected.

Selection of an individual LLA channel involves three levels of switches:

- card selection switch at the output of the common gain amplifier
- sector selection at the input of the common gain amplifier [one of the four sectors/Circuit Card Assembly (CCA)]
- channel selection within the selected sector, using the multiplexers at the buffer/Multiplexer (MUX) outputs

The **HLA card** provides 32 channels to convert analog sensor data inputs to the standard analog bus voltage levels and provides this signal to the IOCU upon demand.

Default configuration is voltage input mode, and the HLA remains in this mode until configured via an I/O backplane command.

Each HLA channel is configurable to four modes of operation: active current loop (HLA 1), passive current loop (HLA 2), voltage input (HLA 3), and voltage source (HLA 4). Channels configured to operate in the current loop mode for active sensors will rely on external sensors supplying a 4-20 mA current across the channel input pins. When the channels are configured for current loop mode for passive sensors, a +15 vdc +/- 10% voltage source provides excitation to the external sensor. An overcurrent latch will latch-off between 24 mA and 30 mA, and will remain latched-off until reset is commanded. In the voltage input mode, analog voltage measurements are performed on full scale input of +/- 5 V balanced differential signals. In voltage source mode, a voltage source provides a +15 vdc +/- 10% voltage across the pins for sensor excitation. The source delivers up to 20 mA of current at the rated voltage. Overcurrent latch-off occurs between 24 mA and 30 mA, and will remain latched-off until reset is commanded.

Two BIT modes check channel addressability, functionality, relative accuracy, gain setting, configuration status and voltage source overcurrent latch status.

Each channel is protected for overvoltage conditions of up to +/- 15 V continuous, provides noise rejection capability and performs I/O function isolation to preclude external sensor failure propagation to other channels.

Selection of an individual HLA channel involves three levels of switches: card selection switch at the output of the common gain amplifier, sector selection at the input of the common gain amplifier, and channel selection within the selected sector, using the multiplexers at the buffer/MUX outputs.

The **AIO card** independently provides 16 channels configurable as balanced differential analog inputs or as balanced differential analog outputs. Each AIO channel is configurable as analog monitor for voltage input (AI) (i.e., it can be preset by the IOCU to one of the following three voltage ranges: full scale sensitivities of +/- 50 mV, +/- 500 mV or +/- 5 V) or for analog output (i.e., it will provide a voltage range of +/- 5 V balanced differential across the output pins and current drive up to 8 mA). Input signals are amplified to analog bus voltage levels and sent to the IOCU when requested. Each AIO channel provides a high input impedance when the channel is configured as an input.

BIT modes for input channels check for addressability, functionality, relative accuracy and gain setting while BIT modes for output channels check for functionality and output verification.

Each channel provides +/- 15 V overvoltage protection when the channel is configured as an input channel or when power is off. Provides also short-circuit protection.

Selection of an individual AIO input or output channel involves three levels of switches: card selection switch at the output of the common gain amplifier, sector selection at the input of the common gain amplifier (one of the four sectors/CCA) and channel selection within the selected sector, using the multiplexers at the LLA Buffer/MUX or output driver hybrids.

The **DIO card** provides 32 channels, each one independently configurable to four modes of operation: discrete input - active source (DI 1), discrete input - passive source (DI 2), discrete output - internal power (DO 1), discrete output - external power (DO 2). Default configuration is for discrete voltage input active source.

A maximum of 20 channels are configurable to provide discrete drive capability for dc loads; these channels can support all the above DIO operational modes. The remaining 12 channels cannot be configured as DO 1.

The DIO card provides 32 isolated power supplies for grounding specification compliance; optocouplers provide channels isolation from gate array. It is also designed to prevent state changes during power-up and power-down sequences. Input configured channels implement overvoltage protection up to +/- 15 V continuous. Input and output configured channels are also protected for short-circuit.

Active source configurations will accept user-supplied discrete voltages from 5 up to 32 vdc, with voltages greater than 3 vdc being registered as a logic (discrete) "1" and voltage levels less than 2.5 vdc being registered as a logic "0". Channels configured for passive source inputs will supply an isolated voltage source on one input pin and a return source on another pin for exciting user switch or solenoid contacts. This configuration may be used to determine the open or close status of an external switch. In this mode the DIO channel will supply + 15 vdc + 13.7/- 10% at 0.2 mA maximum. The impedance between the input pins will be measured and a logic "1" will be registered for an impedance of less than 20 kohm. An impedance of greater than 1 Mohm will register a logic "0".

When configured for internal power mode, the DIO channel will provide isolated discrete drive capability from an internal source. Upon IOCU command, the DIO will apply the internal source. A current monitor will provide short-circuit protection. This configuration can be used for driving small relays, applying control signals or other low power switched drivers. Each channel will apply the internal isolated + 15 vdc + 13.7/- 10% voltage to one external pin and supply return to the other pin. The voltage source will supply up to 24 mA drive capability per channel. Current limiting will be applied above 24 mA with the maximum fault current not to exceed 30 mA.

When configured for external power mode, the DIO will perform a switching function with a user-supplied voltage in the range of 5 to 32 vdc. The channel will be capable of switching up to 24 mA. Current limiting will be applied above 24 mA with the maximum fault current not to exceed 30 mA. The voltage drop across the switching circuit will be less than 1 V, and switching will be accomplished in less than 100 microsec. The output is driven by the IOCU, with a logic "1" meaning to close the switch and with a logic "0" meaning to open the switch. The switch will remain closed or open until commanded to change states.

BIT sequence provides test operations for input configured channels and output configured channels that are reset.

The **SDO card** provides 16 individual isolated solenoid driver channels to switch load voltages from 10 to 120 vdc and load currents up to 0.5 A. Channel isolation is accomplished with 16 individually isolated power supplies and associated optocoupler interface to gate array. Each of these 16 switching channels may be turned on or off by IOCU with a single command, and any combination of channels commands may be performed simultaneously.

The voltage monitor reflects voltage status across the switch and the threshold is set between 4 and 6 V. The overcurrent threshold is set between 500 mA and 750 mA load current. Channels are latched-off under overcurrent conditions; delays in gate array prevents potential channel latch-off as a result of abnormal input voltage interface fluctuations and transient inrush currents. There is a 4.2 sec delay for load overcurrent latch-off for loads between 0.5 A and 0.75 A. Between 0.75 A and 0.9 A, there is a 4 sec delay. And for load current greater than 0.9 A, the delay is 1.0 msec. All channels are short-circuit protected by limiting the current to 3 A.

The SDO card utilizes two BIT operations to assess the health of a channel. Output from voltage monitor is read to determine the state of a power switch and the result is compared to the commanded state. Overcurrent or latch-off status in gate array is read to determine if a set channel has experienced an overload.

The **SPD1553 card** provides 2 independent MIL-STD-1553B dual redundant channels (A and B) with 64 Kwords of SRAM for command/data buffers in each channel, 2 independent RS-485 Serial channels with programmable baud rates and 16 bit discrete Parallel channel.

For the two MIL-STD-1553B dual redundant channels, MIL-STD-1553B protocol chip may be programmed to operate as Bus Controller, Remote Terminal or Bus Monitor. The SPD1553 card will have the capability to transfer commands, status and data on the MIL-STD-1553B bus and to interface with the IOCU to receive configuration commands, receive and transmit MIL-STD-1553B data and transmit card status.

The Serial Digital segment of the card will provide two serial data channels and one 16 bit parallel channel for two-way, low-speed digital data communications.

In performing the output communications, data words will be received from the IOCU for transmission on the selected channel. The Standard Input/Output (SDIO) will format and transmit data at the specified time. Operating as a receiver, the SDIO will collect the data from the channel requested, reformat it and send that data to the IOCU.

The two serial channels provide asynchronous communications in accordance with EIA RS-485 standard for balanced differential circuits as well as the data/timing configuration requirement in EIA RS-449. All serial communications will be point to point, with the SDIO card acting as the link master.

Each channel has two data lines (RD and SD) and two control lines (CS and RS) which can be configured to operate in a full or half duplex as follows: two-wire half duplex, SW handshake (SD); four-wire full duplex, SW handshake (SD, RD); six-wire half duplex, HW handshake (SD, RS, CS); eight-wire full duplex, HW handshake (SD, RD, RS, CS).

The parallel channel provides 16 bits or lines for digital data communications, independently configured as either an input or an output line. The SDIO does not provide any control of the data flow for this channel. All data flow control is performed by the MPLM flight software. The parallel channel conforms to requirements of EIA RS-485 for balanced voltage differential circuits.

The **Power Supply card** provides 6 regulated dc output voltages to properly operate the MDM circuitry. It is configured as a push-pull converter operating at a switching frequency of 100 kHz and it employs PWMs used as voltage-mode controllers, referenced to the secondary signal ground. The input power is referenced to the primary power ground. It provides two reset signals to the MDM CCAs and one logic signal indicating output voltage status, and self-protection circuitry to perform shut down in case of input voltage out-of-tolerance, input overcurrent and output overvoltage.

An inrush current limit circuitry controls the MDM surge current at power-up to 0.75 A. An input voltage monitor circuitry detects the voltage level. When the input voltage increases from its nominal value to above + 150 vdc a shut-down signal is sent to both PWMs through an optocoupler. When it decreases below + 130 vdc, the input voltage monitor circuitry removes the shut-down signal from the PWMs. This causes the power supply outputs to start increasing to their nominal values again. When the input voltage decreases from its nominal value to below + 90 vdc, the voltage level is detected by the input voltage monitor circuitry which sends a shut-down signal to both PWMs.

4.7 SOFTWARE

4.7.1 MPLM Multiplexer-Demultiplexer (MDM) Software

The Flight Operational Software of the MPLM consists of the software running on the MDM computer, in particular of the MPLM MDM Computer Software Configuration Item (CSCI), which is the unique developed flight software for the MPLM and utilizes the Space Station Program MDM Utilities CSCI and the MDM Boot and Diagnostics Firmware CSCI. Some of the commanding/monitoring capabilities are performed via the PDB instead of the MDM standard I/O Card (e.g. for the DA and PPRA).

The MPLM MDM CSCI (MMC) interacts with the following MPLM internal Subsystems:

- the ECLSS and in particular performs functions for the ARS, ACS subsystem, the Fire Detection and Suppression (FDS) subsystem, and the THC subsystem
- the ATCS
- the Electrical Power Distribution and Conditioning (EPDC) subsystem

Once the MPLM is berthed to the ISS and the MPLM MDM active, it becomes a tier III MDM within the C&DH Hierarchy.

During Passive Flights the MPLM MDM is powered-on in the Orbiter for environment checks. In the on-station phase the MPLM is powered on and the MMC controls and provides the ISS for commanding and monitoring of the MPLM internal configuration.

Therefore the MMC, during the on-station phase, only interfaces with the following internal components (referred in the Software Documentation generally as Sensors and Effectors).

- ECS
- Electrical Power System

The interfaces to the MDM INT1/2 are via the MPLM MDM MIL-STD-1553B Local Bus connection and in accordance with the C&DH processing frame concept. It should be highlighted in addition that the MMC acts as a Remote Terminal when connected to the ISS.

During Active Flights the MPLM is also powered on in the Orbiter during ground and on-orbit operations. During these phases the MPLM interfaces the Orbiter via the MPLM MDM MIL-STD-1553B Local Bus. The MMC acts as Remote Terminal with respect to the Orbiter.

The interface to the R/F racks during AF is via the MPLM MDM MIL-STD-1553B User Bus. The R/F racks controls both in the R/F racks duty cycle control and in the management of their contribution to the FDS.

The MDM CSCI identifies the application software of the MDM computer. It utilizes the MDM Utilities CSCI and is supported by the Run-Time system as generated at compile time based upon the Alsys Automatic Data Acquisition (ADA) Run-Time Environment (ADA-RTE). The ADA-RTE is the commercial off the shelf Alsys, as provided with the Cross Compiler for the MDM Target computer. The MDM Utilities have been developed using ADA and Assembler (386IASM/Link-Loc) language.

The MPLM Flight Operational Software consists of:

- the MDM CSCI, that runs on the MDM, together with the Run-Time System and the MDM Utilities CSCI
- the MDM Boot Software CSCI stored in the MDM Electrically Erasable Programmable Read Only Memory (EEPROM). The MDM Boot and Diagnostic Firmware (MDMBF) CSCI controls processor both, startup and diagnostic state

For further information about MPLM software, refer to MLM-SS-AI-0011 and MLM-DD-AI-0001. The procedures for MDM CSCI loading, initialization, configuration and restarting are described in MLM-MA-AI-0004.

4.7.1.1 Computer Software Configuration Item (CSCI) Architecture

The MDM CSCI is designed in order to provide concurrent execution of periodic and aperiodic processes:

- Periodic processes: processes that cyclically monitor the MDM sensors, the PDB and the R/F racks (if manifested)
- Aperiodic processes: processes that process the on-demand requests of command execution incoming from either the ISS or the NSTS. Such commands may request to command the MDM effectors, the PDB or the R/F racks

The MDM CSCI provides execution of processes within specified response time requirements (deadlines).

The main goal of the MDM CSCI is to provide cyclic, synchronized, time scheduled processes based on a 10 second C&DH processing frame structure. The MDM CSCI processing based upon the C&DH processing frame structure is organized as follows:

12.5 ms (80 Hz) frame (MDM subframe)

100 ms (10 Hz) frame (C&DH processing frame)

1 s (1 Hz) frame (C&DH minor frame)

10 s (0.1 Hz) frame (C&DH major frame)

The MDM CSCI is designed to ensure an execution order of a fixed task list for each C&DH frame. The C&DH processing frame structure anticipates command transaction, with all the Remote Terminals (RTs), every C&DH processing frame. Therefore CSCIs tasks providing for command execution are designed to meet their deadlines within 100 ms. The C&DH processing frame structure foresees collection of telemetry contributions from the RTs every C&DH processing frame; the CSCI tasks providing telemetry contributions every 0.1, 1, or 10 s are designed to meet their deadlines accordingly.

To satisfy such severe timing requirements the MDM CSCI is designed to have a fully predictable timing behavior.

As such it provides for:

- fixed task scheduling environment (cyclic executive model)
- fixed format MIL-STD-1553B bus transactions (asynchronous events are synchronized through polling)
- fixed Subsystem I/O
- fixed format telemetry

A minimal set of configuration capabilities is provided. Minimal MDM CSCI on-orbit re-configuration will be guaranteed via fixed processes which are table driven to allow ground initiated re-configuration.

The adopted ADA tasking model is based on a priority-based and preemptive scheduling algorithm; the scheduling model is based upon the 12.5 ms MDM subframe. The task periodic execution is ensured by a task scheduler driven by the Real Time Clock Minor Cycle Interrupt on the MDM.

The MDM CSCI is structured in tasks running at different rates; the primary tasks run at different rates, each one grouping the functionalities required to run at that rate. The task priority is based upon the task rate; the 80 Hz task activates the lower frequency tasks as required. The lower rate objects are strictly independent from one another.

Each CSCI External Interface-both to the Local Bus and the User Bus-has to be managed by a dedicated utility for its specific features. The set of these utilities, called MDM Utilities, is a CSCI and is considered as an external object to the MMC. The MDM Utilities CSCI is in fact a collection of support utilities that are utilized by the Application Software to perform BIT functions and to interface hardware components. The MDM Utilities CSCI does not perform as a stand alone entity but operates within the context of the MMC which has the responsibility for controlling the execution of the MDM software.

The MDM Utilities object performs functions that need immediate readiness, such as processing the ISS/Orbiter incoming commands from the MIL-STD-1553B Local Bus, handling the MIL-STD-1553B User Bus Interface, and processing the scan list data attributes when data are ready from the Input/Output Card Controller (IOCC).

Each CSCI interface is managed by a dedicated utility (MDM Utilities). MDM Utilities are considered as external objects to the MMC. The MDM Utilities group the following utilities:

- time utilities, for:
  - local time update
  - reference time monitoring
  - local time provision
  - transport compensation constant updating
  - drift compensation
- Bus Interface Adapter (BIA) utilities, for communication to/from the Local Bus handling, providing the following capabilities:
  - cyclic provision of available monitoring data from the MPLM MDM to upper level MDM
  - cyclic command acquisition from upper level MDM
  - on-demand data dump
  - on-demand data upload
  - incoming commands integrity guarantee
- IOCC, to manage the communications from/to MPLM Sensor and Effectors connected directly to the MDM
- SPD 1553 Support Utilities, for User Bus and RS-485 Serial Line communication control, containing 1553B support utilities, serial port utilities and parallel port utilities
- Health Monitoring Utilities, providing BIT and error reporting services including:
  - the Power-On Self Test (POST) of the I/O cards
  - the cyclic I/O BIT
  - the background BIT
  - the recording of MDM Utilities or Application Software reported errors
  - the handling of failure condition

4.7.1.2 Computer Software Configuration Item (CSCI) Capabilities

The MDM CSCI operational states are the following:

- the ORBTR_STATE, which allows for the MPLM Active status during active Orbiter operations
- the ISS_STATE, which allows for the MPLM Active status during on-station phase

During each operations phase (namely, the Pre-Launch phase, the Post-Launch phase, the on-station phase, the PTC-Landing phase, and the Post-Landing phase), the MPLM status applying to the MDM CSCI is the Active status. The Inert status applies to the MPLM unpowered operations (namely, launch, transfer between Orbiter/ISS, and re-entry).

The MDM CSCI provides the same set of commands & telemetry data at both Orbiter and ISS interfaces.

It is the responsibility of the MPLM user to properly configure the MMC via MMC Data Tables. Configuration even applies to Committee Consultative Space Data Systems (CCSDS) Standard Commands sent via the MPLM MDM Local Bus. The MMC rejects commands not allowed in the current flight as per MMC Data Tables.

The MMC provides the following functions:

- monitoring and commanding of the R/Fs (when included in the flight manifest), on behalf of either the Orbiter or the Space Station
- monitoring and commanding of the ECS powered equipment
- monitoring and commanding of the electrical power distribution equipment
- detection and isolation of predefined equipment failures, preventing catastrophic or critical hazardous events and failure propagation
- function status data assessment
- detection and isolation of fire events, by processing monitoring data
- monitoring of the MPLM internal pressure

Moreover, the MMC provides a set of services to support:

- diagnosis functions for the MDM health status
- data load, data dump and cyclic command transfer
- cyclic data transmission (for the transmission to ground of telemetry data)

The support provided by the MDM Utilities CSCI concerns:

- data handling through the MIL-STD-1553B Local Bus
- data handling through the MIL-STD-1553B User Bus
- accessibility to sensors/effectors to acquire and transmit data and commands
- data handling through the PDB serial line
- background and cyclic BIT

The following MDM CSCI components have been identified:

- MPLM System
- Failure Detection and Isolation (FDI)
- C&DH
- ACS

- ARS
- THC
- EPDC
- FDS
- ATCS

4.7.1.2.1 MPLM System Software

This component deals with the following capabilities that involve data gathered from end-items belonging to several MPLM subsystems:

- fire isolation automated procedure
- interface scenario setting (ORBITER or ISS)
- activation
- deactivation
- FDI overall control

4.7.1.2.2 Failure Detection and Isolation (FDI) Software

The FDI design involves data provided by hardware [(sensors and Built-in Test Equipment (BITE)] and software processing algorithms to detect and isolate failures. The failure detection process consists of three major steps:

- Out-of-range detection and exception raising - the extraction of system behavior characteristics allowing to establish whether a fault has occurred- by means of cyclic monitoring
- Failure detection - the determination of the failure which has affected the system behavior: this is the diagnostic decision making step
- Failure isolation - the triggering of actions aimed to avoid failure propagation (whenever applicable)

The following exceptions are processed by the FDI:

- hardware end-items errors reported by BIT/BITE
- out-of-tolerance conditions (out of limit or out of range conditions on sensor values or measured/monitored status)
- loss of power to hardware end-items
- loss of data communication
- communication errors

4.7.1.2.3 Command and Data Handling (C&DH) Software

The C&DH component provides MDM BIT support and MDM memory upload/download capabilities, as well as capabilities required by the C&DH architecture, such as time synchronization and management of the User Bus and the PDB serial line.

4.7.1.2.4 Atmosphere Control System (ACS) Software

The ACS component monitors and commands the Cabin Depressurization Assembly (CDA) and PPRA valves and the PDA heaters, monitors the cabin total pressure sensor, performs reduced cabin pressure safing actions, and performs MPLM partial depressurization.

4.7.1.2.5 Atmosphere Revitalization System (ARS) Software

The ARS component provides SSOV command capability and monitors the valve microswitches to determine its open or closed status.

4.7.1.2.6 Temperature and Humidity Control (THC) Software

The THC component provides ISOV monitor and command capability, cabin air temperature sensor monitoring, and cabin fan monitor and command capability.

4.7.1.2.7 Electrical Power Distribution and Conditioning (EPDC) Software

The EPDC component provides monitor and command capabilities for the MPLM power loads and monitor and command capabilities of the HCU. The PDB components [Converters, RPCs, Serial Switches (SSWs), APS] are commanded and monitored via the Serial Command and Monitoring Interface (SCMI) and High Level Command and Monitoring Interface (HLCMI).

4.7.1.2.8 Fire Detection and Suppression (FDS)

The FDS component provides Duct Smoke Detector (DSD) monitor and command capabilities for smoke detection.

4.7.1.2.9 Active Thermal Control Subsystem (ATCS)

The ATCS component provides WOV, WPP, WMV monitor and command capabilities, and WMV Delta-P sensor monitoring.

4.8 ENVIRONMENTAL CONTROL SUBSYSTEM (ECS)

4.8.1 General Description

The ECS is comprises of two main subsystems: the ECLSS, designed to provide an adequate and safe environment for cargo transportation and related crew operations within the cabin of the MPLM, and the TCS, designed to provide passive and active thermal control.

4.8.1.1 Environment Control and Life Support System (ECLSS)

The ECLSS is designed to provide an adequate and safe environment for cargo transportation and related crew operations within the cabin of the MPLM. Its functions include atmosphere pressure control, ventilation of the internal cabin volume, and fire detection and suppression inside the module.

The ECLSS consists of four sections:

- Atmosphere Control System (ACS)
- Atmosphere Revitalization System (ARS)
- Temperature and Humidity Control (THC)
- Fire Detection and Suppression (FDS)

The ECLSS consists of the cabin loop [with fan, ducting, diffusers, return grid flow restrictor, Inter-Module Ventilation (IMV) ducts, and valves], the positive and negative pressure relief assemblies, the CDA, the total pressure sensors for cabin pressure monitoring, cabin air temperature monitoring and smoke particles measurement in the cabin air and the air sampling line.

Because the forward end cone was designed to accommodate powered equipment, the main part of the ECLSS equipment is located there and is collocated with the fire suppression provisions. Figure 4.8-1 represents a functional overview of the ECLSS.

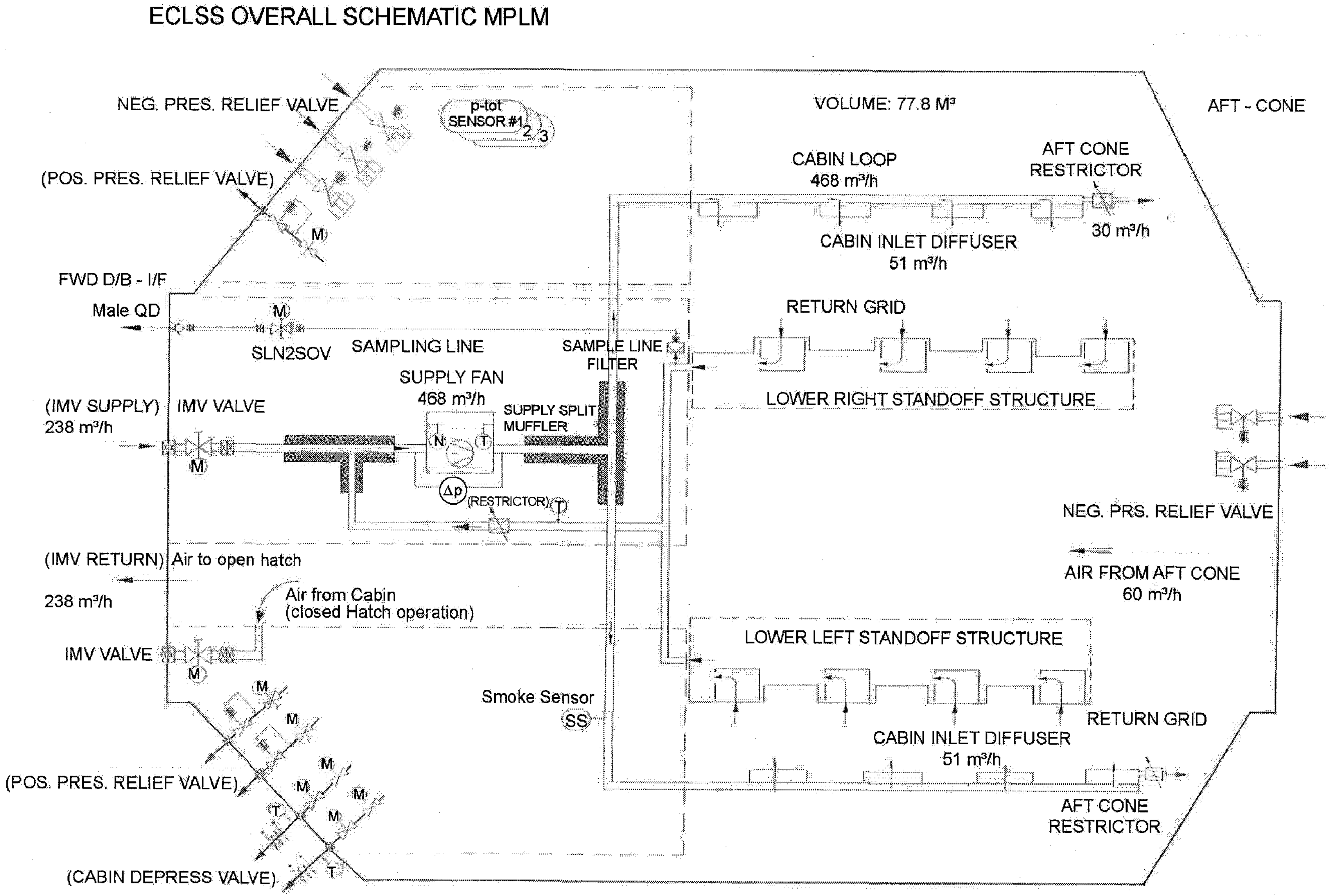


Figure 4.8-1. ECLSS Functional Overview

4.8.1.1.1 Atmosphere Control System (ACS)

The ACS consists of the following equipment:

- Manual Pressure Equalization Valve (MPEV)
- Cabin Depressurization Assembly (CDA)
- Positive Pressure Relief Assembly (PPRA)
- Negative Pressure Relief Assembly (NPRA)
- Total Pressure Sensors (TPS)

The CDA depressurization valve, PPRA, and NPRA have been developed for common use in Spacelab/Shuttle orbiter.

4.8.1.1.1.1 Manual Pressure Equalization Valve (MPEV)

The purpose of the MPEV is to equalize the internal cabin pressure and the vestibule pressure.

The MPEV is a manually operated mechanism which equalizes the differential pressure across the Hatch to 0.01 psid (69 Pa). The MPEV is located on the hatch lower starboard quadrant as viewed from the vestibule. The MPEV operates to flow air at a temperature of 35 to 90°F (1.7 to 32.2°C). Total MPEV leakage (combined port and case) is 4.398 in^3/h (72.066 cc/h) for air at 15.2 psia (104.8 kPa) across the valve. The required endurance for the MPEV during the 15-year life is 3650 cycles. The MPEV is capable of operating over the entire 15.2 psia to $1 \bullet 10^{-5}$ torr (104.8 kPa to $1.3 \bullet 10^{-6}$ kPa) range.

The MPEV is closed for ascent/descent and during the transfer phases. The MPEV is opened before hatch opening to allow pressure equalization and is left open during nominal operation on ISS. The MPEV is closed after Hatch closure before MPLM deberthing. When the Hatch is closed and the MPLM isolated, the MPEV remains open to allow MPLM and Vestibule pressure equalization.

The MPEV is nominally operated after MPLM berthing to the ISS, before opening the hatch or after a contingency depressurization, in order to repressurize the isolated module. The nominal equalization time is required to be less than 180 sec; the repressurization time after contingency depressurization is required to be within 75 hr, although repressurization will typically occur within 33 hr.

4.8.1.1.1.2 Cabin Depressurization Assembly (CDA)

The Depressurization function provides the MPLM with the capability to dump the atmosphere to outer space, primarily in case of contamination or as a response to fire. The CDA consists of two separate branches of valves to dump the cabin atmosphere upon command. In order to meet the one-failure tolerance requirement, each branch consists of two butterfly valves operated by 28 vdc brush type motors arranged in series, a heated vent section to avoid build up of ice or frost particles during depressurization, and a temperature sensor installed at the vent section. The two branches are located in the F/T plate in the forward cone.

Each CDA is provided with a Non-Propulsive Vent (NPV) to reduce thrust or moments on the MPLM. A debris screen on the cabin side of the assembly provides protection from particles larger than 300 μ.

The Depressurization Assembly is designed to obtain a depressurization of the module to a PPO_2 level of 1.0 psi (6.9 kPa) in less than 10 minutes and a total module depressurization of less than 0.40 psi (2.8 kPa) in less than 24 hours with both branches open. The depressurization rate for the MPLM cabin internal pressure is lower than 0.13 psi/s (0.89 kPa/s).

4.8.1.1.1.3 Positive Pressure Relief Assembly (PPRA)

The positive pressure relief function, which consists of dumping air to outer space in case of MPLM overpressure, relies on three independent PPRAs.

The purpose of the PPRA is to vent off gas from the MPLM cabin when the differential pressure between internal cabin and ambient is above 15.05 psi (103.8 kPa), to ensure the module structure does not see pressures above 15.20 psi (104.8 kPa). The PPRA, two-failure tolerant against failing open, consists of three parallel branches, each of which contains a pneumatic pressure relief valve and an electrically driven butterfly shutoff valve with manual override capability installed in series as a backup. The motorized shutoff valve can be closed electrically or by use of the manual override handle. The valve electrical motor is identical to the CDA brush type motor. The minimum valve crack pressure is 15.05 psi (103.8 kPa), the maximum crack pressure is 15.137 psi (104.4 kPa), the maximum relief rate is 149.6 lbm/hr (68 kg/h) (reached at the fully open valve pressure of 15.413 psi [106.3 kPa]).

Each PPRA consists of a Mechanical Relief Valve and a brush motor driven Butterfly Valve arranged in a common valve bore. The electrically commanded valve is mounted upstream in series with the mechanical valve. Each PPRA is provided with a Non-Propulsive Vent to reduce thrust or moments on the MPLM module. Redundant seals are implemented at the assembly mounting flange with the external interface (i.e. external I/F seals are redundant). A debris screen on the cabin side of the assembly provides protection from foreign material.

Two PPRAs are installed on the forward cone upper starboard F/T plate, and the third one is installed on the integral F/T panel.

In both Active and Passive Flights, the PPRAs are OPEN and operative when the MPLM is in the Shuttle cargo bay and during transfer phases; the PPRAs are CLOSED when the MPLM is on ISS (after activation).

4.8.1.1.1.4 Negative Pressure Relief Assembly (NPRA)

The function of the NPRA is to prevent the development of an excessive pressure differential between the outside and the inside of the MPLM which would lead to structural collapse, as might occur during launch abort or during nominal reentry of an unpressurized module. In order to prevent a differential pressure higher than 0.49 psi (3.4 kPa) five valves are required to provide one-failure tolerance for worst case reentry. Three valves are located in the F/T plate of the forward end cone; two valves are located in the aft end cone bulkhead. The NPR valve function is autonomous, power independent and one-failure tolerant against failure to seal. Minimum reseat pressure is 0.1 psi (0.7 kPa).

4.8.1.1.1.5 Total Pressure Sensors (TPS)

The purpose of the three TPS is the total atmosphere pressure monitoring within the MPLM. The TPS design is not common to the Space Station, but is MPLM dedicated. The TPS are mounted on a single bracket located on the MPLM Forward cone +Y tilt panel. Three TPS are designed for an absolute pressure measurement range from 0.02 to 15.96 psi (0.1 to 110.0 kPa) with an accuracy of ± 0.23 psi (± 1.6 kPa).

4.8.1.1.2 Atmosphere Revitalization System (ARS)

The ARS provides the air sampling capability within the MPLM cabin and allows the ISS to analyze the composition and detect the presence of contaminants (trace gas contamination monitoring).

The monitoring function is performed at ISS level. An air sample is drawn and then sent to the ISS to perform the analysis upon ISS start signal. The MPLM ARS is composed of:

- the Atmosphere Sampling Line (ASL), which leads the MPLM cabin air towards the Space Station. A Sampling Line Filter (SLF) is provided to avoid the presence of particulate in the sampled air
- a SSOV, for MPLM isolation from the Space Station
- the male part of a 0.125-inch non self-sealing Fluid Connector, mounted on the Docking/Berthing Interface Bulkhead, to provide the interface with the Space Station ARS. A pressure cap is installed on the MPLM Connector male part for additional isolation when it is not mated with the Space Station interface

4.8.1.1.3 Temperature and Humidity Control (THC)/Module Ventilation

THC/Module Ventilation function is designed to distribute in the MPLM cabin the breathable air collected from the ISS via the IMV Interface, providing ventilation throughout the habitable module areas and preventing dead air pockets, and to return air to the ISS for revitalization. Cabin temperature is monitored; cabin humidity and temperature control is performed on the ISS side.

The THC consists of the following equipment:

- Distribution System Cabin Loop
- two ISOVs
- Cabin Fan Assembly (CFA)

Per Section 3.2.1.1.1.3 of SSP 41164, Capability: Circulate Atmosphere – Ventilation requirements inside the MPLM are 67% of the airflow in the 15 – 40 fpm range, with no air flow below 7 fpm or above 200 fpm.

Figure 4.8-2 shows the payload and cargo stay out zones to maintain proper air flow. These stay out zones are for all three cargo types.

If the outlet air diffusers are blocked by payloads or cargo (as defined in Figure 4.8-2), the crew is instructed via flight rule C20.5.1-12, "MPLM Ventilation Configuration Ingress" (MPLM Flight Rules, Volume C) to use battery powered fans (e.g., Moisture Removal Kit/MRK fans) if needed to increase the air flow inside the MPLM.

If one or more diffusers are blocked, the crew should take the following measures:

- Unblock whatever diffuser is blocked first, or if multiple diffusers are blocked, unload the MPLM from the front of the module to the back, unblocking the blocked diffusers first. For the return flight, block the diffusers as late as possible.
- Use battery operated fans as needed to increase air flow.

Cargo integrators shall coordinate with MPLM/ECLSS and MOD to ensure flight rule C20.5.1-12 is in the mission specific flight rules if the stay out zone in Figure 4.8-2 is violated.

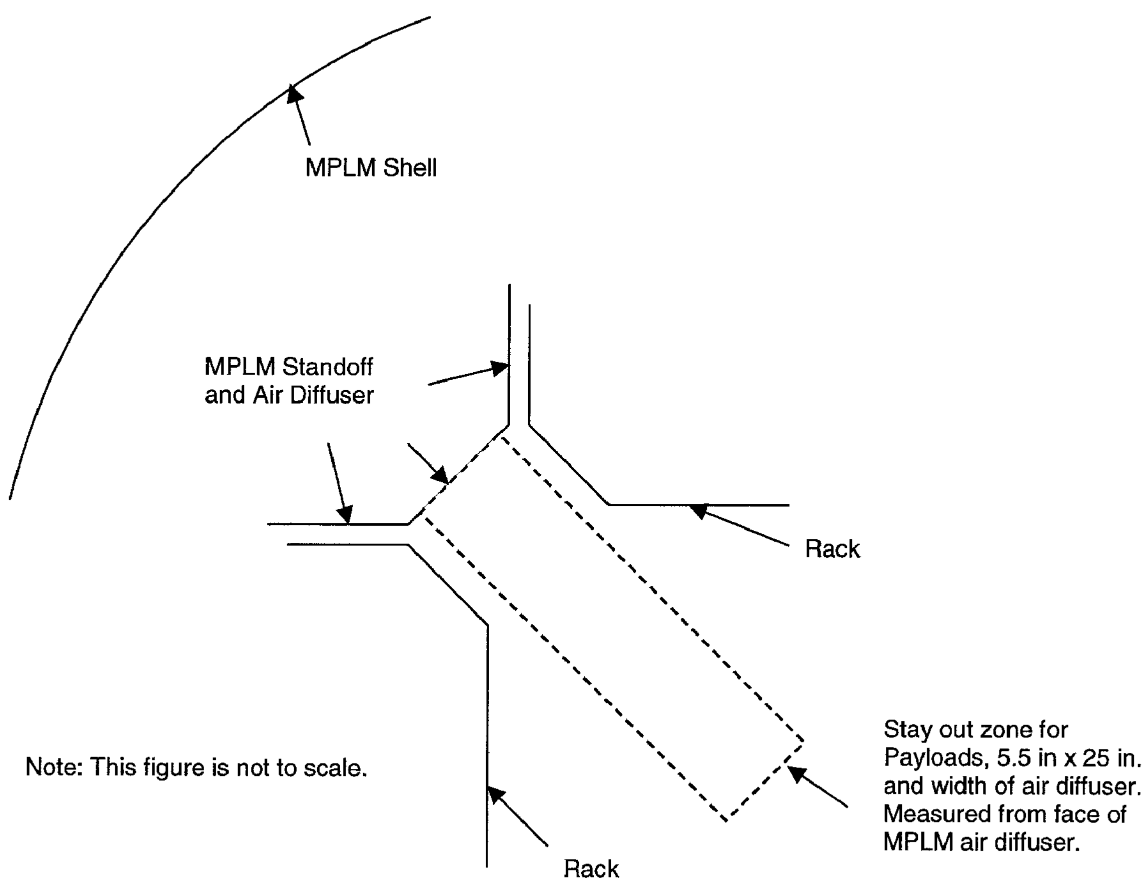


Figure 4.8-2. Stay Out Zone for Payloads and Cargo to Maintain Proper MPLM Air Flow Distribution

4.8.1.1.3.1 Distribution System Cabin Loop

The Distribution System Cabin Loop consists of the supply and return ducts, diffusers and grids, and the noise attenuation mufflers.

The air is pulled from the cabin via return grids situated in the lower cabin corners, 4 on each side. The air return to ISS is delivered through the open hatch during nominal operation and via a separate duct when the hatch is closed. A temperature sensor is installed in the return air duct for cabin temperature monitoring; the temperature sensor can operate in the range between 32 to 140°F (0 and +60°C).

The air diffusers are preadjusted on-ground to guarantee the proper ventilation, although they may be adjusted and closed on ground and on-orbit; the optimum ventilation is obtained with a mass flow rate of about 1801 ft^3/hr (51 m^3/h) per diffuser, which gives an air velocity between 0.249 ft/s (0.076 m/s) and 0.666 ft/s (0.203 m/s) (except in the vicinity of the air diffusers). The cabin air diffusers are located in the upper cabin corners, 4 on each side. Proper ventilation in the aft cone is supplied by two additional dedicated branches, providing an airflow of 1059 ft^3/hr (30 m^3/h) each. The total flow rate is 16527 ft^3/hr (468 m^3/h).

A 300 μ Filter is installed behind each air return grid. No on-orbit maintenance is required.

4.8.1.1.3.2 Inter-Module Ventilation Shutoff Valve (ISOV)

The two ISOVs are installed in the IMV supply and IMV return lines to provide the capability to open or close the air exchange interface from the MPLM to the ISS. Both ISOVs are provided with a protection cap that is installed when the MPLM is isolated.

The ISOVs are butterfly valves actuated by an eccentric/fork mechanism driven by a brush type DC motor. Position indication is provided by means of limit microswitches.

The two Inter-Module Ventilation Shutoff Valves (In and Return) are CLOSED throughout all the Active and Passive Flight phases, with the exception of the on-station phase after MPLM activation, when both ISOVs are OPEN to allow the air exchange between the module and the station (Active and Passive Flight).

4.8.1.1.3.3 Cabin Fan Assembly (CFA)

The CFA provides the required airflow to support cabin smoke detection and air revitalization when the MPLM is attached to ISS and manned with a common ambient.

The CFA is equipped with a variable speed 120 vdc brushless DC motor driven mixed flow fan, an electronic controller to operate the motor and provide speed information, a delta pressure sensor to measure the fan pressure rise, an acoustic enclosure to control case radiated noise, and a structural frame to support the assembly and to provide a structural mounting interface. The motor speed is set to optimize MPLM operation.

The Cabin Fan, together with the DSD and the Air Temperature Sensor, is NOT ACTIVE during Launch, Descent, and Transfer phases of both Active and Passive Flights. During NSTS operation it is ACTIVE in both Active and Passive Flights. On ISS it is ACTIVE in both Active and Passive Flights when the MPLM is active.

Power to the CFA is provided by the MPLM PDB by means of a dedicated 120 vdc outlet controlled by a RPC. The CFA is enabled/disabled via MDM command. A motor speed command (analog signal from MDM) is used to set the CFA speed corresponding to the required air flow rate. The CFA motor speed for MPLM is fixed to 3552 RPM.

4.8.1.1.4 Fire Detection and Suppression (FDS)

For FDS function, one Smoke Detector is installed in the supply air duct downstream of the cabin fan to sustain effective smoke detection while attached to ISS for the volumes cabin, aft cone and lower stand-offs. The sensor is an optical smoke detector whose design is based upon the ISS requirement for commonality between ISS and module. Obscuration and scattering of the red light emitted by a LASER diode passing through the duct air flow results in a ±5 V signal to the MDM.

The MPLM zones containing a credible fire risk are subdivided in three non-hermetically sealed compartments by means of betacloth panels. Fire Suppression Ports allow the crew members to discharge the fire suppressant contained in a PFE into the compartment affected by the fire event.

4.8.1.1.4.1 Duct Smoke Detector (DSD)

The DSD is capable of detecting extremely low smoke concentrations. It is designed for a response time less than 5 sec after smoke particles of greater than 0.3 microns reach the detector. Power to the DSD is provided by the MPLM PDB by means of a dedicated 120 vdc outlet controlled by means of a RPC. The DSD operates directly when supplied with 120 vdc power from the PDB.

The DSD is activated and deactivated in the same scenarios as the Cabin Fan and the Air Temperature sensor. The DSD, together with the Cabin Fan and the Air Temperature Sensor, is NOT ACTIVE during Launch, Descent and Transfer phases of both Active and Passive Flights; during NSTS operation it is ACTIVE in Active Flights and NOT ACTIVE in Passive Flights; on ISS it is ACTIVE in both Active and Passive Flights when the MPLM is active.

In the normal, no-smoke condition, 100% of the transmitted light is received directly by the obscuration photodiode; almost no light is scattered onto the scatter photodiode. When smoke is present, light scatters off the smoke particles and onto the scatter photodiode. Additionally, since the light is scattered and absorbed by the smoke particles, the obscuration photodiode receives a reduced amount of light. The outputs from the two photodiodes are conditioned and made available to the MDM in the form of analog voltages. An algorithm resident in the MDM utilizes the scatter voltages for its basic decision. The obscuration voltage is used to adjust for lens contamination and to verify detector health.

4.8.1.1.4.2 Failure Detection and Isolation

The MPLM FDI is designed to detect and isolate MPLM function failures and/or MPLM equipment failures and to provide information about failures to ISS/NSTS and to GROUND.

The basic FDI rules are:

- there is no need to provide detection and isolation below the lowest configurable level (MPLM Equipment)
- the FDI notification messages consist of the information needed by the ISS/NSTS to react to the MPLM failure, and do not include the detailed measurement and lower level data. The FDI notification messages are made available via telemetry data.
- An exception, input to the FDI processing, is generated upon a monitor out of operational limits or out of range for two consecutive samples of the status monitors.
- It is possible to manually disable/enable any automated capability initiated by an FDI routine, via two independent commands timely constrained with a two-step operation sequence.

Note: During the normal operations the FDI recovery is set in Automated mode. The manual FDI recovery is only used for Ground processing activities or on-orbit after contingencies (e.g. Sensor failure). When the operator enables in manual mode any of the automated capabilities initiated by an FDI routine, an ADVISORY will be generated.

To set FDI recovery in Manual/Automated mode, the following commands are issued:

- Manual FDI recovery enable:
  - MPLM_MAN_FDI_ENA
  - MPLM_<device>_MAN_FDI_INIT
- Automated FDI recovery enable (default):
  - MPLM_AUTO_FDI_ENA
  - MPLM_<device>_AUTO_FDI_INIT

4.8.1.1.4.3 Portable Fire Extinguisher (PFE)

The PFE is transferred from ISS and placed in the forward cone lower area, in a tailored betacloth enclosure. A close-out panel door allows quick accessibility to this item in a potential emergency situation.

The PFE consists of a carbon dioxide tank, equipped with valves, a pressure gauge, and a discharge nozzle.

The PFE is transferred back to ISS prior to MPLM undocking.

4.8.1.1.4.4 Portable Breathing Apparatus (PBA)

In order to provide breathable atmosphere to the crew members in the event of a hazardous atmosphere condition, one PBA is transferred from ISS to MPLM.

The PBA is housed in the forward cone port area, in a tailored betacloth enclosure, within 12 ft (3658 mm) of the MPLM entrance. A dedicated opening in the nearby close-out panel allows quick accessibility to this item in a potential emergency situation. The PBA mainly consists of an oxygen tank and a face mask.

The PFE and the PBA are located within 3 ft (914 mm) of each other and are transferred back to ISS prior to MPLM undocking.

4.8.1.2 Thermal Control Subsystem (TCS)

The TCS includes the Active Thermal Control Subsystem (ATCS) and the Passive Thermal Control Subsystem (PTCS).

The ATCS collects the heat loads rejected by the active cargo and transfers them to the Orbiter or to the ISS. This function is performed by means of a water loop, which includes one WPP, one On/Off Valve, one Modulating Valve, one Differential Pressure Sensor (DPS), hard and flex lines, and Quick Disconnects (Q/Ds).

The PTCS protects the MPLM from external environmental influences, minimizes the heat leakage/gains, and prevents condensation inside the MPLM.

The PTCS equipment includes:

- Thermal Control Coating (MDPS external surface finish)
- Multi-Layer Insulation which covers all of the MPLM shell, including the Hatch and PCBM external/internal surfaces
- insulation material, which covers the ATCS equipment
- items which reduce (washers) or increase (fillers) the thermal conductivity at the interface level
- heaters arranged on the shell external surface, to prevent internal condensation and ATCS water loop freezing
- heaters arranged externally on each Depressurization Assembly, to prevent icing inside the Non-Propulsive vent during the depressurization
- heaters arranged on the ROFU PDA, to prevent water freezing inside the jumpers

4.8.1.2.1 Active Thermal Control Subsystem (ATCS)

The ATCS collects and transfers the heat loads rejected by the R/F racks (when included in the flight manifest - Active Missions) to the NSTS or to the ISS. The ATCS coolant is water.

The ATCS Loop consists of the following items:

Heat sources:

- 5 R/Fs racks
- MPLM internal environment (cabin heat gain, pump dissipation)

Heat Sinks:

- NSTS cargo heat exchanger (during transportation phase)
- ISS-Node (during on-station phase)
- T0-HX (during ground operation)

ATCS components:

- Plumbing: hard and flex lines, bends and fittings, Self Sealing Quick Disconnect (SSQD), Metal Bellows Expander (MBE)
- WPP
- WOV
- WMV and related Delta-P sensor

Figure 4.8-3 represents an overview of the ECLSS.

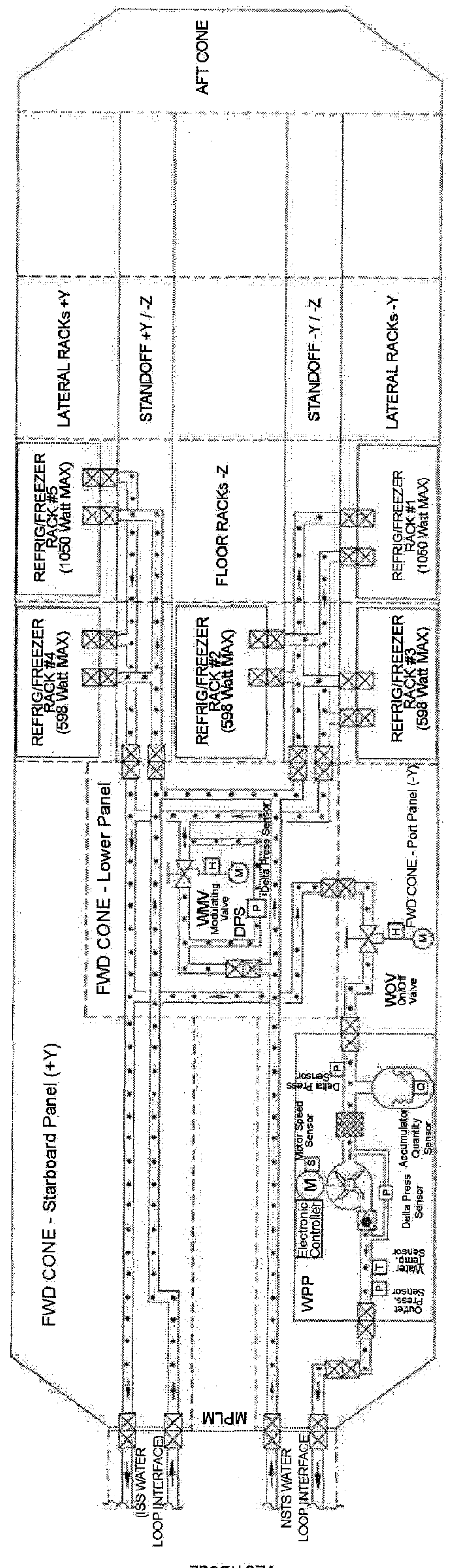


Figure 4.8-3. Water Loop Functional Overview

The ATCS is operative throughout the MPLM active mission, including on ground pre-launch and post-landing phases, since its purpose is to guarantee the collection and transportation of waste thermal energy from the R/Fs.

During Active Flight pre-launch and post-landing phases (on ground) and during post-launch and pre-landing phases (in the NSTS cargo bay) when the MPLM is active, the MPLM WPP is active, the WOV is open and the WMV is controlled via MDM/Delta-P sensor; the pressure drop across the R/Fs is maintained to 2 psid (nominal). The water circulation in both cases is provided by the WPP. The heat exchange is provided by the cargo heat exchanger through the ROFU PDA in the cargo bay. During the on station phase the WPP is not active and is isolated from the ISS water loop in order to protect the pump accumulator from ISS loop pressure variations; the WOV in this case has to be closed before the hydraulic connection with the ISS loop and the water thermal expansion in the ATCS loop is allowed by the implementation of a MBE (not connected to the ISS loop), which prevents the pressure from rising above a predefined level.

In Passive Flights, since no R/Fs are manifested, the ATCS is not required to operate; the hardware is reconfigured and the R/F kit is removed, together with the ROFU PDA and the Battery. The R/F kit includes the WPP, the Water On/Off Valve (WOV, electronic unit, valve motor and relevant interconnecting harness), the WOV to WPP outlet piping and the WOV to the loop first Q/D inlet piping. A portion of the ATCS piping is present in both the passive and active configurations, although during passive missions no water is flown.

The reference heat loads on the ATCS loop from the various mission phases, including R/Fs, WPP, valves dissipation and heat gain from ambient, are from 0 to 3000 W.

The water pump is provided to support the transportation phase (NSTS). During the on station phase the water circulation is provided by the ISS loop.

The WOV and the WMV are two identically designed valves performing two different functions. They both consist of a 28 vdc stepper motor valve and of an electronic unit providing motor control and interface to the PDB and MDM.

- the WOV, mounted on the port panel of the forward cone support structure, is located in the WPP branch, and is used to isolate the WPP from the ISS Water Loop during the operation phases attached to ISS. Moreover it is used to adjust the integrated MPLM-Orbiter water loop pressure drop. The WOV is provided with position indicator and manual override. The valve is connected to the PDB, for power supply, and to the MDM for control and monitoring.
- the WMV, installed on the lower panel of the forward cone support structure, supports active configuration adjusting of the coolant flow rate according to the R/Fs configuration. The WMV is provided with position indicator and manual override, although manual operation is not foreseen in any nominal or contingency scenario. The valve is connected to the PDB, for power supply, and to the MDM for control and monitoring.

The SSQDs are used for the external interfaces and to ensure a suitable modularity of the piping to facilitate the ground operations required for either maintenance needs or integration purposes.

The DPS, arranged on a 0.25 in. (6.35 mm) diameter line, parallel to the Modulating Valve branch, provides continuous pressure monitoring signal to be transferred to the modulating valve control system.

4.8.1.2.1.1 Plumbing

The Metal Bellows Expander (MBE) is used to limit to a defined value the pressure rise inside the MPLM ATCS water loop branch, where water thermal expansion through the accumulator is not allowed. The MBE consists of a single assembly incorporating case, metal bellows system, gas charging port, and ATCS water loop connection adapter. The gas adopted in the MBE is Nitrogen. The MBE can overtake 13 milliliters as swept volume with the complete compression of the bellows.

Eighteen Caps are used to restore the double seal configuration at the following half Q/Ds:

- MPLM to ISS I/F Q/Ds
- MPLM to ROFU PDA I/F Q/Ds, during flights without R/F racks
- MPLM to R/F racks, in the R/F racks locations not used to accommodate a R/F rack
- WPP GSE I/F Q/Ds, during flights with R/F racks
- half Q/Ds following the active-to-passive reconfiguration

All the ATCS equipment, including the piping (hard and flex lines), are thermally insulated with insulating material in order to avoid condensate formation on the external surfaces.

4.8.1.2.1.2 Water Pump Package (WPP)

The WPP, mounted on the port panel of the forward cone support structure, and electrically interfacing with the PDB and the MDM, is a hermetically sealed centrifugal type unit, actuated by a DC brushless motor (powered at 120 vdc) controlled by a dedicated electronic driver; the motor is cooled by the loop coolant itself.

The WPP consists of a single assembly incorporating the following major components:

- 1 Water Pump Unit
- 1 Accumulator with a nitrogen pressurization charge
- 1 25 μ Filter
- 1 Check Valve (located downstream the pump)
- 1 Accumulator quantity sensor
- 2 absolute Pressure Sensors (inlet and outlet)
- 1 DPS (across the pump)
- 1 outlet Water Temperature sensor

- appropriate connection coupling, lines and seals including interface lines and fluid ports for GSE.

The WPP is part of the Reconfiguration R/F Kit, as well as the WOV, the WOV Electronic box and part of the piping. Hence, it is mounted on the MPLM during Active Flights only. The WPP is NOT ACTIVE during the launch, ascent, transfer and descent phases and during the on ISS phase, since on station the MPLM water loop is linked to the ISS loop. The WPP is ACTIVE on NSTS (Active Flights only).

The WPP operates upon application of 120 vdc power from the PDB (closing the dedicated RPC), and reception from the MDM of the ON command, which enables the Controller operation. The pump speed is 12350 RPM. The water flow will not be not less than 475 lb/h (215 kg/hr) for a resistance of not less than 18 psid (124.1 kPa).

4.8.1.2.1.3 Water On/Off Valve (WOV)

The WOV consists of a stepper motor actuated valve and an electronic unit designed to control the valve motor and to provide the interface with the PDB and the MDM.

The valve includes the Body Module (i.e. the structure containing the fluid), the Seat/Seal Module (to accommodate the valve seat), the Fluid Interface Module (providing the interface of the valve with the water loop lines), the Function Module, comprising the gears and motor. The motor is attached to the valve housing.

WOV actuation in OPEN or CLOSE position is performed by the external controller (NSTS or ISS), when required, sending the relevant commands to the MPLM MDM.

A step command from MDM starts the motor. It consists of a pulse train command (T = 12.5 msec, 50% duty cycle, 40 Hz) with as many pulses as needed (about 1350 + 400 steps) by the stepper motor to move the valve from one position to the other. The actuation time from the fully closed position to the fully open position (or from the fully open to the fully closed) is therefore about 88 s.

4.8.1.2.1.4 Water Modulating Valve (WMV)

The WMV hardware is the same adopted for the WOV; the WMV is used to perform a modulating function, and can assume any position between fully open and fully closed, as required, to maintain a fixed pressure drop across the R/F racks.

The WMV is active only during Active Flights. During Passive Flights, although still mounted on the MPLM, it is not operated and its status is not monitored.

During Active Flights, the valve is maintained in the NOT CLOSED position that optimizes the pressure drop across the R/F racks.

4.8.1.2.1.5 Differential Pressure Sensor (DPS)

The DPS provides continuous fluid pressure monitoring signal to the MDM.

The transducer uses a variable reluctance method to provide an output proportional to the input pressure differential.

The DPS provides continuous pressure monitoring signal for Modulating Valve control.

4.8.1.3.1 Passive Thermal Control Subsystem (PTCS)

The purpose of the PTCS is to assure the MPLM survivability in the space environment and to limit the heat leak/gain through the pressure shell. In particular, the PTCS prevents water freezing in the ATCS lines, maintains the internal surface temperatures above the dew point to prevent condensation and below 120°F (48.9°C) to protect the crew. The PTCS operates in both Active and Passive Flights. The MPLM PTCS consists of:

- MLI blankets
- Closed Cell Thermal Insulation Foam
- Thermal Control Coating
- Thermal Insulators
- Electrical Heaters

4.8.1.3.1.1 Thermal Insulation

MLI Blankets are installed between the MDPS and the pressurized shell to form a complete envelope. Each blanket consists of many layers of Double Aluminized Kapton (DAK) foils with Dacron net separators fixed with ball fasteners, double buttons or Velcro straps. The ball fasteners are adopted to fix the blankets that do not require removal during the mission, such as those surrounding the cylindrical shell. The double buttons connect the thermal blankets to the bulkhead interface belt straps. The Velcro straps are mainly adopted for the blankets that have to be removed on station to allow hatch opening.

The MLI Blankets are electrically grounded to the MPLM structure, and all layers inside the blanket are electrically bonded to maintain an equal electrical potential. The MLI thermal conductivity data is shown in Figure 4.8-4.

The ATCS loop pipings and components require thermal insulation to prevent vapor condensation on their external surfaces in order to avoid bacterial growth and protect the electronic equipment. Closed cell thermal insulation foam is used to protect the ATCS lines and components against vapor condensation. Connections, Valves, Expanders, and WPP insulation foam is accommodated within an external protection (NARMCO shells), which can be removed for inspection purposes. ISOTHERM C1 and Insul-K are the insulation foam materials.

The MDPS external surface finish (Thermal Control Coating) is selected to have specific thermal characteristics in order to minimize the heat transfer to the orbital environment and to maintain the MDPS temperature within the specified temperature limits (-250°F to 300°F [-157°C to 149°C]). High Thermal resistance washers are used as thermal insulators for thermal decoupling between two items interfacing mechanically, such as water loop piping and support structures, or between MPLM shell and MDPS.

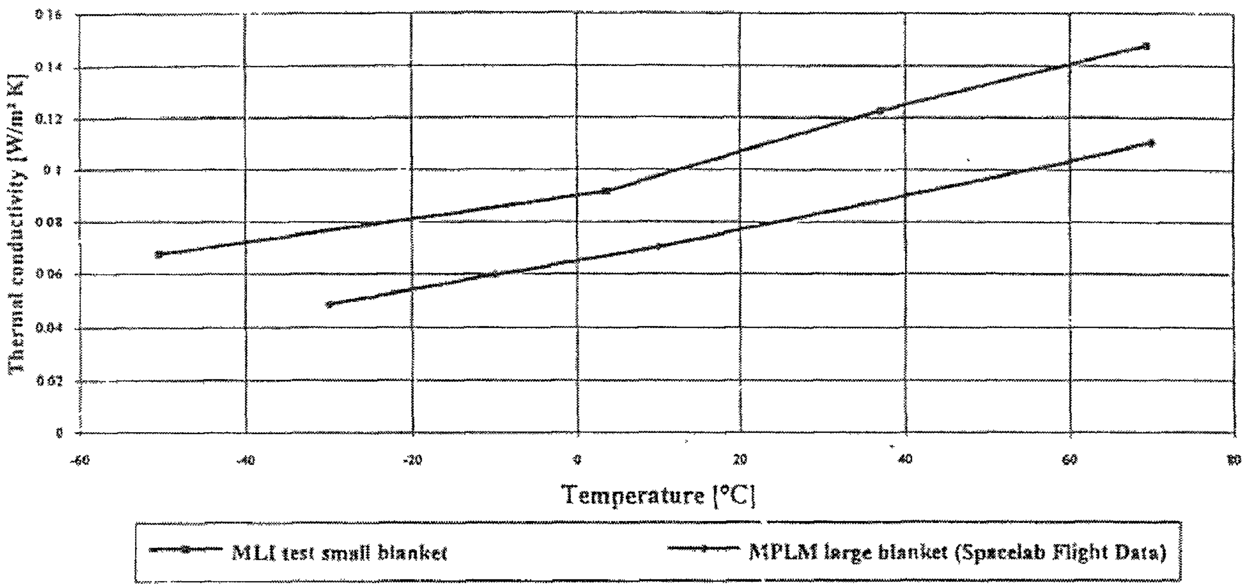


Figure 4.8-4. MLI Thermal Conductivity

4.8.1.3.1.2 Heaters

Two groups of electrical heaters are installed on the MPLM:

- PDA Heaters
- Shell heaters

PDA heaters prevent freezing in the ROFU PDA Q/Ds when there is no water circulation through the pipes, i.e. during MPLM deployment to/from the ISS and during nominal ISS operation, or in the NSTS cargo bay in contingency operation, in case of water loop malfunction.

The Shell Heaters are needed during both active and passive missions to avoid vapor condensation at the internal side of the pressurized shell and water freezing in the ATCS water loop and at the MPLM CBM Q/Ds.

The Bulkhead Q/Ds are always installed in the MPLM, during both Active and Passive Missions. Note that during Passive Missions water is removed from the loop, so freezing can occur only during Active Missions. When inside the NSTS cargo bay there is no water circulation through the Bulkhead I/F Q/D. Freezing is prevented by means of the 28 vdc Shell Heaters, located on the external side of the shell. During MPLM transfer phase, there is no water circulation through the Bulkhead I/F Q/D, and the Shell Heaters are unpowered. When attached to ISS, there is water circulation through the Bulkhead Q/Ds, which are now part of the Space Station internal environment, and no freezing is anticipated. Moreover, when inside the NSTS cargo bay and during Transfer, the Bulkhead Q/Ds are protected by MLI, and the dedicated Caps are installed on the Q/Ds, providing additional seal protection.

The MPLM forward cone Q/Ds are directly facing the external vacuum only during Passive Missions, when the ROFU PDA is not installed and the forward cone Q/Ds are used to seal the relevant unused forward cone penetrations. Note that during Passive Missions water is removed from the loop, so freezing cannot occur in these Q/Ds.

4.8.1.3.1.2.1 Payload Disconnect Assembly (PDA) Heaters

Two PDA-ROFU heater circuits are provided to prevent freezing of water in the ROFU supply and return lines when the MPLM water loop is not active. Each of these heater circuits dissipates 16 watts at a nominal voltage of 28 VDC. The Orbiter supplied voltage to these heaters can range between 24 and 32 VDC.

<u>Cargo bay operation:</u>

- during launch/ascent phase the PDA Heaters are OFF
- when the MPLM is active, under nominal conditions, water freezing in the ROFU PDA is prevented by water circulation. During active MPLM operation the PDA heaters are powered by the NSTS to prevent freezing in case of water loop contingency; the NSTS provides two 28 vdc power lines to the MPLM HCU
- after MPLM deactivation (before the deployment to ISS) or before MPLM activation (after deployment from ISS) the PDA heaters are powered by the dedicated Battery, which provides two 28 vdc Power lines to the MPLM HCU

<u>Deployment to/from ISS operation:</u>

- during the transfer phase the PDA heaters are powered by the dedicated Battery

<u>On station operation:</u>

- before MPLM activation and after MPLM deactivation, the PDA heaters are powered by the dedicated Battery
- when the MPLM is active, the battery is deactivated and PDA heaters are powered via the HCU by two separate chains
  - by the ISS, via a dedicated line (on Node 2) or via the PDB (on Node 1)
  - by the MPLM, via the PDB

4.8.1.3.1.2.2 Shell Heaters

The heaters are installed on the external side of the shell. The shell heaters are connected in parallel in two separate systems: 22 heater circuits powered at 28 vdc, sized to avoid water vapor condensation when the MPLM is in the orbiter cargo bay and 19 heater circuits powered at 120 vdc sized to avoid water vapor condensation when the MPLM is on the ISS. Each heater circuit is driven by a single thermostat.

The 28 vdc Shell Heaters are grouped, depending on their physical location, into 22 independent circuits, each one with 2 to 6 heaters in parallel. Each circuit is powered by a dedicated HCU 28 vdc power outlet, and has a thermostat to perform the On/Off control, allowing power supply to the relevant heaters in the circuit only when required to maintain the temperature in the required range. Therefore, each thermostat performs a duty-cycle control of its own circuit. The 22 heater circuits can be considered functionally divided in two separate chains (Chain#1 and Chain#2), each one being fed by a 28 vdc power line provided by NSTS and distributed by the MPLM HCU via dedicated outlets. The two chains do not implement a functional redundancy since both chains must be operative to provide the requested function.

The 120 vdc Shell Heaters are grouped, depending on their physical location, into 19 independent circuits, each one with 2 to 6 heaters in parallel. Each circuit is powered by a dedicated HCU 120 vdc power outlet, and has a thermostat to perform the On/Off control. The 19 heater circuits are considered functionally grouped in a single chain, fed by a 120 vdc power line provided by ISS and distributed by the MPLM HCU via dedicated outlets.

The 28 vdc and the 120 vdc Shell Heaters will not be supplied at the same time. The 28 vdc Shell Heaters can be powered only when MPLM is inside the NSTS cargo bay, while the 120 vdc Shell Heaters can be powered only when MPLM is attached to ISS.

Heating function is not required during the NSTS ascent and descent phases, when the MPLM is inside the NSTS cargo bay with the cargo bay boors closed. Freezing phenomena may occur when the MPLM is inside the NSTS cargo bay with the cargo bay doors opened, during the MPLM Transfer Phase between NSTS and ISS, or when the MPLM is attached to the ISS. The occurrence and the time after which the freezing phenomena occurs depends on the duration of the above mentioned phases.

Cargo bay operation:

- during launch and ascent phases, the shell heaters are OFF
- before MPLM MDM activation, the shell heaters are powered ON via the HCU by 2 redundant NSTS chains commanded by 2 NSTS SSPs as soon as the NSTS Payload Bay (PLB) doors are opened, after launch, or the ROEU is connected to the module. The shell heaters are powered off after module deactivation before ROEU disconnection for MPLM deployment to ISS or before NSTS PLB doors closure for descent. The shell heaters chains are independent from the module MDM and PDB.

Deployment to/from ISS operation:

- during the transfer phase the shell heaters are OFF

On station operation:

- when the MPLM is berthed on Node 1, the shell heaters are powered by the ISS via the HCU, which is connected to PDB RPC # 23; therefore the HCU and shell heaters activation follows the PDB activation
- when the MPLM is berthed on Node 2, the shell heaters are powered directly by the ISS via the HCU; in this case the HCU and shell heaters activation is independent from the PDB.

The HCU is described in further detail in Section 4.5.2.

5.0 CARGO ENVIRONMENTAL CONSTRAINTS

This section describes the natural and induced environments that will be experienced by the MPLM accommodated cargo during the various operational phases. The cargo design must be such that any possible cargo damage or malfunction due to the environmental conditions will not adversely affect the MPLM or the crew. Unless otherwise specified, all environmental constraints listed in this chapter are applicable to all cargo, regardless of the type.

5.1 ENVIRONMENT

The MPLM accommodated cargo must be capable of withstanding the environment described in the following paragraphs without loss of functionality or degradation of the cargo performance.

5.2 INDUCED ENVIRONMENT

The MPLM accommodated cargo must be capable of withstanding the induced environment described in the following paragraphs without loss of functionality or degradation of the performance.

5.2.1 Mechanical Environment

Integrated racks shall provide positive margin of safety when exposed to design values unless superceded by the results of the flight-specific CLA.

5.2.1.1 Acceleration

Payload equipment transported in the MPLM will experience the acceleration environment reported in Table 5.2-1 (based on hard-mounted conditions). The following constraints apply:

- the design values derived from the table will be superseded by the results from flight specific Coupled Loads Analysis (CLA)
- for on-orbit (on-station) conditions, the acceleration environment will be 0.2 g in any direction, when the attach points A, B, C and D are employed. For a tilted rack position, the rack will be subjected to the interface loads defined in SSP 41017 at the attach points I and J.

RSPs transported in the MPLM will experience the acceleration environment reported in JSC 28169.

In addition to the acceleration environment defined here, the user need also consider the crew induced loads defined in Section 5.5.1.

Table 5.2-1. Payload Equipment Load Factors (Equipment Frequency 35Hz)

Liftoff	X	Y	Z
(g)	±7.7	±11.6	±9.9
Landing	**X**	**Y**	**Z**
(g)	±5.4	±7.7	±8.8
Note: Load factors apply concurrently in all possible combinations for each event and are shown in the rack coordinate system defined in SSP 41017, Part 2, paragraph 3.1.3.			

5.2.1.2 Vibration

The vibration environment includes the effects of the following phenomena:

- acoustic noise
- random vibrations
- sinusoidal/shock

Racks shall meet the vibration requirements defined in SSP 41017.

5.2.1.3 Shock

The MPLM accommodated cargo may experience the ground handling shock environment described in Figure 5.2-1. The shock environment due to the on-station crew IVA is defined in SSP 30256.

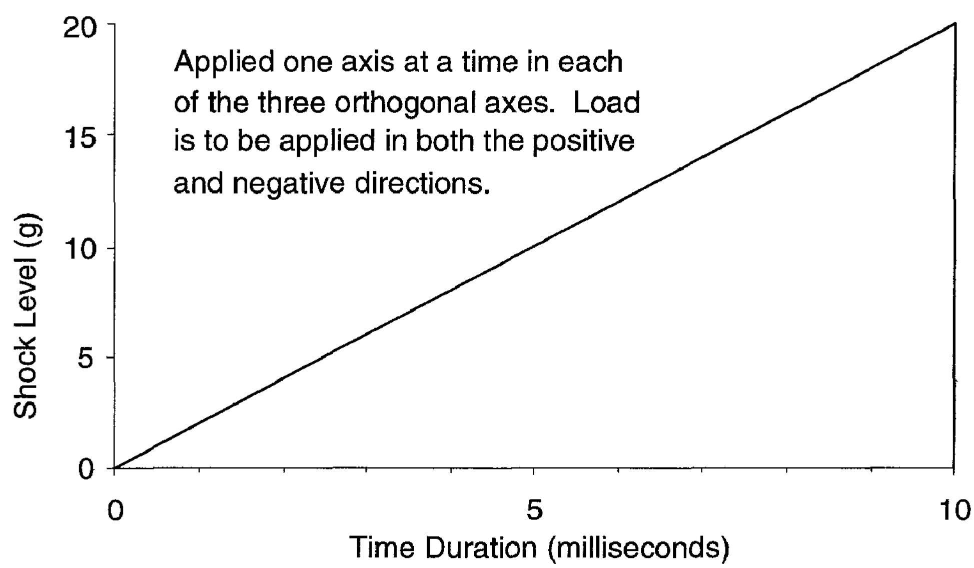


Figure 5.2-1. Ground Handling Shock Load

5.3 THERMAL ENVIRONMENT

The MPLM internal thermal environment is detailed in the following paragraphs.

5.3.1 Temperature

The MPLM accommodated cargo may be exposed to the temperature environment provided in Table 5.3-1 (these data include the worst-case assumptions that have driven the MPLM design). Table 5.3-2 shows the operational temperature environment.

Cargo shall be certified to be safe to withstand the temperatures defined in Table 5.3-1.

Table 5.3-1. Design Temperature Environment

Phase	Temperature	
	Active Flights 3)	Passive Flights
Pre-Launch	57.2 to 86 °F 14 to 30 °C	68 to 80 °F 20 to 26.7 °C
Launch/Ascent	68 to 86 °F 20 to 30 °C	65 to 80 °F 18.3 to 26.7 °C
On-Orbit (Orbiter Cargo Bay) 1)	60.8 to 114.8 °F 16 to 46 °C	50 to 111 °F 10 to 43.9 °C
On-Orbit (On-Station)	60.8 to 109.4 °F 16 to 43 °C	65 to 113 °F 18.3 to 45 °C
On-Orbit (Orbiter Cargo Bay) 2)	51.8 to 113 °F 11 to 45 °C	50 to 111 °F 10 to 43.9 °C
Descent/Landing	50 to 107.6 °F 10 to 42 °C	50 to 109 °F 10 to 42.8 °C
Post-Landing	50 to 107.6 °F 10 to 42 °C	60 to 100 °F 15.6 to 37.8 °C
Ferry-Flight	59.9 to 86 °F 15.5 to 30 °C	60 to 100 °F 15.6 to 37.8 °C

Notes:

1) This item also covers the Orbiter-to-ISS transfer phase (MPLM deployment), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.
2) This item also covers the ISS-to-Orbiter transfer phase (MPLM retrieval), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.
3) Design temperature ranges were derived from MLM-HB-AI-0001.

Table 5.3-2. Operational Temperature Environment

Phase	Temperature	
	Active Flights 3)	Passive Flights
Pre-Launch	TBD	70 to 74 °F 21.1 to 23.3 °C
Launch/Ascent	TBD	68 to 74 °F 20 to 23.3 °C
On-Orbit (Orbiter Cargo Bay) 1)	TBD	55 to 70 °F 12.8 to 21.1 °C
On-Orbit (On-Station)	TBD	70 to 90 °F 21.1 to 32.2 °C
On-Orbit (Orbiter Cargo Bay) 2)	TBD	62 to 74 °F 16.7 to 23.3 °C
Descent/Landing	TBD	62 to 74 °F 16.7 to 23.3 °C
Post-Landing	TBD	60 to 90 °F 15.6 to 32.2 °C
Ferry-Flight	TBD	60 to 90 °F 15.6 to 32.2 °C

Notes:

1) This item also covers the Orbiter-to-ISS transfer phase (MPLM deployment), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.
2) This item also covers the ISS-to-Orbiter transfer phase (MPLM retrieval), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.
3) Operational temperature ranges for active flights are TBD pending further definition of active flight scenarios.

5.3.2 Dew Point Temperature

Table 5.3-3 provides the maximum dew point for the various MPLM mission phases.

Cargo shall be certified to be safe to the dew points specified in Table 5.3-3.

Table 5.3-3. Maximum Dew Point Temperatures

Phase	Active Flights	Passive Flights
Pre-Launch	54.5°F 12.5°C	35°F 1.7°C
Launch/Ascent	54.5°F 12.5°C	35°F 1.7°C
On-Orbit (Orbiter Cargo Bay) 1)	54.5°F 12.5°C	35°F 1.7°C
On-Orbit (On-Station)	60°F 15.5°C	60°F 15.5°C
On-Orbit (Orbiter Cargo Bay) 2)	50°F 10°C	60°F 15.5°C
Descent/Landing	50°F 10°C	60°F 15.5°C
Post-Landing	50°F 10°C	60°F 15.5°C
Ferry-Flight	60°F 15.5°C	60°F 15.5°C

Notes:

1) This item also covers the Orbiter-to-ISS transfer phase (MPLM deployment), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.
2) This item also covers the ISS-to-Orbiter transfer phase (MPLM retrieval), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.

5.3.3 Pressure

The MPLM accommodated cargo will be exposed to the pressure environment provided in Tables 5.3-4 (data based on a nominal mission timeline and on expected external environmental conditions for design) and 5.3-5 (these data include all worst-case assumptions which have driven the MPLM design).

Cargo shall be certified to be safe to withstand the pressure defined in Tables 5.3-4 and 5.3-5.

Table 5.3-4. Pressure Environment (Nominal Data)

Phase	Pressure
Pre-Launch	13.9 to 15.2 psia 95.8 to 104.8 kPa
Launch/Ascent	13.9 to 15.2 psia 95.8 to 104.8 kPa
On-Orbit (Orbiter Cargo Bay) 1)	13.9 to 15.2 psia 95.8 to 104.8 kPa
On-Orbit (On-Station)	13.9 to 15.2 psia 95.8 to 104.8 kPa
On-Orbit (Orbiter Cargo Bay) 2)	13.9 to 15.2 psia 95.8 to 104.8 kPa
Descent/Landing	13.9 to 15.2 psia 95.8 to 104.8 kPa
Post-Landing	13.9 to 15.2 psia 95.8 to 104.8 kPa
Ferry-Flight	13.9 to 15.2 psia 95.8 to 104.8 kPa

Notes:

1) This item also covers the Orbiter-to-ISS transfer phase (MPLM deployment), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.

2) This item also covers the ISS-to-Orbiter transfer phase (MPLM retrieval), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.

Table 5.3-5. Pressure Environment (Contingency Data)

Phase	Pressure
Pre-Launch	13.9 to 15.2 psia 95.8 to 104.8 kPa
Launch/Ascent	0 to 15.2 psia 0 to 104.8 kPa
On-Orbit (Orbiter Cargo Bay) 1)	0 to 15.2 psia 0 to 104.8 kPa
On-Orbit (On-Station)	0 to 15.2 psia 0 to 104.8 kPa
On-Orbit (Orbiter Cargo Bay) 2)	0 to 15.2 psia 0 to 104.8 kPa
Descent/Landing	0 to 15.2 psia 0 to 104.8 kPa
Post-Landing	13.9 to 15.2 psia 95.8 to 104.8 kPa
Ferry-Flight	13.9 to 15.2 psia 95.8 to 104.8 kPa

Notes:

1) This item also covers the Orbiter-to-ISS transfer phase (MPLM deployment), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.
2) This item also covers the ISS-to-Orbiter transfer phase (MPLM retrieval), by assuming that the transfer operation occurs while the ISS maintains the nominal attitude.

5.3.3.1 Differential Pressure

5.3.3.1.1 Depressurization

The MPLM accommodated cargo shall withstand a maximum depressurization rate of 7.656 psi/min (880 Pa/s) without undergoing permanent structural deformation or functional degradation.

5.3.3.1.2 Repressurization

The MPLM accommodated cargo shall withstand a maximum repressurization rate of 6.96 psi/min (800 Pa/s) without undergoing permanent structural deformation or functional degradation.

5.3.3.2 Pressurized Containers/Pressure Vessels/Cargo Pressure Relief

Pressurized containers/pressure vessels to be stowed as payloads on the MPLM must meet the requirements of NASA-STD-5001 and NASA-STD-5003. Safety analyses of the integrated payload configuration shall be performed to ensure that structural positive pressure levels can be satisfied if the experiment gas is introduced into the MPLM in a failure mode or an operational mode. Pressurized gas systems with a total expanded gas volume exceeding 400 liters at Standard Conditions shall limit the gas flow after a single failure to less than 240 SLPM after 400 liters at Standard Conditions has been released to the cabin air.

5.3.3.3 Atmosphere Composition

The MPLM accommodated cargo shall withstand the module atmosphere defined in Table 5.3-6.

Table 5.3-6. Atmospheric Environment

	Nominal	Maximum
O_2 Partial Pressure	2.83 to 3.35 psia 19.5 to 23.1 kPa	3.63 psia 25.0 kPa
CO_2 Partial Pressure	0.058 psia < 0.4 kPa	0.232 psia 1.6 kPa

5.3.4 Module Closeout

The MPLM accommodated cargo will experience the environmental conditions at module closeout shown in Table 5.3-7.

Table 5.3-7. Module Closeout Environment

Temperature	65 - 75°F 18.3 - 23.9°C
Pressure	14.8 - 14.9 psia 102.0 - 102.7 kPa
Maximum Dew Point	< 35°F [1)] < 1.7°C

Note:

1) This value applies to initial Passive flights. Starting with UF-3, the maximum dew point will be < 62°F (16.7°C) (TBC).

5.4 ELECTROMAGNETIC ENVIRONMENT

The cargo accommodated inside the MPLM shall withstand the electromagnetic environment defined for the Orbiter (ICD-A-21350) and the ISS (SSP 30243).

5.5 HUMAN FACTOR ENVIRONMENT

5.5.1 Intra-Vehicular Activity Crew Induced Loads

The MPLM accommodated cargo may be subjected to an inadvertent kick or push-off. The maximum crew-induced loads dimensioning for cargo design are given in Table 5.5-1.

Cargo shall be able to withstand kickloads as defined in Table 5.5-1.

Table 5.5-1. Crew Induced Loads

Crew System or Structure	Load Type	Load	Load Direction
Tether	Concentrated Pull (Tension)	170 lbf (756 N) limit 340 lbf (1512 N) ultimate	Longitudinal Axis
Tether Attach Points	Concentrated	170 lbf (756 N) limit 340 lbf (1512 N) ultimate	Any Direction
Handrail Attach Points	Concentrated	250 lbf (1112 N) ultimate	Any Direction
Handholds, Handrails	Concentrated	125 lbf (556 N) limit 250 lbf (1112 N) ultimate	Any Direction
Foot Restraints (2 feet)	Concentrated, at the plate surface	100 lbf (445 N) limit 150 lbf (667 N) limit	Any Direction Any Direction
	Torsion	150 ft lbf (203 N-m)	Torsion Vector Normal to Foot Plate
Levers, Handles, Operating Wheels, Controls	Push or Pull concentrated on most extreme tip or edge	50 lbf (222 N) limit 75 lbf (334 N) ultimate	Any Direction
Small Knobs	Twist (Torsion)	11 ft lbf (15 N-m) limit 17 ft lbf (23 N-m) ultimate	Any Direction
Cabinets and any normally exposed equipment	Concentrated, applied by flat round surface with an area of 4 in^2 (0.1016 m^2)	125 lbf (556 N) limit 175 lbf (778 N) ultimate	Any Direction
Window Assembly	Blunt object impact	125 lbf (556 N) limit	Any Angle of Incidence

5.5.2 Translation Paths

Minimum cross sectional dimensions of translation paths for one crewmember in light clothing shall be as shown in Figure 5.5-1 for integrated MPLM cargo.

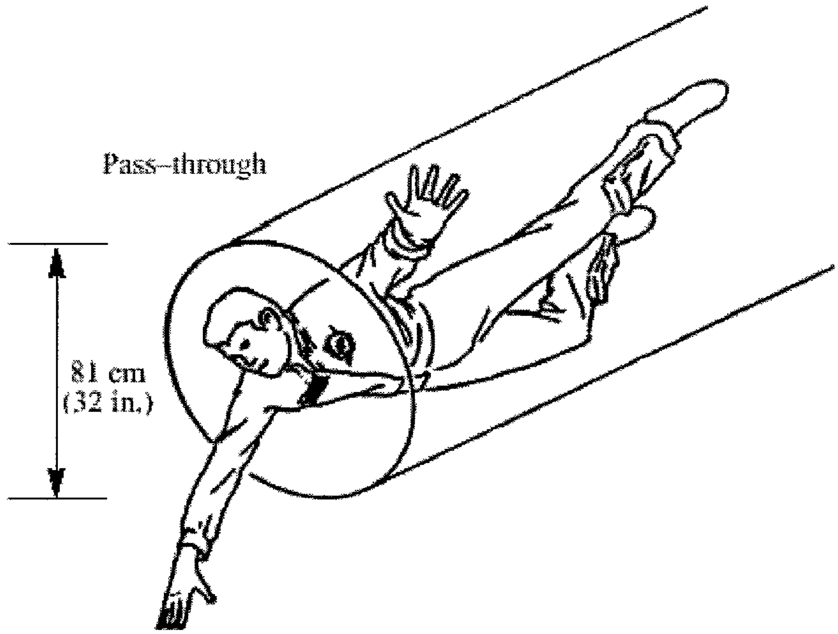


Figure 5.5-1. Minimum Translation Path Dimensions

5.5.3 Surface Temperature

The temperature of any integrated rack surface with which the crew may have incidental or unlimited contact shall be in the range 0°F (-18°C) to 120°F (49°C) during all operational phases.

5.5.4 Surface Finish

All materials, mechanical fasteners, electrical connectors/components, etc. of payloads that interface with the MPLM shall have surface finishes that meet the requirements of NSTS 1700.7B. SSP 30233 may be utilized as a guide.

5.5.5 Illumination

The MPLM internal environment is provided with a nominal illumination level corresponding to 108 lux measured at a distance of 30 in. (0.762 m) from the floor, equidistant from the port and starboard rack front surfaces. Any other special illumination shall be provided by the cargo.

5.5.6 Materials and Processes

The cargo to be transported to/from the ISS by the MPLM shall be designed by using materials and processes as specified in the document NSTS 1700.7B.

5.5.7 Cleanliness

All cargo surfaces shall be clean to the visibly clean sensitive level, in accordance with the document JSC-SN-C-0005.

5.5.8 Contamination

The MPLM accommodated cargo shall withstand the particulate environment corresponding to the Class 100000, as per Figure 5.5-2. The MPLM ventilation system implements 11800 μin. (300 μm) filters to prevent particulate and debris collection inside the Cabin Fan and the air loop ducting.

The MPLM accommodated cargo shall withstand the worst-case trace gas concentration environment defined in JSC 20584.

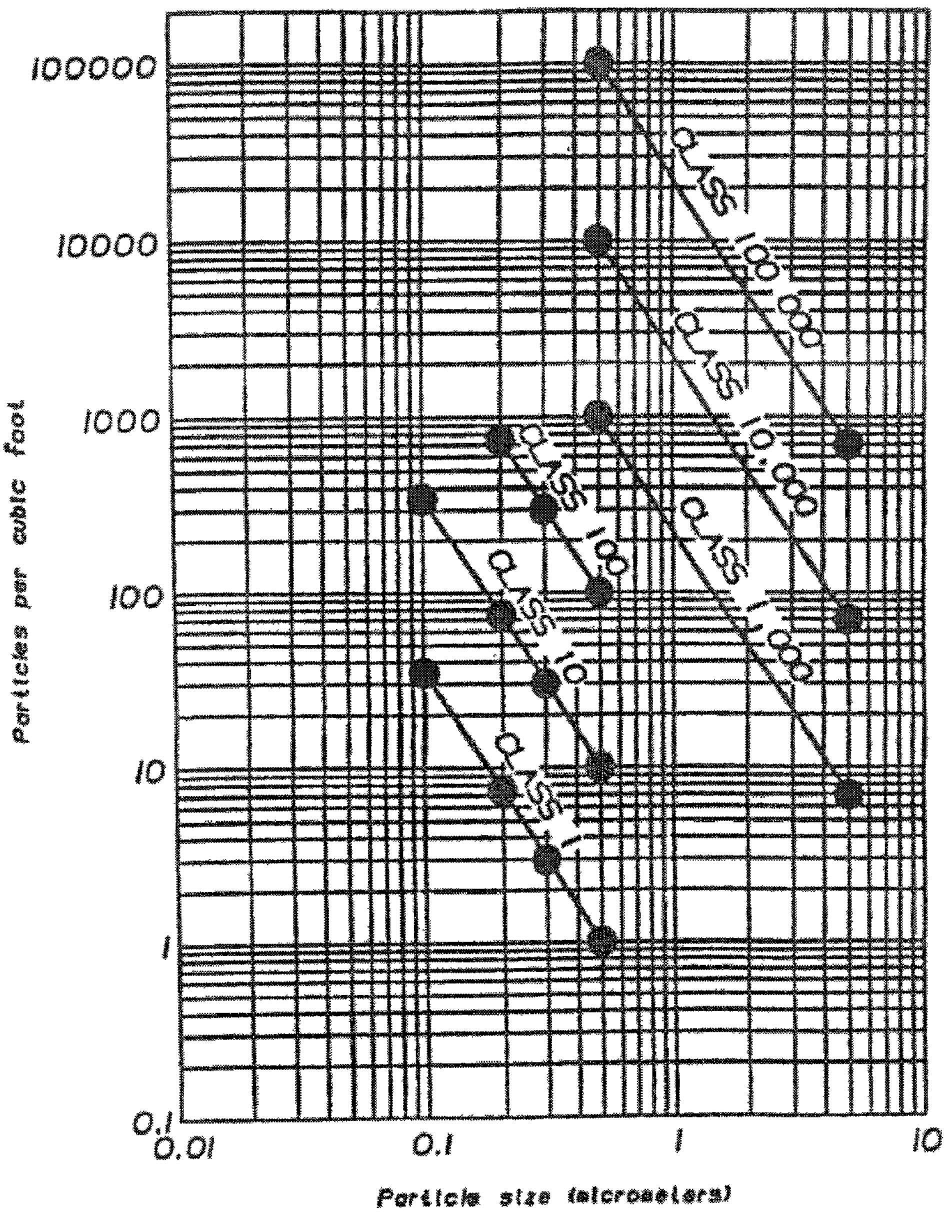


Figure 5.5-2. Contamination Environment

Note: The particle concentrations shown in this figure are defined for class purposes only and do not necessarily represent the size distribution to be found in any particular situation.

5.5.9 Ionizing Radiation

The MPLM accommodated cargo shall withstand an ionizing radiation environment of 2.7 rad silicon per 10 days.

5.6 FIRE SUPPRESSANT

The MPLM used fire suppressant will be carbon dioxide (CO_2); the maximum CO_2 concentration after a fire suppression event will be less than 0.23 psia (1.59 kPa).

6.0 OPERATIONS

Because the objective of MPLM is to support the ISS assembly and resupply, the MPLM performs on-orbit operations with a minimum of resource requirements from the NSTS and from ISS. In particular, MPLM operations:

- guarantee an adequate environment for Cargo and R/F transportation
- guarantee the execution of cargo loading/unloading operations

The MPLM is zero-failure tolerant. No in-flight maintenance is performed. Safety critical functions (positive pressure relief, negative pressure relief) are two-failure tolerant in order to prevent catastrophic events involving damage to the crew, the ISS, or the NSTS.

Activities on the ISS are carried out manually by the crew, jointly by the crew and ground controllers, or automatically by a plan execution function in conjunction with the ISS. The crew has sufficient command and control data on board to support operations during loss of communication with ground facilities. Display ISS capabilities allow the crew to monitor and control critical functions (such as pressure, fire) and to display these data from different pressurized modules at the same time. The same concept applies to NSTS operations.

Automatic activation/deactivation and checkout sequences (with confirmation breakpoints) are available to relieve the crew from step by step operations. Alternate manual activation/deactivation and checkout is always possible, if preferred. In general, manual procedures are intended mostly for ground operations, especially for checkout purposes, although automatic procedures are available on ground as well as in-flight.

6.1 CARGO INTEGRATION

6.1.1 MPLM Stand Alone Ground Processing

The MPLM Stand Alone Ground Processing includes all activities carried out at KSC on all three MPLM Flight Units from their initial delivery, through the Rack Integration, and during Post-Landing Turnaround.

6.1.1.1 Inspections

The purpose of this activity is to visually verify the integrity of the MPLM and detect possible damages occurred during transportation or during the flight.

The module external and internal sides are visually inspected and photographs may be taken of any relevant element.

Inspections are performed in the MPLM initial post delivery processing and during routine post-landing turnaround operations.

The MPLM is configured as follows:

- MPLM installed horizontally in the ERS
- AAC removed (internal inspection only)

- Hatch open (internal inspection only)
- PAF and LWPF installed
- MPLM powered off
- Drag on lights and air conditioning available

No specific GSE is required for inspections.

6.1.1.1.1 External Inspection

During external inspections MPLM external sections (forward and aft cones, cylinder, AAC, hatch) are inspected. The module is closed and installed in the ERS.

6.1.1.1.2 Internal Inspection

During internal inspections MPLM internal sections (forward and aft cones internal side, Stand-offs, rack locations) are visually inspected. The AAC is removed, the hatch is open and the LWPF elements are installed. Drag on lights and air conditioning are provided.

6.1.1.2 Checkout

The purpose of this activity is to check the copper path of MPLM subsystems and external interfaces with both NSTS and ISS and to verify the correct subsystems functionality.

Checkouts are performed before the first mission after transportation at KSC (Post Delivery Verification Test, PDV), after maintenance (Pre-Integration Checkout, PIC) and after rack installation.

During the tests, the MPLM and relevant Fluid Ground Support Equipment (FGSE) are commanded, controlled and monitored by TCMS (Test, Checkout and Monitoring System). For the tests requiring NSTS interfacing the MPLM ROEU PDA is connected to the TCMS via the Orbiter Docking System (ODS).

The various checkouts are executed following as close as possible the NSTS and Node activation and deactivation sequences. This approach allows storage of the data acquired during the tests for operations support.

The MPLM configuration is the following:

- MPLM installed horizontally in the ERS
- AAC removed
- Hatch open
- PAF/LWPF installed
- External air conditioning available
- MPLM powered on

6.2 MECHANICAL GROUND SUPPORT EQUIPMENT (MGSE)

The MGSE is designed to provide support to the MPLM system, its subsystems, and various equipment elements. It is not specifically designed for the purpose of MPLM payload support. However, it has payload support capability in the areas of transportation and access support.

The MGSE consists of the operational means used for the handling, transportation, servicing, alignment, and environmental protection of the assembled MPLM, with or without payloads installed in the racks.

MGSE servicing equipment fills, drains, and leak checks the fluid loops of the thermal control system.

An overview of MGSE is listed below. A more detailed description is given in K-SS-09.5.1, MPLM Ground Processing Plan.

- Lightweight Personnel Floor (LWPF)
- Personnel Access Floor (PAF)
- Element Rotation Stand (ERS)
- Rack Insertion Device (RID)
- Weight and CG End Effector (W&CG EE)
- Dryden Early Access Platform (DEAP)
- Removable End Access Platform (REAP)
- Ground Air Conditioning Unit (GACU)
- Hatch Access Structure (HAS)

<u>Structural</u>

- Element Rotation Stand (ERS). This is the stand that the MPLMs reside in for Space Station Processing Facility (SSPF) Test Operations. There are 2 stands in the highbay. ERS 1 currently houses MPLM FM1. ERS 2 currently houses FM2.

<u>Fluids</u>

- There is currently no Fluid Support Equipment configured, since it is not required for Passive MPLM Missions. Once FM3 arrives (First Active MPLM), additional Fluids Support Equipment will be configured for Active MPLM Powered Operations.

6.3 ELECTRICAL GROUND SUPPORT EQUIPMENT (EGSE)

Mission Integration Document 82K05072 identifies the required GSE and provides information concerning layout and cabling. EGSE is staged at the proper footprint in preparations for PDV. An overview of EGSE is listed below. Specific details are provided in K-SS-09.5.1, Section 3.6.

Power

- One Trilectron 120 vdc Power Supply which is currently configured for ERS 1 (MPLM FM1).
- One 120 vdc MPLM Ground Power Supply which is currently configured for ERS 2 (MPLM FM2).
- *One 28 vdc Power Supply which supports both test stands for NSTS Powered Operations.*

C&DH

- Data Bus Tester (DBT), used to monitor the MPLM 1553 bus traffic during powered operations.
- TCMS Local Bus FEPS. There are currently 2 local bus (1553) FEPS, one for each ERS stand. They can be cross configured if required to support either stand.
- MDM Interface Simulator (MIS). Currently only used during Post Delivery Verifications to simulate the active elements of the MPLM which are not installed for Passive Missions.

6.4 GROUND OPERATIONS

The MPLM launch preparations are performed in the SSPF located in the Industrial Area at KSC. The MPLM arrives at the SSPF in an Alenia-provided transportation container upon initial delivery or in the Multi-Mission Support Equipment (MMSE), or canister, following an ISS mission. The MPLM is processed into the SSPF through the facility airlock and cleaned for entry into the highbay cleanroom.

Once inside the highbay, the MPLM is removed from the canister/container using a 30-ton cab-operated bridge crane and the Cargo Element Lifting Assembly (CELA). The module is then placed in the ERS and secured for processing.

For initial delivery of an MPLM, the module undergoes PDV to ensure that all systems are functioning properly following transportation. For a returning ISS mission, racks that have been returned from orbit are removed from the MPLM following installation in the ERS. If necessary, the MPLM is converted from the passive configuration to the active configuration, or vice versa, by removing or installing the Active Thermal Mission Kit (ATMK).

For all MPLM missions, racks are loaded through the 96-inch AAC using the RID and W&CG EE. After rack installation, the RSPs are installed, and the MPLM subsystems powered-up and checked out to verify no damage occurred during Rack/RSP installation. The AAC is then installed, an AAC heater test performed, and any required flight software is installed and checked out. Utilization experiment operations are then performed, just prior to MPLM closeouts. *For active missions, a Post Rack Installation Test (PRIT) is also performed* prior to RSP installation to verify active rack interfaces to the MPLM.

The MPLM is then transferred to the Launch Package Integration Stand (LPIS). For active flights, the shell heater battery will be installed and, if required, Cargo Integration Test Equipment (CITE) testing will be performed. The MPLM will then undergo final closeouts. Weight and balance testing will be performed as the MPLM is removed from the LPIS and installed into the canister for transportation to the launch pad and installation into the PLB of the Orbiter.

6.4.1 MPLM/Payload Integration

After the MPLM is processed in the SSPF, it is transported to the launch pad where it is vertically installed into the Orbiter PLB. During active missions, freezers are installed into the MPLM in the SSPF, but conditioned cargo must be installed in the MPLM during Late Access Operations (L-7 to L-4 days). Late Access Operations are performed at the launch pad in the Payload Changeout Room (PCR) with the MPLM powered and the PLB doors open. Similarly, conditioned cargo is removed post-flight during Early Access Operations (R+3 to R+6 days) while the MPLM is still in the Orbiter PLB.

When landings occur at KSC, the primary landing site, conditioned cargo is removed in the OPF with the PLB doors open. When landings occur at the alternate landing site [i.e., Dryden Flight Research Center (DFRC)], conditioned cargo is removed at the Mate/Demate Device (MDD) with the PLB doors closed.

For the MPLM to successfully support the requirements of conditioned cargo, it must have a near continuous supply of power, data and cooling resources available during all ground operations in which the MPLM contains conditioned cargo. Various configurations use both Orbiter and GSE resources and are described herein. MPLM interfaces with the Orbiter in the PLB are described in ICD-A-21350, SSP 21350 Active MPLM and in SSP 21351 Passive MPLM.

6.4.1.1 Reconfiguration

Reconfiguration of MPLM includes the activities required to modify the flight unit from active to passive, or vice versa, and to configure the module harness for berthing to Node 1 or Node 2. The items involved in these activities are the ROFU PDA, the R/F kit for the fluid interface, battery and electrical harness.

Every new configuration is completely checked out before the beginning of the next mission preparation during the Pre-Integration Checkout.

6.4.1.1.1 Active to Passive/Passive to Active Reconfiguration

During active to passive reconfiguration the R/F kit is removed (or installed) during passive to active reconfiguration.

The R/F kit includes the WPP and associated NARMCO shell, the Water on/off valve (WOV: electronic unit, valve motor and relevant interconnecting harness), the MBE including the relevant I/O branch and NARMCO shell, the male Q/D necessary to fix the hanging branch to the bracket once the MBE and relevant piping has been removed, the WOV to WPP outlet piping, and the WOV to the loop first Q/D inlet piping.

The R/F kit is present only in the Active Flight and is installed or removed according to the MPLM mission configuration. If the MPLM does not change configuration from one flight to another, the WPP is serviced as required in the module.

The ATCS piping present in both the passive and active configurations is deserviced during the active to passive reconfiguration.

R/F kit removal/installation activities will be performed with TCS loop empty, which implies servicing after Flexible Hose (FH) installation (passive to active reconfiguration) or deservicing before FH removal (active to passive reconfiguration).

6.4.1.1.2 Node 1 to Node 2/Node 2 to Node 1 Reconfiguration

When the MPLM is attached to ISS Node 2, the shell heater power is derived directly from ISS 120 vdc Auxiliary Power feed. When the MPLM is attached to Node 1, the 120 vdc Auxiliary Power is not directly provided, therefore power to the HCU is supplied through the PDB using the R/F #5 dedicated RPC, since in the flights for which berthing to Node 1 is foreseen such R/F is not manifested (passive flights or active flights with less than 5 manifested R/Fs).

The connection of the HCU to the PDB to allow berthing to Node 1 is obtained with proper cable harness configuration. Because the MPLM shipping configuration is the one compatible with Node 2, reconfiguration is likely to be performed during initial post shipping processing, as well as between flights where berthing to different nodes is required.

6.4.1.2 Cargo/Rack Installation/Removal

The PAF/LWPF will be removed, the MPLM rotated 90 degrees (keel starboard) for floor and ceiling rack installation and the PAF/LWPF re-installed. The RID and W&CG EE will be configured to remove racks from the RHA, perform rack weight and balance testing and install racks into the MPLM. After all floor and ceiling racks are installed, the PAF will be removed, the MPLM rotated back to keel down and the PAF re-installed. The RID and end effector will then be used to remove racks from RHA's, perform weight and CG and install port and starboard racks.

6.4.1.3 Non Agenzia Spaziale Italiana (ASI) Flight Items Installation/Deinstallation

The non ASI flight items to be mounted on the MPLM are:

- ROEU PDA
- ROFU PDA
- FRGF
- Space Vision System (SVS) Targets

The PDAs are the ROEU and ROFU on the MPLM side of the interface. The ROFU PDA is mounted only if the MPLM is configured for active flight. The SVS targets are 25 reflecting surfaces designed to be mounted on the MPLM external surface to enhance radar tracking.

These activities are performed with the MPLM installed in the ERS that provides the required accessibility. No module rotation is assumed necessary for performing these tasks. Following the SVS installation, an optical survey is performed to verify proper target installation.

6.5 FLIGHT OPERATIONS

The nominal flight operations describe all the anticipated mission activities to achieve the objective of the specific MPLM mission. These operations are primarily automatic processes for simplicity and to limit crew work-load as much as possible.

In general, no Ground support, besides routine, is necessary to support nominal operations.

The nominal flight operations allow for the execution of activities identified in the following phases:

In the POST-LAUNCH PHASE the nominal operations allow for the successful execution, as far as MPLM functionalities are concerned, of:

- Launch/Ascent
- MPLM Operations in the NSTS cargo bay (Post-Launch)
- MPLM AF Activation and Checkout while in NSTS (Post-Launch)
- MPLM AF Operations while in NSTS
- MPLM PF Operations while in NSTS
- MPLM AF Deactivation while in NSTS (Post-Launch)
- ISSA/NSTS Activities prior to MPLM Deployment
- MPLM Deployment to ISSA (with SSRMS or SRMS)

In the ON-STATION PHASE the nominal operations allow for the successful execution, as far as MPLM functionalities are concerned, of:

- ISSA/MPLM Configuration for Activation
- MPLM on-station Activation and Checkout
- MPLM AF/PF on-station Activation and Checkout
- MPLM on-station Operations
- MPLM Ingress
- Cargo Unloading/Loading (including racks, R/Fs)
- MPLM Egress
- MPLM AF/PF on-station Deactivation
- ISSA/MPLM Configuration for Unberthing

In the PRE-LANDING PHASE the nominal operations allow for the successful execution, as far as MPLM functionalities are concerned, of:

- MPLM Transfer to NSTS
- MPLM Operations in NSTS cargo bay (Pre-Landing)
- MPLM AF Activation and Checkout while in NSTS (Pre-Landing)

- MPLM AF Deactivation while in NSTS (Pre-Landing)
- Descent/Landing

The details about nominal flight operations analysis and procedures are contained in MLM-RP-AI-0047, MLM-RQ-AI-0003, and MLM-RP-AI-0177.

6.5.1 Flight Phases

6.5.1.1 Ascent

The Launch Phase starts with the lift off and ends when the NSTS exits the atmosphere.

MPLM nominal internal temperature at launch is 72°F (22.2°C). The passive thermal protection is designed to maintain internal temperature above the dew point to avoid condensation and to prevent water freezing in critical areas.

MPLM nominal internal pressure at launch is 14.90 psi (102.7 kPa). The maximum launch internal pressure is 15.1 psi (104.1 kPa). The PPR function is designed to maintain a positive differential pressure across the primary structure below 15.2 psi (104.8 kPa) when the module is isolated.

During launch/ascent as well as during descent/landing no MPLM active operations are required. During launch the MPLM provides and maintains the following functions:

- Negative pressure relief function
- Positive Pressure relief function
- Passive Thermal Protection
- Water loop within nominal pressure range (AF only)
- Structural and physical I/F with NSTS (sustain in general the launch environment)

No procedures are needed during this phase for MPLM.

6.5.1.2 MPLM Operations in the NSTS Cargo Bay

This Phase starts with the NSTS cargo bay doors opening and ends with the MPLM ready for transfer.

The passive thermal protection is designed to maintain internal temperature above the dew point to avoid condensation and to prevent water freezing in critical areas.

The PPR function is designed to maintain a positive differential pressure across the primary structure below 15.2 psi (104.8 kPa) when the module is isolated.

Heater power and data provisions are made available from the NSTS to the MPLM from the time the NSTS PLB doors are opened and until the MPLM is removed from the NSTS after launch/ascent.

6.5.1.3 Descent

The MPLM configuration and functionalities are the same as per MPLM Launch/Ascent (see Section 6.5.1.1).

6.5.1.4 Pre-launch Refrigerator/Freezer (R/F) Support and Late Access Activities

Late access activities are required to install cold cargo in the R/F racks and to support the relevant active MPLM Operations at the launch pad. The cold cargo installation is performed prior to PLB door closure. The Cargo Handling Equipment Kit (CHEK) is used to handle conditioned cargo from/to the R/F racks in vertical orientation. KSC personnel support items (lights, air conditioning, support floor, fire suppression, etc) are used for activities support inside MPLM. The above activities and the relevant deconfiguration/closeout operations will be completed within L-80 hours, while after the P/L bay doors closure the support is provided until approximately T-20 minutes to comply with the maximum R/F power off time of 6 hours. After the final hatch closeout, a leak check of the relevant Gask-o-Seal is performed.

The MPLM is configured as follows:

- MPLM in P/L bay (vertical)
- Hatch open
- AAC installed
- MPLM powered on
- R/F activated
- temperature stabilized (P/L bay doors open)
- Payload Late Access Kit (PLAK) and Payload Late Access Platform (PLAP) integrated

Integration between PLAK and PLAP is completed prior to hardware arrival at the PCR.

The following GSE are required:

- PLAK
- PLAP
- Pad MPLM cooling servicers
- Hatch GSE support

6.5.1.5 Post-Landing Early Access

This support is similar to the one used for pre-launch operations. An external and mobile GSE (service GSE), equivalent to the one required for pre-launch, supports the R/F racks via the Orbiter T-0 during Orbiter towing to OPF (KSC) or MDD (DFRC). The service GSE is connected to the Orbiter within 2 hours after landing, and remains connected until the cold cargo is removed from the R/F racks.

The MPLM is configured as follows:

- MPLM installed in cargo bay (horizontal orientation)
- Hatch open
- AAC installed
- MPLM powered on
- R/F rack activated from external GSE via T-0 interface
- LWPF Supporting Structures and PAF installed

In case of NSTS landing at KSC, the early access occurs at OPF with the PLB doors open. Access to the MPLM is via Removable End Access Platform (REAP).

In case of NSTS landing at DFRC, the early access occurs at the Mate Demote Facility with the PLB doors closed. Access to the MPLM is via the HAS and the Dryden Early Access Platform (DEAP). In this case, the access to the Orbiter cargo bay is through the cabin airlock.

The following GSE are required:

- Mobile cooling servicers
- REAP
- HAS
- DEAP

6.6 CONTINGENCY OPERATIONS

6.6.1 Flight Operations

Contingency operations encompass all the activities that have to be performed should a major contingency event occur.

Contingency operations include both the detection of, and response to, the contingency events. Contingencies are defined as Emergency and Warning conditions that require immediate crew involvement. As these contingencies are time critical, having impacts on the crew, the isolation process should be as quick as possible. The recovery may be handled and supported by the Ground as well. Contingencies normally lead to a risk for the achievement of mission objectives. If critical for the crew, they are analyzed before the mission and at least the detection and isolation procedures (if not the recovery) are well established.

The main contingencies identified for the flight operations are the following:

- Response to Fire (both on ISS and in NSTS)
- Fire Prevention (both on ISS and in NSTS)

- Inconsistent WPP Activation (ISS only)
- Response to high pressure
- Loss of PPR function (NSTS)
- ISS Response to DP/DT (on ISS only)
- Depressurization and Repressurization
- Response to Loss of Pressure (both on ISS and in NSTS)
- Response to Toxic Spill (ISS only)
- Loss of cooling
- Loss of Communication
- Loss of PDB Communication
- Loss of power
- Mission Abort

6.6.2 Ground Operations

The Contingency Ground Operations describe the activities that have to be performed on the MPLM when the Module is installed in the NSTS Cargo Bay in the following cases:

- Launch delay
- Scrub Turnaround
- Launch termination

The requirements and procedures relevant to the above contingencies are provided in MLM-RP-AI-0174 and MLM-RQ-AI-0004.

6.7 FLIGHT ANOMALY RESOLUTION

The flight anomalies identify a subset of contingencies that do not require an immediate crew response, because they do not lead to the loss of a critical function. They are defined as Caution and Advisory messages. Most of the anomalies are handled with the FDI, both in terms of detection and identification and in terms of immediate response (isolation). It is not always necessary to restore the lost or degraded MPLM functionality. When this is the case, the function will be fully restored on the ground.

The typical malfunctions are addressed in the FDI and Caution and Warning section of the document. Because anomalies will be mission peculiar, no additional information about anomaly resolution is provided.

The details about malfunction and anomalies resolution are contained in MLM-RP-AI-0047, MLM-RQ-AI-0003, and MLM-RP-AI-0177.

7.0 DESIGN REQUIREMENTS FOR PAYLOADS

7.1 DESIGN REQUIREMENTS DEFINITION

This Section defines design requirements imposed on all experiment equipment carried aboard MPLM. The purpose of these requirements is to ensure physical and functional compatibility between the experiment and the MPLM/Orbiter during all phases of an MPLM mission and to minimize the risk of damage and/or hazardous conditions which would affect the safety of personnel or equipment. It is not the purpose of these requirements to ensure that the experiments will meet their scientific and functional objectives. The experiment objectives, design, development, and performance will be the responsibility of the experiment developer and/or user (subject to mission peculiar constraints which may be imposed for any particular mission). Any deviations from the requirements of this Section will only be considered following a formal request from an experimenter to NASA.

7.2 MECHANICAL DESIGN REQUIREMENTS

7.2.1 Crew Interface

7.2.1.1 General

The requirements of this Section apply to the design of all experiment equipment that has a man-machine interface. Where specific requirements are not presented or referenced, the following documents may be used as design guides:

- NASA-STD-3000
- MIL-STD-1472B
- MSC-07387.

7.2.1.2 Loose Equipment Restraint

Means must be provided for convenient temporary containment or restraint of all loose experiment equipment that cannot be contained or restrained by MPLM provisions. This includes items which become loose as a result of disassembly or transfer on-orbit. All fasteners, latches, retainers, etc. that are handled by the crew on-orbit must be made captive.

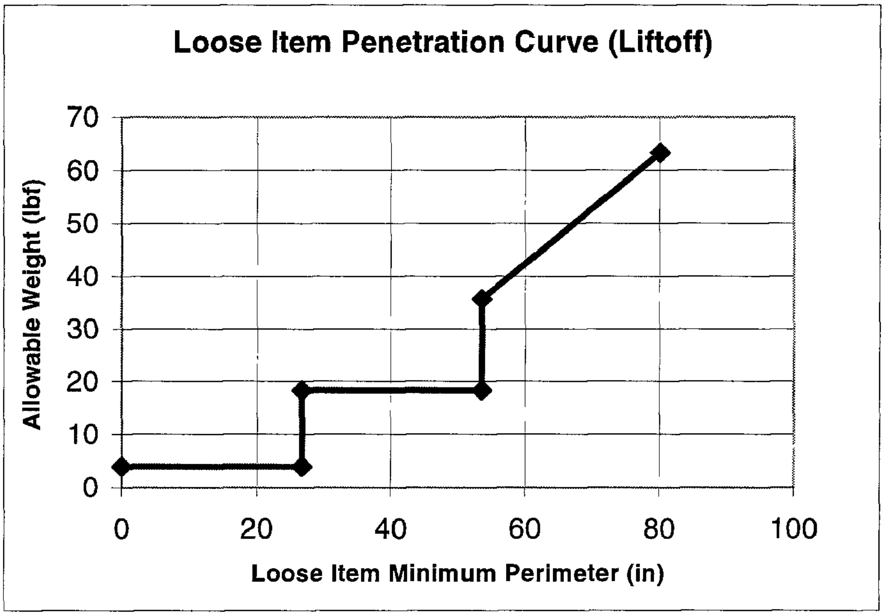
When the crew has to leave the MPLM in an emergency case, loose items might not be stowed or restrained securely. Thus, during reentry and landing, loose items could cause penetration damage to the MPLM. For items equal to or less than 5 kg, no additional restraint other than 'on-orbit' considerations are necessary. However, to minimize potential non-safety related damage to the MPLM and other payload systems, larger items must have a means of positive security when not in transit (i.e., from un-stowing to transfer, etc.). All loose items over 5 kg shall be reviewed against Figure 7.2-1 to ensure that no potential safety hazard occurs. If the items being un-stowed fall below the curve, no further design considerations are necessary. Figure 7.2-1 defines the penetration hazard as a function of the impacting equipment mass and its contact surface perimeter. This perimeter is understood to be the equivalent triangular perimeter of the contacting surface cross section.

Equipment outside the boundary curve has to be adequately restrained during all handling phases. The equipment must be designed to meet the loads resulting from a 7.2 feet/second Orbiter landing sink rate with a factor of safety of 1.4 when restrained in an emergency location; i.e., a location other than the normal ascent or entry/landing location. Equipment restrained in a normal launch/landing configuration must be designed for a 9.6 feet/second Orbiter landing sink rate.

Furthermore, loose experiment equipment must not be allowed to come in contact with the MPLM during flight maneuvers. The payload user must meet the requirements specified in SSP 50005.

Perimeter (in.)	Allowable Weight (lb)	
	Liftoff	Landing
p = 0.00 p < 26.7	3.96	5.43
p ≥ 26.7 p < 53.5	18.3	25.2
p ≥ 53.5 p ≤ 80.0	w = 1.05(p) – 20.6 [1]	w = 1.43(p) –27.7 [1]

[1] p = perimeter (in.), w = weight (lb)



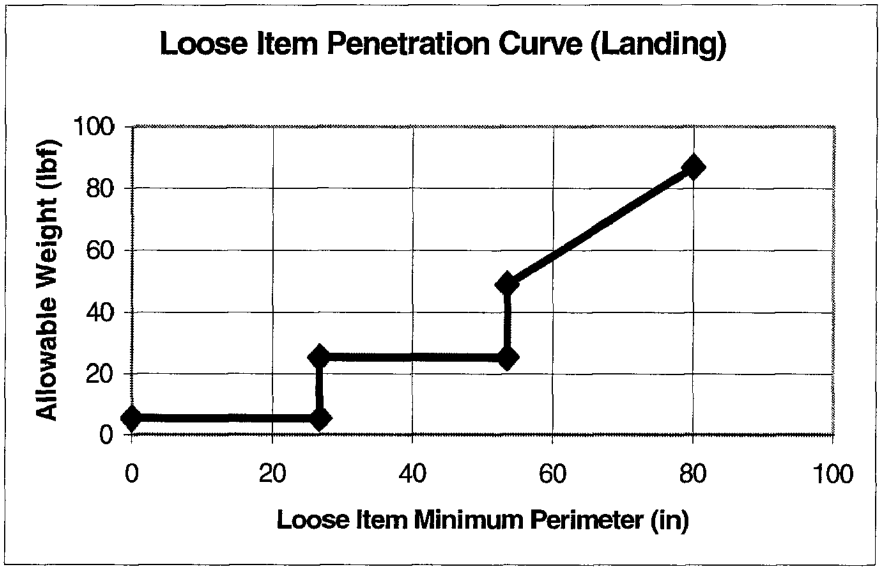


Figure 7.2-1. Loose Items Penetration

7.2.1.3 Area Closures

Experiment equipment shall be designed to prevent loose equipment such as small tools, screws, bolts, nuts, fuses, etc. from drifting into inaccessible areas. An inaccessible area is defined as any area with an opening that will accept a loose and floating object of 10 mm in diameter which cannot be retrieved or captured by using a retrieval tool and/or a crewman reaching his hand and forearm into the area.

7.3 GROUND SUPPORT EQUIPMENT (GSE) INTERFACE REQUIREMENTS

Experiment GSE which interface with MPLM flight and/or GSE hardware must meet the same requirements as Experiment - MPLM flight interface requirement.

7.4 TEST AND INTEGRATION

7.4.1 Test Requirements

The requirements for testing experiment equipment prior to integration with MPLM are located in the Operations and Maintenance Requirements and Specifications (OMRS) document, File II, Volume II – P350.

7.4.2 Integration and Checkout Requirements

The requirements for integration of experiment equipment with the MPLM and the requirements for experiment checkout during and subsequent to integration are located in OMRS File VIII, Volume I – U5112 and File VIII, Volume III – U024.

8.0 SAFETY

The cargo to be transported to/from the ISS in the MPLM shall meet the requirements of NSTS 1700.7B and shall not contaminate the MPLM, ISS, or NSTS.

APPENDIX A.1 ABBREVIATIONS & ACRONYMS

AAC	Aft Access Closure
ACBM	Active Common Berthing Mechanism
ACS	Atmosphere Control System
ADA	Automatic Data Acquisition
ADA-RTE	Automatic Data Acquisition Run-Time Environment
AF	Active Flight
AIO	Analog Input/Output
APCU	Assembly Power Converter Unit
APS	Auxiliary Power Supply
ARIS	Active Rack Isolation System
ARS	Atmosphere Revitalization System
ASI	Agenzia Spaziale Italiana
ASL	Atmosphere Sampling Line
ATCS	Active Thermal Control Subsystem
ATMK	Active Thermal Mission Kit
AVS	Avionics System
BAT	Battery
BIA	Bus Interface Adapter
BIT	Built-in Test
BITE	Built-in Test Equipment
BLSA	Brace Locking System Assembly
C&DH	Command and Data Handling
CBM	Common Berthing Mechanism
CCA	Circuit Card Assembly
CCBD	Configuration Control Board Directive
CCSDS	Committee Consultative Space Data Systems
CCW	Counterclockwise
CDA	Cabin Depressurization Assembly
CELA	Cargo Element Lifting Assembly
CFA	Cabin Fan Assembly
CG	Center of Gravity
CHEK	Cargo Handling Equipment Kit

CITE	Cargo Integration Test Equipment
CLA	Coupled Loads Analysis
CMU	Command and Monitoring Unit
CSCI	Computer Software Configuration Item
CTB	Cargo Transfer Bag
CTBE	Cargo Transfer Bag Equivalent
CW	Clockwise
DA	Depressurization Assembly
DAK	Double Aluminized Kapton
DBT	Data Bus Tester
DCN	Document Change Notice
DDCU	DC-to-DC Converter Unit
DEAP	Dryden Early Access Platform
DFRC	Dryden Flight Research Center
DI	Discrete Input
DIO	Discrete Input/Output
DO	Discrete Output
DOF	Degrees of Freedom
dP	Delta Pressure
DPS	Differential Pressure Sensor
DSD	Duct Smoke Detector
ECLSS	Environmental Control and Life Support System
ECP	Engineering Change Proposal
ECS	Environmental Control Subsystem
EEL	Emergency Egress Lighting
EEPROM	Electrically Erasable Programmable Read Only Memory
EGSE	Electrical Ground Support Equipment
ELPS	Emergency Lighting Power Supply
ELS	Emergency Lighting Strip
EMC	Electromagnetic Compatibility
EPDC	Electrical Power Distribution and Conditioning
ERS	Element Rotation Stand
EVA	Extravehicular Activity

F/T	Feed-through
FDI	Failure Detection and Isolation
FDS	Fire Detection and Suppression
FEPS	Front End Processor
FGSE	Fluid Ground Support Equipment
FH	Flexible Hose
FRGF	Flight Releasable Grapple Fixture
FTP	File Transfer Protocol
FWD	Forward
GACU	Ground Air Conditioning Unit
GLA	General Luminary Assembly
GSE	Ground Support Equipment
HAS	Hatch Access Structure
HCU	Heater Control Unit
HEA	Handrail Equipment Anchors
HLA	High Level Analog
HLCMI	High Level Command and Monitoring Interface
HTC	Human Tended Configuration
I/F	Interface
I/O	Input/Output
ICD	Interface Control Document
IDD	Interface Definition Document
in.	Inch
IOCC	Input/Output Card Controller
IOCU	Input/Output Control Unit
IMV	Inter-Module Ventilation
ISOV	Inter-Module Ventilation Shutoff Valve
ISPR	International Standard Payload Rack
ISS	International Space Station
ISSA	International Space Station Assembly
IVA	Intra-Vehicular Activity

JEM	Japanese Experiment Module
JSC	Johnson Space Center
kg	Kilogram
kPa	Kilopascals
KSC	John F. Kennedy Space Center
lb	Pound
LLA	Low Level Analog
LLS	Launch and Landing Site
LPIS	Launch Package Integration Stand
LWPF	Lightweight Personnel Floor
MBE	Metal Bellows Expander
MDD	Mate/Demate Device
MDE	Mission Dependent Equipment
MDM	Multiplexer-Demultiplexer
MDMBF	Multiplexer-Demultiplexer Boot and Diagnostic Firmware
MDPS	Meteoroid and Debris Protection System
MELFI	Minus Eighty Degree Laboratory Freezer for ISS
MGSE	Mechanical Ground Support Equipment
MIP	Mission Integration Plan
MIS	MDM Interface Simulator
MLI	Multi-Layer Insulation
mm	Millimeter
MMC	MPLM MDM CSCI
MMSE	Multi-Mission Support Equipment
MPEV	Manual Pressure Equalization Valve
MPLM	Multi-Purpose Logistics Module
MRK	Moisture Removal Kit
MSFC	George C. Marshall Space Flight Center
MUX	Multiplexer
N/A	Not Applicable
Ni/Cd	Nickel Cadmium
NASA	National Aeronautics and Space Administration

NPRA	Negative Pressure Relief Assembly
NPV	Non-Propulsive Vent
NSTS	National Space Transportation System
ODA	Orbiter Disconnect Assembly
ODS	Orbiter Docking System
OIU	Orbiter Interface Unit
OMRS	Operations and Maintenance Requirements and Specifications
ORU	Orbital Replacement Unit
OTM	Output Transformation Matrix
P/L	Payload
PAF	Personnel Access Floor
PBA	Portable Breathing Apparatus
PCBM	Passive Common Berthing Mechanism
PCN	Program Control Number
PCR	Payload Changeout Room
PDA	Payload Disconnect Assembly
PDB	Power Distribution Box
PDV	Post Delivery Verification Test
PF	Passive Flight
PFE	Portable Fire Extinguisher
PHC	Permanent Human Configuration
PIC	Pre-Integration Checkout
PLAK	Payload Late Access Kit
PLAP	Payload Late Access Platform
PLB	Payload Bay
POST	Power-On Self Test
PPR	Positive Pressure Relief
PPRA	Positive Pressure Relief Assembly
PRCB	Program Requirements Control Board
PRIT	Post Rack Installation Test
PTCS	Passive Thermal Control Subsystem
PVLR	Pre-Verification Loads Review
PWR	Power

Q/D	Quick Disconnect
R/F	Refrigerator/Freezer
R&MA	Restraints and Mobility Aids
RAB	Rack Attachment Block
RCA	Remote Control Assembly
RCS	Reference Coordinate System
REAP	Removable End Access Platform
REV	Revision
RFR	Refrigerator/Freezer Rack
RHA	Rack Handling Adapter
RID	Rack Insertion Device
RMS	Remote Manipulator System
ROEU	Remote Operated Electrical Umbilical
ROFU	Remote Operated Fluid Umbilical
RPC	Remote Power Controller
RPM	Revolutions per Minute
RSP	Resupply Stowage Platform
RSR	Resupply Stowage Rack
RT	Remote Terminal
RTN	Return
SCMI	Serial Command and Monitoring Interface
SDIO	Standard Input/Output
SIR	Standard Interface Rack
SLF	Sampling Line Filter
SLPM	Standard Liters Per Minute
SRMS	Shuttle Remote Manipulator System
SPDA	Secondary Power Distribution Assembly
SSOV	Sampling Line Shutoff Valve
SSP	Standard Switch Panel
SSPF	Space Station Processing Facility
SSQD	Self Sealing Quick Disconnect
SSRMS	Space Station Remote Manipulator System
SSW	Serial Switch

STEA	Seat Track Equipment Anchors
SVS	Space Vision System
TBC	To Be Confirmed
TBD	To Be Determined
TCMS	Test, Checkout, and Monitoring System
TCS	Thermal Control Subsystem
THC	Temperature and Humidity Control
TPS	Total Pressure Sensor
UF	Utilization Flight
UIP	Utility Interface Panel
USOS	United States On-Orbit Segment
VAB	Vehicle Assembly Building
VAR	Verification Analysis Review
vdc	Volts Direct Current
W&CG EE	Weight and Center of Gravity End Effector
WMV	Water Modulating Valve
WOV	Water On/Off Valve
WPP	Water Pump Package
ZSR	Zero G Stowage Rack

APPENDIX A.2 APPLICABLE AND REFERENCE DOCUMENTS

The following is a list of applicable and reference documents. All documents contained in this list are applicable as of the latest revision at the time of publication of this IDD.

KSC

Document Number	Title
82K05072	Mission Integration Document SPPF
K-SS-09.5.1	MPLM Ground Processing Plan

MSFC

Document Number	Title
ISS-MPLM-PLAN-005	MPLM Sustaining Engineering Plan
MSC-07387	Crew Stations Specification
UOTAT-49	MPLM Structures Task - Vol. 1: Analysis Archival Documentation

JSC

Document Number	Title
D683-43437–1–3	Illustrated Parts Breakdown Lab A Restraints and Mobility Aids (RMA)
ICD-A-21350	Shuttle Orbiter/Multi-Purpose Logistics Module (MPLM) Cargo Element Interfaces
JSC 20584	Spacecraft Maximum Allowable Concentrations for Airborne Contaminants
JSC 28169	Interface Control Document for the International Space Station Resupply Stowage Platform 1 Stowage System to Cargo Providers
JSC-SN-C-0005	NASA Specification Contamination Control Requirements for the Space Shuttle Program
NSTS 14046	Payload Verification Requirements
NSTS 1700.7B	Safety Policy and Requirements for Payloads Using the Space Transportation System
NSTS 37329	Structural Integration Analyses Responsibility Definition for Space Shuttle Vehicle and Cargo Element Developers
SSP 30233	Space Station Requirements for Materials & Processes
SSP 30242	Space Station Cable/Wire Design and Control Requirements for Electromagnetic Compatibility
SSP 30243	Space Station Specification, System Requirements for Electromagnetic Compatibility
SSP 30256	Extravehicular Activity (EVA) Standard Interface Control Document
SSP 30257	Intravehicular Activity Restraints and Mobility Aids Standard Interface Control Document

SSP 30312	Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program
SSP 30482, Vol. 1	Electrical Power Specification Standard
SSP 30573	Space Station Fluid Procurement and Use Specification
SSP 30575	Space Station Interior and Exterior Operational Location Coding System
SSP 41017	Rack to Mini Pressurized Logistics Module Interface Control Document (Parts 1 and 2)
SSP 41155	Refrigerator/Freezer Rack to Mini Pressurized Logistics Module Interface Control Document
SSP 41164	Italian Mini-Pressurized Logistics Module
SSP 42007	USOS to MPLM ICD
SSP 50005	International Space Station Flight Crew Standard
SSP 50251	ARIS-to-Module Interface Control Document
SSP 57000	Pressurized Payloads Interface Requirements Document
SSP 57005	ARIS-to-Pressurized Payload Interface Control Document
SSP 57006	ARIS Users Guide
SSP 57007	International Standard Payload Rack (ISPR) Structural Integrators Handbook

Military/NASA Standards and Specifications

Document Number	Title
MIL-STD-1472B	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1553B	Digital Time Division Command/Response Multiplexed Databus
NASA-STD-3000	Man-Systems Integration Standards
NASA-STD-5001	Structural Design and Test Factors of Safety for Spaceflight Hardware
NASA-STD-5003	Fracture Control Requirements for Payloads Using the Space Shuttle
NHB 8060.1	Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion

Alenia

Document Number	Title
MLM-DD-AI-0001	Software Design Document for the MPLM MDM CSCI
MLM-HB-AI-0001	MPLM Cargo Accommodation Handbook
MLM-HB-AI-0002	MPLM Operations Handbook
MLM-IC-AI-0014	MPLM Mechanical ICD Report
MLM-MA-AI-0004	Software User's Manual for the MPLM MDM CSCI
MLM-RP-AI-0013	MPLM Mass Properties
MLM-RP-AI-0047	MPLM Orbital Operations Analysis and Requirements
MLM-RP-AI-0174	MPLM Inputs to Launch/Landing Site Procedures
MLM-RP-AI-0177	MPLM Orbital Operations Procedures and Data Inputs
MLM-RP-AI-0552	Passive MPLM Validated Dynamic Model Reduction and OTM Generation
MLM-RQ-AI-0003	MPLM Command & Control and FDI Requirements
MLM-RQ-AI-0004	MPLM Ground Processing Requirements: inputs to OMRS
MLM-SS-AI-0011	Software Requirements Document for the MPLM MDM CSCI

Drawings:

683-60581	Locker Assembly, Stowage System
SEG33111805	M01 Bag Assembly
SEG33111806	M02 Bag Assembly

APPENDIX B MATH MODELS

B.1 INTRODUCTION

Because of the importance of mathematical models in verifying the MPLM system for flight, this appendix has been provided to aid the user in both developing mathematical models for use in verifying the MPLM system for flight, and in performing design analyses using MPLM mathematical models.

Section B.2 of this appendix provides information on obtaining MPLM mathematical models for design analyses. Section B.3 describes the structural mathematical models and their interfaces, while Section B.4 provides similar data for the thermal mathematical models. Additional information is provided in Reference 1. (Sustaining plan)

B.2 MODEL REQUESTS

The MPLM mathematical models can be made available upon request to aid the user in developing proper loads and thermal environments. These requests should be made through TBD. (Note – hope to incorporate process through web, so web address would be provided here.) Figure B.2-1 contains a model request form that should be completed and mailed to (e-mail address here). To ensure the models are provided in time for any unique user analyses, please provide X weeks for development and delivery of the relevant mathematical models.

TBD

Figure B.2-1. Model Request Form

B.3 STRUCTURAL MATHEMATICAL MODELS

This section provides information on structural mathematical models to be used for user and MPLM System analyses. The MPLM shell model for launch/landing and on-orbit analyses are described in Section B.3.1. This section also provides information on model interfaces. Section B.3.2 describes the rack knee brace models currently available for MPLM analyses. Verification requirements for user models delivered for MPLM verification analyses are summarized in Section B.3.3.

B.3.1 MPLM Shell Model

Two models of the MPLM are available for design and verification analyses. A launch and landing model is available for coupled loads analyses and is expected to be the most useful for user design analyses. Additionally, the on-orbit model is also available for on-orbit design analyses should it be deemed necessary.

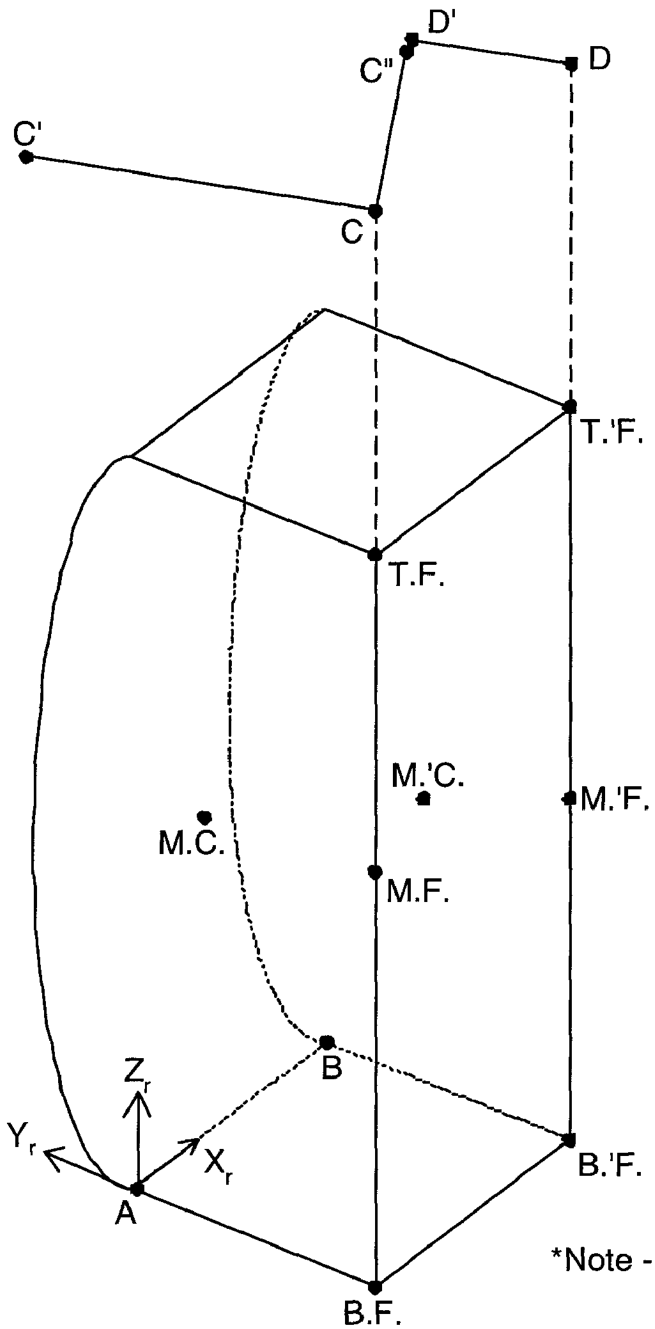
Alenia developed the reduced MPLM shell structural models from a detailed, test verified, NASTRAN finite element model. These reduced models are documented in References 2 and 3. The models are in Craig-Bampton reduced format. Currently, no finite element models are available for design or verification analyses. The reduced models contain all interface points necessary for coupling with the orbiter, racks, and ISS. Table B.3-1 contains the interface points for the orbiter, including the remotely operated fluid and electrical umbilicals. Table B.3-2 contains the rack interface locations. Notice that the shell interfaces are defined in local rack coordinate systems. The local rack coordinate system and interface locations are graphically depicted in Figure B.3-1. Table B.3-3 contains the on-orbit interfaces, including the grapple fixtures.

Users who request the MPLM models for their design analyses will be delivered the shell models and sufficient information on proper model usage. This information will include not only the interface description from above, but also check data, e.g., unconstrained normal models and model mass properties, to ensure the user has received the correct model and is able to duplicate the check data.

Table B.3-1. MPLM-to-Orbiter Interface Locations

Grid Point Identification	Description	Interface Position (in.)[1]		
		X	Y	Z
990101	Port Stabilizer Trunnion	63.6001	-94.00	14.0
990102	Starboard Stabilizer Trunnion	63.6001	94.00	14.0
990103	Port Primary Trunnion	256.3301	-94.00	14.0
990104	Starboard Primary Trunnion	256.3301	94.00	14.0
990105	Keel Trunnion	161.9301	0.00	-95.0
990201	Port ROFU	47.7501	-68.04	-8.6
990202	Starboard ROEU	47.7501	68.04	-8.6

[1] In MPLM coordinates. Add 1000 inches to X position values and 400 inches to Z position values to place in orbiter coordinate system.



TF - Top Front Left
MF - Middle Front Left
BF - Bottom Front Left
MC - Middle Center Left
T'F - Top Front Right
M'F - Middle Front Right
B'F - Bottom Front Right
M'C - Middle Center Right
● - Indicates geometric point of interest

*Note - *Not* drawn to scale.

Figure B.3-1. MPLM Rack Coordinate Systems

Table B.3-2. Rack-to-MPLM Interface Geometry and Degrees of Freedom (DOF)

Fitting Identification	Interface Location (in.)[1]			DOF
	X_r	Y_r	Z_r	
A	0.0000	0.0000	0.0000	X_r, Y_r, Z_r
B	39.3000	0.0000	0.0000	Y_r, Z_r
C'	-0.0902	0.6709	77.6421	X_r, Y_r, Z_r
C"	37.8295	0.6709	77.6421	X_r, Y_r, Z_r
D'	39.3898	0.6709	77.6421	X_r, Y_r, Z_r

[1] The rack coordinate system shall be used as the output system at these MPLM interface locations.

Table B.3-3. MPLM On-Orbit Interface Locations

Grid Point Identification	Description	Interface Position (in.)		
		X	Y	Z
990301	-Y Grapple Fixture	87.874	50.0	73.43
990302	+Y Grapple Fixture	87.874	310.0	73.43
	TBD – Power bolt locations from PCBM model			

B.3.2 Knee Brace Models

The knee brace provides the structural interface between the ISS racks (or rack like hardware) and the MPLM shell. Because of the wide tolerance on the upper attach location, these models are provided separately to ensure proper model coupling with the MPLM shell. Figure B.3-2 graphically depicts a typical knee brace model. The three knee brace models are documented in Reference 2. Users requiring a unique knee brace model should contact TBD. Brief descriptions of the three model versions currently available are provided below.

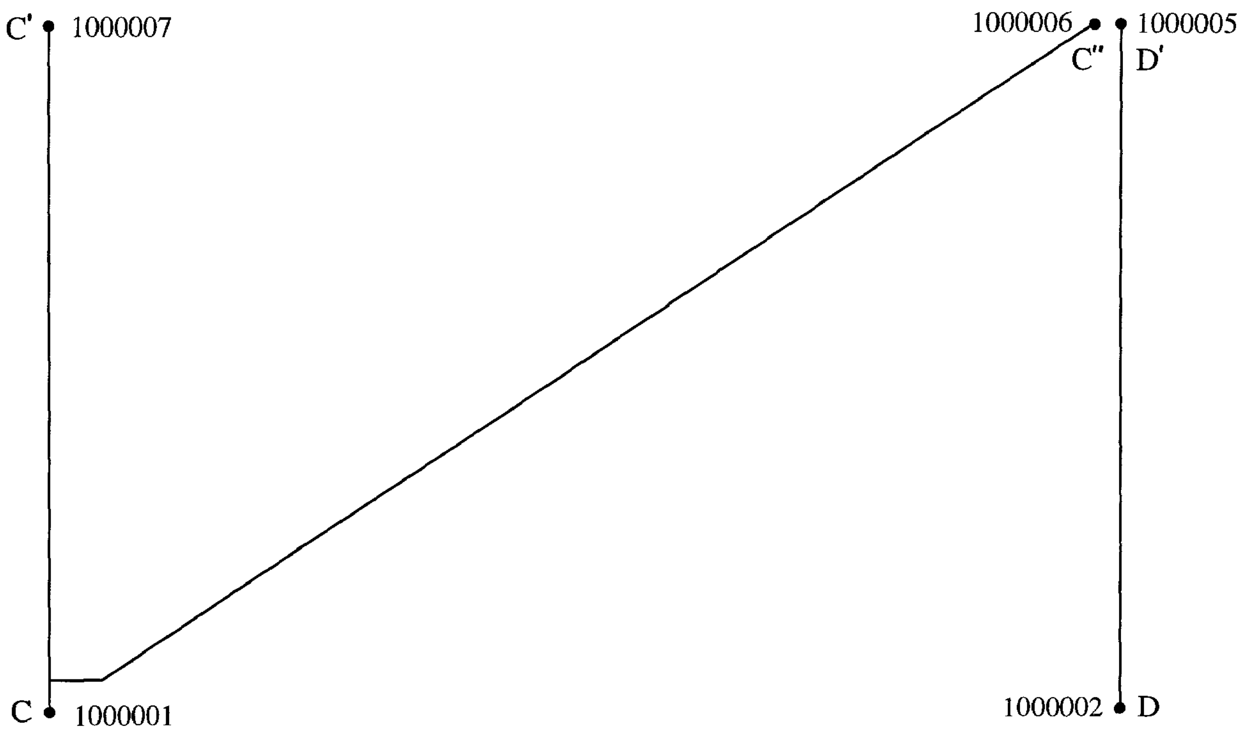


Figure B.3-2. Knee Brace Model

B.3.2.1 US Element Racks

Racks developed for use in US elements (e.g., ISPR and ExPRESS) have the knee brace Z dimension in line with the MPLM shell. The knee brace interfaces for these type racks are presented in Table B.3-4.

Table B.3-4. NASA Rack-to-Knee Brace Interfaces

Interface Position	Grid Point ID	Input Coordinate System	Interface Location in Rack Coordinates (in.)			Output Coordinate System
			X	Y	Z	
C	1000001	3	-0.0900	-24.4843	77.6421	3
D	1000002	3	39.3898	-24.4843	77.6421	3
C'	1000007	3	-0.0902	0.6709	77.6421	3
C"	1000006	3	37.8295	0.6709	77.6421	3
D'	1000005	3	39.3898	0.6709	77.6421	3

B.3.2.2 NASDA Racks

Racks developed for use in the Japanese Experiment Module (JEM) will have interfaces based on the NASDA racks. The knee brace model interfaces for these racks are provided in Table B.3-5.

Table B.3-5. NASDA Rack-to-Knee Brace Interfaces

Interface Position	Grid Point ID	Input Coordinate System	Interface Location in Rack Coordinates (in.)			Output Coordinate System
			X	Y	Z	
C	1000001	3	-0.09055	-23.9763	77.2439	3
D	1000002	3	39.3897	-23.9763	77.2439	3
C'	1000007	3	-0.0902	0.6709	77.6421	3
C"	1000006	3	37.8295	0.6709	77.6421	3
D'	1000005	3	39.3898	0.6709	77.6421	3

B.3.2.3 Rack Stowage Platform (RSP)

The RSP was developed to carry cargo packed in soft bags. The knee brace model interfaces to the RSP is provided in Table B.3-6.

Table B.3-6. RSP-to-Knee Brace Interfaces

Interface Position	Grid Point ID	Input Coordinate System	Interface Location in Rack Coordinates (in.)			Output Coordinate System
			X	Y	Z	
C	1000001	3	-0.0900	-23.9800	76.5900	3
D	1000002	3	39.3900	-23.9800	76.5900	3
C'	1000007	3	-0.0902	0.6709	77.6421	3
C"	1000006	3	37.8295	0.6709	77.6421	3
D'	1000005	3	39.3895	0.6709	77.6421	3

B.3.3 Verification Loads Analysis Model Requirements

After the completion of the rack design analyses, a verification loads analysis will be performed. The verification loads analysis cycle begins with the NSTS Pre-Verification Loads Review (PVLR) at approximately L-11 months. Integrated math models are due at least two weeks before the PVLR so that the MPLM model integrator has adequate time to ensure the models are properly configured for the verification loads analysis.

Generic templates and requirements for model test verification are provided in NSTS 14046 and NSTS 37329. It is the rack integrator's responsibility to coordinate mathematical model test verification, including internal components (e.g., experiments), with the Shuttle Structures Working Group. Because the coupled MPLM model is integrated by a single model integrator, additional requirements above those documented in NSTS 14046 and NSTS 37329 are delineated here to ensure a smooth verification loads analysis cycle.

Per NSTS 37329, the final measured weight and CG of the actual integrated flight rack shall be within +/- 50 lbs and +/- 1 inch CG of the math models mass properties. If these conditions are not met, the rack integrator shall contact the MPLM integrator to determine if any additional analysis is necessary.

B.3.3.1 Delivery Format

Before delivery to the MPLM model integrator, the rack integrator is responsible for integrating the knee brace models discussed in Section B.3.2 with their rack model. The integrated rack model shall be delivered in Craig-Bampton modally reduced form (see Reference 4) and shall contain the 14 MPLM boundary Degrees of Freedom (DOF) in the order and position as defined in Table B.3-5. U. S. Customary engineering units shall be used (length in inches, force in pounds-force, time in seconds) unless prior approval for alternate units has been given by the MPLM model integrator. The fixed interface mode set should be truncated to 70 Hz, but in no case should the number of kept modal DOF exceed 36 without prior coordination with the MPLM model integrator.

The model shall be provided in ASCII format with at least 16 digits of accuracy. The preferred delivery form is an MSC NASTRAN OUTPUT4 file using Fortran format (1P,3E23.16).

The preferred model transfer method is by way of the ***telnet*** using File Transfer Protocol (FTP). If the rack integrator so chooses, the model may be delivered via Electronic Mail or on a 1.44 Mb floppy (DOS format) mailed to the MPLM model integrator. A pilot model transfer will be made two weeks prior to the official model delivery date to ensure that the model delivery system functions satisfactorily. Deviations from these delivery format guidelines shall be coordinated with the MPLM model integrator well in advance of the model delivery.

B.3.3.2 Analytical Quality

A static gravity check execution should be made with only the MPLM interfaces constrained to ensure that the model obeys Newton's second law. Specifically, the rack integrator should ensure that no reaction forces exist except at the structural boundary. The integrated rack model mass properties should be compared to the best available hardware mass properties to verify that the model's mass and CG truly represent the physical hardware.

The integrated rack model should be reasonably free of constraints, as demonstrated by good rigid body (or free-free) modes. Appropriate separation between the largest rigid body eigenvalue and smallest elastic eigenvalue is typically six to eight orders of magnitude. Should the rack integrator desire, a strain energy check may also be performed to demonstrate that the integrated rack model is reasonably free of constraints. The rack integrator should provide analytical verification that the reduction preserves the essential characteristics of the model.

B.3.3.3 Model Documentation

The integrated rack model documentation shall contain:

- Physical units
- Model interfaces (grid point number, geometrical location, output coordinate system definition, and connecting degrees of freedom)
- Mass properties
- Bulk data listing (or equivalent)
- Plots (undeformed, deformed modal)
- Unconstrained and constrained eigenvalue summary tables
- Verification data

- Demonstration that the model is reasonably free of constraints
- Gravity check executions
- Reduced model verification
- Mass properties comparison
- Dynamic test verification (a reference to additional documentation may be provided should the rack integrator so desire)
- If the model is to be used for stress recovery, evidence of its suitability for such purpose (e.g., correlation with strain gauge measurements)

• Coupled loads analysis output requests (if applicable)

Any omission of the above data should be coordinated with the MPLM model integrator.

B.3.3.4 Verification Loads Analysis Output Requests

As a standard service, the rack integrator will be provided with MPLM-to-rack interface forces, integrated rack net load factors, and generalized responses for both accelerations and displacements. Requests for internal rack data should be coordinated at least two in advance to the integrated rack model delivery to ensure this non-standard recovery may be accommodated.

The rack integrator is also responsible for delivering a displacement Output Transformation Matrix (OTM) suitable for recovering relative deflections at various locations on the rack structure. Figure B.3-1 pictorially depicts these locations while Table B.3-7 tabulates the locations of these deflection points of interest.

Table B.3-7. Rack Coordinates for Deflection Recoveries

Location Identification		Coordinate[1][2]			DOF
		X_r	Y_r	Z_r	
B	B fitting	39.30	0.00	0.00	X_r
TF	Top Front Left	-0.98	-25.58	74.19	X_r, Y_r, Z_r
MF	Middle Front Left	-0.98	-25.58	39.41	X_r, Y_r, Z_r
BF	Bottom Front Left	-0.98	-25.40	0.00	X_r, Y_r, Z_r
MC	Middle Center Left	-0.98	-10.63	39.48	X_r, Y_r, Z_r
T'F	Top Front Right	40.10	-25.58	74.19	X_r, Y_r, Z_r
M'F	Middle Front Right	40.10	-25.58	39.41	X_r, Y_r, Z_r
B'F	Bottom Front Right	40.10	-25.40	1.46	X_r, Y_r, Z_r
M'C	Middle Center Right	40.10	-10.63	39.48	X_r, Y_r, Z_r

[1] Locations are in rack coordinates.
[2] Except for the B fitting, locations need not be exact.

Because truncated modes are used in the development of the integrated rack Craig-Bampton model, the user will need to define the displacement OTM using a mode acceleration procedure. Specifically;

$$\{d\} = [A_b \quad A_k]\begin{Bmatrix} \ddot{u}_b \\ \ddot{\xi}_k \end{Bmatrix} + [D_b]\{u_b\}$$

where

$\{d\}$ = The deflections of interest (in inches)

A_b = The boundary partition of the acceleration OTM

A_k = The kept normal modes partition of the acceleration OTM

$\ddot{u}_b$ = The boundary (i.e., physical) accelerations

$\ddot{\xi}_k$ = The kept modal (i.e., generalized) accelerations

D_b = The boundary deflection OTM

u_b = The boundary (i.e., physical) displacements

B.3.3.5 Verification Stress Analyses

It is the rack integrator's responsibility to ensure that integrated rack is structurally adequate for the verification loads environments. The results of the verification strength analysis will be summarized for the Structures Working Group at the Verification Analysis Review (VAR) at approximately L-3.5 months.

B.4 THERMAL MATHEMATICAL MODELS

Simplified MPLM thermal models are available to support MPLM thermal analysis efforts. These analytical models of the MPLM have been supplied by Alenia and verified by Marshall Space Flight Center (MSFC). These MPLM thermal models are maintained under configuration control to ensure that various users have consistent thermal modeling tools. In order to obtain a listing of the thermal library or to receive a specific thermal model, contact Randy McClendon at MSFC.

MPLM TRASYS models are necessary to calculate radiation conductors and external heating effects. There are three TRASYS configurations maintained in the MPLM thermal model library: MPLM mated inside the Orbiter payload bay with the payload bay doors closed, MPLM mated inside the Orbiter payload bay with the payload bay doors open, and MPLM mated inside the payload bay with the payload bay doors open and the Orbiter docked to ISS. Each of these three models consists of the MPLM mated inside the NASA 390-node Orbiter payload bay model. These models must be updated to reflect specific payload geometries and configurations.

MPLM SINDA models are available to support all mission phases from pre-launch through post-landing ferry flight. In order to be compatible with the TRASYS models, the MPLM SINDA models were integrated into the NASA 390-node Orbiter model. Again, these models must be updated to reflect specific payload configurations.

B.5 REFERENCES

1. MPLM Sustaining Engineering Plan, ISS-MPLM-PLAN-005
2. Passive MPLM Validated Dynamic Model Reduction and OTM Generation, MLM-RP-AI-0552.
3. Knee Brace Models for MPLM Design and Verification Analyses, TBD.

4. Coupling of Structures for Dynamic Analysis, AIAA Journal, Volume 6, pp 1313-1319, R. R. Craig Jr. and M. C. C. Bampton, July 1968.

APPENDIX C REQUIREMENTS IMPLEMENTATION MATRIX

The intent of the Requirements Implementation Matrix is to identify the parties responsible for verifying that the requirements of integrating cargo and payloads into the MPLM as defined in this document are met.

REQUIREMENTS IMPLEMENTATION MATRIX

Paragraph	Title	Brief Description of Requirement *	R (
2.2.1.a	Maximum Weight	The integrated MPLM shall not exceed 31,000 lbs.	KS
2.2.1.b	Maximum Weight	The cargo shall not exceed 20,000 lbs.	KS
2.2.2	C.G. Constraints	shall be within range specified.	KS
2.3.4.2.a	Payload Removal	Individual payload items shall conform to IVA requirements.	PD
2.3.4.2.b	Payload Removal	Individual payload items shall limit size to fit through CBM hatches.	PD
3.1.2.1.a	Rack Static Envelope	shall not exceed envelope defined in SSP 41017.	PD
3.1.2.1.b	Rack Dynamic Envelope	shall not exceed envelope defined in SSP 41017.	PD
3.1.2.2.a	ARIS Rack Static Envelope	shall not exceed envelope defined in SSP 41017.	PD
3.1.2.2.b	ARIS Rack Dynamic Envelope	shall not exceed envelope defined in SSP 41017.	PD
3.1.2.3.a	RSP Static Envelope	shall not exceed envelope defined in JSC 28169.	PD
3.1.2.3.b	RSP Dynamic Envelope	shall not exceed envelope defined in JSC 28169.	PD
3.2.8	Bonding	Each MPLM accommodated cargo shall provide a bonding receptacle, according to guidelines specified in Figure 3.2-13.	PD
3.3	Power and Signal Harnesses	Active rack cable and wire interface shall be compliant with SSP 30242.	PD
3.5.2.1.1	Coolant Specification	The payload cooling loop plumbing shall be compatible with SSP 30573 Table 4.1-1.9.2 (Heat Transport Fluid, IATC).	PD
3.5.2.1.2	Air Heat Load	Total airborne heat load from the payload complement to the MPLM shall not exceed the values of Table 3.5-2 with linear interpolation for ambient temperatures between those specified.	PD
3.5.2.1.3.1.a	Fire Protection	Active cargo shall comply with the fire protection and selection criteria as defined in Figure 3.5-2.	PD
3.5.2.1.3.1.b	Fire Protection	If smoke detectors are embedded, the related data shall be provided through the User Bus.	PD
3.5.2.1.3.2	Fire Suppression	Each rack which contains a potential fire source shall provide a dedicated interface for the PFE to permit fire suppression by the crew as specified.	PD
3.5.2.2.1.a	Maximum Continuous Power	MPLM integrated cargo shall not exceed 2400 W while in the Orbiter cargo bay.	CE
3.5.2.2.1.b	Maximum Continuous Power	MPLM integrated cargo shall not exceed 2200 W during on-ground processing and while on ISS.	CE
3.5.2.2.1.c	Maximum Continuous Power at Each Rack Location	Payload Developer shall not exceed the limits defined in Table 3.5-3.	PD
3.5.2.2.6	MPLM Reverse Energy/Current	The MPLM reverse energy/current shall be as defined in SSP 41155.	
3.5.2.2.7	MPLM Soft Start/Stop Capability	The MPLM power interface shall have soft start/stop characteristics as defined in SSP 41155.	
3.6.3.a	Heat Rejection	Maximum continuous heat rejection at the Orbiter Payload Bay Heat Exchanger for MPLM is 3000 W in accordance with ICD-A-21350, Section 6.0.	CE
3.6.3.b	Heat Rejection	Maximum MPLM heat load transferred to the USOS will be 3250 W in accordance with SSP 42007, Section 3.2.2.3.	CE
4.8.1.1.3	Module Ventilation	Cargo integrators shall coordinate with MPLM/ECLSS and MOD to ensure flight rule C20.5.1-12 is in the mission specific flight rules if the stay out zone in Figure 4.8-2 is violated.	CE

Paragraph	Title	Brief Description of Requirement *	Resp Org	Origin
5.2.1	Mechanical Environment	Integrated racks shall provide positive margin of safety when exposed to design values unless superceded by the results of the flight-specific CLA.		IDD
5.2.1.1	Acceleration	Racks shall withstand the acceleration environment defined in Table 5.2-1.		IDD
5.2.1.2	Vibration	Racks shall meet the vibration requirements defined in SSP 41017.		SSP 41017
5.3.1	Temperature	Cargo shall be certified to be safe to withstand the temperatures defined in Table 5.3-1.	PD	IDD
5.3.2	Dew Point Temperature	Cargo shall be certified to be safe to the dew points specified in Table 5.3-3.	PD	IDD
5.3.3	Pressure	Cargo shall be certified to be safe to withstand the pressure defined in Tables 5.3-4 and 5.3-5.	PD	IDD
5.3.3.1.1	Depressurization	MPLM accommodated cargo shall withstand a maximum depressurization rate of 7.74 psi/min (880 Pa/s) without undergoing permanent structural deformation or functional degradation.	PD	
5.3.3.1.2	Repressurization	MPLM accommodated cargo shall withstand a maximum repressurization rate of 12 psi/min (1,380 Pa/s) without undergoing permanent structural deformation or functional degradation.	PD	
5.3.3.2.a	Cargo Pressure Relief	Safety analyses of the integrated payload configuration shall be performed to ensure that structural positive pressure levels can be satisfied if the experiment gas is introduced into the MPLM in a failure mode or an operational mode.	PD	IDD
5.3.3.2.b	Pressure Vessels	The operational mode (specification leak rate) integrated payload cumulative leak rate shall be equal to or less than TBD liters per hour.		IDD
5.3.3.3	Atmosphere Composition	MPLM accommodated cargo shall withstand the module atmosphere defined in Table 5.3-6.	PD	IDD
5.4	Electromagnetic Environment	Cargo accommodated inside the MPLM shall withstand the electromagnetic environment defined for the Orbiter (ICD-A-21350) and the ISS (SSP 30243).	PD	ICD-A-21350 and SSP 30243
5.5.1	Intra-Vehicular Activity Crew Induced Loads	Cargo shall be able to withstand kickloads as defined in Table 5.5-1.	PD	IDD

Paragraph	Title	Brief Description of Requirement *	Resp Org	Origin
5.5.2	Translation Paths	Minimum cross sectional dimensions of translation paths for one crewmember in light clothing shall be as shown in Figure 5.5-1 for integrated MPLM cargo.		SSP 50005
5.5.3	Surface Temperature	The temperature of any integrated rack surface with which the crew may have incidental or unlimited contact shall be in the range 0 deg. F (-18 deg. C) to 120 deg. F (49 deg. C) during all operational phases.	PD	IDD
5.5.4	Surface Finish	All materials, mechanical fasteners, electrical connectors/components, etc. of payloads that interface with the MPLM shall have surface finishes that meet the requirements of NSTS 1700.7B. SSP 30233 may be utilized as a guide.	PD	NSTS 1700.7B
5.5.5	Illumination (special)	Any special illumination shall be provided by the cargo. MPLM is provided with a nominal illumination level corresponding to 108 lux measured at a distance of 30 in. (0.762 m) from the floor, equidistant from the port and starboard rack front surfaces.	PD	IDD
5.5.6	Materials and Processes	Cargo to be transported to/from the ISS by the MPLM shall be designed by using materials and processes as specified in NSTS 1700.7B.	PD	NSTS 1700.7B
5.5.7	Cleanliness	All cargo surfaces shall be clean to the visibly clean sensitive level, in accordance with the document JSC-SN-C-0005.	PD	JSC-SN-C-0005
5.5.8.a	Contamination	The MPLM accommodated cargo shall withstand the particulate environment corresponding to the Class 100000, as per Figure 5.5-1.	PD	IDD
5.5.8.b	Contamination	The MPLM accommodated cargo shall withstand the worst-case trace gas concentration environment defined in JSC 20584.	PD	JSC 20584
5.5.9	Ionizing Radiation	The MPLM accommodated cargo shall withstand an ionizing radiation environment of 2.7 rad silicon per 10 days.	PD	IDD
7.2.1.2	Loose Equipment Restraint	All loose items over 5 kg shall be reviewed against Figure 7.2-1 to ensure that no potential safety hazard occurs.		IDD
7.2.4.6	Area Closures	Experiment equipment shall be designed to prevent loose equipment such as small tools, screws, bolts, nuts, fuses, etc. from drifting into inaccessible areas.	PD	IDD
8.0	Safety	The cargo to be transported to/from the ISS in the MPLM shall meet the requirements of NSTS 1700.7B and shall not contaminate the MPLM, ISS, or NSTS.		NSTS 1700.7B

Paragraph	Title	Brief Description of Requirement *	Resp Org	Origin
		* See document for full description		

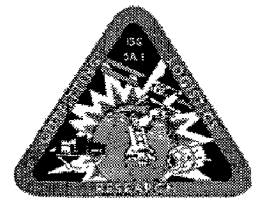
APPENDIX "D"

MPLM MISSION HISTORY

This document is intended to be a repository of significant MPLM data collected during each mission. As we continue to fly, mission data will be added as appropriate.

It should be noted that the early missions might have areas where data is missing. This is because as we became more and more familiar with the hardware, we became aware of the kinds of data that needed to be collected. The format of the data collected is based on the last two missions (i.e., UF-1 and UF-2). Where a measurement or data is missing because that item was not recorded (early missions) the words "**NO DATA**" will appear beneath the data heading. Where there is or should be data and it is just missing, the words "**DATA NOT AVAILABLE** " will appear beneath the data heading.

Flight: STS – 102



Mission: 5A.1

STS-102 Swaps International Space Station Crews

Space Shuttle Discovery spent almost 13 days in orbit, with over eight of those days docked to the International Space Station. While at the orbital outpost, the STS-102 crew attached the Leonardo Multi-Purpose Logistics Module, transferred supplies and equipment to the station, completed two space walks, and delivered the Expedition Two crew.

The Crew

James Wetherbee	Commander
James Kelly	Pilot
Andy Thomas	Mission Specialist
Paul Richards	Mission Specialist
James Voss	Mission Specialist (Up)
Susan Helms	Mission Specialist (Up)
Yury Usachev	Mission Specialist (Up)
Sergei Krikalev	Mission Specialist (Down)
William Shepherd	Mission Specialist (Down)
Yuri Gidzenko	Mission Specialist (Down)

Mission Data

Launch Date	03/08/01	5:42 am CST	KSC
Landing Date	03/21/01	1:31 am CST	KSC
Launch Pad	39-B		KSC
Orbiter	OV – 103	Discovery	
MPLM Module	FM –1	Leonardo	
Module Weight	9,671 lbs		
MPLM Cargo Wt Up	12,670 lbs		
MPLM Cargo Wt Down	4,635 lbs		
Orbit Altitude	173 nautical miles		
Mission Duration	12 days, 19 hours, 49 minutes		

MPLM Mission Support Team

5A.1 Shift Assignments

Name	Room	Shift	Discipline
Shawn Reagan*	IMC	3	Mission Engineer
Allen Shariett*	IMC	1	System Engineer
Randy McClendon	IMC	3	MPLM Element Manager
David Harwell	IMC	1	Mission Engineer
Charlotte Hazel	IMC	2	Mission Engineer
Jim Hutchins	IMC	2	Boeing Manager
Alisa Wells	IMC	2	Boeing Systems
Jon Holladay	MER	3	Engineering Manager
Greg Day	MER	1	Boeing TCS
Ken Shih	MER	2	Boeing TCS

Notes:

*** 5A.1/STS-102 Mission Leads**

1. **Shift 1 – 5:00 AM – 2:00 PM** — **Execute 2 Shift**
2. **Shift 2 – 1:00 PM – 10:00 PM** — **Crew Sleep Shift**
3. **Shift 3 – 9:00 PM – 6:00 AM** — **Execute 1 Shift**

Mission Objectives / Goals

STS-102

The primary objective of this flight was to deliver and integrate the International Space Station 5A.1 launch package into the orbiting Stage 5A.

<u>Shuttle Payload Bay Cargo:</u>

Leonardo - Multi-Purpose Logistics Module

For a complete description of the MPLM, see "Back Up Information" at the end of this appendix.

On STS-102, Leonardo was filled with equipment and supplies to outfit the U.S. Destiny Laboratory Module, which was delivered by STS-98. The MPLM is a pressurized module that carried to orbit six U.S. Laboratory System Racks, Resupply Stowage Platforms (RSP), Resupply Stowage Racks (RSR) and a Human Research Facility (HRF) rack. The racks and RSPs contain crew rotation hardware, avionics hardware, spare hardware, stowage items, Crew Health Care System (Checs) items, the ISS ergometer, Mobile Servicing System (MSS) Robotic Workstation (RWS) equipment and HRF experiment unique equipment.

Integrated Cargo Carrier

The Integrated Cargo Carrier, or ICC, is an externally mounted, unpressurized, aluminum flatbed pallet, coupled with a keel-yoke assembly that expands the shuttle's capability to transport cargo.

On STS-102, the ICC is the carrier which transported the Early Ammonia Servicer, the Rigid Umbilical, The Lab Cradle Assembly with the Module to Truss Structure Attach System -A, the Pump Flow Control Assembly and the External Stowage Platform.

In-Cabin Payloads

Development Test Objective (DTO) 700-14 - Single String Global Positioning System. The purpose of the Single String Global Positioning System DTO is to evaluate the performance of a Global Positioning System, or GPS, receiver being developed for operational use by the shuttle. The Miniaturized Airborne GPS Receiver was designed and manufactured by Rockwell Collins for military aircraft. It has been modified to work in the space environment, and communicate with the shuttle's computers. GPS data will be downlinked during all mission phases. When development, flight test and certification activities are complete two more GPS receivers may be added to provide a fully redundant replacement for existing Tactical Air Navigation systems, and improve orbiter capabilities for orbit and entry navigation.

Secondary Payloads

The Wide-Band Shuttle Vibration Forces Measurement (WSVFM) experiment is managed by the Jet Propulsion Laboratory (JPL) to obtain flight measurements of the vibration forces acting between a payload and its mounting structure, including acceleration data at high and low frequencies.

Get-Away-Special (GAS) –783 A GAS payload managed by Washington University in St. Louis that contains 47 passive experiments provided by schools in the St. Louis area.

Space Experiment Module (SEM-09) – utilizes an existing GAS canister, divided into ten modules to accommodate small zero – or – micro – gravity experiments designed and constructed by elementary and middle school students.

Mission Related / Mission Unique Documentation:

MSFC-RQMT-3048	Integrated MPLM Requirements Document (IMRD) for Assembly Flight 5A.1
NSTS-21455	Mission Integration Plan (MIP) for 5A.1
ICD-A-21350	Shuttle Orbiter to MPLM Cargo Element Interfaces
SSP-42007	USOS to MPLM ICD

Safety:

Baseline Hazard Reports for the MPLM Module

MPLM Module (Alenia)			
Doc Number	**Title**	**Review**	**Use**
MLM-RP-AI-0055	System Hazard Analysis for Flight OP's (Phase III written March 1998)	Phase II May 22, 1997 Phase III May 28, 1998	Reviewed by the ISS SRP and approved for Flight 5A.1 and subsequent missions. Baseline Flight Hazard Analysis for all MPLM modules.
MLM-RP-AI-0054	Ground Safety Data Package for FM1 (Written in 1998)	1998	Reviewed by the GSRP and approved for Flight 5A.1 and all subsequent passive missions for ground processing. Baseline Ground Hazard Analysis for all MPLM modules.

Hazard Report for the Integrated MPLM Cargo Element

MPLM Integrated Cargo (MSFC)			
Doc Number	**Title**	**Review**	**Comment**
JA91 (99-82)	Flight 5A.1 Multi Purpose Logistics Module (MPLM) Cargo Element Integrated (CEI) Phase III SDP	Phase II Jan 21, 1999 Phase III May 28 1999 Phase □III Dec 13, 2000	Reviewed by the ISS SRP and approved for the Flight 5A.1 mission. The additional Phase III review was added due to the number of cargo changes caused by the addition of Flight 5A.1.

Hazard Report for the MPLM/Orbiter Intefaces

MPLM/Orbiter Integrated (MSFC)			
Doc Number	**Title**	**Review**	**Comment**
ISS-MPLM-DOC-002	Multi Purpose Logistics Module (MPLM)/Orbiter Integrated Phase III SDP (final version written on Feb 5, 2001)	Feb 14, 2001	Reviewed by the ISS SRP and approved for Flight 5A.1 and all subsequent passive missions. An additional review is necessary prior to the first active mission due to the lack of maturity of Orbiter cooling hardware during the review. This report is based on the following referenced hazard reports and forms the basis for subsequent MPLM/Orbiter re-flight assessments.
MLM-RP-AI-0055	System Hazard Analysis for Flight OP's	May 28, 1998	MPLM Module Hazard Analysis by Alenia

Mission Elapsed Time (MET) Event Timeline

Flight Day 1: 03/08/01

MPLM KSC Closeout Environmental Conditions:

Pressure: 14.98 psia
Temperature: 74.3 ^{0}F
Dew Point: 27.6 ^{0}F

Launch: 5:42 am CST
MPLM in Shuttle Payload Bay

1st Environment Check:

Pressure = 14.91 psia
Temperature = 73.4 °F

Flight Day 2: 03/09/01

MPLM in Shuttle Payload Bay

Flight Day 3: 03/10/01

MPLM in Shuttle Payload Bay

Shuttle Rendezvous with ISS

Shuttle Docking: 12:38 am CST

Transfer Op

Cabin Depress to 10.2 PSI

1st Crew Rotation

Flight Day 4: 03/11/01

MPLM in Shuttle Payload Bay

EVA

- Disconnect / Stow PMA 3 Umbilicals
- Remove Node 1 Ecomm Antenna
- LCA Transfer
- Remove Rigid Umbilical and Install
- Move PMA 3 to Port Side of Node 1 Port

Cabin Repress

Flight Day 5: 03/12/01

MPLM Berthing Operations

MPLM Berth 12:02 am CST

2nd Crew Rotation

Vestibule Pressurization
Vestibule Outfitting
MPLM Activation

EVA Tool Configuration

MPLM Ingress / Transfer Setup

Flight Day 6: 03/13/01

MPLM Attached to ISS
MPLM Transfer Activities

EVA

- ESP Remove & Install
- PFCS Remove & Install

Cabin Depress to 10.2 PSI

Flight Day 7: 03/14/01

MPLM Attached to ISS
MPLM Transfer Activities

Development Test Objective (DTO) 257
DTO 263
3rd Crew Rotation

Flight Day 8: 03/15/01

MPLM Attached to ISS
MPLM Transfer Activities

Flight Day 9: 03/16/01

MPLM Attached to ISS
MPLM Transfer Activities
Vestibule Deoutfitting

ISS Reboost
Crew Conference
EMU Transfer to ISS

Flight Day 10: 03/17/01

MPLM Attached to ISS
MPLM Deactivation
Vestibule Depress

MPLM Closeout conditions:
Pressure = 14.78 psia,
Temperature = 74.5 °F
Dew Point: 53.0 ^{0}F

Flight Day 11: 03/18/01

MPLM Re-berthing Operations
MPLM Re-berth 6:08 am CST
Total time MPLM docked to ISS - 6 days, 6 hours, 6 minutes
MPLM in Shuttle Payload Bay
Shuttle Undock: 10:32 pm CST
Fly-around / Separation Burns

Flight Day 12: 03/19/01

MPLM in Shuttle Payload Bay

Cabin Stow
Deorbit Briefing

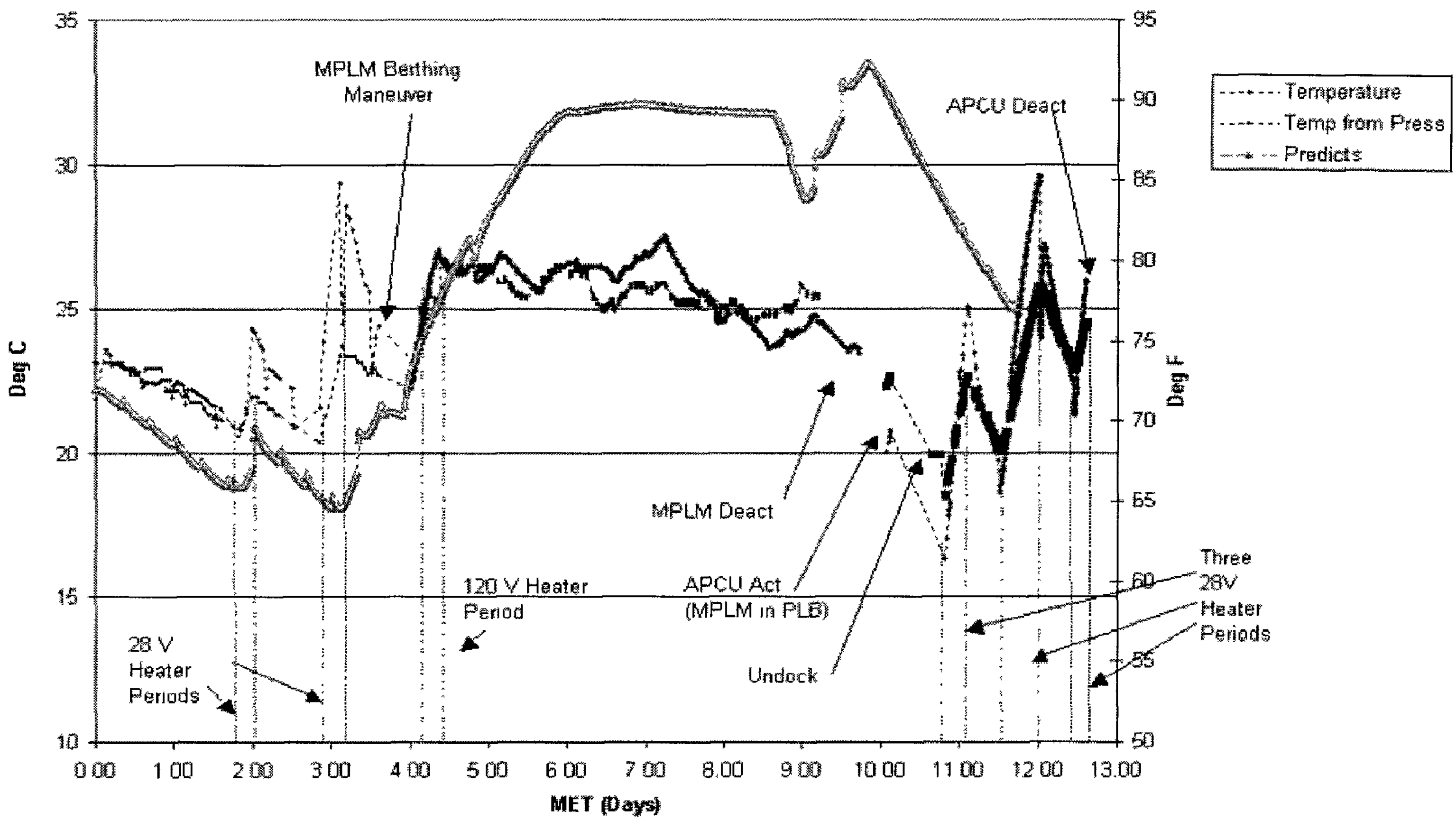
Flight Day 13: 03/20/01

MPLM in Shuttle Payload Bay

Deorbit Prep
Deorbit Burn
Landing **1:31 am CST**

MPLM Mission Data Summary
Mission 5A.1

5A.1 Temperature Data:



5A.1 Mission Heater Power Timeline:

Mission Elapsed Time (Hours) in PLB

44.29 On		Up Trip
46.80 Off	Time On = 2.51 Hours	Up Trip
68.12 On		Up Trip
75.43 Off	Time On = 7.31 Hours	Up Trip
259.93 On		Down Trip
266.32 Off	Time On = 6.79 Hours	Down Trip
278.60 On		Down Trip
288.02 Off	Time On = 9.42 Hours	Down Trip
299.20 On		Down Trip
302.20 Off	Time On = 3.00 Hours	Down Trip

Total Time On = 29.03 Hours

5A.1 - Orbiter Attitude Timeline:

MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	SSpt 2orb	%Sun	DD/HH:MM:SS	Alt	Comment
0.00	0.64	LVLH	P 0	Y 0	R 0	0	0	180	127	101	-51.1	53	104	252	61	0/ 0:00:00	78	LIFTOFF
0.64	0.77	IH	P 115	Y 35	R 122	0	5	166	63	59	-51.0	113	56	51	61	0/ 0:38:38	78	OMS-2
1.42	2.04	LVLH	P 0	Y 270	R 0	0	0	180	36	108	-50.9	141	119	241	62	0/ 1:25:00	103	+ZLV +YVV
3.46	0.51	IH	P 127	Y 14	R 297	0	181	39	306	109	-50.6	124	247	21	62	0/ 3:27:40	103	NC-1
3.97	12.44	LVLH	P 180	Y 0	R 0	0	0	0	115	58	-50.5	69	56	145	62	0/ 3:58:16	103	-ZLV -XVV
16.41	0.36	IH	P 300	Y 57	R 76	0	99	9	265	103	-48.7	85	257	304	64	0/16:24:34	135	NC-2 NPC
16.77	2.37	LVLH	P 90	Y 50	R 90	0	0	40	199	88	-48.6	19	277	30	63	0/16:45:56	135	BIAS -ZLV +YVV
19.13	7.22	LVLH	P 180	Y 0	R 0	0	0	0	52	71	-48.2	125	66	240	64	0/19:08:02	141	-ZLV -XVV
26.35	0.53	IH	P 274	Y 313	R 43	0	178	19	257	48	-47.1	80	319	176	63	1/ 2:21:01	141	NC-3 NH
26.88	10.12	LVLH	P 180	Y 0	R 0	0	0	0	52	111	-47.0	125	116	302	63	1/ 2:52:36	141	-ZLV -XVV
37.00	0.67	LVLH	P 0	Y 270	R 0	0	0	180	30	124	-45.4	135	143	217	64	1/13:00:01	171	+ZLV +YVV
37.67	0.33	IH	P 33	Y 58	R 192	0	1	138	114	51	-45.3	72	48	15	64	1/13:40:09	171	NC-4
38.00	0.75	LVLH	P 270	Y 0	R 0	0	180	90	94	135	-45.2	87	135	94	65	1/13:59:58	199	-Z Target Track
38.75	0.36	LVLH	P 285	Y 0	R 0	0	180	105	104	47	-45.1	80	46	271	65	1/14:45:16	199	-Z Target Track
39.11	0.25	LVLH	P 270	Y 0	R 0	0	180	90	45	87	-45.1	135	85	355	65	1/15:06:51	199	-Z Target Track
39.36	0.23	IH	P 61	Y 72	R 172	0	348	112	91	42	-45.0	89	42	54	65	1/15:21:48	199	TI
39.59	1.25	LVLH	P 280	Y 0	R 0	0	180	100	97	135	-45.0	85	135	108	65	1/15:35:30	205	-Z Target Track
40.84	0.20	LVLH	P 330	Y 0	R 0	0	180	150	47	76	-44.8	132	71	48	65	1/16:50:28	205	-Z Target Track
41.04	0.25	LVLH	P 0	Y 0	R 0	0	0	180	45	88	-44.8	135	88	88	65	1/17:02:38	205	+ZLV +XVV
41.29	2.36	LVLH	P 90	Y 0	R 0	0	0	90	50	66	-44.7	126	60	145	66	1/17:17:20	205	Rbar on to Vbar
43.65	48.91	LVLH	P 114	Y 0	R 0	0	0	67	125	121	-44.3	60	126	338	65	1/19:38:56	205	BIAS -XLV +ZVV
92.56	1.44	LVLH	P 90	Y 24	R 90	0	0	67	107	58	-35.9	75	57	271	63	3/20:33:22	201	BIAS -XLV +YVV
94.00	26.35	LVLH	P 114	Y 0	R 0	0	0	67	46	126	-35.6	124	135	250	63	3/22:00:01	201	BIAS -XLV +ZVV
120.35	24.29	LVLH	P 114	Y 0	R 0	0	0	66	120	144	-30.7	73	148	313	62	5/ 0:21:18	200	BIAS -XLV +ZVV
144.65	0.00	LVLH	P 110	Y 5	R 1	0	4	70	47	137	-26.0	118	146	256	62	6/ 0:38:42	201	DTO 257
144.65	0.08	LVLH	P 110	Y 5	R 1	0	4	70	47	138	-26.0	117	146	257	62	6/ 0:38:57	201	LVLH Hold
144.73	0.09	LVLH	P 114	Y 0	R 0	0	0	67	86	148	-26.0	107	153	275	62	6/ 0:43:35	201	BIAS -XLV +ZVV
144.82	0.00	LVLH	P 105	Y 6	R 359	0	6	75	118	153	-25.9	78	155	296	62	6/ 0:49:00	201	DTO 263
144.82	0.04	LVLH	P 105	Y 6	R 359	0	6	75	118	152	-25.9	77	155	296	62	6/ 0:49:06	201	LVLH Hold
144.86	1.57	LVLH	P 114	Y 0	R 0	0	0	67	113	152	-25.9	79	154	305	62	6/ 0:51:25	201	BIAS -XLV +ZVV
146.43	1.39	LVLH	P 84	Y 0	R 180	0	0	84	212	54	-25.6	47	324	313	62	6/ 2:25:30	301	BIAS -XLV -ZVV
147.81	12.11	LVLH	P 114	Y 0	R 0	0	0	67	61	151	-25.3	104	154	278	62	6/ 3:48:37	207	BIAS -XLV +ZVV
159.92	1.75	LVLH	P 90	Y 24	R 90	0	0	67	63	54	-23.0	112	51	232	62	6/15:55:01	203	BIAS -XLV +YVV
161.67	28.50	LVLH	P 114	Y 0	R 0	0	0	67	64	155	-22.6	101	157	282	62	6/17:40:01	203	BIAS -XLV +ZVV
190.16	1.59	LVLH	P 90	Y 24	R 90	0	0	67	295	61	-16.9	112	301	124	61	7/22:09:53	203	BIAS -XLV +YVV
191.75	2.11	LVLH	P 327	Y 0	R 0	0	180	147	58	160	-16.6	180	163	136	61	7/23:45:06	203	BIAS +ZLV +XVV
193.86	18.47	LVLH	P 114	Y 0	R 0	0	0	67	36	152	-16.2	112	162	270	61	8/ 1:51:26	203	BIAS -XLV +ZVV
212.32	3.02	LVLH	P 327	Y 0	R 0	0	180	147	163	48	-12.4	45	18	280	61	8/20:19:26	211	BIAS +ZLV +XVV
215.34	0.88	LVLH	P 180	Y 0	R 45	0	270	45	5	79	-11.8	167	26	266	61	8/23:20:32	211	BIAS -ZLV -XVV
216.22	39.68	LVLH	P 114	Y 0	R 0	0	0	67	103	12	-11.6	87	12	311	61	9/ 0:13:09	211	BIAS -XLV +ZVV
255.90	1.07	LVLH	P 90	Y 0	R 0	0	0	90	176	65	-3.6	26	8	25	61	10/15:53:56	208	-XLV +ZVV
256.97	0.30	IH	P 212	Y 336	R 149	0	0	34	3	129	-3.3	141	176	276	61	10/16:58:07	208	Move Away Inrtl
257.27	0.08	LVLH	P 161	Y 0	R 0	0	360	19	149	174	-3.3	84	177	346	61	10/17:16:16	208	Flyaround
257.35	0.08	LVLH	P 200	Y 0	R 0	0	180	20	13	166	-3.2	104	177	6	61	10/17:21:16	208	Flyaround
257.44	0.08	LVLH	P 239	Y 0	R 360	0	180	59	6	146	-3.2	123	176	25	61	10/17:26:16	208	Flyaround

MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	SSpt 2orb	%Sun	DD/HH:MM:SS	Alt	Comment
257.52	0.08	LVLH	P 278	Y 0	R 360	0	180	98	4	127	-3.2	143	175	45	61	10/17:31:16	208	Flyaround
257.60	0.08	LVLH	P 317	Y 360	R 360	0	180	137	3	108	-3.2	162	170	64	61	10/17:36:16	212	Flyaround
257.69	0.08	LVLH	P 356	Y 360	R 360	0	181	176	3	88	-3.2	176	58	84	61	10/17:41:16	212	Flyaround
257.77	0.08	LVLH	P 35	Y 360	R 0	0	360	145	3	69	-3.2	158	8	103	61	10/17:46:16	212	Flyaround
257.85	0.08	LVLH	P 74	Y 360	R 0	0	360	106	4	49	-3.1	139	5	123	61	10/17:51:16	212	Flyaround
257.94	0.08	LVLH	P 113	Y 360	R 0	0	360	67	6	30	-3.1	119	3	142	61	10/17:56:16	212	Flyaround
258.02	0.07	LVLH	P 152	Y 0	R 0	0	360	28	17	10	-3.1	100	3	162	61	10/18:01:16	212	Flyaround
258.09	0.11	LVLH	P 184	Y 0	R 0	0	181	4	155	7	-3.1	84	3	178	61	10/18:05:27	212	Final Sep
258.21	0.22	IH	P 8	Y 8	R 218	0	181	103	178	79	-3.1	11	11	205	61	10/18:12:18	212	Item 21 Cancel
258.43	1.51	LVLH	P 0	Y 310	R 0	0	0	180	127	103	-3.0	54	107	257	61	10/18:25:39	212	Bias +ZLV +YVV
259.94	4.04	LVLH	P 180	Y 0	R 0	0	0	0	3	70	-2.7	159	8	250	61	10/19:56:19	210	-ZLV -XVV
263.98	2.58	LVLH	P 180	Y 0	R 45	0	270	45	196	72	-1.9	24	320	114	61	10/23:58:46	210	BIAS -ZLV -XVV
266.56	11.96	LVLH	P 180	Y 0	R 0	0	0	0	36	178	-1.4	92	179	358	61	11/ 2:33:46	210	-ZLV -XVV
278.53	0.12	IH	P 144	Y 27	R 151	0	180	48	357	47	1.1	137	357	275	61	11/14:31:34	210	FCS Checkout
278.64	1.07	LVLH	P 180	Y 0	R 0	0	0	0	359	122	1.1	148	182	302	61	11/14:38:41	210	-ZLV -XVV
279.71	0.16	IH	P 309	Y 325	R 203	0	178	160	182	149	1.3	59	181	192	61	11/15:42:37	209	RCS Hotfire
279.87	3.67	LVLH	P 180	Y 0	R 0	0	0	0	358	49	1.4	139	358	229	61	11/15:52:14	209	-ZLV -XVV
283.54	0.32	IH	P 267	Y 322	R 175	0	175	9	308	176	2.1	92	183	7	61	11/19:32:19	209	Orbit Adjust
283.86	18.46	LVLH	P 180	Y 0	R 0	0	0	0	182	99	2.2	9	194	81	61	11/19:51:21	209	-ZLV -XVV
302.31	0.15	IH	P 197	Y 18	R 170	0	111	143	339	104	5.9	155	236	78	61	12/14:18:43	204	IMU ALIGN
302.47	0.12	IH	P 219	Y 312	R 202	0	131	128	56	112	6.0	122	118	124	61	12/14:27:57	204	VERIFICATION
302.58	1.70	IH	P 174	Y 352	R 231	0	39	78	360	81	6.0	171	359	142	61	12/14:35:05	204	-XSI
304.29	2.19	IH	P 210	Y 0	R 270	0	25	86	30	91	6.3	150	91	181	61	12/16:17:09	204	COMM
306.47	0.41	IH	P 278	Y 321	R 178	0	1	32	232	170	6.8	84	188	334	61	12/18:28:22	204	D O Burn
306.88	0.33	IH	P 181	Y 10	R 143	0	172	165	351	85	6.9	169	300	69	61	12/18:52:49	204	EI-5 INRTL
307.21	0.00	LVLH	P 37	Y 359	R 2	0	0	0	0	0	0.0	90	0	0	61	12/19:12:46	204	EI-5 LVLH

5A.1 - Beta Angle:

See Orbiter Timeline above for Beta Angle data.

5A.1 – MPLM Pressure Prior to Transfer to ISS:

NO DATA

5A.1 – MPLM Pressure Attached to ISS:

NO DATA

5A.1 – MPLM Voltage & Current Draw:

NO DATA

5A.1 – MPLM Cabin Fan Current & Speed:

NO DATA

5A.1 – MPLM Pressure & Temperature During 24 Hour Ops in PLB:

NO DATA

5A.1 – MPLM PDB Voltage During 24 Hour Ops in PLB:

NO DATA

5A.1 – MPLM Environmental Check During Extended Ops in PLB:

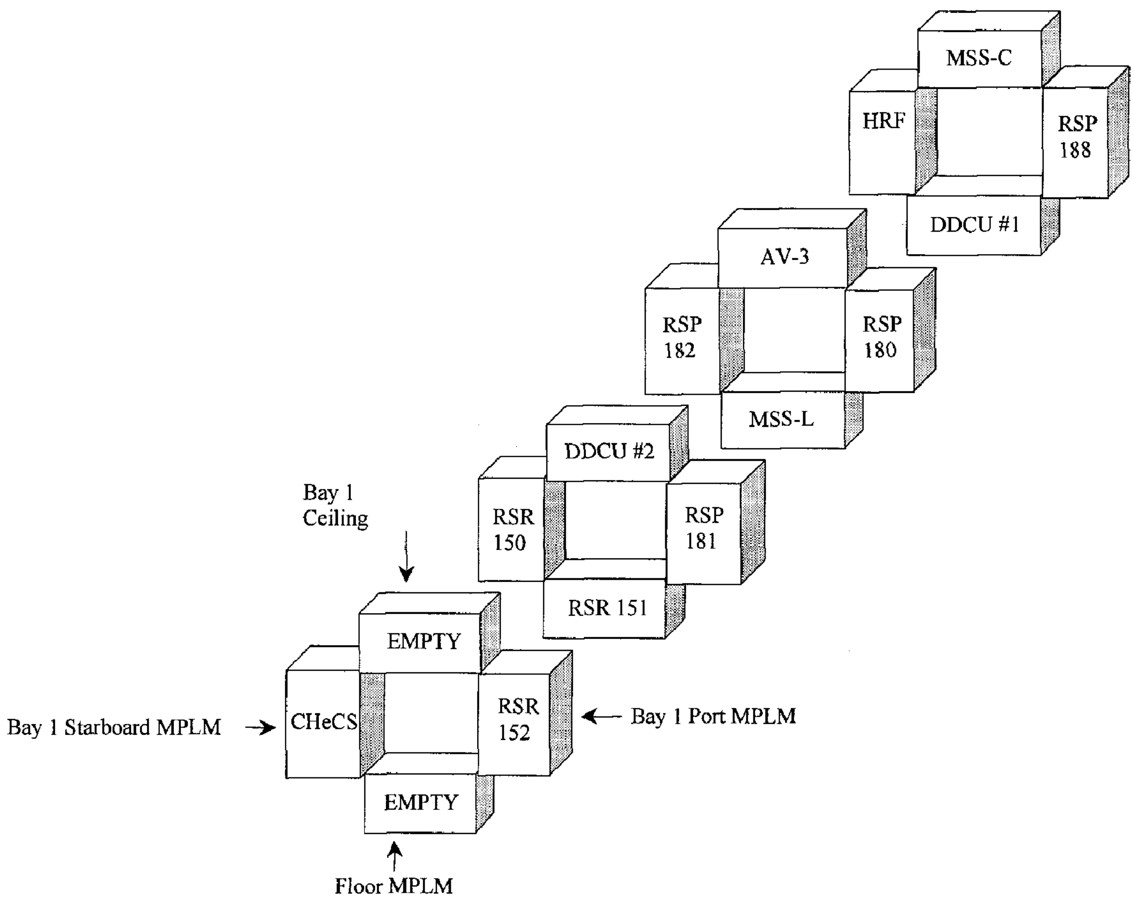
NO DATA

5A.1 – MPLM Heater Voltage & Current During Extended Ops in PLB

NO DATA

MPLM Cargo Manifest – Up

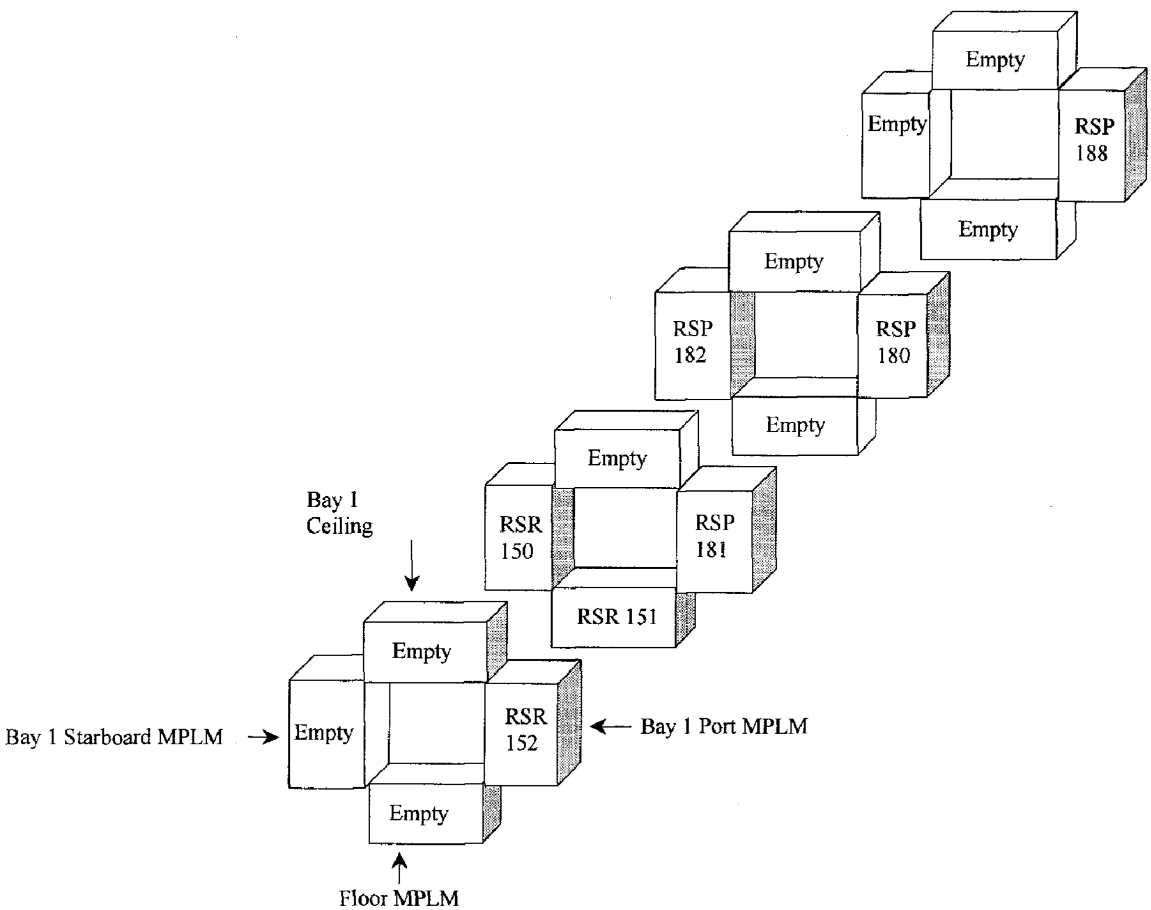
Type	Number	
RSP	4	
RSR	3	
HRF	1	
DDCU	2	
System Rack	3	
CHeCS	1	
Liquid Containers	3	CWC
Pressure Vessels	1	GASMAP



5A.1 Launch Rack Configuration

MPLM Cargo Manifest – Down

Type	Number	
RSP	4	
RSR	3	
Liquid Containers	CWC	5
Pressure Vessels	0	0



5A.1 Landing Rack Configuration

MPLM Mission Generated Paper

Waivers:

- **No Waivers written during mission**

Problem Reports (PRs):

- **PRACA 2620** (mentioned in In-Flight Anomaly section below)

CHITS (Mission Action Request):

- **ISS-0069 Maximum Allowable Temperature for MPLM MDM**

The following maximum temperature values should be used for the MPLM MDM (IMDM01SW4807T): maximum limit is 90°C. If flight data shows temperature around 80°C, assess whether temperature will continue to 90°C. If yes, turn off MDM.

Items – For – Investigation (IFI):

- **No IFIs written during mission**

Significant Flight Notes:

- **Flight Note PHFN087**
  –Updated MPLM Environment Check procedure - turn on the GLAs before deactivating Cabin Fan. Deactivating Cabin Fan with small load on the bus could cause APCU to trip due to back EMF.

- **Flight Note OSFN975**
  –Procedure to swap out MPLM Lamp Housing Assy (LHA) with a failed LHA in Node 1

- **Flight Note THFN225A**
  –Crew dimmed GLAs upon MPLM egress, therefore, this flight note updated the Environment Check to turn on the 120 Vdc shell heaters before deactivating the Cabin Fan in order to avoid the back EMF problem.

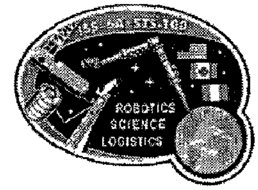
In-Flight Anomaly:

- **During MPLM deactivation to reconfigure power from APCU to DDCU, the cabin fan RPC (#11) showed 8.78 Vdc with the RPC open. This caused a failure message.**
- **During subsequent activation, voltage level was as expected with the RPC closed.**
- **Root cause investigation determined that the fan was spinning due to airflow in the module, which generated a back EMF. No corrective action required since voltage was less than 10 Vdc.**
- **Anomaly closed as PRACA 2620.**

Lessons Learned:

- **Rack transfers did not take as long as planned - all system racks transferred in a couple of hours**
- **Return manifest needs to be frozen much sooner in the process**
- **Need 2 chairs at the MNEMO console**
- **MNEMO needs separate console from VI**
- **Need to coordinate call signs - there was some confusion on calling Alenia or MNEMO**
- **MNEMO should provide formal inputs for MPLM**
- **Need more info on RAPID1 if we are going to use it as a tool to analyze new return configurations**

Flight: STS – 100



Mission: 6A

STS-100 Delivers Canadarm2 to International Space Station

Endeavour and its crew spent almost 12 days on orbit, eight of which were spent in joint operations with the International Space Station crew. Endeavour's crew delivered and installed a new robotic arm and helped to transfer equipment and supplies between vehicles.

The Crew

Kent V. Rominger	Commander
Jeffrey S. Ashby	Pilot
Cris Hadfield, CSA	Mission Specialist 1
John L. Phillips	Mission Specialist 2
Scott Parazynski	Mission Specialist 3
Umberto Guidoni, ESA	Mission Specialist 4
Yuri Lonchakov, Rosaviakosmos	Mission Specialist 5

Mission Data

Launch Date	04/19/01	1:41 pm CST	KSC
Landing Date	05/01/01	11:11 am CST	EAFB
Launch Pad	39-A		
Orbiter	OV – 105	Endeavour	
MPLM Module	FM –2	Raffaello	
Module Weight	9,789 lbs		
MPLM Cargo Wt Up	9,581 lbs		
MPLM Cargo Wt Down	4,915 lbs		
Orbit Altitude	173 nautical miles		
Mission Duration	11 days, 21 hours, 30 minutes		
	Mission extended 23 hrs 32 min; scheduled to land KSC at 11:39 am on 04/30/01; landing delayed due to conditions at KSC; landed at Edwards AFB.		

MPLM Mission Support Team

6A Shift Assignments

Name	Room	Shift	Discipline
Shawn Reagan	MER	2	Mission Engineer
Dave Robeson	MER	2	Boeing
Allen Shariett*	MER	3	System Engineer
Vic Bell	MER	3	Boeing (1/2 mission)
Mike Robinson	MER	3	Boeing (1/2 mission)
Randy McClendon	IMC	3	MPLM Element Manager
David Harwell*	IMC	1	Mission Engineer
Charlotte Hazel	IMC	2	Mission Engineer
Jon Holladay	MER	1	Engineering Manager
Greg Day	MER	1	Boeing TCS
Ken Shih	MER	2	Boeing TCS

Notes:

*** 6A/STS-100 Mission Leads**

4. **Shift 1 – 5:00 AM – 2:00 PM** **Execute 2 Shift**
5. **Shift 2 – 1:00 PM – 10:00 PM** **Crew Sleep Shift**
6. **Shift 3 – 9:00 PM – 6:00 AM** **Execute 1 Shift**

Mission Objectives / Goals

STS-100

The primary objective of this flight was to deliver and integrate the International Space Station 6A launch package into the ISS.

Cargo Bay Payloads:

Space Station Remote Manipulator System

The Space Station Remote Manipulator System, or SSRMS, is the next generation Canadarm and is a bigger, better, smarter version of the space shuttle's robotic arm and was built by the Canadian Space Agency. The new arm, which is also referred to as Canadarm2, is 17.6 meters (57.7 feet) long when fully extended and has seven motorized joints. This arm is capable of handling large payloads and assisting with docking the space shuttle. The SSRMS is self-relocatable with a Latching End Effector, so it can be attached to complementary ports spread throughout the station's exterior surfaces.

Raffaello - Multi-Purpose Logistics Module

For a complete description of the MPLM, see "Back Up Information" at the end of this appendix.

Of the 16 racks the MPLM module can carry, STS-100 will bring four resupply stowage racks, four resupply stowage platforms and two scientific experiment racks to the station.

The two scientific experiment racks, EXPRESS Rack No. 1 and EXPRESS Rack No. 2, will add additional science capability to the station. EXPRESS stands for EXpedite the PRocessing of Experiments to the Space Station. The EXPRESS Rack concept was developed to support small payloads on orbit with a shortened ground integration period. EXPRESS Rack No. 2 is the first station rack equipped with the Active Rack Isolation System, or ARIS, which is designed to isolate the experiment within the rack from vibrations occurring in the rest of the space station.

The four Resupply Stowage Racks and four Resupply Stowage Platforms contain equipment required for activation of the two EXPRESS racks and the ARIS system, components to augment existing station systems, spare parts for systems already on the station, and food and supplies to support the crew.
After Raffaello is unloaded, used equipment and trash will be transferred to it from the station for return to Earth inside Endeavour's payload bay.

Ultra High Frequency Antenna

The Ultra High Frequency, or UHF, antenna will be attached to the station's U.S. Laboratory Destiny by space walking Astronauts Chris Hadfield and Scott Parazynski during the mission's first space walk.

The antenna, on a 1.2-meter (4-foot) boom, is part of the UHF Communications Subsystem of the station. It will interact with systems already aboard the station, including the Space-to-Space Station Radio transceivers. A second antenna will be delivered on STS-115/11A next year.

Once in operation the UHF subsystem will be used for space-to-space communication -- voice, commands and telemetry for the space station. It can support up to five users on the same frequency and provides:

- Two-way voice communications between the station and space walkers, the station and orbiter and between the Mission Control Center in Houston and space walkers.

- Orbiter commanding of critical station functions such as going to free drift during undocking operations. Commands are encrypted for security. That capability is to be used during Endeavour's undocking on STS-100.

- ISS transmission of critical telemetry to the orbiter during undocking operations, again beginning with STS-100 undocking.

Mission Related / Mission Unique Documentation:

NSTS-21309	Mission Integration Plan (MIP) for 6A
ICD-A-21350	Shuttle Orbiter to MPLM Cargo Element Interfaces
SSP-42007	USOS to MPLM ICD

Safety:

MPLM Series Assessment for the MPLM Module.

MPLM Module (Alenia)			
Doc Number	**Title**	**Review**	**Use**
MLM-RP-AI-0462	Safety Verification Analysis for MPLM FM2 Flight OP's (Written on May 27, 1999)	2000	Reviewed by the ISS SRP and reviewed out of board. Similar/Series equipment for MPLM FM2.
MLM-RP-AI-0523	Ground Safety Data Package for FM2 (Written on May 31. 1999)	1999	Reviewed by the GSRP and approved for Flight 6A and all subsequent passive missions for ground processing. Modifies MLM-RP-AI-0054 for FM-2.

Reflight Assessment for the MPLM/Orbiter Integrated Hazard Analysis

MPLM/Orbiter Integrated (Boeing Huntsville)			
Doc Number	**Title**	**Review**	**Comment**
SSMDH-0189A	International Space Station Mission 6A MPLM Reflight/Series Assessment (Written in April 2001)	April 2001	Reviewed by the ISS SRP and approved out of board for the Flight 6A mission.

Mission Elapsed Time (MET) Event Timeline

Flight Day 1: 04/19/01

MPLM KSC Closeout Environmental Conditions:
Pressure: 14.86 psia
Temperature: 70.7 °F
Dew Point: Data Not Available
Launch: 1:41 pm CST
MPLM in Shuttle Payload Bay
1st Environment Check:
Pressure = 14.81 psia
Temperature = 69.0 °F

Flight Day 2: 04/20/01

MPLM in Shuttle Payload Bay

Flight Day 3: 04/21/01

MPLM in Shuttle Payload Bay
Shuttle Rendezvous with ISS
Shuttle Docking: 8:59 am CST
Transfer Op
Cabin Depress to 10.2 PSI
1st Crew Rotation

Flight Day 4: 04/22/01

MPLM in Shuttle Payload Bay
EVA
UHF Antenna Installation
SSRMS Deploy & Installation

Flight Day 5: 04/23/01

MPLM Berthing Operations

MPLM Berth **11:00 am CST**

2nd Crew Rotation

Vestibule Pressurization
Vestibule Outfitting
MPLM Activation

EVA Tool Configuration

MPLM Ingress / Transfer Setup

Flight Day 6: 04/24/01

MPLM Attached to ISS
MPLM Transfer Activities

EVA
Finish SSRMS Installation

Flight Day 7: 04/25/01

MPLM Attached to ISS
MPLM Transfer Activities

3rd Crew Rotation

Flight Day 8: 04/26/01

MPLM Attached to ISS
MPLM Transfer Activities

Flight Day 9: 04/27/01

MPLM Attached to ISS
MPLM Transfer Activities
Vestibule Deoutfitting
MPLM Deactivation
Vestibule Depress
MPLM Closeout conditions:
Pressure = 14.82 psia
Temperature = 78.0 °F
Dew Point: Data Not Available
MPLM Re-berthing Operations
MPLM Re-Berth 3:58 pm CST
Total time MPLM docked to ISS - 4 days, 4 hours, 58 minutes

Flight Day 10: 04/28/01

ISS Reboost
Crew Conference
EMU Transfer to ISS

Flight Day 11: 04/29/01

MPLM in Shuttle Payload Bay
Shuttle Undock: 12:34 am CST
Fly-around / Separation Burns

Flight Day 12: 04/30/01

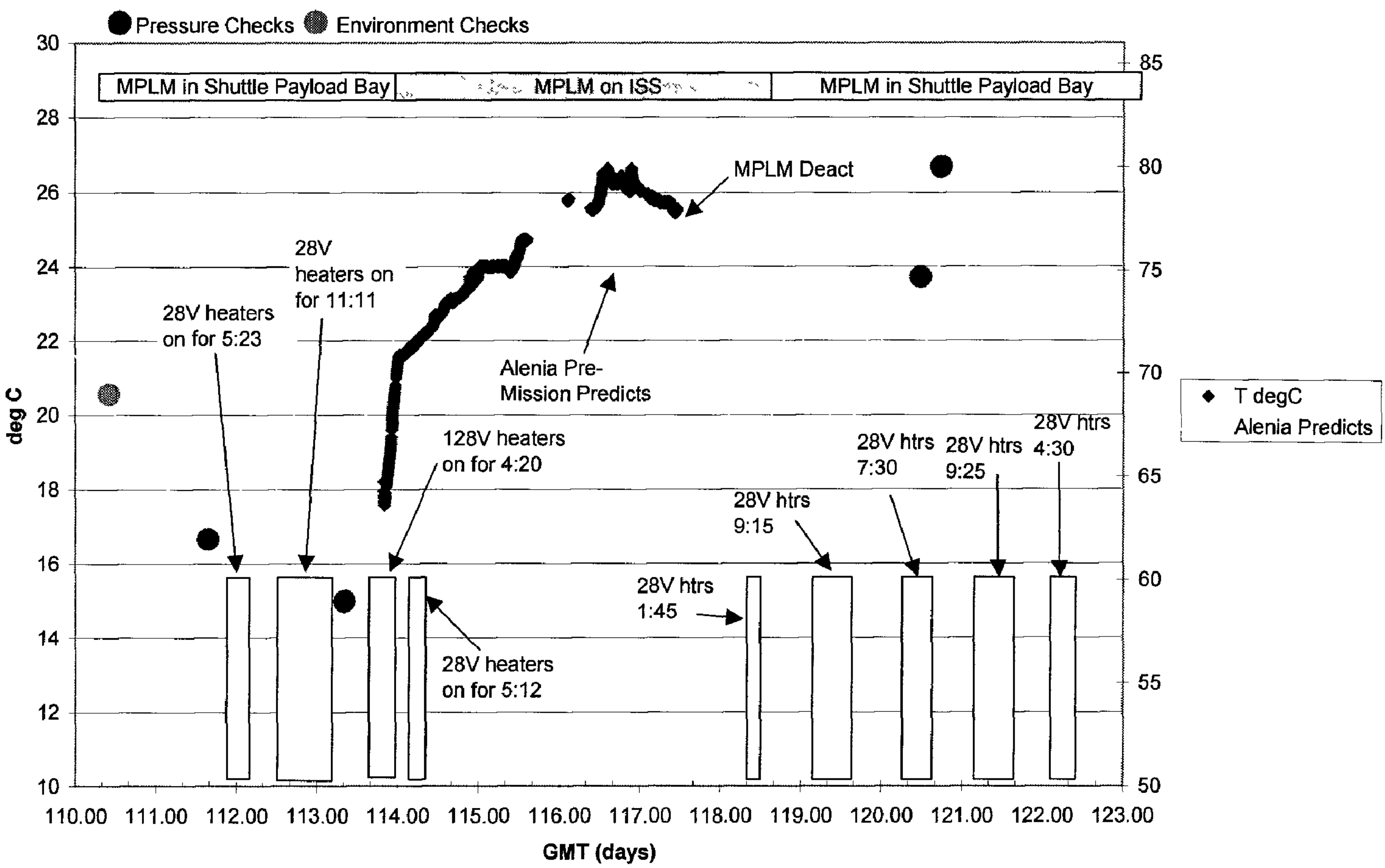
MPLM in Shuttle Payload Bay
Cabin Stow
Deorbit Briefing

Flight Day 13: 05/01/01

MPLM in Shuttle Payload Bay
Deorbit Prep
Deorbit Burn
Landing: 11:11 am CST

MPLM Mission Data Summary
Mission 6A

6A - Temperature Data:



6A – Mission Heater Power Timeline:

Voltage	Day	Hour	Minute	Summary	
28 Vdc	111	15	31	1230 watts	
	111	20	54	5.38333333 hours	
					Mission comment:
28 Vdc	112	7	57	1200	probably only single string
	112	19	8	11.1833333 hours	
28 Vdc	113	8	32	1170 watts	
	113	13	54	5.36666667 hours	
120 Vdc	113	19	53	922 watts	
	114	0	53	5 hours	
28 Vdc	117	21	58	980 watts	
	117	23	41	1.71666667 hours	
28 Vdc	118	12	8	watts	
	118	21	24	9.26666667 hours	
28 Vdc	119	12	50	980 watts	
	119	20	11	7.35 hours	
28 Vdc	120	9	3	980 watts	
	120	19	28	10.4166667 hours	
28 Vdc	121	6	13	980 watts	
	121	10	36	4.38333333 hours	

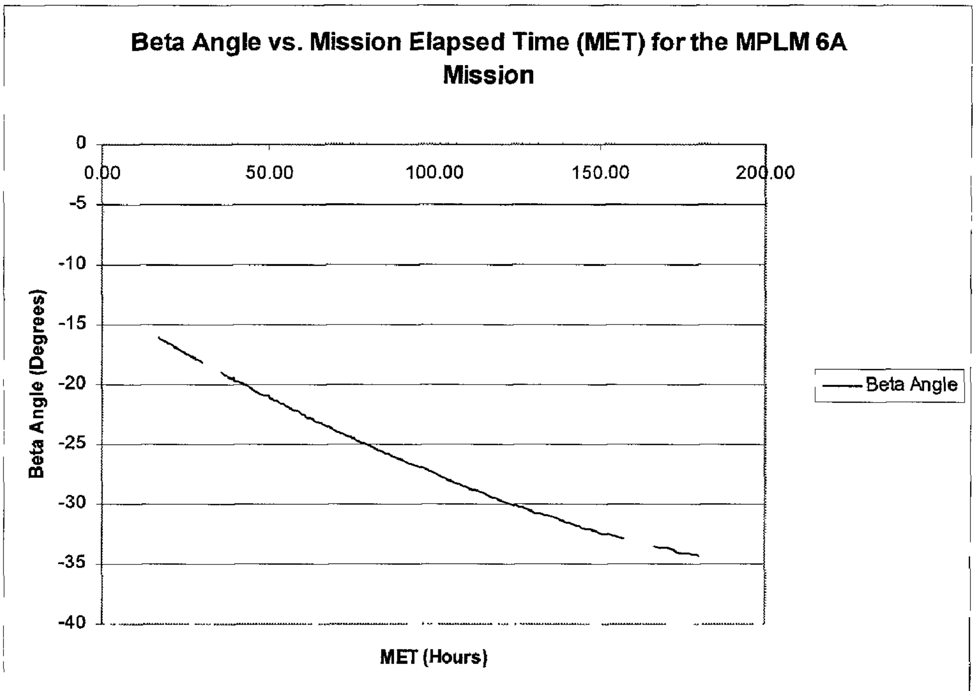
Hours of heater operation during nominal mission timeline =	47.27	
Total hours of heater operation =	60.07	
Total Orbiter Energy Used during Mission =	54.3198	kW-hrs

6A – Orbiter Attitude Timeline:

MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	SSpt 2orb	$Sun	DD/HH:MM:SS	Alt	Comment
0.00	0.42	LVLH	P 0	Y 0	R 0	0	0	180	325	7	4.0	96	356	6	59	0/ 0:00:00	129	LIFTOFF
0.42	1.06	IH	P 69	Y 327	R 324	0	182	115	313	168	3.9	98	189	107	59	0/ 0:25:01	129	OMS-2 (2 OMS)
1.48	2.15	LVLH	P 180	Y 90	R 0	0	0	0	321	175	3.4	94	183	3	59	0/ 1:28:39	129	-ZLV +YVV
3.62	0.40	IH	P 45	Y 342	R 139	0	181	36	170	18	3.0	72	3	162	59	0/ 3:37:21	129	NC-1 (2 OMS)
4.02	11.99	LVLH	P 180	Y 0	R 0	0	0	0	357	78	3.0	168	344	258	59	0/ 4:01:21	157	-ZLV -XVV
16.01	0.31	IH	P 350	Y 24	R 145	0	181	22	181	86	0.7	5	342	243	59	0/16:00:46	157	NC-2 & NPC
16.32	1.72	LVLH	P 180	Y 0	R 0	0	0	0	359	137	0.6	133	181	317	59	0/16:19:21	154	-ZLV -XVV
18.05	0.23	IH	P 176	Y 339	R 85	0	164	104	353	83	0.3	170	315	9	59	0/18:02:43	154	IMU Align
18.27	0.18	IH	P 267	Y 355	R 116	0	24	129	263	87	0.3	83	273	64	59	0/18:16:28	154	SLM 2
18.46	0.05	IH	P 2	Y 302	R 197	0	200	137	267	94	0.2	87	266	108	59	0/18:27:29	154	SLM 3
18.51	0.29	IH	P 1	Y 302	R 200	0	214	136	267	98	0.2	87	262	121	59	0/18:30:37	154	SLM 4
18.80	1.33	LVLH	P 180	Y 90	R 0	0	0	0	87	9	0.2	91	9	189	59	0/18:47:51	154	H2O Dump
20.13	5.86	LVLH	P 180	Y 0	R 0	0	0	0	181	33	-0.1	57	360	147	59	0/20:07:31	154	-ZLV -XVV
25.98	0.48	IH	P 97	Y 319	R 351	0	179	142	2	147	-1.2	123	178	109	59	1/ 1:59:01	154	NC-3 (2 OMS)
26.46	10.37	LVLH	P 180	Y 0	R 0	0	0	0	1	43	-1.3	133	1	223	59	1/ 2:27:46	154	-ZLV -XVV
36.83	1.99	LVLH	P 0	Y 270	R 0	0	0	180	60	174	-3.2	93	175	185	60	1/12:50:01	192	+ZLV +YVV
38.82	0.37	IH	P 305	Y 39	R 346	0	184	170	176	58	-3.5	33	7	293	60	1/14:49:11	192	NC-4 (2 OMS)
39.19	0.10	LVLH	P 270	Y 0	R 0	0	180	90	3	111	-3.6	159	171	21	61	1/15:11:35	207	-Z Target Track
39.29	1.07	LVLH	P 275	Y 0	R 0	0	180	95	4	129	-3.6	140	175	44	61	1/15:17:42	207	-Z Target Track
40.37	0.09	LVLH	P 285	Y 0	R 0	0	180	105	18	11	-3.8	101	4	296	61	1/16:22:07	207	-Z Target Track
40.46	0.24	IH	P 303	Y 27	R 352	0	356	167	164	55	-3.8	38	21	318	61	1/16:27:47	207	TI (L OMS)
40.70	1.08	LVLH	P 270	Y 0	R 0	0	180	90	4	103	-3.8	167	165	13	61	1/16:41:56	207	-Z Target Track
41.78	0.37	LVLH	P 340	Y 0	R 0	0	180	160	176	74	-4.0	17	13	266	61	1/17:46:50	209	-Z Target Track
42.15	0.31	LVLH	P 0	Y 0	R 0	0	0	180	155	9	-4.1	82	4	352	61	1/18:08:48	209	+ZLV +XVV
42.45	1.10	LVLH	P 90	Y 0	R 0	0	0	90	171	27	-4.1	64	4	64	61	1/18:27:15	209	+Rbar to +Vbar
43.56	0.29	LVLH	P 74	Y 358	R 2	0	359	106	173	112	-4.4	23	163	322	61	1/19:33:29	209	Free Drift for
43.85	51.37	LVLH	P 113	Y 0	R 0	0	0	67	176	83	-4.4	8	31	30	61	1/19:50:54	209	BIAS -XLV +ZVV
95.22	1.81	LVLH	P 90	Y 23	R 90	0	0	67	329	56	-13.1	140	332	162	61	3/23:13:17	205	Bias -XLV +YVV
97.03	1.62	LVLH	P 327	Y 0	R 0	0	180	147	167	100	-13.4	17	127	227	61	4/ 1:02:02	205	Bias +ZLV +XVV
98.66	7.06	LVLH	P 113	Y 0	R 0	0	0	67	18	132	-13.6	135	161	247	61	4/ 2:39:21	209	Bias -XLV +ZVV
105.72	1.30	LVLH	P 131	Y 0	R 0	0	0	49	155	36	-14.8	58	17	98	61	4/ 9:43:01	206	MOM MGMT DRIFT
107.02	0.20	LVLH	P 138	Y 0	R 0	0	0	42	165	95	-15.0	15	108	43	61	4/11:01:11	206	ISS Free Drift
107.22	0.33	LVLH	P 131	Y 0	R 0	0	0	49	158	43	-15.0	51	19	90	61	4/11:13:11	206	ISS CMG TA
107.55	74.78	LVLH	P 113	Y 0	R 0	0	0	67	18	56	-15.1	142	24	167	61	4/11:33:01	206	Return to TEA
182.33	2.25	LVLH	P 90	Y 23	R 90	0	0	67	214	83	-25.7	34	282	37	62	7/14:20:01	209	Bias -XLV +YVV
184.59	1.66	LVLH	P 84	Y 0	R 180	0	0	84	331	63	-26.0	141	316	204	62	7/16:35:14	208	Bias -XLV -ZVV,
186.25	52.58	LVLH	P 113	Y 0	R 0	0	0	67	29	117	-26.2	141	136	233	62	7/18:15:01	208	Bias -XLV +ZVV
238.83	0.13	LVLH	P 113	Y 0	R 0	0	0	67	84	148	-31.7	93	148	289	63	9/22:50:01	215	Free Drift
238.97	0.23	LVLH	P 113	Y 0	R 0	0	0	67	127	139	-31.7	67	145	320	63	9/22:58:01	215	Move Away Track
239.20	0.08	LVLH	P 113	Y 0	R 0	0	0	67	148	98	-31.7	33	105	14	63	9/23:11:44	215	Flyaround
239.28	0.15	LVLH	P 152	Y 0	R 0	0	0	28	145	114	-31.7	42	128	33	63	9/23:16:44	215	Flyaround
239.43	0.02	LVLH	P 270	Y 0	R 350	0	180	90	50	150	-31.7	109	156	68	63	9/23:25:41	215	Maneuver IMAX
239.45	0.06	LVLH	P 270	Y 0	R 350	0	180	90	57	153	-31.7	104	157	73	63	9/23:27:01	215	LVLH Hold
239.51	0.07	LVLH	P 270	Y 0	R 0	0	180	90	87	148	-31.7	92	148	88	63	9/23:30:51	215	End of Filming
239.58	0.08	LVLH	P 270	Y 0	R 0	0	180	90	111	146	-31.8	79	148	103	63	9/23:34:49	215	Flyaround

MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	SSpt 2orb	$Sun	DD/HH:MM:SS	Alt	Comment
239.66	0.08	LVLH	P 309	Y 0	R 0	0	180	129	80	148	-31.8	95	148	123	63	9/23:39:49	215	Flyaround
239.75	0.08	LVLH	P 348	Y 0	R 0	0	180	168	55	140	-31.8	112	146	142	63	9/23:44:49	215	Flyaround
239.83	0.02	LVLH	P 27	Y 0	R 0	0	0	153	41	127	-31.8	127	139	162	63	9/23:49:49	215	Flyaround
239.85	0.45	LVLH	P 36	Y 0	R 0	0	0	144	39	123	-31.8	131	136	166	63	9/23:51:01	215	LVLH Hold
240.30	11.32	LVLH	P 180	Y 0	R 0	0	0	0	32	92	-31.8	148	94	272	63	10/ 0:18:17	215	-ZLV -XVV
251.63	4.51	LVLH	P 180	Y 90	R 0	0	0	0	230	135	-32.7	57	212	32	63	10/11:37:31	212	-ZLV +YVV
256.14	0.17	IH	P 79	Y 44	R 13	0	256	57	117	132	-33.0	70	135	6	63	10/16:08:16	214	Free Drift for
256.31	20.40	LVLH	P 180	Y 90	R 0	0	0	0	228	126	-33.0	57	226	46	63	10/16:18:31	214	-ZLV +YVV
276.71	0.18	IH	P 220	Y 25	R 240	0	46	103	63	165	-34.3	97	166	124	63	11/12:42:31	208	IMU ALIGN
276.89	0.41	IH	P 134	Y 10	R 242	0	348	102	312	118	-34.3	127	235	166	63	11/12:53:21	208	IMU VERIF
277.30	3.16	IH	P 157	Y 325	R 331	0	84	86	1	94	-34.3	176	170	282	63	11/13:17:54	208	-XSI
280.46	3.67	IH	P 128	Y 334	R 241	0	107	167	330	90	-34.5	150	269	281	63	11/16:27:31	208	COMM ATT
284.13	0.39	IH	P 315	Y 52	R 305	0	23	54	169	69	-34.7	23	26	59	63	11/20:07:46	208	D O Burn OOP
284.52	0.38	IH	P 5	Y 318	R 325	0	177	139	103	144	-34.7	82	144	150	63	11/20:30:57	208	EI-5 INRTL
284.90	0.00	LVLH	P 39	Y 358	R 0	0	0	0	0	0	-34.7	90	0	0	63	11/20:53:46	208	EI-5 LVLH

6A Beta Angle:



6A – MPLM Pressure Prior to Transfer to ISS:

NO DATA

6A – MPLM Pressure Attached to ISS:

NO DATA

6A – MPLM Voltage & Current Draw:

NO DATA

6A – MPLM Cabin Fan Current & Speed:

NO DATA

6A – MPLM Pressure & Temperature During 24 Hour Ops in PLB:

NO DATA

6A – MPLM PDB Voltage During 24 Hour Ops in PLB:

NO DATA

6A – MPLM Environmental Check During Extended Ops in PLB:

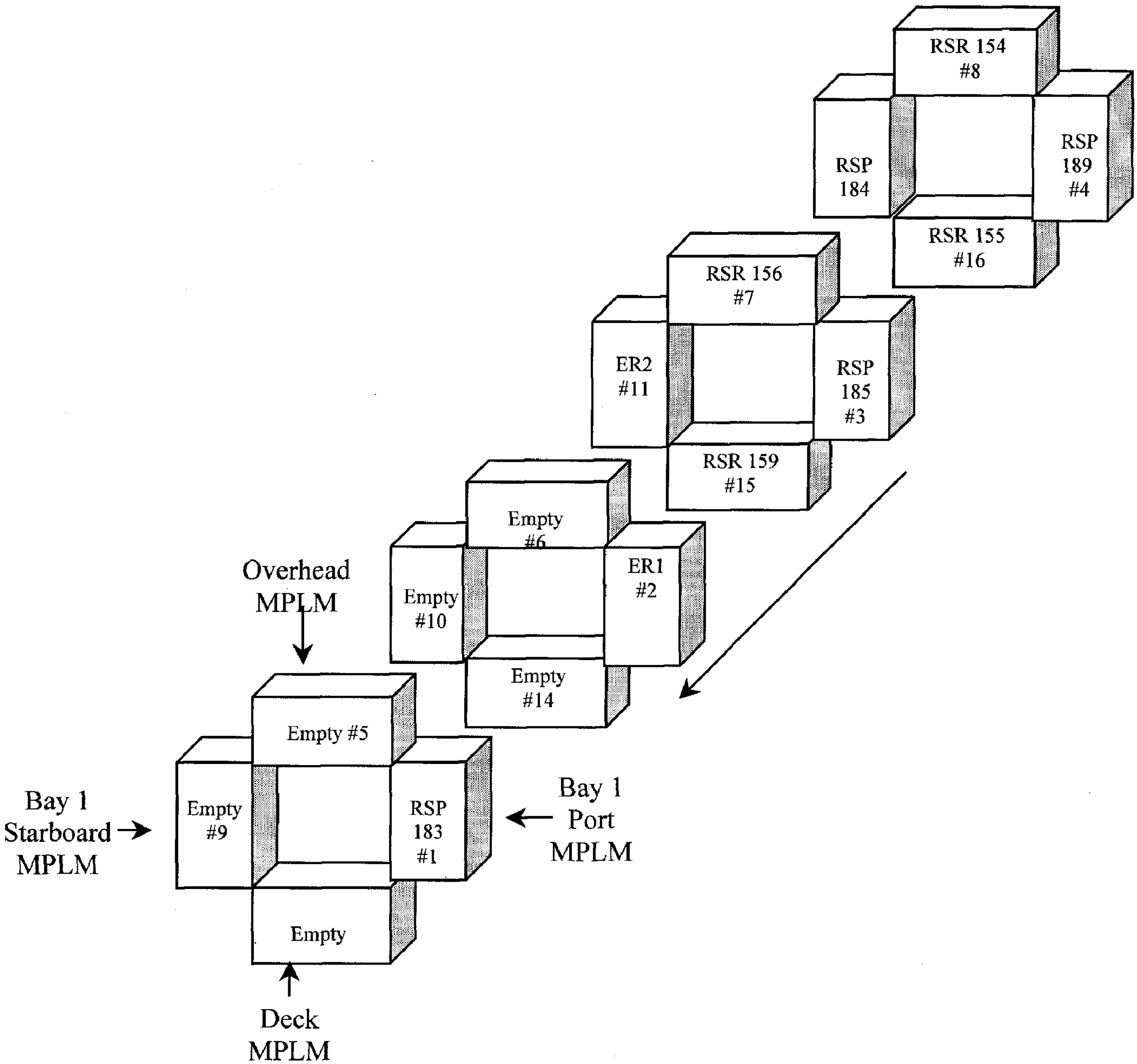
NO DATA

6A – MPLM Heater Voltage & Current During Extended Ops in PLB

NO DATA

MPLM Cargo Manifest – Up

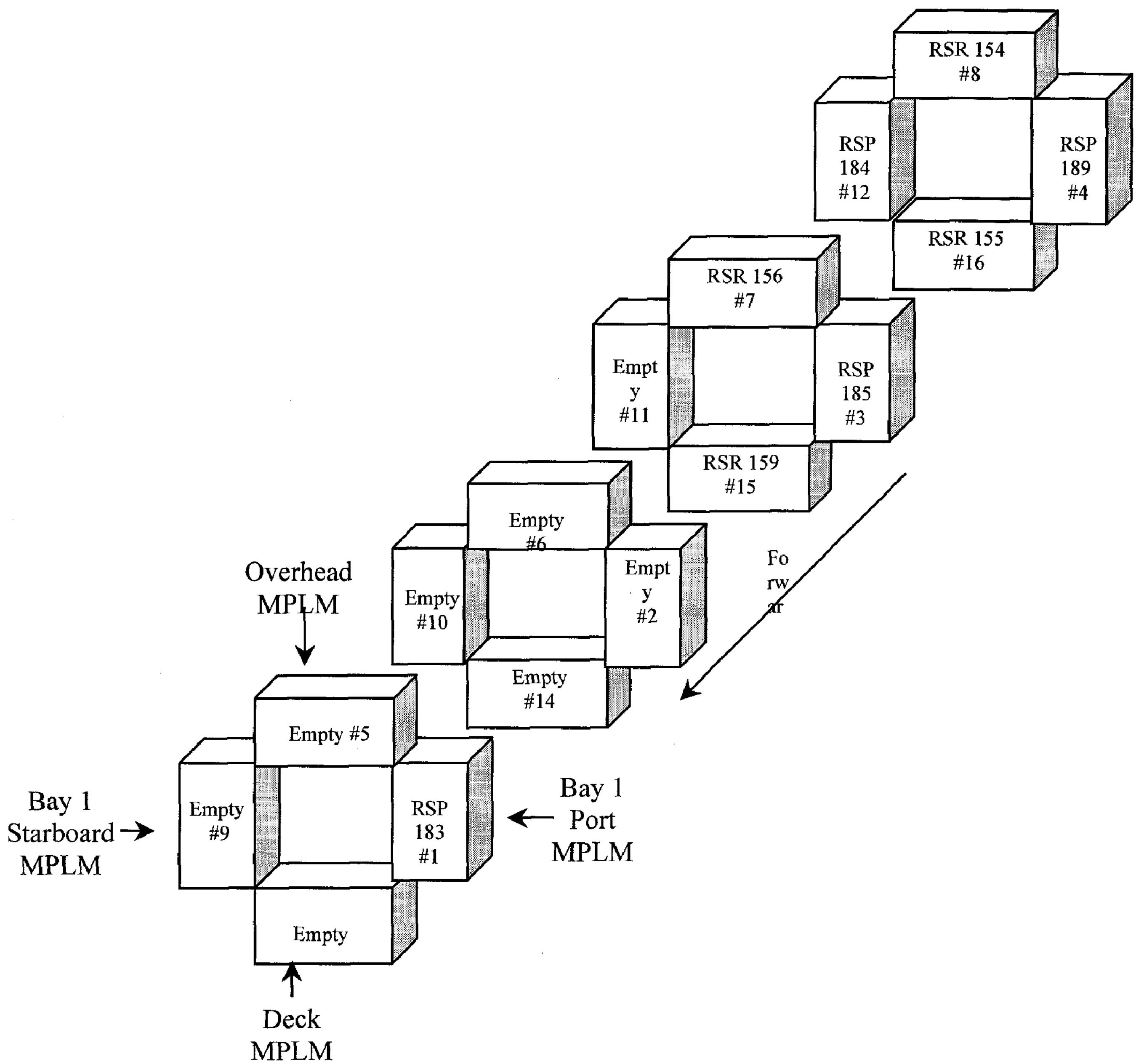
Type	Number	
RSP	4	
RSR	4	
Express Rack	2	
Liquid Containers	3	CWC
	6	PWR
Pressure Vessels	0	0



6A Launch Rack Configuration

MPLM Cargo Manifest – Down

Type	Number	
RSP	4	
RSR	4	
Express Rack	0	Left on ISS
Liquid Containers	1	CWC
Pressure Vessels	0	0



6A Landing Rack Configuration

MPLM Mission Generated Paper

Waivers:

- No Waivers written during mission

Problem Reports (PRs):

- No Problem Reports written during mission

CHITS (Mission Action Request):

ISS0026 Don't need to install ground strap between Node 1 and MPLM
ISS0058 Move MPLM Knee Braces to ISS
Disapproved – MPLM Knee Braces were designed specifically for the MPLM

Items – For – Investigation (IFI):

- No IFIs written during mission

Significant Flight Notes:

- Only one string of 28Vdc heaters turned on in Payload Bay. Resulted in lower than expected temperature at environment check before MPLM deploy.

- Several discussions about returning CWCs in MPLM

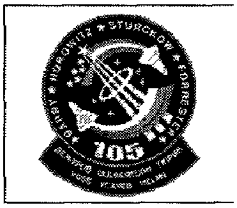
- Mission extended 2 days.

In-Flight Anomaly:

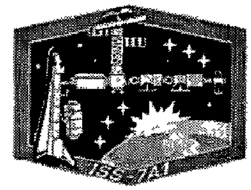
- No In-Flight Anomalies written during mission

Lessons Learned:

- No Lessons Learned written during mission



Flight: STS – 105



Mission: 7A.1

STS-105 Swaps International Space Station Crews

Space Shuttle Discovery spent 12 days in orbit, with eight of those days docked to the International Space Station. While at the orbital outpost, the STS-105 crew attached the Leonardo Multi-Purpose Logistics Module, transferred supplies and equipment to the station, completed two space walks and deployed a small spacecraft called Simplesat.

The Crew

Scott Horowitz	Commander
Rick SturoKow	Pilot
Daniel Barry	Mission Specialist
Patrick Forrester	Mission Specialist
Frank Culbertson	Space Station Crew (Up)
Vladimir Dezhurov, Rosaviakosmos	Space Station Crew (Up)
Mikhail Tyruin, Rosaviakosmos	Space Station Crew (Up)
Yury Usachev, Rosaviakosmos	Space Station Crew (Down)
James Voss	Space Station Crew (Down)
Susan Helms	Space Station Crew (Down)

Mission Data

Launch Date	08/10/01	4:10 pm CST	KSC
Landing Date	08/22/01	1:23 pm CST	KSC
Launch Pad	39-A		
Orbiter	OV – 103	Discovery	
MPLM Module	FM –1	Leonardo	
Module Weight	9,671 lbs		
MPLM Cargo Wt Up	11,027 lbs		
MPLM Cargo Wt Down	7,373 lbs		
Orbit Altitude	122 nautical miles		
Mission Duration	11 days, 21 hours, 13 minutes		
	Extended one revolution		

MPLM Mission Management Team

7A.1 Shift Assignments

Name	Room	Shift	Discipline
Shawn Reagan	MER	1	System Engineer
Allen Shariett	MER	3	System Engineer
Randy McClendon	IMC	Float	MPLM Element Manager
David Harwell	IMC	2	Mission Engineer
Charlotte Hazel*	IMC	1	Mission Engineer
Keith Presson	MER	3	System Engineer
Gordon DeRamus	IMC	3	Mission Engineer
Jon Holladay*	MER	2	System Engineer
Mike Robinson	MER	2	Boeing TCS
Greg Day	MER	1	Boeing TCS
Carl Ise	IMC	2	Mission Engineer
Carley Rohrig	IMC	Float	System Engineer

Notes:

*** 7A.1/STS-102 Mission Leads**

7. **Shift 1 – 5:00 AM – 2:00 PM** **Execute 1 Shift**
8. **Shift 2 – 1:00 PM – 10:00 PM** **Execute 2 Shift**
9. **Shift 3 – 9:00 PM – 6:00 AM** **Crew Sleep Shift**

Mission Objectives / Goals

STS-105

The primary objective of this flight was to deliver and integrate the International Space Station 7A.1 launch package into the ISS.

Cargo Bay Payloads:

Leonardo - Multi-Purpose Logistics Module

For a complete description of the MPLM, see "Back Up Information" at the end of this appendix.

For STS-105, Leonardo will be outfitted with 12 racks of experiments and equipment. Two EXPRESS racks will be transferred to ISS. In addition to these two racks, there are six Resupply Stowage Racks and four Resupply Stowage Platforms filled with logistics and supplies requiring transfer to ISS.

Materials International Space Station Experiment

The Materials International Space Station Experiment, or MISSE, Project is a NASA/Langley Research Center-managed cooperative endeavor to fly materials and other types of space exposure experiments on the International Space Station. The objective is to develop early, low-cost, non-intrusive opportunities to conduct critical space exposure tests of space materials and components planned for use on future spacecraft.

Johnson Space Center, Marshall Space Flight Center, Glenn Research Center, the Materials Laboratory at the Air Force Research Laboratory and Boeing Phantom Works are participants with Langley in the project.

The MISSE experiment will be the first externally mounted experiment conducted on the ISS. The experiments are in four Passive Experiment Containers, or PECs, that were initially developed and used for an experiment on Mir in 1996 during the Shuttle-Mir Program.

Hitchhiker Experiments Advancing Technology

The Hitchhiker Experiments Advancing Technology, or HEAT, is a collection of Get Away Special (GAS) canisters all under the direction of Goddard Space Flight Center. It consists of the following experiments:

Advanced Carrier Equipment Avionics System
The Advanced Carrier Equipment, or ACE, Avionics System has been designed to replace the Hitchhiker Avionics.

Simplesat
Simplesat is an engineering satellite designed to evaluate the use of inexpensive commercial hardware for spacecraft. It is expected that Simplesat will demonstrate Global Positioning System attitude control and fine pointing control while in free-flyer low-Earth orbit.

Student Experiment Module
The Student Experiment Module, or SEM, is housed in a sealed, extended 0.14-cubic-meter (5-cubic-foot) canister mounted in the aft position of the port adapter beam. The SEM will contain up to 10 small, enclosed modules, each containing a separate, passive experiment designed and constructed by students.

G-774
The objective of the G-774 experiment is to increase the understanding of smoldering combustion in a long-term microgravity environment. This experiment will focus on one-dimensional smoldering polyurethane foam.

GAS Canister G-780 Payload
The GAS G-780 payload is sponsored by Mayo High School, Rochester, Minn. The objective of the G-780 experiment is to investigate cell growth in microgravity. The experiment utilizes six growing chambers containing various seed types.

Mission Related / Mission Unique Documentation:

NSTS-21438	Mission Integration Plan (MIP) for 7A.1
ICD-A-21350	Shuttle Orbiter to MPLM Cargo Element Interfaces
SSP-42007	USOS to MPLM ICD

Safety:

MPLM Reflight Assessment for the FM 1 MPLM Module.

MPLM Module (Alenia) **Doc Number**	**Title**	**Review**	**Comment**

Reflight Assessment for the MPLM/Orbiter Integrated Hazard Analysis

MPLM/Orbiter Integrated (MSFC) **Doc Number**	**Title**	**Review**	**Comment**
ISS-MPLM-DOC-009	Multi Purpose Logistics Module (MPLM)/Orbiter Integrated Reflight Assessment (Written in July 2001)	July 2001	Reviewed by the ISS SRP and approved out of board for the Flight 7A.1 mission.

Pressure Vessel Assessment

Pressure Vessel Assessment (MSFC) **Doc Number**	**Title**	**Review**	**Comment**
ISS-MPLM-DOC-010	Assessment of Transporting the Portable Fire Extinguisher (PFE) onboard the Multi Purpose Logistics Module (MPLM) for the Flight 7A.1 Mission (Written July 2001)	July 20, 2001	Reviewed by the ISS SRP and approved out of board for the Flight 7A.1 mission.

Mission Elapsed Time (MET) Event Timeline

Flight Day 1: 08/10/01

MPLM KSC Closeout Environmental Conditions:
Pressure: Data Not Available
Temperature: Data Not Available
Dew Point: Data Not Available
Launch: 4:10 pm CST
MPLM in Shuttle Payload Bay
1st Environment Check:
Pressure = 14.94 psia
Temperature = 74.3 °F

Flight Day 2: 08/11/01

MPLM in Shuttle Payload Bay

Flight Day 3: 08/12/01

MPLM in Shuttle Payload Bay
Shuttle Rendezvous with ISS
Shuttle Docking: 12:38 am CST
Ingress
Middeck Transfers Begin

Flight Day 4: 08/13/01

MPLM in Shuttle Payload Bay
Begin Expedition Crew Handover
MPLM Berthing Operations
MPLM Berth 10:55 am CST
MPLM Activation (Part 1)
MPLM Activation (Part 2)

Flight Day 5: 08/14/01

MPLM Attached to ISS
MPLM Ingress / Transfer Setup
MPLM Transfer Activities
ISS Re-boost #1

Flight Day 6: 08/15/01

MPLM Attached to ISS
MPLM Attached to ISS
MPLM Transfer Activities

ISS Re-boost #2
10.2 Cabin Depress

Flight Day 7: 08/16/01

MPLM Attached to ISS
MPLM Transfer Activities

EVA

Flight Day 8: 08/17/01

MPLM Attached to ISS
MPLM Transfer Activities

ISS Re-boost #3

Flight Day 9: 08/18/01

MPLM Attached to ISS
MPLM Transfer Activities

EVA

Flight Day 10: 08/19/01

MPLM Attached to ISS
MPLM Deactivation
MPLM Closeout conditions:
Pressure = 14.78 psia
Temperature = 71.6 °F
Dew Point: 50.0 °F
MPLM Re-berthing Operations
MPLM Re-Berth 2:15 pm CST
MPLM Back in Payload Bay
Total time MPLM docked to ISS - 6 days, 3 hours, 20 minutes

Flight Day 11: 08/20/01

MPLM in Shuttle Payload Bay

Shuttle Undock 9:52 am CST

Fly-around / Separation Burns

Simplesat Deploy

Flight Day 12: 09/21/01

MPLM in Shuttle Payload Bay

Cabin Stow

Deorbit Briefing

Flight Day 13: 08/22/01

MPLM in Shuttle Payload Bay

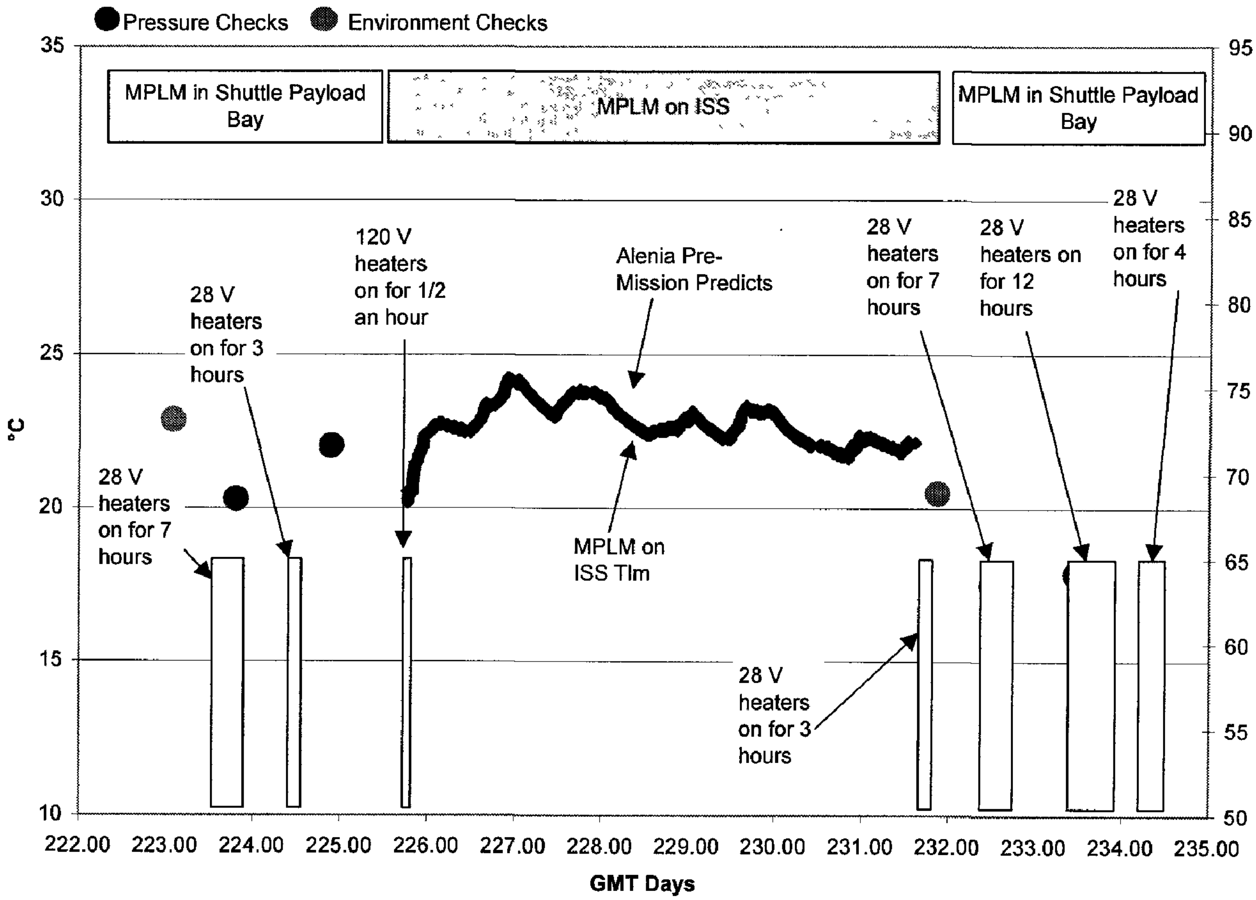
Deorbit Prep

Deorbit Burn

Landing 1:23 pm CST

MPLM Mission Data Summary
Mission 7A.1

7A.1 - Temperature Data:



7A.1 – Mission Heater Power Timeline:

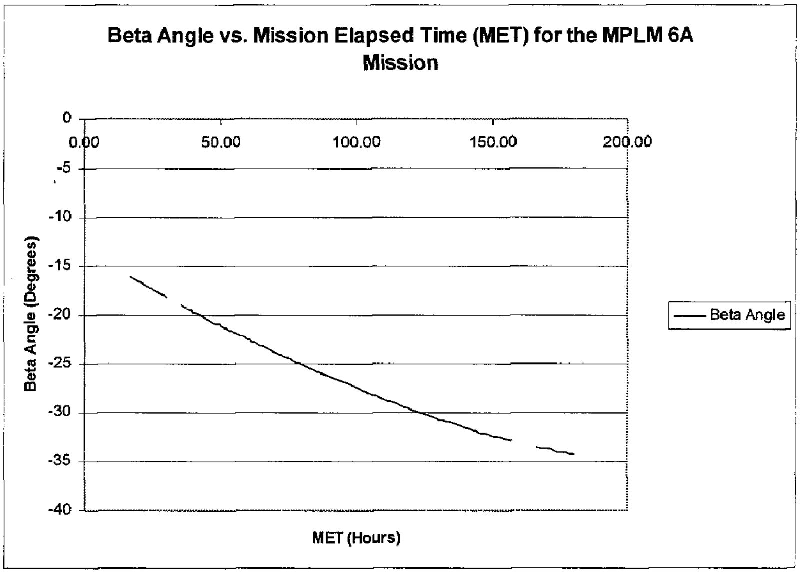
Voltage	Day	Hour	Minute	Summary Actual		Summary Scheduled	
	223	16	20	1180.00	watts		
	224	0	20	0.00	hours	8	hours
	224	12	22	1180.00	watts		
	224	19	30	7.13	hours	7.5	hours
	225	9	52	1180.00	watts		
	225	12	58	3.10	hours	3	hours
	8	22	25		watts		
	9	1	27	3.03	hours	3	hours
30.7 Vdc at	9	17	0		watts		
fuel cell	10	0	10	7.17	hours	8	hours
31.0 Vdc @ fuel cell	10	12	55	1011.00	watts		
28.8 Vdc at HCU	11	1	15	12.33	hours	8.5	hours
31.0 Vdc @ fuel cell	11	11	41		watts		
	11	15	27	3.77	hours	3	hours

hours of heater operation during nominal mission timeline =
scheduled hours of heater operation for nominal mission timeline =
total hours of heater operation =

7A.1 – Orbiter Attitude Timeline:

MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	SSpt 2orb	%Sun	DD/HH:MM:SS	Alt	Comment
0.00	0.50	LVLH	P 0	Y 0	R 0	0	0	180	302	41	34.3	110	323	25	59	0/ 0:00:00	106	LIFTOFF
0.50	0.80	IH	P 65	Y 33	R 201	0	180	156	283	145	34.2	98	224	147	59	0/ 0:30:01	106	OMS-2 Att
1.30	2.45	LVLH	P 180	Y 270	R 0	0	0	0	203	142	34.0	56	197	343	59	0/ 1:18:13	106	PLB Opening and
3.75	0.48	IH	P 147	Y 27	R 333	0	179	19	141	66	34.2	45	54	221	59	0/ 3:45:17	106	NC-1
4.24	21.55	LVLH	P 180	Y 0	R 0	0	0	0	299	141	34.1	108	215	339	60	0/ 4:14:08	127	-ZLV -XVV
25.79	0.70	IH	P 145	Y 21	R 153	0	192	94	224	114	29.4	49	238	155	60	1/ 1:47:20	127	NC3 Burn
26.48	12.39	LVLH	P 180	Y 0	R 0	0	0	0	318	135	29.3	122	214	323	60	1/ 2:29:05	131	-ZLV -XVV
38.86	1.67	LVLH	P 180	Y 90	R 0	0	0	0	296	101	26.7	116	257	77	60	1/14:52:31	131	Waste dump
40.55	0.13	IH	P 19	Y 359	R 221	0	357	174	332	113	26.3	145	228	121	60	1/16:32:53	131	NH Burn Att
40.68	0.66	LVLH	P 37	Y 0	R 360	0	360	143	332	113	26.2	144	227	154	60	1/16:40:54	131	LVLH between
41.34	0.23	IH	P 221	Y 343	R 142	0	179	169	218	44	26.1	57	330	313	60	1/17:20:30	131	NC4 Burn
41.57	0.66	LVLH	P 270	Y 0	R 0	0	180	90	334	98	26.1	153	251	9	62	1/17:34:29	211	Rendezvous
42.24	0.67	LVLH	P 281	Y 0	R 0	0	180	101	208	114	25.9	36	228	164	62	1/18:14:12	211	-Z Traget Track
42.91	0.29	IH	P 248	Y 333	R 155	0	172	151	245	28	25.8	79	334	221	62	1/18:54:29	211	TI Burn Att
43.19	1.41	LVLH	P 270	Y 0	R 0	0	180	90	332	115	25.8	143	225	28	62	1/19:11:39	214	-Z Traget Track
44.61	0.35	LVLH	P 0	Y 0	R 0	0	0	180	264	25	25.5	87	335	357	62	1/20:36:20	214	+ZLV +XVV
44.96	1.06	LVLH	P 90	Y 0	R 0	0	0	90	248	27	25.4	80	335	79	62	1/20:57:29	214	-XLV +ZVV
46.02	0.22	LVLH	P 37	Y 357	R 3	0	0	143	203	73	25.2	28	307	327	62	1/22:01:03	214	free drift
46.24	46.39	LVLH	P 113	Y 0	R 0	0	0	67	204	95	25.1	25	258	18	62	1/22:14:10	214	LVLH TEA
92.62	2.34	LVLH	P 327	Y 0	R 0	0	180	147	345	77	15.8	160	310	44	61	3/20:37:21	215	Reboost config 4
94.77	1.65	LVLH	P 90	Y 23	R 90	0	0	67	4	82	15.3	171	27	184	61	3/22:46:02	211	WASTE DUMP
96.42	62.42	LVLH	P 113	Y 0	R 0	0	0	67	346	97	15.0	164	245	210	61	4/ 0:25:01	211	TEA
158.83	2.23	LVLH	P 329	Y 0	R 0	0	180	149	358	67	2.6	157	355	36	61	6/14:50:01	210	Reboost config 4
161.06	1.44	LVLH	P 90	Y 23	R 90	0	0	67	19	70	2.2	153	41	197	61	6/17:03:49	210	Dump Att
162.50	44.75	LVLH	P 113	Y 0	R 0	0	0	67	359	60	1.9	150	358	173	61	6/18:30:01	210	LVLH TEA
207.25	2.65	LVLH	P 90	Y 23	R 90	0	0	67	16	60	-6.7	147	26	194	61	8/15:15:01	213	Dump Att
209.90	22.68	LVLH	P 113	Y 0	R 0	0	0	67	159	22	-7.3	69	8	92	61	8/17:53:52	213	LVLH TEA
232.58	1.15	LVLH	P 114	Y 0	R 0	0	0	66	165	125	-11.4	37	160	349	61	9/16:34:57	217	LVLH TEA
233.73	1.27	LVLH	P 114	Y 0	R 0	0	0	66	20	141	-11.7	126	165	257	61	9/17:44:01	217	LVLH Hold
235.01	0.21	LVLH	P 180	Y 0	R 0	0	0	0	44	18	-11.9	103	13	193	61	9/19:00:21	217	Fly Around
235.22	1.51	LVLH	P 180	Y 0	R 0	0	0	0	14	64	-11.9	150	26	243	61	9/19:13:05	217	-ZLV -XVV
236.73	0.90	IH	P 109	Y 353	R 210	0	52	123	126	179	-12.2	90	179	235	61	9/20:43:49	213	+ZSI SSAT
237.63	1.72	LVLH	P 180	Y 0	R 0	0	0	0	167	95	-12.4	14	113	85	61	9/21:37:34	213	-ZLV -XVV
239.35	0.29	IH	P 247	Y 344	R 123	0	344	29	146	27	-12.7	68	16	126	61	9/23:20:48	213	ORB ADJUST BURN
239.64	15.72	LVLH	P 180	Y 0	R 0	0	0	0	44	19	-12.7	103	13	194	61	9/23:38:07	213	-ZLV -XVV
255.36	0.17	LVLH	P 271	Y 0	R 1	0	180	91	110	16	-15.6	85	15	265	61	10/15:21:31	206	free drift
255.53	2.73	LVLH	P 180	Y 90	R 0	0	0	0	109	123	-15.6	74	135	305	61	10/15:31:39	206	-ZLV +YVV
258.26	0.50	LVLH	P 0	Y 85	R 180	0	0	0	118	46	-16.1	70	43	224	61	10/18:15:26	206	BIAS -ZLV +YVV
258.76	19.07	LVLH	P 180	Y 90	R 0	0	0	0	132	165	-16.2	73	161	341	61	10/18:45:26	206	-ZLV +YVV
277.83	0.26	IH	P 58	Y 10	R 306	0	111	124	57	95	-19.6	123	96	125	61	11/13:49:43	207	IMU
278.09	0.36	IH	P 294	Y 79	R 85	0	124	99	116	86	-19.6	65	79	287	61	11/14:05:24	207	VERIF
278.45	1.77	IH	P 17	Y 329	R 147	0	90	90	0	95	-19.7	175	176	270	61	11/14:26:48	207	-XSI Rad Cold
280.22	3.82	IH	P 46	Y 339	R 290	0	223	52	31	90	-20.0	149	89	324	61	11/16:13:01	207	Comm Attitude
284.03	0.22	IH	P 245	Y 320	R 113	0	1	35	108	23	-20.6	83	22	138	62	11/20:01:58	213	D O Burn Att
284.25	0.25	IH	P 86	Y 61	R 230	0	179	172	128	153	-20.6	74	158	189	62	11/20:15:12	213	EI-25

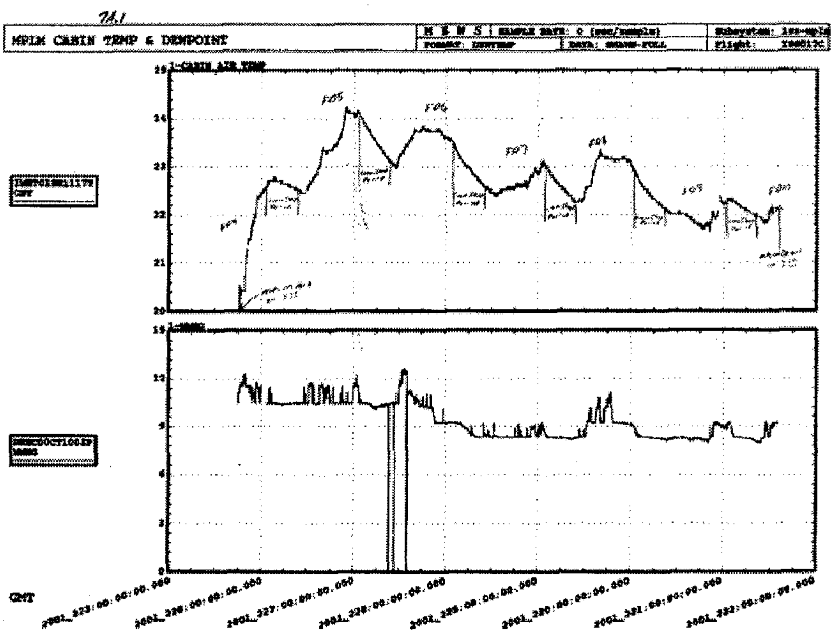
7A.1 - Beta Angle:



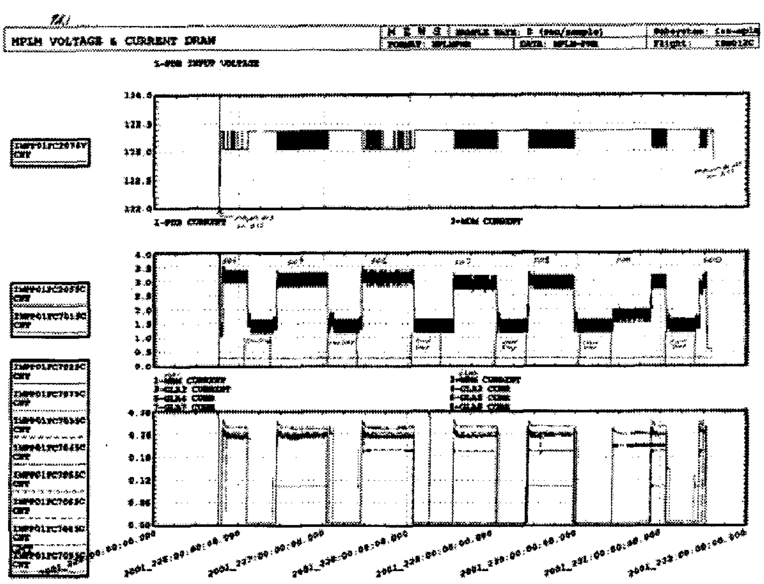
7A.1 – MPLM Pressure Prior to Transfer to ISS:

NO DATA

7A.1 – MPLM Pressure Attached to ISS:



7A.1 – MPLM Voltage & Current Draw:



7A.1 – MPLM Cabin Fan Current & Speed:

NO DATA

7A.1 – MPLM Pressure & Temperature During 24 Hour Ops in PLB:

NO DATA

7A.1 – MPLM PDB Voltage During 24 Hour Ops in PLB:

NO DATA

7A.1 – MPLM Environmental Check During Extended Ops in PLB:

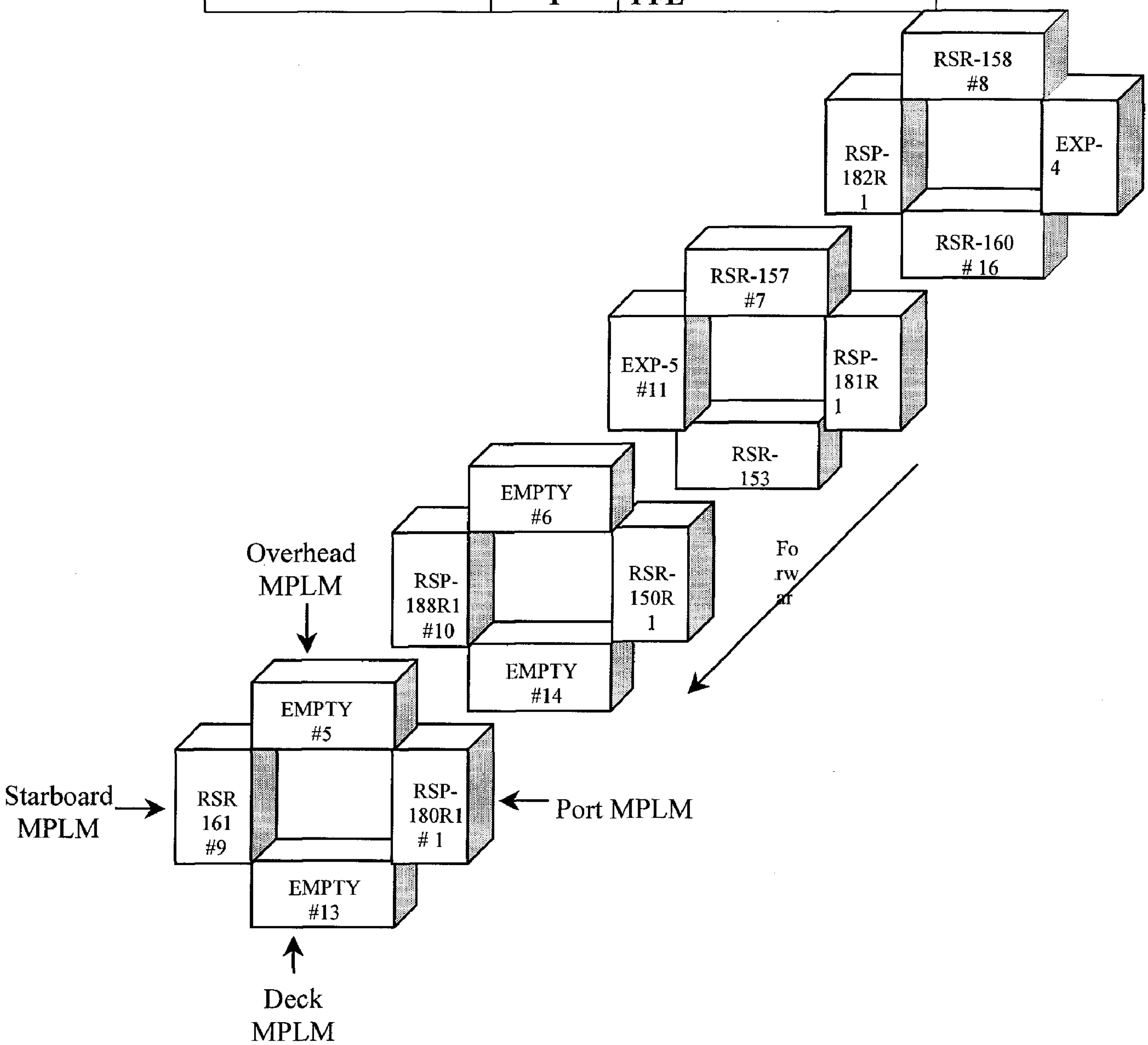
NO DATA

7A.1 – MPLM Heater Voltage & Current During Extended Ops in PLB

NO DATA

MPLM Cargo Manifest – Up

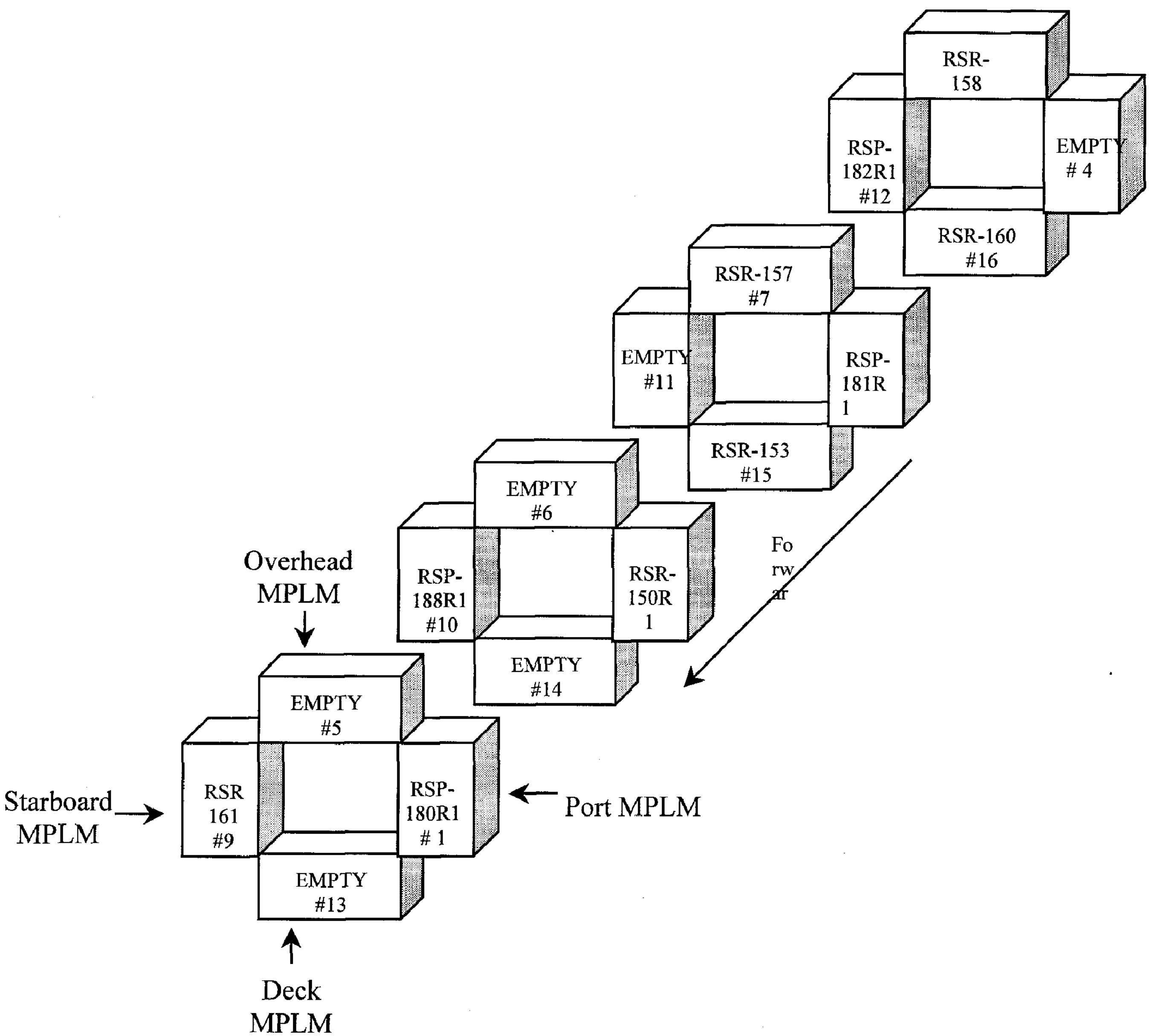
Type	Number	
RSP	4	
RSR	6	
Express Rack	2	
Liquid Containers	0	0
Pressure Vessels	1	SAFER
	1	GSM
	1	VGA
	1	PFE



7A.1 Launch Rack Configuration

MPLM Cargo Manifest – Down

Type	Number	
RSP	4	
RSR	6	
Express Rack	0	Left on ISS
Liquid Containers	10	CWC-1 leaker
	1	EDV
Pressure Vessels	1	PBA



7A.1 Landing Rack Configuration

MPLM Mission Generated Paper

Waivers:

- **No Waivers written during mission**

Problem Reports (PRs):

- **No Problem Reports written during mission**

CHITS (Mission Action Request):

ISS0060	Evaluate Contingency Rack Lower Launch Restraint Removal Procedure
ISS0008	Evaluate Return of EDV/CWC Combination on STS-105/7A.1 MPLM
ISS0046	7A.1 Transfer (US): Per-flight MPLM
ISS0062	7A.1 Transfer (Russian): FD-02 MPLM
ISS0057	EVR: On-Orbit Confirmation of CBCS Target Overlay
ISS0064	7A.1 Transfer (US): FD-03 MPLM
ISS0073	MPLM MDM Data Dump During ISS Phase
ISS0066	CBM Procedure for SSRMS Contingency MPLM Mate
ISS0075	7A.1 Transfer (US): Inputs to FD-06 MPLM Transfer
ISS0113	PMA2 Depress Final Pressure Criteria
ISS0110	7A.1 Transfer (US): Post MPLM Un-Berth

Items – For – Investigation (IFI):

IFI – MER - 519 Metal Shavings Found in MPLM
IFI – MER – 520 MPLM Over Voltage Event

Significant Flight Notes:

ROFN 827	Modified MPLM Install (Contingency)
ACFN 910	Metal Shavings
ACFN 036	CWC Locations in MPLM, A/L per IMS [FD9,1] Withdrawn [FD9,3]

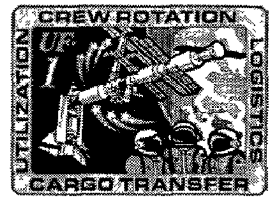
In-Flight Anomaly:

- **No In-Flight Anomalies written during mission**

Lessons Learned:

- **Data Not Available**

Flight: STS – 108



Mission: UF-1

STS-108 Swaps International Space Station Crews

The final shuttle flight of 2001 came to an end when Space Shuttle Endeavour landed at Kennedy Space Center, Fla., at 11:55 a.m. CST (1755 GMT) Dec. 17, 2001.

STS-108 was the 12th shuttle flight to visit the International Space Station and the first since the installation of the Russian airlock called Pirs on the station. Endeavour delivered the Expedition Four crew to the orbital outpost. The Expedition Three crew returned to Earth on Endeavour.

While at the station, the crew conducted one spacewalk and attached the Raffaello Multi-Purpose Logistics Module to the station so that about 2.7 metric tons (3 tons) of equipment and supplies could be unloaded. The crew later returned Raffaello to Endeavour's payload bay for the trip home.

The Crew

Dominic L. Gorie	**Commander**
Mark E. Kelly	**Pilot**
Linda M. Godwin	**Mission Specialist**
Daniel M. Tani	**Mission Specialist**
Yury Onufrienko, Rosaviakosmos	**Mission Specialist (Up)**
Carl E. Walz	**Mission Specialist (Up)**
Daniel W. Bursch	**Mission Specialist (Up)**
Frank Culbertson	**Mission Specialist (Down)**
Mikhail Tyurin, Rosaviakosmos	**Mission Specialist (Down)**
Vladimir Dezhurov, Rosaviakosmos	**Mission Specialist (Down)**

Mission Data

Launch Date	12/05/01	4:19 pm CST	KSC
Landing Date	12/17/01	11:55 am CST	KSC
Launch Pad	39-B		
Orbiter	OV – 105	Endeavour	
MPLM Module	FM –2	Raffaello	
Module Weight	9,789 lbs		
MPLM Cargo Wt Up	10,500 lbs		
MPLM Cargo Wt Down	9,750 lbs		
Orbit Altitude	122 nautical miles		
Mission Duration	11 days, 19 hours, 36 minutes		
	Extended?		

MPLM Mission Management Team

UF-1 Shift Assignments

Name	Room	Shift	Discipline
Shawn Reagan	MER	3	System Engineer
Allen Shariett	MER	2	System Engineer
Randy McClendon	IMC	Float	MPLM Element Manager
David Harwell*	MER	1	Mission Engineer
Charlotte Hazel	IMC	1	Mission Engineer
Keith Presson	MER	3	System Engineer
Gordon DeRamus	IMC	3	Mission Engineer
Jon Holladay*	IMC	2	System Engineer
Mike Robinson	MER	1	Boeing TCS
Greg Day	MER	2	Boeing TCS
Carl Ise	IMC	2	Mission Engineer

Notes:

* UF-1/STS-108 Mission Leads

10. Shift 1 – 5:00 AM – 2:00 PM — Execute 1 Shift
11. Shift 2 – 1:00 PM – 10:00 PM — Execute 2 Shift
12. Shift 3 – 9:00 PM – 6:00 AM — Crew Sleep Shift

Mission Objectives / Goals

STS-108

The primary objective of this flight was to deliver and integrate the Russian airlock called Pirs into the orbiting International Space Station.

Cargo Bay Payloads:

Raffaello - Multi-Purpose Logistics Module

For a complete description of the MPLM, see "Back Up Information" at the end of this appendix.

Avian Development Facility

The second generation of avian development hardware, the Avian Development Facility, is designed for space experiments that use Japanese quail eggs. The facility's main objective on STS-108 is to validate its subsystems and reduce the risk in developing the next generation of avian development hardware, the Egg Incubator. Secondary objectives will be the support of two experiments studying how the lack of gravity affects the development of avian embryos.

Commercial Biomedical Testing Module Experiment

A promising treatment for Osteoporosis is being tested during STS-108 by Amgen Inc., a biotechnology firm in Thousand Oaks, Calif. Osteoporosis is a debilitating disease that can lead to bone fractures and result in reduced quality of life for the elderly. Before launch, the treatment, the protein osteoprotegerin, will be given to 12 mice and 12 mice will receive a placebo. Other similarly treated mice will stay on the ground. This experiment will contribute to Amgen's ground-based studies of OPG. Since space flight induces a complete, more systematic, accelerated bone loss, it is expected to provide a good model for osteoporosis and potential treatments.

Multiple Application Customized Hitchhiker-1

Multiple Application Customized Hitchhiker-1, which is also known as MACH-1, is a collection of experiments mounted on a crossbay GAS bridge assembly. The experiments include: STARSHINE-2, the Prototype Synchrotron Radiation Detector, Collisions Into Dust Experiment-2, Capillary Pump Loop, and Space Experiment Module-11.

STARSHINE 2

STARSHINE 2 will be the third satellite of Project Starshine -- the Student Tracked Atmospheric Research Satellite for Heuristic International Networking Experiment -- to be deployed. More than25,000 students from 26 countries will track STARSHINE 2 as it orbits Earth for eight months. The students will use the information that they collect to calculate the density of the Earth's upper atmosphere. Starshine will fly into space in a Hitchhiker canister in the payload bay of Endeavour and will be deployed 240 miles (387 kilometers) above the Earth.

Mission Related / Mission Unique Documentation:

NSTS – 21391	Mission Integration Plan (MIP) for UF-1
ICD-A-21350	Shuttle Orbiter to MPLM Cargo Element Interfaces
SSP-42007	USOS to MPLM ICD

Safety:

MPLM Reflight Assessment for the FM 2 MPLM Module.

MPLM Module (Alenia)			
Doc Number	**Title**	**Review**	**Comment**

Reflight Assessment for the MPLM/Orbiter Integrated Hazard Analysis

MPLM/Orbiter Integrated (MSFC)			
Doc Number	**Title**	**Review**	**Comment**
ISS-MPLM-DOC-011	Flight UF-1 Multi Purpose Logistics Module (MPLM)/Orbiter Integrated Reflight Assessment (Written on September 19, 2001)	November 16, 2001	Reviewed by the PSRP and approved out of board for the Flight UF-1 mission. Note that all future passive mission will be reviewed by the PSRP.

Pressure Vessel Assessment

Pressure Vessel Assessment (MSFC)			
Doc Number	**Title**	**Review**	**Comment**
ISS-MPLM-DOC-013	Assessment of Transporting Pressurized Vessels onboard the Multi Purpose Logistics Module (MPLM) during the Flight UF-1 Mission (Written on October 2, 2001)	November 16, 2001	Reviewed by the PSRP and approved out of board for the Flight UF-1 mission. The PSRP requested that from this point on, pressure vessel assessments be included in the MPLM/Orbiter Reflight Assessment.

Mission Elapsed Time (MET) Event Timeline

Flight Day 1: 12/05/01

MPLM KSC Closeout Environmental Conditions:
Pressure: 14.85 psia
Temperature: 70.0 °F
Dew Point: Data Not Available
Launch: 4:19 pm CST
MPLM in Shuttle Payload Bay
1st Environment Check:
Pressure = 15.00 psia,
Temperature = 75.2 °F

Flight Day 2: 12/06/01

MPLM in Shuttle Payload Bay

Flight Day 3: 12/07/01

MPLM in Shuttle Payload Bay
Shuttle Rendezvous with ISS
Shuttle Docking: 2:03 pm CST
Middeck Transfer Ops
Expedition Crew Handover

Flight Day 4: 12/08/01

MPLM in Shuttle Payload Bay

EVA

MPLM Berthing Operations

MPLM Berth **11:55 am CST**

MPLM Activation

MPLM Attached to ISS

Flight Day 5: 12/09/01

MPLM Attached to ISS

Re-boost ISS

MPLM Transfer Activities

Flight Day 6: 12/10/01

MPLM Attached to ISS

MPLM Transfer Activities

EVA

Flight Day 7: 12/11/01

MPLM Attached to ISS

MPLM Transfer Activities

Re-boost ISS

Flight Day 8: 12/12/01

MPLM Attached to ISS

MPLM Transfer Activities

Re-boost ISS

EMU Transfer to ISS

Flight Day 9: 12/13/01

MPLM Attached to ISS

MPLM Transfer Activities

MPLM Deactivation

Vestibule Depress

Vestibule De-outfitting

Flight Day 10: 12/14/01

MPLM Closeout conditions:
Pressure = 14.84 psia
Temperature = 72.0 °F
Dew Point: 51.0 °F
MPLM Re-berthing Operations
MPLM Re-Berth 4:44 pm CST
MPLM in Shuttle Payload Bay
Total time MPLM docked to ISS - 6 days, 4 hours, 49 minutes
MPLM in Shuttle Payload Bay
Shuttle Undock: 11:28 am CST

Flight Day 11: 12/15/01

MPLM in Shuttle Payload Bay
Fly-around / Separation Burns
Starshine Deploy

Flight Day 12: 12/16/01

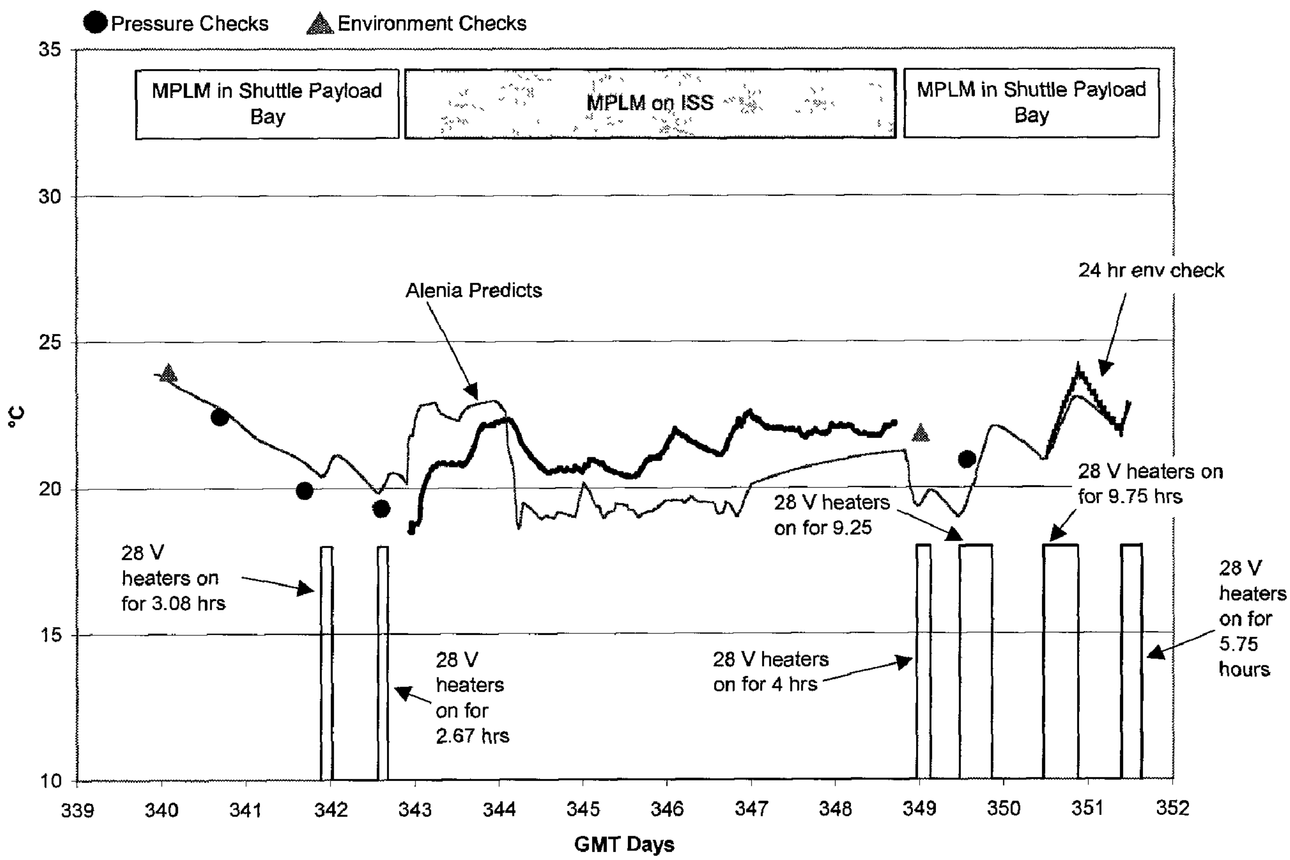
MPLM in Shuttle Payload Bay

Flight Day 13: 12/17/01

MPLM in Shuttle Payload Bay
Deorbit Prep
Deorbit Burn
Landing: 11:55 am CST

MPLM Mission Data Summary
Mission UF-1

UF-1 - Temperature Data:



UF1 – Mission Heater Power Timeline:

		Mission Elapsed Time					Power / Energy Summary				
		Day	Hour	Minute							
Heater Cycle #1											
	Planned	0	18	36	28.00	volts	36.5	amps	1079.00	watts	
		1	3	5	8.48	hours			9153.52	watt-hours	
	Actual	0	18	36		volts		amps	0.00	watts	
		0	18	36	0.00	hours			0.00	watt-hours	
Heater Cycle #2											
	Planned	1	16	20	28.00	volts	36.5	amps	1079.00	watts	
		1	23	35	7.25	hours			7822.75	watt-hours	
	Actual	1	23	0	31.00	volts	33	amps	1023.00	watts	
		2	2	7	3.12	hours			3188.35	watt-hours	
Heater Cycle #3											
	Planned	2	15	0	28.00	volts	36.5	amps	1079.00	watts	
		2	17	50	2.83	hours			3057.17	watt-hours	
	Actual	2	15	12	28.00	volts	36.5	amps	1022.00	watts	
		2	17	52	2.67	hours	(est)		2725.33	watt-hours	
Heater Cycle #4											
	Planned	9	0	10	28.00	volts	36.5	amps	1079.00	watts	
		9	3	55	3.75	hours			4046.25	watt-hours	
	Actual	9	0	37	30.00	volts	38	amps	1140.00	watts	
		9	4	43	4.10	hours			4674.00	watt-hours	
Heater Cycle #5											
	Planned	9	13	25	28.00	volts	36.5	amps	1079.00	watts	
		9	20	40	7.25	hours			7822.75	watt-hours	
	Actual	9	13	4		volts		amps	1020.00	watts	
		9	22	19	9.25	hours			9435.00	watt-hours	
Heater Cycle #6											
	Planned	10	13	5	28.00	volts	36.5	amps	1079.00	watts	
		10	21	45	8.67	hours			9351.33	watt-hours	
	Actual	10	12	56	28.25	volts	34.291	amps	968.55	watts	per MPLM_HCU screen
		10	22	37	9.68	hours			9378.79	watt-hours	
Heater Cycle #7											
	Planned	11	12	50	28.00	volts	36.5	amps	1079.00	watts	
		11	14	45	1.92	hours			2068.08	watt-hours	
	Actual	11	11	9	28.25	volts	34.291	amps	968.72	watts	
		11	16	49	5.67	hours			5489.42	watt-hours	

actual hours of heater operation during nominal mission timeline =	34.48	hours
scheduled hours of heater operation during nominal mission timeline =	40.15	hours
Total Energy Used for Mission =	34.89	kW-hrs
Orbiter cryo savings =	8.43	kW-hrs

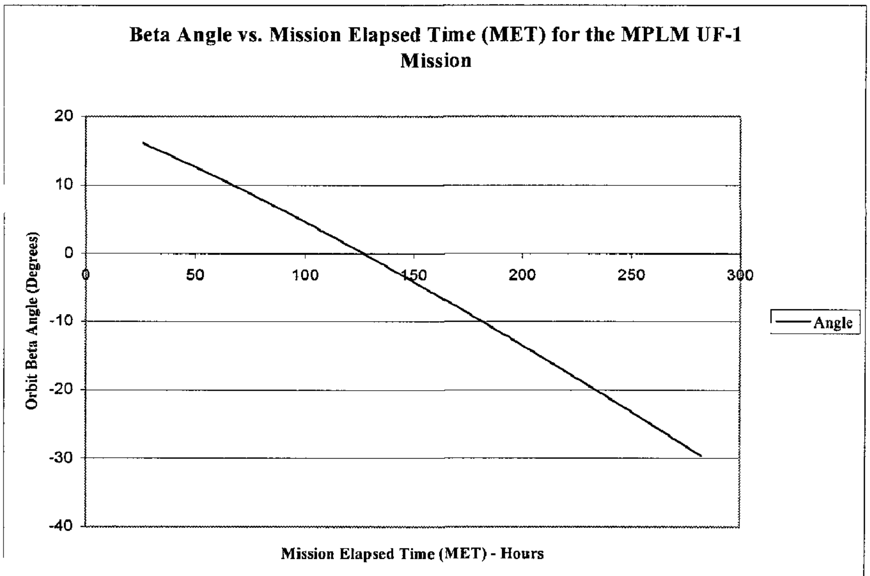
UF1 – Orbiter Attitude Timeline:

MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	SSpt 2orb	%Sun	DD/HH:MM:SS	Alt	Comment
0.00	0.48	LVLH	P 0	Y 0	R 0	0	0	180	339	72	19.8	152	312	71	57	0/ 0:00:00	75	LIFTOFF
0.48	0.07	LVLH	P 96	Y 3	R 358	0	3	84	343	94	19.8	163	258	190	57	0/ 0:29:01	75	Starting Att
0.56	0.76	IH	P 133	Y 358	R 64	0	168	176	213	143	19.8	60	202	208	57	0/ 0:33:20	75	OMS-2
1.32	1.60	LVLH	P 180	Y 90	R 0	0	0	0	301	139	19.7	110	217	37	59	0/ 1:19:05	126	-ZLV +YVV
2.92	0.21	IH	P 44	Y 26	R 62	0	276	6	292	120	19.4	109	238	64	59	0/ 2:55:09	126	ITEM 21 CANCEL
3.13	0.44	IH	P 167	Y 49	R 229	0	180	39	37	33	19.4	116	21	114	59	0/ 3:07:37	126	NC-1
3.57	15.17	LVLH	P 70	Y 0	R 0	0	0	110	324	145	19.4	117	202	221	60	0/ 3:33:59	166	BIAS -XLV +ZVV
18.73	0.24	IH	P 160	Y 47	R 55	0	1	106	324	151	17.3	113	198	230	60	0/18:44:05	166	ITEM 21 CANCEL
18.98	0.41	IH	P 39	Y 293	R 357	0	177	167	199	61	17.3	34	329	288	60	0/18:58:32	166	NC-2
19.39	6.48	LVLH	P 180	Y 0	R 0	0	0	0	215	149	17.2	65	199	26	60	0/19:23:19	173	-ZLV -XVV
25.87	0.18	IH	P 41	Y 292	R 359	0	179	6	198	62	16.3	33	330	125	60	1/ 1:52:22	173	ITEM 21 CANCEL
26.05	0.27	IH	P 170	Y 8	R 65	0	133	159	204	168	16.3	79	185	167	60	1/ 2:03:01	173	NC-3 NPC
26.32	12.20	LVLH	P 70	Y 0	R 0	0	0	110	319	155	16.3	105	197	231	60	1/ 2:19:07	179	BIAS -XLV +ZVV
38.52	3.14	LVLH	P 180	Y 90	R 0	0	0	0	73	60	14.5	104	59	239	60	1/14:31:02	179	-ZLV +YVV
41.66	0.35	IH	P 26	Y 290	R 345	0	180	139	195	58	14.0	35	337	262	60	1/17:39:25	179	NC-4 NH
42.01	0.44	LVLH	P 270	Y 0	R 0	0	180	90	346	75	14.0	159	317	345	60	1/18:00:20	179	-Z TGT TRK
42.45	0.00	LVLH	P 280	Y 0	R 0	0	180	100	307	162	13.9	100	194	89	60	1/18:26:51	179	-Z TGT TRK
42.45	0.50	LVLH	P 280	Y 0	R 0	0	180	100	306	163	13.9	100	194	90	60	1/18:26:57	179	NCC
42.95	0.23	LVLH	P 285	Y 0	R 0	0	180	105	194	78	13.8	19	311	207	60	1/18:56:48	179	-Z TGT TRK
43.18	0.07	LVLH	P 275	Y 0	R 0	0	180	95	230	18	13.8	78	346	263	60	1/19:10:54	179	-Z TGT TRK
43.25	0.24	IH	P 16	Y 304	R 334	0	194	147	208	49	13.8	45	332	280	60	1/19:15:08	179	TI
43.49	0.64	LVLH	P 270	Y 0	R 0	0	180	90	345	67	13.8	153	328	336	61	1/19:29:30	200	-Z TGT TRK
44.13	0.59	LVLH	P 295	Y 0	R 0	0	180	115	231	162	13.7	79	194	126	61	1/20:07:47	202	-Z TGT TRK
44.72	0.05	LVLH	P 352	Y 0	R 0	0	180	172	194	87	13.6	14	281	265	61	1/20:43:12	202	-Z TGT TRK
44.77	0.34	LVLH	P 0	Y 0	R 0	0	0	180	194	83	13.6	15	298	277	61	1/20:46:28	202	+ZLV +XVV
45.11	0.62	LVLH	P 90	Y 0	R 0	0	0	90	194	93	13.5	14	256	356	61	1/21:06:41	202	-XLV +ZVV
45.73	0.17	LVLH	P 90	Y 0	R 0	0	0	90	343	54	13.4	140	339	142	61	1/21:44:01	204	DAP FREE
45.90	0.20	IH	P 266	Y 60	R 320	0	358	96	344	97	13.4	163	245	181	61	1/21:54:01	202	Free Drift
46.10	0.13	IH	P 140	Y 23	R 70	0	1	135	256	168	13.4	87	192	228	61	1/22:06:01	202	Free Drift
46.23	0.03	IH	P 115	Y 321	R 65	0	1	170	194	110	13.4	24	213	260	61	1/22:14:01	202	Free Drift
46.27	0.05	IH	P 98	Y 307	R 52	0	270	180	196	93	13.4	16	261	267	61	1/22:16:01	202	Free Drift
46.32	0.10	IH	P 62	Y 294	R 18	0	192	170	197	71	13.3	25	321	279	61	1/22:19:01	202	Free Drift
46.42	0.08	IH	P 346	Y 307	R 308	0	186	155	206	35	13.3	59	344	303	61	1/22:25:01	202	Free Drift
46.50	0.10	IH	P 327	Y 329	R 294	0	184	149	245	14	13.3	84	347	322	61	1/22:30:01	202	Free Drift
46.60	0.02	IH	P 314	Y 353	R 289	0	181	146	327	24	13.3	110	347	346	61	1/22:36:01	202	Free Drift
46.62	0.00	IH	P 312	Y 357	R 289	0	180	146	331	27	13.3	114	346	350	61	1/22:37:13	202	Free Drift
46.62	0.46	LVLH	P 325	Y 360	R 0	0	179	145	330	28	13.3	114	345	350	61	1/22:37:14	202	STS ATT CNTL
47.09	0.02	LVLH	P 111	Y 0	R 0	0	0	69	230	17	13.2	79	347	99	61	1/23:05:08	202	BIAS -XLV +ZVV
47.11	0.18	LVLH	P 111	Y 0	R 0	0	0	69	244	15	13.2	84	347	105	61	1/23:06:26	202	ISS ATT CNTL
47.29	26.48	LVLH	P 111	Y 360	R 360	0	360	69	338	38	13.2	125	344	148	61	1/23:17:26	202	MOMENTUM MGMT
73.77	1.90	LVLH	P 90	Y 21	R 90	0	0	69	57	88	9.1	123	87	238	61	3/ 1:46:11	207	BIAS -XLV +YVV
75.67	0.06	LVLH	P 111	Y 0	R 0	0	0	69	197	148	8.8	59	190	322	61	3/ 3:40:01	207	BIAS -XLV +ZVV
75.73	0.29	LVLH	P 111	Y 0	R 0	0	0	69	192	134	8.8	45	192	336	61	3/ 3:43:39	207	ISS ATT CNTL
76.02	12.18	LVLH	P 111	Y 360	R 360	0	360	69	189	68	8.7	24	339	44	61	3/ 4:01:01	207	MOMENTUM MGMT
88.20	0.59	LVLH	P 111	Y 360	R 360	0	360	69	186	96	6.8	9	228	16	61	3/16:12:01	201	STS ATT CNTL

MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	SSpt Zorb	%Sun	DD/HH:MM:SS	Alt	Comment
88.70	0.17	LVLH	P 329	Y 0	R 0	0	180	149	338	162	6.7	107	187	232	61	3/16:41:45	201	BIAS +ZLV +XVV
88.87	1.49	LVLH	P 329	Y 0	R 0	0	180	149	197	156	6.6	67	187	172	61	3/16:52:01	201	REBOOST 1
90.35	1.90	LVLH	P 90	Y 21	R 90	0	0	69	341	77	6.4	157	306	161	61	3/18:21:15	202	BIAS -XLV +YVV
92.25	0.06	LVLH	P 111	Y 0	R 0	0	0	69	351	134	6.1	135	189	246	61	3/20:15:01	202	BIAS -XLV +ZVV
92.31	0.56	LVLH	P 111	Y 0	R 0	0	0	69	348	149	6.1	121	187	260	61	3/20:18:42	202	ISS ATT CNTL
92.87	22.40	LVLH	P 111	Y 360	R 360	0	360	69	186	81	6.0	11	325	30	61	3/20:52:01	202	MOMENTUM MGMT
115.27	4.83	LVLH	P 111	Y 360	R 360	0	360	69	357	132	2.2	138	184	244	61	4/19:15:56	205	DAP A13 (B13)
120.10	17.17	LVLH	P 111	Y 360	R 360	0	360	69	199	176	1.3	86	181	295	61	5/ 0:05:48	208	DAP A12 (B12)
137.27	0.60	LVLH	P 111	Y 360	R 360	0	360	69	178	119	-1.7	29	176	352	61	5/17:16:01	208	STS ATT CNTL
137.86	0.14	LVLH	P 329	Y 0	R 0	0	180	149	6	162	-1.8	108	178	131	61	5/17:51:45	208	BIAS +ZLV +XVV
138.00	1.56	LVLH	P 329	Y 0	R 0	0	180	149	173	165	-1.8	75	178	164	61	5/18:00:01	208	REBOOST 2
139.56	1.96	LVLH	P 90	Y 21	R 90	0	0	69	348	67	-2.1	154	333	169	61	5/19:33:35	208	BIAS -XLV +YVV
141.52	0.06	LVLH	P 111	Y 0	R 0	0	0	69	6	156	-2.4	114	177	267	61	5/21:31:11	204	BIAS -XLV +ZVV
141.58	0.19	LVLH	P 111	Y 0	R 0	0	0	69	13	169	-2.5	101	178	280	61	5/21:34:36	204	ISS ATT CNTL
141.77	18.59	LVLH	P 111	Y 360	R 360	0	360	69	175	146	-2.5	56	177	325	61	5/21:46:01	204	MOMENTUM MGMT
160.35	0.51	LVLH	P 111	Y 360	R 360	0	360	69	173	109	-5.9	20	162	2	61	6/16:21:17	206	STS ATT CNTL
160.86	0.19	LVLH	P 85	Y 0	R 180	0	0	85	350	143	-6.0	126	187	121	61	6/16:51:49	206	BIAS -XLV -ZVV
161.05	1.30	LVLH	P 85	Y 0	R 180	0	0	85	354	100	-6.0	168	211	165	61	6/17:03:01	206	REBOOST 3
162.35	2.24	LVLH	P 90	Y 21	R 90	0	0	69	295	78	-6.2	105	283	109	61	6/18:20:51	208	BIAS -XLV +YVV
164.58	0.06	LVLH	P 111	Y 0	R 0	0	0	69	20	160	-6.7	109	173	272	61	6/20:35:01	208	BIAS -XLV +ZVV
164.65	0.62	LVLH	P 111	Y 0	R 0	0	0	69	56	172	-6.7	94	173	286	61	6/20:38:45	208	ISS ATT CNTL
165.27	41.98	LVLH	P 111	Y 360	R 360	0	360	69	169	40	-6.8	51	9	72	61	6/21:16:01	208	MOMENTUM MGMT
207.25	0.50	LVLH	P 111	Y 360	R 360	0	360	69	16	64	-14.7	150	30	175	61	8/15:15:01	213	STS ATT CNTL
207.75	2.25	LVLH	P 90	Y 21	R 90	0	0	69	115	84	-14.8	65	83	251	61	8/15:45:03	213	BIAS -XLV +YVV
210.00	0.23	LVLH	P 111	Y 0	R 0	0	0	69	122	21	-15.2	76	18	97	61	8/18:00:01	213	BIAS -XLV +ZVV
210.23	0.22	LVLH	P 111	Y 0	R 0	0	0	69	23	42	-15.3	128	20	151	61	8/18:13:55	213	ISS ATT CNTL
210.45	21.52	LVLH	P 111	Y 360	R 360	0	360	69	15	90	-15.3	165	91	202	61	8/18:27:01	213	MOMENTUM MGMT
231.97	0.46	LVLH	P 111	Y 360	R 360	0	360	69	20	76	-19.5	156	54	187	62	9/15:58:16	210	STS ATT CNTL
232.43	0.17	LVLH	P 329	Y 0	R 0	0	180	149	148	40	-19.6	57	23	294	62	9/16:25:45	210	BIAS +ZLV +XVV
232.60	0.70	LVLH	P 329	Y 0	R 0	0	180	149	76	20	-19.6	95	20	234	62	9/16:36:01	210	REBOOST 4 COLA
233.30	1.80	LVLH	P 90	Y 0	R 0	0	0	90	26	91	-19.7	135	26	138	62	9/17:18:11	210	-XLV +ZVV
235.10	0.05	LVLH	P 90	Y 0	R 0	0	0	90	21	107	-20.1	153	131	198	62	9/19:06:00	211	DAP FREE
235.15	0.85	LVLH	P 90	Y 0	R 0	0	0	90	23	118	-20.1	144	144	210	62	9/19:09:04	211	DAP LVLH
236.00	0.00	LVLH	P 270	Y 0	R 0	0	180	90	29	135	-20.3	128	154	49	62	9/20:00:00	211	Fly Around
236.00	0.02	LVLH	P 270	Y 0	R 0	0	180	90	29	135	-20.3	128	154	49	62	9/20:00:01	211	First Sep
236.02	0.49	IH	P 121	Y 35	R 105	0	180	66	62	156	-20.3	101	159	54	62	9/20:01:20	211	DAP INRTL
236.51	0.46	IH	P 312	Y 8	R 78	0	359	136	324	143	-20.4	119	204	167	62	9/20:30:31	211	Second SEP
236.97	3.88	LVLH	P 180	Y 50	R 0	0	0	0	71	95	-20.4	109	95	275	61	9/20:58:09	206	BIAS -ZLV +YVV
240.85	0.29	IH	P 26	Y 309	R 339	0	51	24	203	56	-21.1	40	330	103	62	10/ 0:50:44	206	ITEM 21 CANCEL
241.14	0.37	IH	P 306	Y 344	R 256	0	5	16	73	24	-21.2	97	23	171	62	10/ 1:08:19	206	Orbit Adjust
241.51	10.10	LVLH	P 180	Y 0	R 180	0	0	180	338	102	-21.2	155	340	257	62	10/ 1:30:18	206	+ZLV -XVV
251.60	4.00	IH	P 282	Y 336	R 89	0	25	101	259	179	-23.1	90	181	102	62	10/11:36:06	199	+ZSI
255.60	0.72	IH	P 284	Y 359	R 98	0	218	68	17	158	-23.9	113	172	320	62	10/15:35:50	199	Free Drift
256.32	0.48	LVLH	P 90	Y 0	R 180	0	0	90	325	135	-24.0	125	210	129	62	10/16:19:01	199	-XLV -ZVV
256.80	0.45	IH	P 125	Y 18	R 287	0	359	58	260	26	-24.1	86	334	242	62	10/16:47:58	199	Free Drift
257.25	3.18	IH	P 325	Y 341	R 105	0	223	26	220	179	-24.2	89	180	348	62	10/17:14:58	199	+ZSI

MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	Sspt Zorb	%Sun	DD/HH:MM:SS	Alt	Comment
260.43	0.30	IH	P 140	Y 331	R 109	0	358	38	143	122	-24.8	43	140	15	62	10/20:28:58	199	SIMPLEX
260.73	17.38	LVLH	P 180	Y 90	R 0	0	0	0	245	94	-24.9	65	266	85	62	10/20:43:53	199	-ZLV +YVV
278.11	0.24	IH	P 219	Y 312	R 202	0	156	89	134	92	-28.4	56	43	207	62	11/14:06:28	194	IMU ALIGN
278.35	0.11	IH	P 184	Y 55	R 289	0	52	79	322	66	-28.4	136	306	264	62	11/14:21:04	194	VERIFICATION
278.46	1.80	IH	P 292	Y 67	R 190	0	110	98	0	95	-28.4	175	176	291	62	11/14:27:52	194	-XSI
280.27	1.92	IH	P 274	Y 36	R 353	0	137	64	330	69	-28.9	350	272	356	62	11/16:16:09	194	COMM
282.19	0.37	IH	P 310	Y 357	R 250	0	360	112	59	36	-29.2	108	32	89	62	11/18:11:37	194	D O BURN
282.57	0.42	IH	P 171	Y 301	R 134	0	178	86	148	30	-29.3	32	89	176	62	11/18:33:59	194	MM 303 ENTRY
282.98	0.00	LVLH	P 38	Y 359	R 1	0	0	0	0	0	0.0	90	0	0	60	11/18:58:50	194	MM 304 ENTRY

UF-1 - Beta Angle:



UF1 – MPLM Pressure Prior to Transfer to ISS:

DATA NOT AVAILABLE

UF1 – MPLM Pressure Attached to ISS:

DATA NOT AVAILABLE

UF1 – MPLM Voltage & Current Draw:

DATA NOT AVAILABLE

UF1 – MPLM Cabin Fan Current & Speed:

DATA NOT AVAILABLE

UF1 – MPLM Pressure & Temperature During 24 Hour Ops in PLB:

DATA NOT AVAILABLE

UF1 – MPLM PDB Voltage During 24 Hour Ops in PLB:

DATA NOT AVAILABLE

UF1 – MPLM Environmental Check During Extended Ops in PLB:

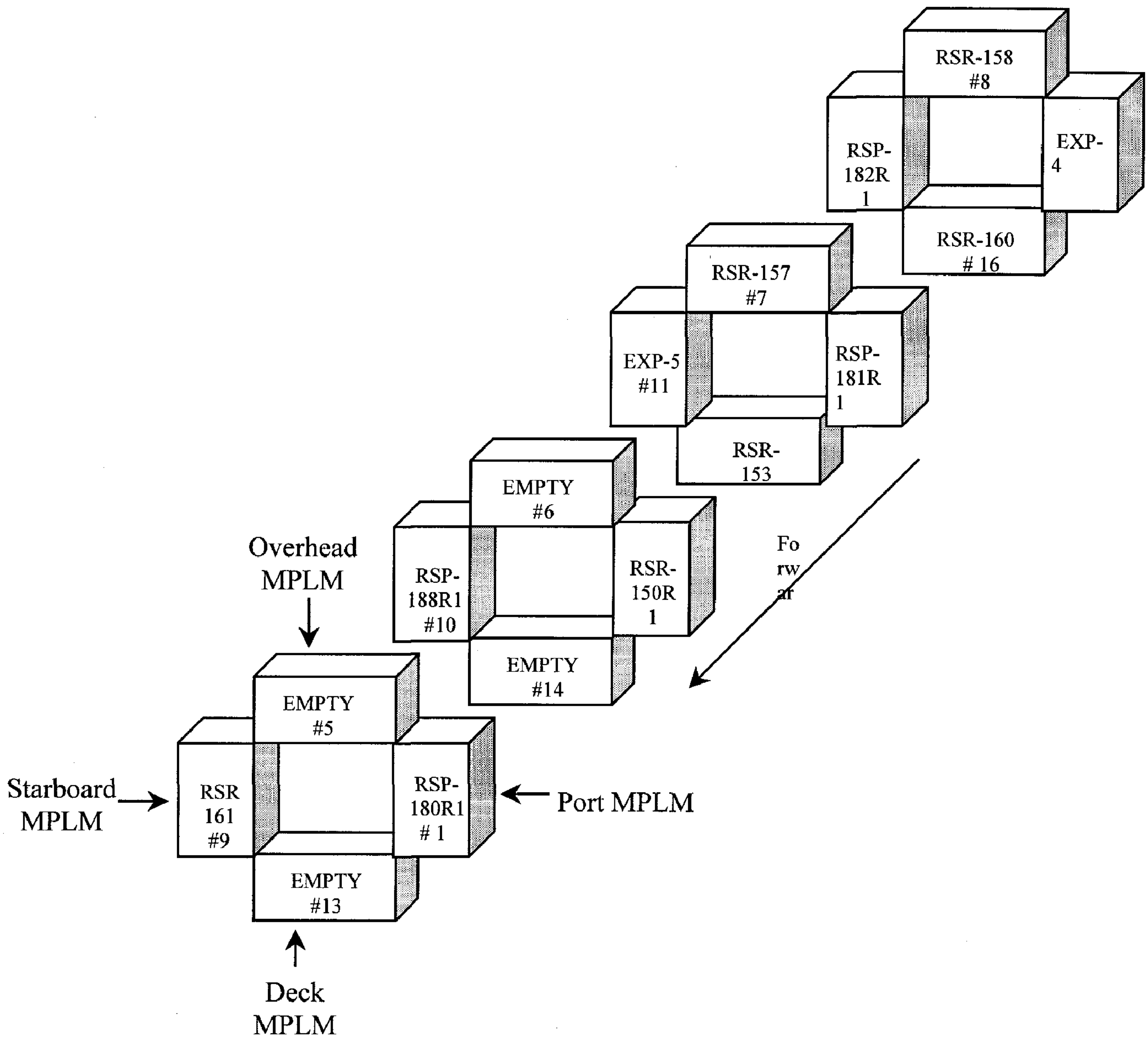
DATA NOT AVAILABLE

UF1 – MPLM Heater Voltage & Current During Extended Ops in PLB

DATA NOT AVAILABLE

MPLM Cargo Manifest – Up

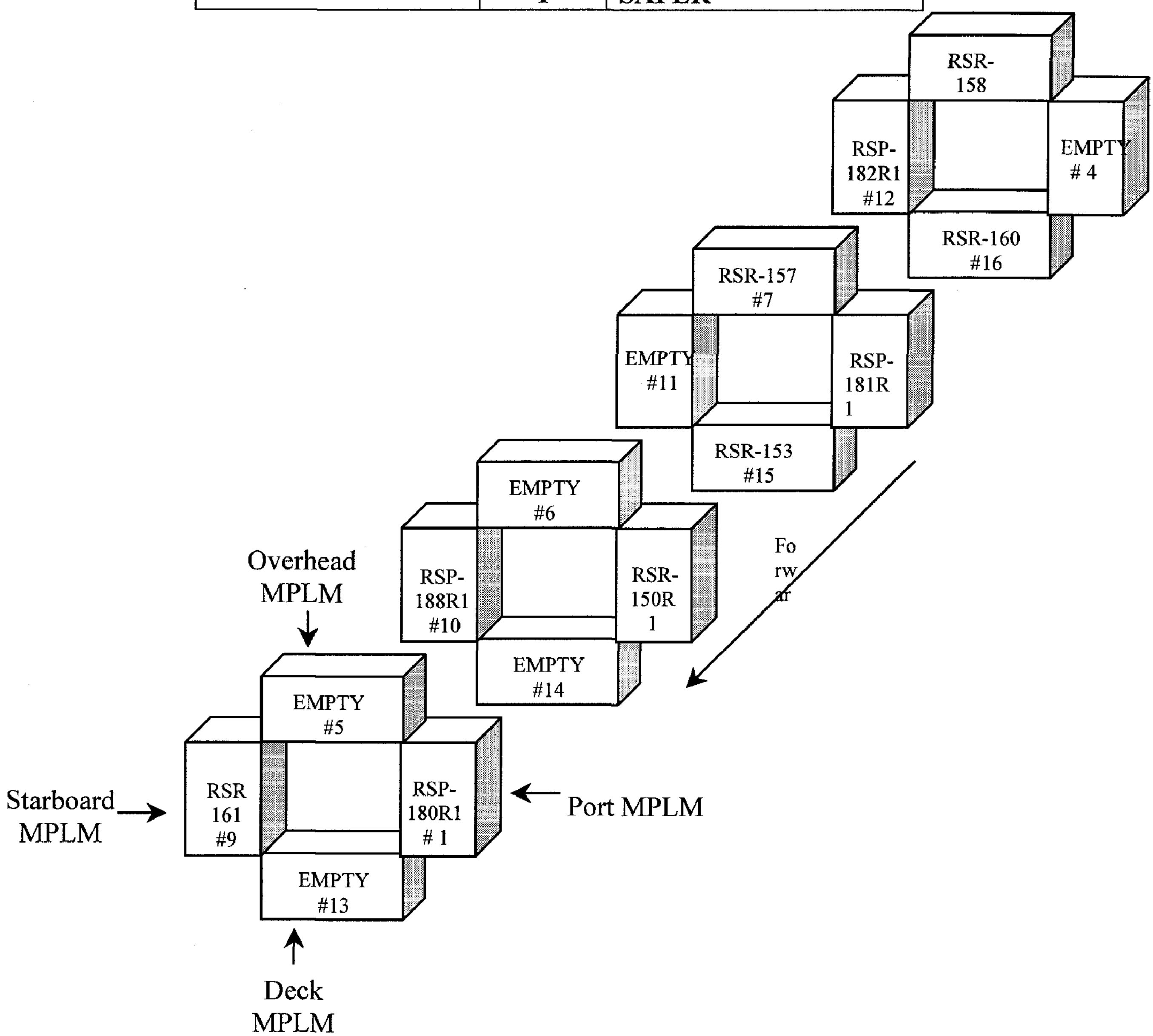
Type	Number	
RSP	4	
RSR	6	
Express Rack	2	
Liquid Containers	2	PWR
	9	CWC
Pressure Vessels	1	PBA
	1	VGA
	1	SAFER



UF-1 Launch Rack Configuration

MPLM Cargo Manifest – Down

Type	Number	
RSP	4	
RSR	6	
Express Rack	0	Left on ISS
Liquid Containers	4	EDV
	2	KTO
	12	CWC
Pressure Vessels	3	PBA
	1	SAFER



UF-1 Landing Rack Configuration

MPLM Mission Generated Paper

Waivers:

- **No Waivers written during mission**

Problem Reports (PRs):

- **No Problem Reports written during mission**

CHITS (Mission Action Request):

ISS0031	**Return foam in MPLM** **MNEMO requested that foam be bagged to prevent FOD and off-gassing.**
ISS0053	**Return Russian battery in MPLM** **MNEMO requested that battery be double bagged.**
ISS0107	**Hatch closure assessment.**

Items – For – Investigation (IFI):

- **Mission extended one day.**

Significant Flight Notes:

ROFN 827	Modified MPLM Install (Contingency)
ACFN 910	Metal Shavings
ACFN 036	CWC Locations in MPLM, A/L per IMS [FD9,1] Withdrawn [FD9,3]

In-Flight Anomaly:

- **No In-Flight Anomalies written during mission**

Lessons Learned:

- **Data Not Available**

STS – 108 / UF-1

Flight: STS – 111 **Mission: UF-2**

STS-111 Endeavour Delivers Expedition Five Crew

The International Space Station received a new crew and a new platform for its robotic arm when STS-111 visited in June 2002. STS-111, which was the14th shuttle mission to visit the orbital outpost, launched June 5 and landed June 19.

STS-111 delivered the Expedition Five crew to the station and returned the Expedition Four crew to Earth. Space Shuttle Endeavour also delivered and the Mobile Base System, or MBS. The STS-111 astronauts also performed three spacewalks. Among the objectives completed during the spacewalks was permanent installation of the MBS onto the station and replacement of a wrist roll joint on the station's robotic arm. The STS-111 crew also unloaded supplies and science experiments from the Leonardo Multi-Purpose Logistics Module, which made its third trip to the orbital outpost.

When Endeavour landed, it marked the end of a record-setting flight by the Expedition Four crew. Expedition Four crew spent 196 days in space, which gives Flight Engineers Carl Walz and Dan Bursch the U.S. space flight endurance record. The previous record was 188 days. Walz also holds the U.S. record for cumulative time in space with 231 days, and Bursch is second with 227 days. STS-111 Mission Specialist Franklin Chang-Díaz become only the second human to launch into space seven times during the mission.

The Crew

Kenneth Cockrell	**Commander**
Paul Lockhart	**Pilot**
Franklin Chang-Diez	**Mission Specialist**
Philippe Perrin, CNES	**Mission Specialist**
Valery Korzun, Rosaviakosmos	**Space Station Crew (Up)**
Peggy Whitson	**Space Station Crew (Up)**
Sergei Treschev	**Space Station Crew (Up)**
Yury Onufienko, Rosaviakosmos	**Space Station Crew (Down)**
Carl Walz	**Space Station Crew (Down)**
Dan Bursch	**Space Station Crew (Down)**

Mission Data

Launch Date	06/05/02	12:58 pm CST	KSC
Landing Date	06/19/02	11:55 am CST	EAFB
Launch Pad	39-A		
Orbiter	OV – 105	Endeavour	
MPLM Module	FM –1	Leonardo	
Module Weight	9,671 lbs		
MPLM Cargo Wt Up	13,861 lbs		
MPLM Cargo Wt Down	10,341 lbs		
Orbit Altitude	122 nautical miles		
Mission Duration	13 days, 20 hours, 35 minutes		
	Mission extended; scheduled to land at KSC; landing delayed due to conditions at KSC; landed at Edwards AFB.		

MPLM Mission Management Team

UF-2 Shift Assignments

Name	Room	Shift	Discipline
Shawn Reagan*	MER	1	Mission Engineer
Allen Shariett	MER	3	System Engineer
Gordon DeRamus	MER	2	MPLM Safety
Keith Presson	MER	1	MPLM Thermal
Shaun Glasgow	MER	2	MPLM Thermal
Dave Patterson	MER	3	MPLM Thermal
Dallas Clark	IMC/MER	1/2	Mission Engineer
Mike Morelan	IMC/MER	3/3	Mission Engineer
David Harwell	IMC	3	Mission Engineer
Jon Holladay	IMC	2	Engineering Manager
Richard Kuhns*	IMC	1	Mission Engineer
Greg Budig	IMC	2	Boeing TCS
Ken Shih	IMC	3	Boeing TCS

Notes:

* UF-2/STS-111 Mission Leads

1. Shift 1 – 5:00 AM – 2:00 PM Execute 1 Shift
2. Shift 2 – 1:00 PM – 10:00 PM Execute 2 Shift
3. Shift 3 – 9:00 PM – 6:00 AM Crew Sleep Shift

Mission Objectives / Goals

STS-111

The primary objective of this flight was to deliver and integrate the Mobile Remote Servicer Base System into the orbiting International Space Station.

Cargo Bay Payloads:

Mobile Remote Servicer Base System

The Mobile Remote Servicer Base System, or MBS, is the second part of the International Space Station's three-piece Mobile Servicing System. The MBS is a work platform that moves along rails on the International Space Station's Integrated Truss Structure. It will provide lateral mobility for Canadarm2, the station's robot arm, as it traverses the main trusses.

The MBS is slated to be attached to the Mobile Transporter on Flight Day 6. STS-111 spacewalkers will make power, data and video cable connections and bolt it to the transporter during the mission's second spacewalk on Flight Day 7. On Flight Day 8, the MBS will be checked out.

Leonardo - Multi-Purpose Logistics Module

For a complete description of the MPLM, see "Back Up Information" at the end of this appendix.

During STS-111, Leonardo will contain about 2,540 kilograms (5,600 pounds) of cargo. It will also contain eight Resupply Stowage Racks, five Resupply Stowage Platforms, two International Stowage Racks and two new scientific experiment racks for the station. The new science rack, EXPRESS Rack 3, will increase the orbital outpost's science capabilities. The other scientific rack is the Microgravity Science Glovebox. Other cargo includes supplies and equipment for the station's new residents, the Expedition Five crew.

Mission Related / Mission Unique Documentation:

NSTS-21467 Mission Integration Plan (MIP) for UF-2
ICD-A-21350 Shuttle Orbiter to MPLM Cargo Element Interfaces
SSP-42007 USOS to MPLM ICD

Safety:

MPLM Reflight Assessment for the FM 1 MPLM Module.

MPLM Module (Alenia)			
Doc Number	**Title**	**Review**	**Comment**
AL-RP-AI-0054	MPLM FM1 Reflight Safety Assessment for UF-2 Mission		Reviewed by the PSRP and approved out of board for the Flight UF-2 mission.

Reflight Assessment for the MPLM/Orbiter Integrated Hazard Analysis

MPLM/Orbiter Integrated (MSFC)			
Doc Number	**Title**	**Review**	**Comment**
ISS-MPLM-DOC-012	Flight UF-2 Multi Purpose Logistics Module (MPLM)/Orbiter Integrated Reflight Assessment (Written on February 15, 2002)		Reviewed by the PSRP and approved out of board for the Flight UF-2 mission.

Mission Elapsed Time (MET) Event Timeline

Flight Day 1: 06/05/02

MPLM KSC Closeout Environmental Conditions:

Pressure: 14.94 psia
Temperature: 72.1 °F
Dew Point: 29.3 °F

Launch: 4:23 pm CST
MPLM in Shuttle Payload Bay

1st Environment Check:
Pressure = 15.07 psia
Temperature = 76.3 °F

Flight Day 2: 06/06/02

MPLM in Shuttle Payload Bay

Flight Day 3: 06/07/02

MPLM in Shuttle Payload Bay

Shuttle Rendezvous with ISS

Shuttle Docking: 11:25 am CST

Flight Day 4: 06/08/02

MPLM in Shuttle Payload Bay
MPLM Berthing Operations
MPLM Berth 9:28 am CST
Vestibule Pressurization
Vestibule Outfitting
MPLM Activation
MPLM Ingress / Transfer Setup
MPLM Attached to ISS

Flight Day 5: 06/09/02

MPLM Attached to ISS
MPLM Transfer Activities

EVA

Flight Day 6: 06/10/02

MPLM Attached to ISS
MPLM Transfer Activities

Flight Day 7: 06/11/02

MPLM Attached to ISS
MPLM Transfer Activities
EVA

Flight Day 8: 06/12/02

MPLM Attached to ISS
MPLM Transfer Activities

Flight Day 9: 06/13/02

MPLM Attached to ISS
MPLM Transfer Activities
EVA

Flight Day 10: 06/14/02

MPLM Deactivation
Vestibule Depress
MPLM Closeout conditions:
Pressure = 14.76 psia
Temperature = 73.0 °F
Dew Point: 52.2 °F
MPLM Re-berthing Operations
MPLM Re-Berth 3:11 pm CST
MPLM in Shuttle Payload Bay
Total time MPLM docked to ISS - 6 days, 5 hours, 43 minutes

Flight Day 11: 06/15/02

MPLM in Shuttle Payload Bay
Shuttle Undock: 9:32 am CST
Fly-around / Separation Burns

Flight Day 12: 06/16/02

MPLM in Shuttle Payload Bay

Cabin Stow
Deorbit Briefing

Flight Day 13: 06/17/02

MPLM in Shuttle Payload Bay

Mission extended 2 days; scheduled to land at KSC; landing delayed due to conditions at KSC; landed at Edwards AFB.

Flight Day 14: 06/18/02

MPLM in Shuttle Payload Bay

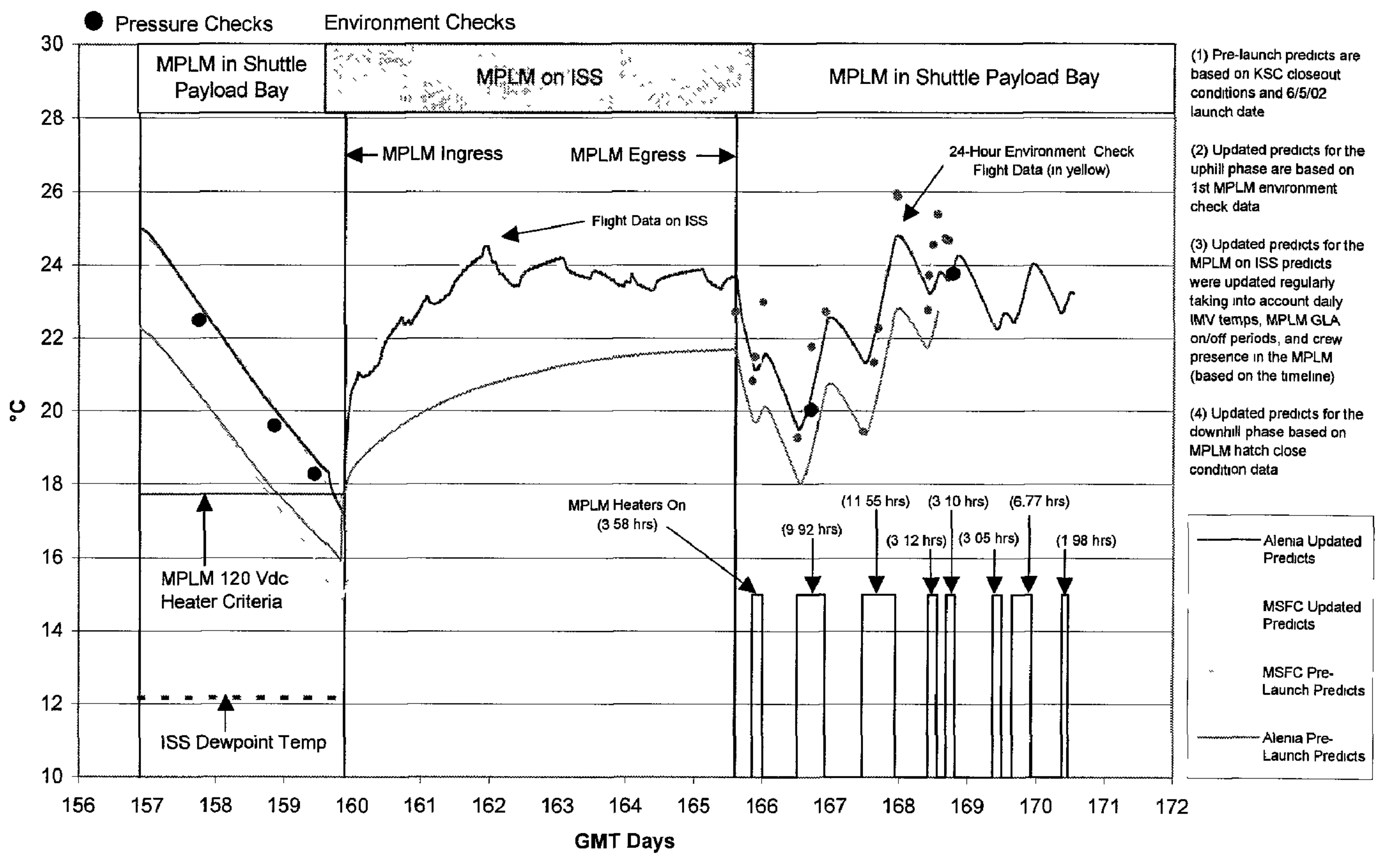
Flight Day 15: 06/19/02

MPLM in Shuttle Payload Bay

Deorbit Prep
Deorbit Burn
Landing: 12:58 pm CST

MPLM Mission Data Summary
Mission UF-2

UF-2 - Temperature Data:



UF2 – MPLM Mission Heater Power Timeline:

Up Trip Heater Cycles

	Mission Elapsed Time Day	Hour	Minute	Power / Energy Summary					
Heater Cycle #1									
Planned	0	17	15	28.00	volts	36.50	amps	1079.00	watts
	1	2	5	8.83	hours			9531.17	watt-hours
Actual	0	17	15	28.00	volts	38.53	amps	1078.97	watts
	0	17	15	0.00	hours			0.00	watt-hours
Heater Cycle #2									
Planned	1	19	30	28.00	volts	36.50	amps	1079.00	watts
	2	2	15	6.75	hours			7283.25	watt-hours
Actual	1	19	30	28.00	volts	38.53	amps	1078.97	watts
	1	19	30	0.00	hours			0.00	watt-hours
Heater Cycle #3									
Planned	2	12	5	28.00	volts	36.50	amps	1079.00	watts
	2	14	50	2.75	hours			2967.25	watt-hours
Actual	2	12	5	28.00	volts	38.53	amps	1078.97	watts
	2	12	5	0.00	hours	(est)		0.00	watt-hours

Down Trip Heater Cycles

	Day	Hour	Minute						
Heater Cycle #4									
Planned	8	22	40	28.00	volts	36.50	amps	1079.00	watts
	9	1	30	2.83	hours			3057.17	watt-hours
Actual	8	22	57	28.45	volts	34.80	amps	990.06	watts
	9	2	38	3.68	hours			3646.72	watt-hours
Heater Cycle #5									
Planned	9	14	30	28.00	volts	36.50	amps	1079.00	watts
	9	23	55	9.42	hours			10160.58	watt-hours
Actual	9	14	45	28.44	volts	34.76	amps	988.46	watts
	10	0	39	9.90	hours			9785.76	watt-hours
Heater Cycle #6									
Planned	10	13	40	28.00	volts	36.50	amps	1079.00	watts
	10	23	50	10.17	hours			10969.83	watt-hours
Actual	10	13	44	28.41	volts	34.81	amps	989.07	watts
	11	1	18	11.57	hours			11440.19	watt-hours
Heater Cycle #7									
Planned	11	11	0	28.00	volts	36.50	amps	1079.00	watts
	11	13	20	2.33	hours			2517.67	watt-hours

Actual	11	12	41	28.65	volts	34.87	amps	998.88	watts
	11	15	48	3.12	hours			3113.18	watt-hours

Up-Trip actual hours of heater operation during nominal mission timeline =	0.00	hours
Up-Trip scheduled hours of heater operation during nominal mission timeline =	18.33	hours
Total Up-trip Energy Used for Heaters =	0.00	kW-hrs
Orbiter cryo savings =	19.78	kW-hrs
Down-Trip actual hours of heater operation during nominal mission timeline =	28.27	hours
Down-Trip scheduled hours of heater operation during nominal mission timeline =	24.75	hours
Total Down-trip Energy Used for Heaters =	27.99	kW-hrs
Orbiter cryo savings =	-1.28	kW-hrs
Total Actual (Nominal) Mission Hours of Heater Operation =	28.27	hours
Total Scheduled Mission Hours of Heater Operation =	43.08	hours
Nominal Mission Total Energy Used for Heaters =	27.99	kW-hrs
Total Orbiter Cryo Savings =	18.50	kW-hrs

Contingency Heater Cycles

Contingency Heater Cycle #8

Actual	11	19	0	28.65	volts	34.85	amps	998.54	watts
	11	22	6	3.10	hours			3095.47	watt-hours

Contingency Heater Cycle #9 Note - no telemitry available

Actual	12	11	25	28.65	volts	34.85	amps	998.54	watts
	12	14	28	3.05	hours			3045.54	watt-hours

Contingency Heater Cycle #10 Note - no telemitry available

Actual	12	17	51	28.65	volts	34.85	amps	998.54	watts
	13	0	46	6.92	hours			6906.56	watt-hours

Contingency Heater Cycle #11 Note - no telemitry available

Actual	13	11	36	28.65	volts	34.85	amps	998.54	watts
	13	13	33	1.95	hours			1947.15	watt-hours

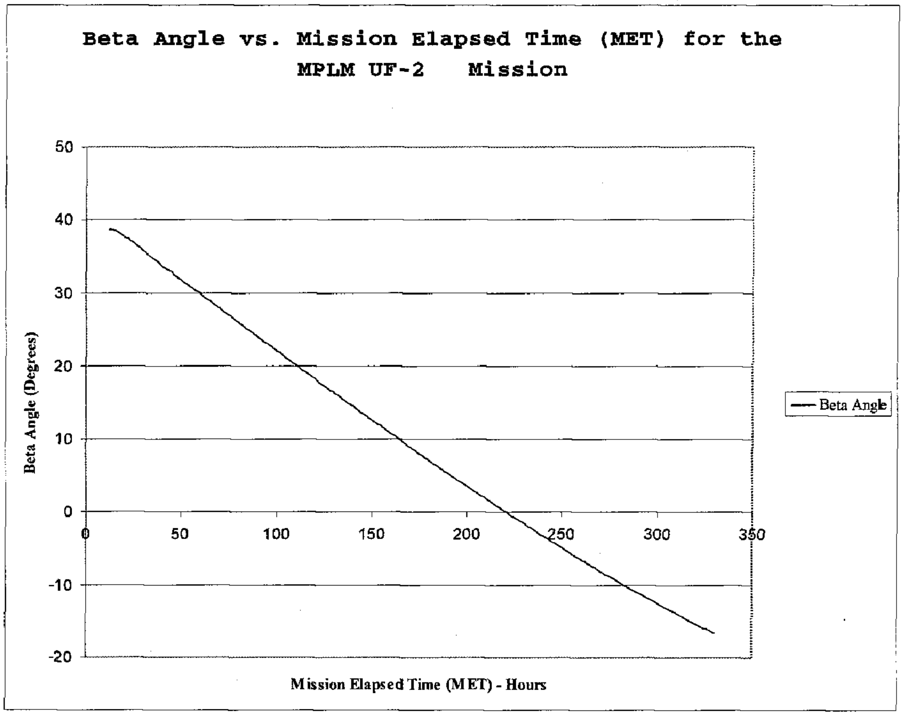
Total Contingency Hours of Heater Operation =	15.02	hours
Total Contingency Energy Used for Heaters =	14.99	kW-hrs
Total Mission hours of Heater Operation =	43.28	hours
Nominal and Contingency Total Energy Used during mission for heaters=	42.98	kW-hrs

UF2 – Orbiter Attitude Timeline:

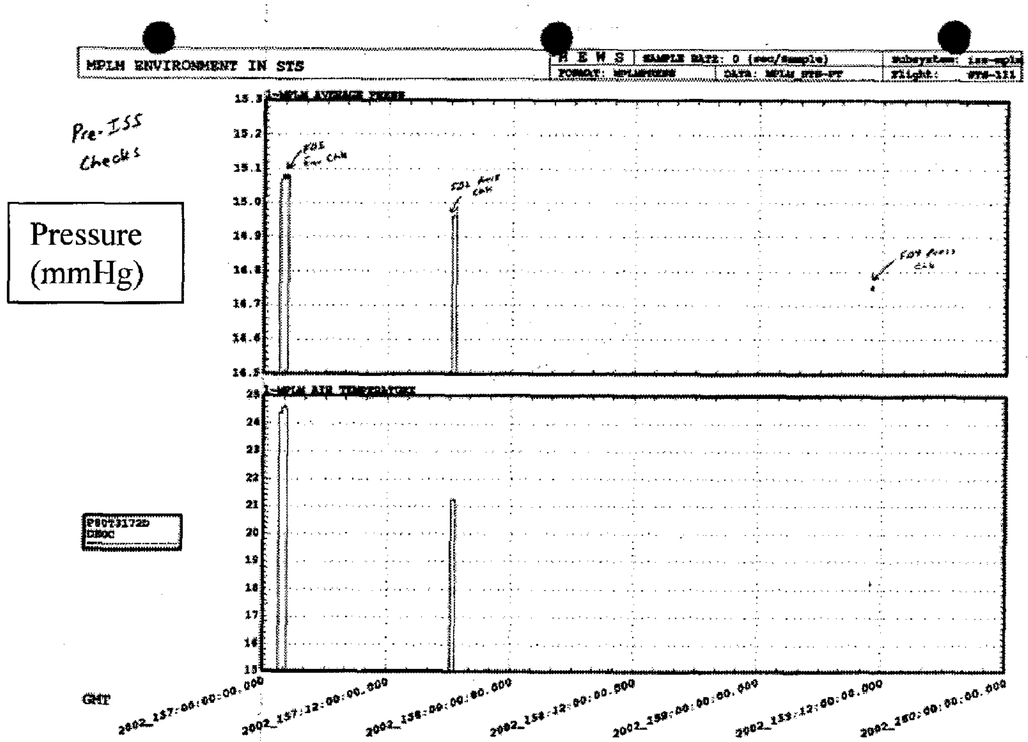
MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	SSpt 2orb	%Sun	DD/HH:MM:SS	Alt	Comment
0.00	0.48	LVLH	P 0	Y 0	R 0	0	0	180	291	46	42.2	105	316	20	59	0/ 0:00:00	77	LIFTOFF
0.48	0.91	IH	P 49	Y 358	R 265	0	178	152	283	137	42.1	99	222	140	59	0/ 0:28:58	77	OMS-2
1.39	2.10	LVLH	P 180	Y 90	R 0	0	0	0	355	138	41.9	132	185	5	61	0/ 1:23:34	109	-ZLV +YVV
3.49	0.43	IH	P 56	Y 21	R 74	0	181	36	103	42	41.4	81	42	155	63	0/ 3:29:36	109	NC-1
3.92	12.87	LVLH	P 180	Y 0	R 0	0	0	0	318	83	41.3	138	280	261	63	0/ 3:55:11	157	-ZLV -XVV
16.79	0.61	IH	P 44	Y 24	R 78	0	191	96	114	43	38.7	74	40	86	62	0/16:47:08	153	NC-2
17.40	8.60	LVLH	P 180	Y 0	R 0	0	0	0	318	69	38.5	134	300	242	62	0/17:23:53	158	-ZLV -XVV
26.00	0.47	IH	P 56	Y 22	R 78	0	180	55	105	38	36.8	81	37	137	62	1/ 1:59:57	158	NC-3 NH
26.47	10.65	LVLH	P 180	Y 0	R 0	0	0	0	321	74	36.7	139	295	250	62	1/ 2:28:19	158	-ZLV -XVV
37.13	1.88	LVLH	P 180	Y 90	R 0	0	0	0	55	93	34.5	125	94	274	62	1/13:07:31	165	-ZLV +YVV
39.00	0.16	IH	P 231	Y 1	R 99	0	359	167	263	36	34.1	80	326	1	62	1/15:00:03	165	NC-4
39.16	0.41	LVLH	P 270	Y 0	R 0	0	180	90	319	121	34.1	130	227	38	62	1/15:09:30	165	-Z TGT TRK
39.56	0.46	LVLH	P 280	Y 0	R 0	0	180	100	230	133	34.0	62	219	135	62	1/15:33:50	165	-Z TGT TRK
40.03	0.07	LVLH	P 295	Y 0	R 0	0	180	115	221	58	33.9	50	314	245	63	1/16:01:31	208	-Z TGT TRK
40.10	0.10	LVLH	P 270	Y 0	R 0	0	180	90	259	35	33.9	84	326	262	63	1/16:06:00	208	-Z TGT TRK
40.20	0.16	LVLH	P 285	Y 0	R 0	0	180	105	273	34	33.9	91	326	287	63	1/16:12:36	208	-Z TGT TRK
40.36	0.28	IH	P 243	Y 1	R 101	0	164	153	245	37	33.9	75	326	324	63	1/16:21:47	208	TI
40.64	0.72	LVLH	P 270	Y 0	R 0	0	180	90	322	114	33.8	136	234	29	63	1/16:38:37	211	-Z TGT TRK
41.36	0.52	LVLH	P 295	Y 0	R 0	0	180	115	214	96	33.7	34	259	197	63	1/17:21:41	211	-Z TGT TRK
41.89	0.08	LVLH	P 352	Y 0	R 0	0	180	172	231	45	33.6	64	322	320	63	1/17:53:10	211	-Z TGT TRK
41.96	0.37	LVLH	P 0	Y 0	R 0	0	0	180	240	40	33.6	71	324	337	63	1/17:57:41	211	+ZLV +XVV
42.33	1.01	LVLH	P 91	Y 0	R 0	0	0	89	235	43	33.5	67	323	63	63	1/18:19:37	211	-XLV +ZVV
43.33	0.08	IH	P 65	Y 68	R 257	0	359	120	214	118	33.3	43	226	298	63	1/19:20:01	205	Post-Dock Drift
43.42	0.23	IH	P 223	Y 52	R 102	0	359	159	215	68	33.3	40	305	318	63	1/19:25:01	205	Post-Dock Drift
43.65	0.10	IH	P 235	Y 324	R 96	0	195	167	307	38	33.2	112	328	12	63	1/19:39:01	205	Post-Dock Drift
43.75	0.33	IH	P 250	Y 287	R 109	0	186	153	327	67	33.2	140	308	36	63	1/19:45:01	205	Post-Dock Drift
44.08	0.05	IH	P 40	Y 308	R 258	0	142	177	324	113	33.2	139	234	114	63	1/20:05:01	205	Post-Dock Drift
44.13	0.36	LVLH	P 3	Y 359	R 2	0	32	177	322	118	33.1	134	229	126	63	1/20:08:01	205	LVLH HOLD
44.49	39.97	LVLH	P 113	Y 0	R 0	0	0	67	327	95	33.1	146	261	209	63	1/20:29:24	205	BIAS -XLV +ZVV
84.46	34.94	LVLH	P 113	Y 358	R 355	0	360	67	332	96	25.3	151	257	212	62	3/12:27:32	208	Bias -XLV +ZVV
119.40	1.68	LVLH	P 30	Y 0	R 180	0	0	30	19	100	18.6	159	119	109	61	4/23:24:14	205	MNVR Reboost 1
121.08	13.33	LVLH	P 113	Y 0	R 0	0	0	67	326	34	18.3	118	339	143	61	5/ 1:05:01	206	BIAS -XLV +ZVV
134.42	2.75	LVLH	P 90	Y 23	R 90	0	0	67	210	126	15.7	46	214	24	61	5/14:25:01	210	BIAS -XLV +YVV
137.17	22.50	LVLH	P 113	Y 0	R 0	0	0	67	227	159	15.2	76	196	307	61	5/17:10:01	210	BIAS -XLV +ZVV
159.67	1.40	LVLH	P 30	Y 0	R 180	0	0	30	16	43	11.1	131	15	168	61	6/15:40:01	211	MNVR Reboost 2
161.06	2.06	LVLH	P 90	Y 23	R 90	0	0	67	315	84	10.8	135	278	135	61	6/17:03:47	207	BIAS -XLV +YVV
163.12	18.88	LVLH	P 113	Y 353	R 3	0	352	67	340	143	10.4	125	195	256	61	6/19:07:11	207	BIAS -XLV +ZVV
182.00	2.25	LVLH	P 90	Y 23	R 90	0	0	67	176	120	7.0	30	173	356	61	7/14:00:03	211	BIAS -XLV +YVV
184.25	22.92	LVLH	P 113	Y 0	R 0	0	0	67	351	49	6.6	139	350	162	61	7/16:15:01	211	BIAS -XLV +ZVV
207.17	1.38	LVLH	P 85	Y 0	R 180	0	0	85	5	147	2.5	123	177	118	61	8/15:10:01	209	MNVR Reboost 3
208.55	2.39	LVLH	P 90	Y 23	R 90	0	0	67	262	96	2.3	82	264	81	61	8/16:32:48	211	BIAS -XLV +YVV
210.94	21.51	LVLH	P 113	Y 0	R 0	0	0	67	352	167	1.9	103	182	280	61	8/18:56:28	211	BIAS -XLV +ZVV
232.45	1.47	LVLH	P 90	Y 0	R 0	0	0	90	30	176	-1.8	93	178	267	61	9/16:26:56	214	-XLV +ZVV
233.92	0.08	LVLH	P 90	Y 0	R 0	0	0	90	6	160	-2.0	110	178	250	61	9/17:55:01	216	FLY AROUND
234.00	0.08	LVLH	P 129	Y 0	R 0	0	0	51	3	140	-2.0	130	177	269	61	9/18:00:01	216	FLY AROUND

MET	DUR	AtRef	Pitch	Yaw	Roll	R-Rate deg/hr	Eclk	Econe	Sclk	Scone	Beta	Theta	Phi	SSpt 2orb	%Sun	DD/HH:MM:SS	Alt	Comment
234.08	0.08	LVLH	P 168	Y 0	R 0	0	0	12	2	120	-2.0	149	176	288	61	9/18:05:01	216	FLY AROUND
234.17	0.08	LVLH	P 207	Y 0	R 0	0	180	27	2	101	-2.1	169	169	308	61	9/18:10:01	216	FLY AROUND
234.25	0.08	LVLH	P 246	Y 0	R 0	0	180	66	2	81	-2.1	171	14	327	61	9/18:15:01	216	FLY AROUND
234.33	0.08	LVLH	P 285	Y 0	R 0	0	180	105	2	62	-2.1	152	4	347	61	9/18:20:01	216	FLY AROUND
234.42	0.08	LVLH	P 324	Y 0	R 0	0	180	144	3	42	-2.1	132	3	6	61	9/18:25:01	216	FLY AROUND
234.50	0.08	LVLH	P 3	Y 0	R 0	0	0	177	5	23	-2.1	113	2	26	61	9/18:30:01	216	FLY AROUND
234.58	0.08	LVLH	P 42	Y 0	R 0	0	0	138	35	4	-2.1	93	2	45	61	9/18:35:01	216	FLY AROUND
234.67	0.08	LVLH	P 81	Y 0	R 0	0	0	99	172	17	-2.1	73	2	64	61	9/18:40:01	216	FLY AROUND
234.75	0.08	LVLH	P 120	Y 0	R 0	0	0	60	176	36	-2.2	54	3	84	61	9/18:45:01	216	FLY AROUND
234.83	0.05	LVLH	P 159	Y 0	R 0	0	0	21	177	56	-2.2	34	4	103	61	9/18:50:01	216	FLY AROUND
234.88	0.12	LVLH	P 180	Y 0	R 0	0	180	0	178	66	-2.2	24	5	114	61	9/18:52:43	216	FINAL SEP
235.00	1.43	LVLH	P 180	Y 0	R 0	0	0	0	176	38	-2.2	52	3	142	61	9/19:00:01	216	-ZLV -XVV
236.43	0.38	IH	P 248	Y 26	R 64	0	0	23	176	42	-2.4	48	4	115	61	9/20:25:37	216	Orbit Adjust Bu
236.80	18.74	LVLH	P 180	Y 90	R 0	0	0	0	96	23	-2.5	88	23	203	61	9/20:48:10	199	-ZLV +YVV
255.54	0.19	IH	P 127	Y 13	R 29	0	274	51	79	52	-5.6	99	51	281	61	10/15:32:16	196	RCS Hotfire
255.72	2.18	LVLH	P 180	Y 90	R 0	0	0	0	100	144	-5.6	84	145	325	61	10/15:43:28	196	-ZLV +YVV
257.91	0.53	IH	P 119	Y 314	R 74	0	62	82	359	68	-6.0	158	357	118	61	10/17:54:21	196	RAMBO Burn
258.44	19.49	LVLH	P 180	Y 90	R 0	0	0	0	97	63	-6.0	84	63	243	61	10/18:26:12	199	-ZLV +YVV
277.92	0.20	IH	P 61	Y 316	R 336	0	59	145	19	114	-9.1	190	144	138	61	11/13:55:25	196	IMU ALIGN
278.12	0.44	IH	P 26	Y 38	R 332	0	133	146	133	135	-9.1	62	144	185	61	11/14:07:21	196	VERIFICATION
278.56	1.63	IH	P 106	Y 297	R 245	0	109	91	1	94	-9.2	176	173	289	61	11/14:33:46	196	-XSI
280.19	3.36	IH	P 94	Y 324	R 6	0	241	51	30	89	-9.4	150	88	312	61	11/16:11:42	196	COMM
283.56	17.16	LVLH	P 180	Y 90	R 0	0	0	0	246	155	-9.9	80	203	23	61	11/19:33:35	196	-ZLV +YVV
300.72	0.18	IH	P 61	Y 316	R 336	0	126	139	19	113	-12.5	190	143	97	61	12/12:43:08	196	IMU ALIGN
300.90	0.47	IH	P 26	Y 38	R 332	0	176	114	131	135	-12.5	62	143	140	61	12/12:54:02	202	VERIFICATION
302.37	1.65	IH	P 103	Y 297	R 246	0	71	87	1	94	-12.6	176	172	251	61	12/13:22:23	202	-XSI
303.02	3.27	IH	P 93	Y 324	R 5	0	288	37	30	89	-12.8	150	86	277	61	12/15:01:11	202	COMM
306.28	17.35	LVLH	P 180	Y 90	R 0	0	0	0	111	141	-13.3	77	143	323	61	12/18:17:15	202	-ZLV +YVV
323.63	0.17	IH	P 232	Y 26	R 300	0	18	104	139	118	-15.6	48	129	70	61	13/11:38:02	197	IMU ALIGN
323.80	0.39	IH	P 210	Y 301	R 281	0	5	57	34	122	-15.6	134	139	110	61	13/11:48:05	197	VERIFICATION
324.19	1.75	IH	P 101	Y 297	R 247	0	23	79	1	94	-15.7	176	172	202	61	13/12:11:42	197	-XSI
325.95	5.26	IH	P 93	Y 324	R 5	0	323	41	30	88	-15.9	150	87	254	61	13/13:56:45	199	COMM
331.21	0.08	IH	P 237	Y 22	R 49	0	0	0	0	0	0.0	90	0	0	61	13/19:12:20	199	D O Burn

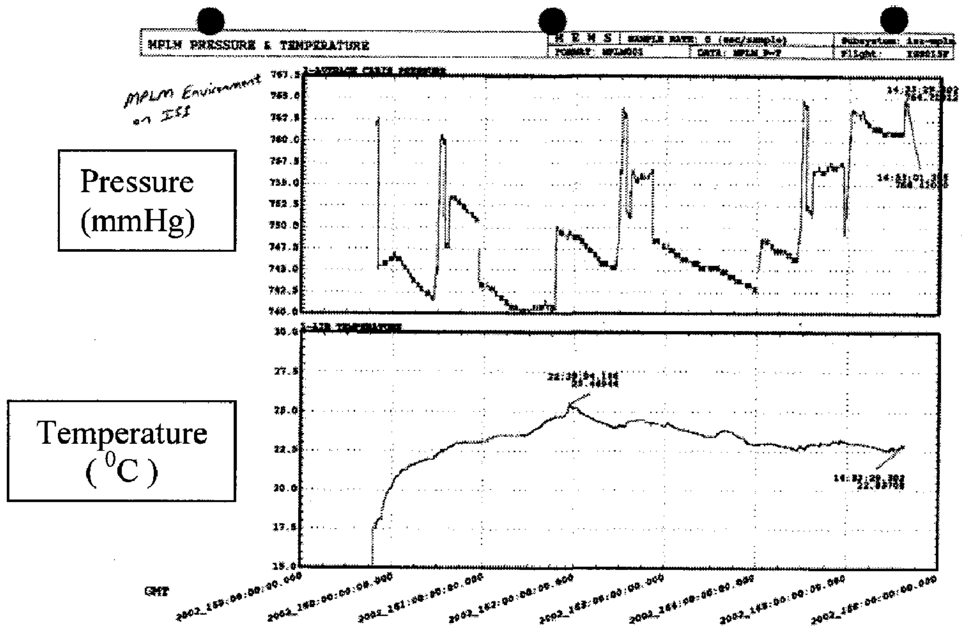
UF-2 Beta Angle:



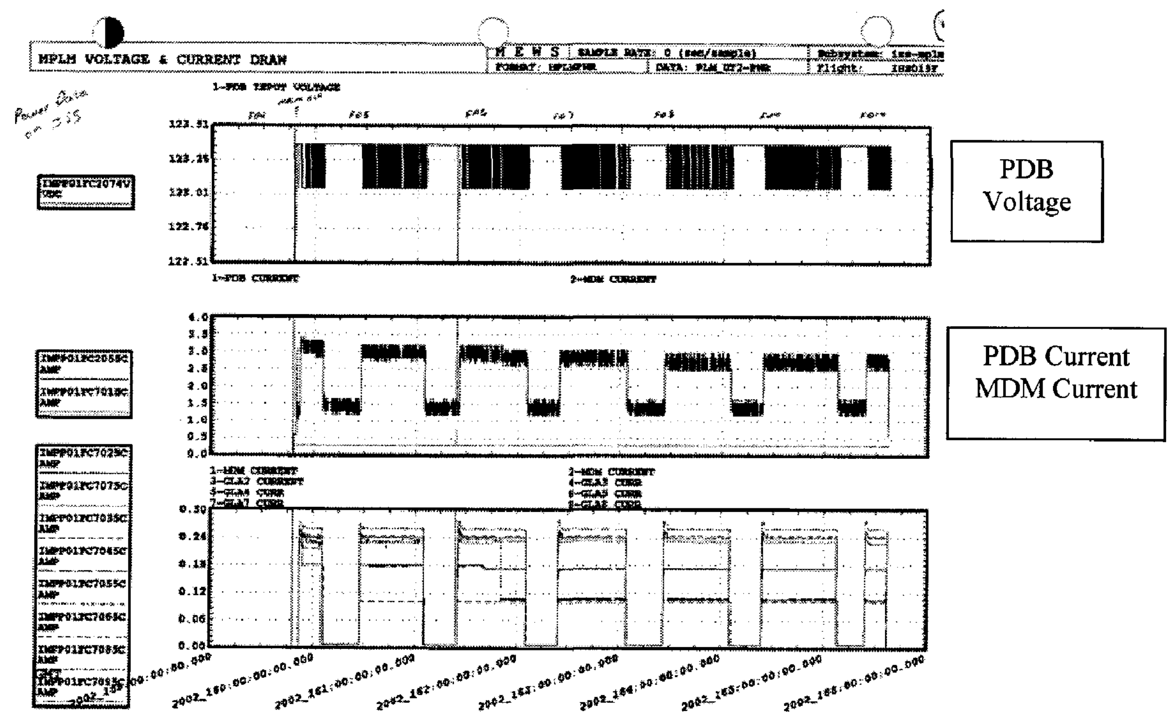
UF2 – MPLM Pressure Prior to Transfer to ISS:



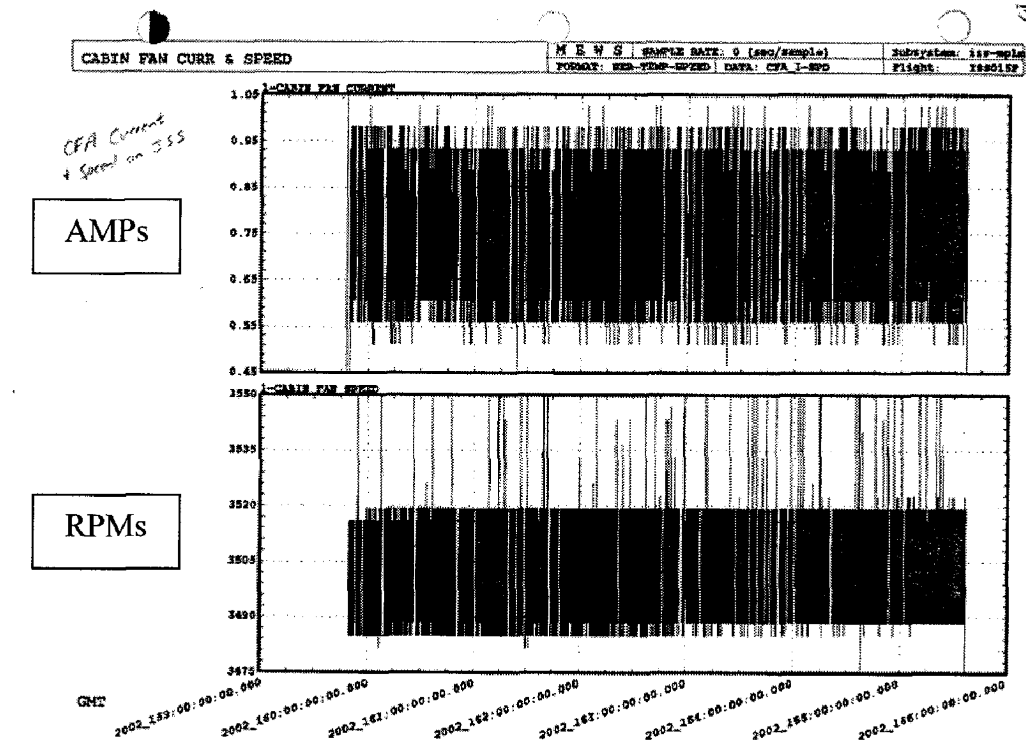
UF2 – MPLM Pressure Attached to ISS:



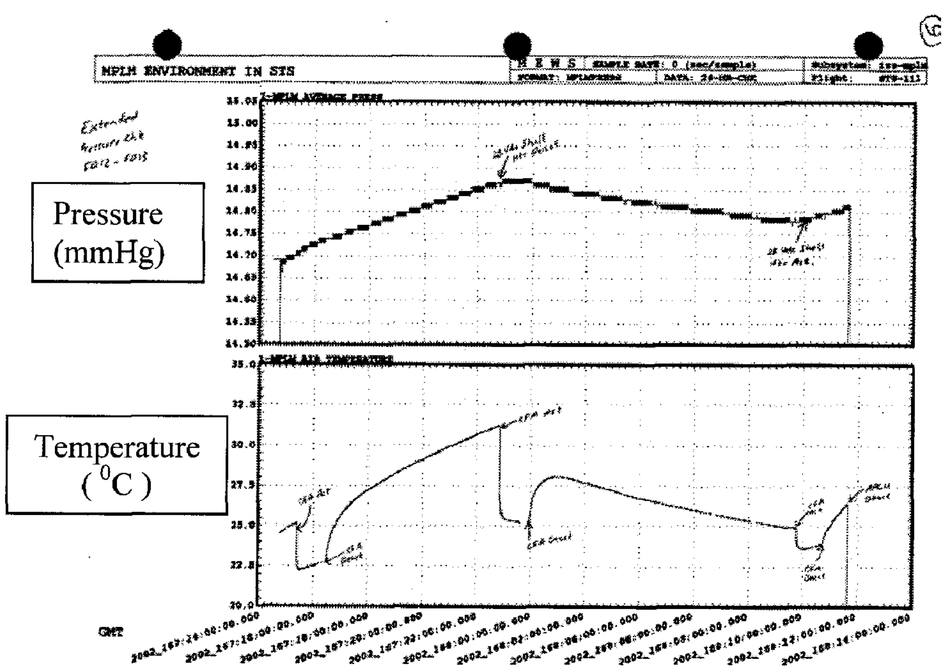
UF2 – MPLM Voltage and Current Draw:



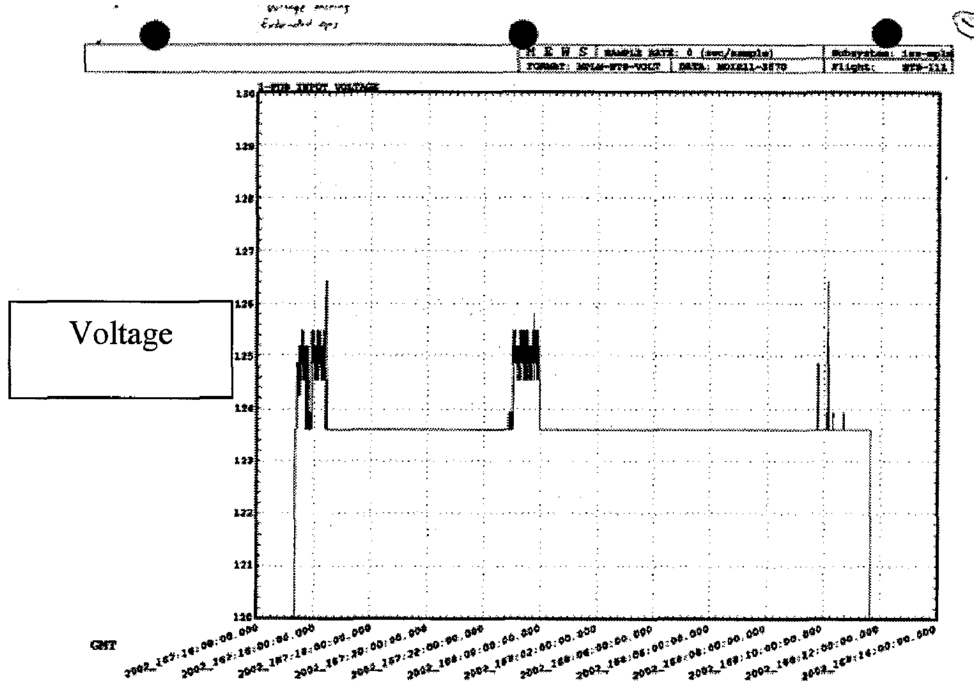
UF2 – Cabin Fan Current and Speed:



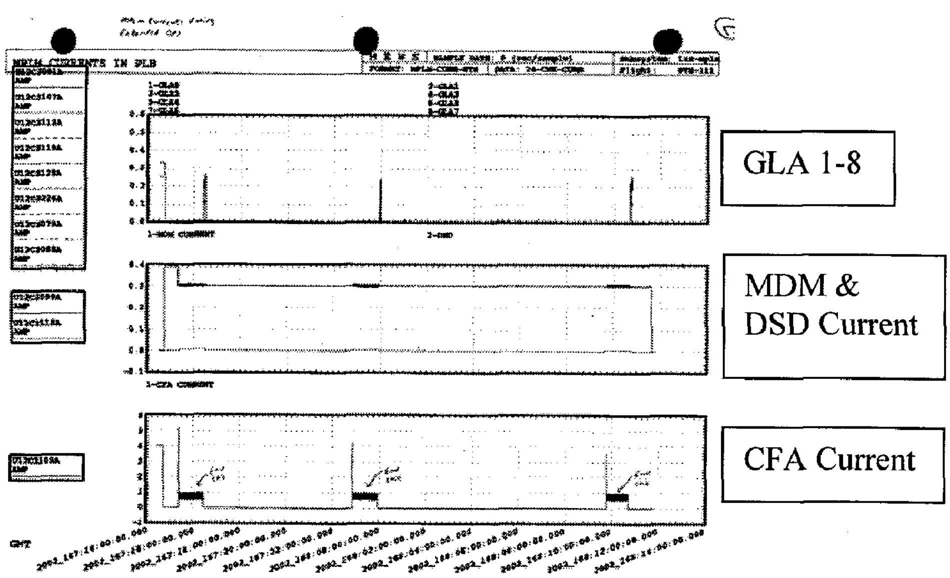
UF2 – MPLM Pressure & Temperature During 24 Hour Ops in PLB:



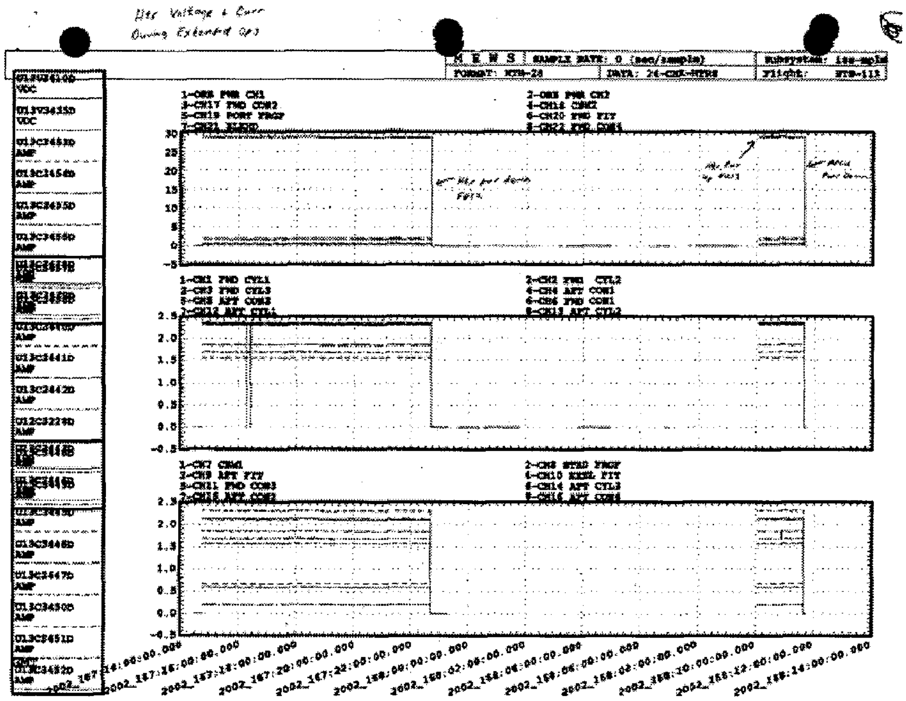
UF2 – MPLM PDB Voltage During 24 Hour Ops in PLB:



UF2 – MPLM Environmental Check During Extended Ops in PLB:

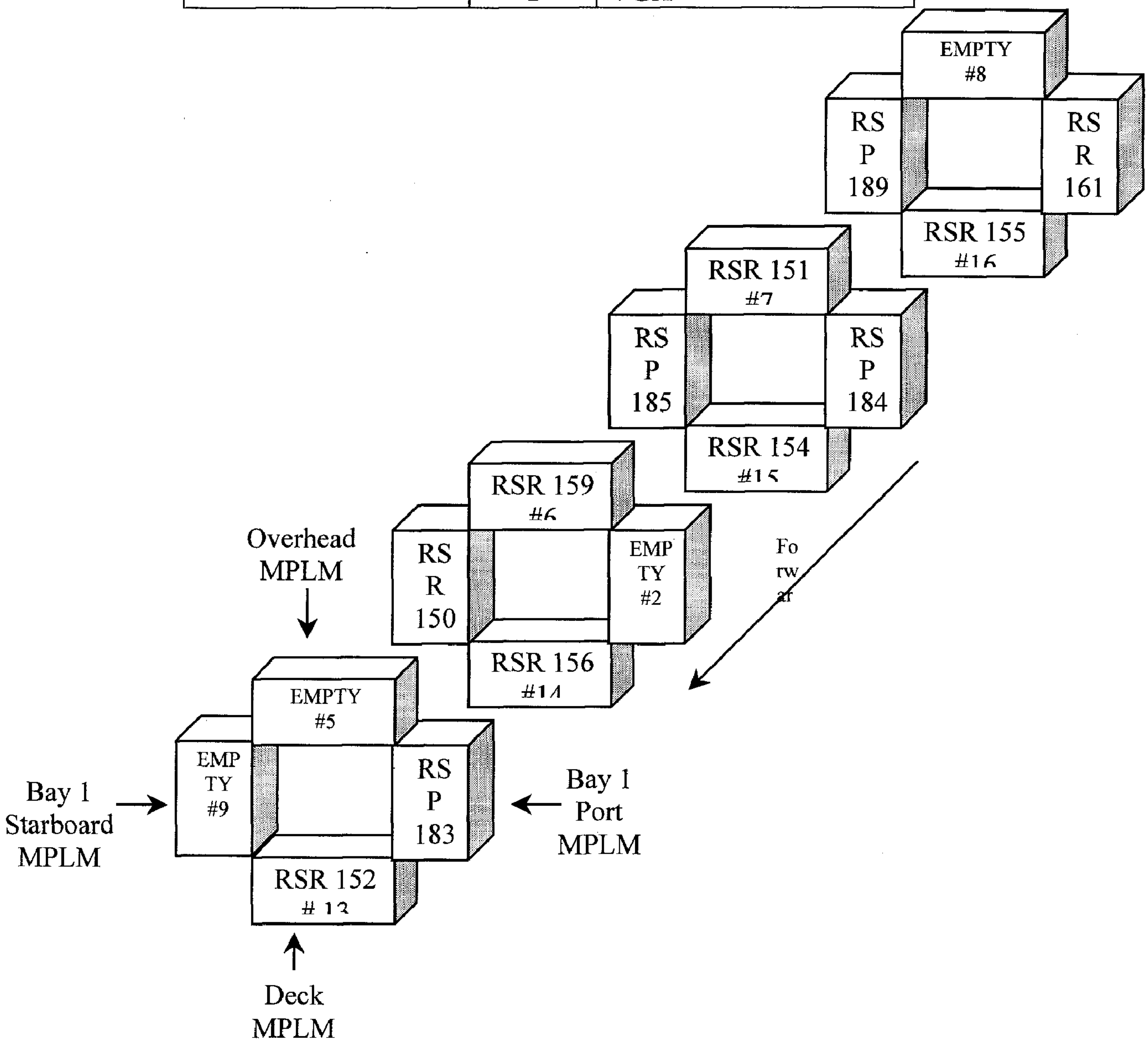


UF2 – MPLM Heater Voltage & Current During Extended Ops in PLB:



MPLM Cargo Manifest – Up

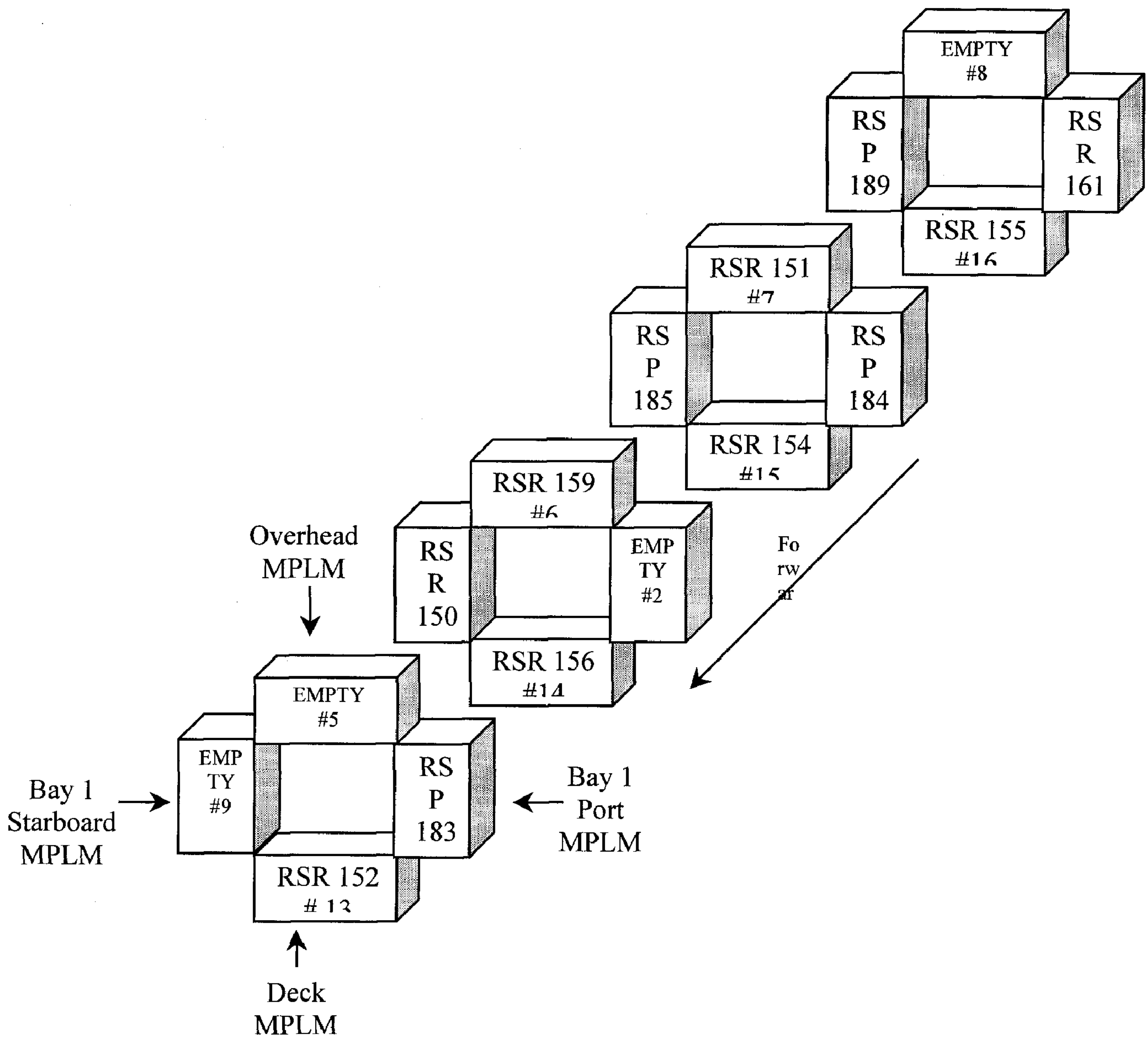
Type	Number	
RSP	4	
RSR	8	
Liquid Containers	0	0
Pressure Vessels	1	SAFER
	1	PBA
	1	VGA



UF-2 Launch Rack Configuration

MPLM Cargo Manifest – Down

Type	Number	
RSP	4	
RSR	8	
Liquid Containers	3	EDV
	4	KTO
	1	Rubber Lined Bag
Pressure Vessels	1	SAFER
	1	GSM
	1	VGA



UF-2 Landing Rack Configuration
MPLM Mission Generated Paper

Waivers:

- **No Waivers written during mission**

Problem Reports (PRs):

- **No PRs written during mission**

CHITS (Mission Action Request):

ISS – 118 Hatch Closure CHIT

Items – For – Investigation (IFI):

IFI – 805 Initial MPLM Temperature/Pressure Higher Than Expected

Significant Flight Notes:

- **No Significant Flight Notes written during mission**

In-Flight Anomaly:

- **No In – Flight Anomalies written during mission**

Lessons Learned:

1. Mission unique support data needs to be available for first shift access (for example KSC data: OMRS requirements, closeout conditions, crack/reseat for PPRAs, leakage data, cabin fan performance data, Orbiter payload bay purge, etc.). (JH/GB)

   Rationale: At the first environmental check the cabin air pressure was above the Flight Rule limit. We did not have the tested crack and reseat PPRA data so we did not know if the PPRAs cracked or not. We thought that Keith should have the data but he was in transit to JSC and unavailable. We were lucky that Ken had the data at home with him. He said that Cindy had emailed the data the Friday after the first launch attempt, but this did not help the first shift, which was already in Houston. (JH/GB)

2. MPLM team shift reports for both the IMC and MER, need to be standardized and available for review by all shifts in both IMC and MER. Shift reports should include ALL CHITs that were reviewed, when reviewed, and who reviewed. Any impacts/comments or lack thereof should also be indicated. (JH/GB)

3. IMC and MER MPLM members should also do a combined shift handover. (JH/GB)

4. IMC log input requirements should be standardized for the FileMaker Pro file. The Module and Subsystem headings should be deleted or deactivated. The Topics list should be updated (e.g., change Logistics to Handover). (JH/GB)

5. The chain of command for the support team needs to be more clearly identified to address for example shift modifications (e.g., don't need to decide schedule modifications by group consensus). (JH/GB)

6. Add contact person's name and organization when documentation (Chits, shift reports, etc.) references coordination. (JH/GB)

7. There is not enough information regarding trash WRT safety assessments. Alenia wants more detail of what is in the trash bags (Spacehab and Russian) for their safety assessments. Does Alenia have a description of ALL of the other hardware to be packed and stowed in an MPLM? If not, how's this different from trash?

8. Daily management report sent to: Shawn Reagan, Jan Davis, Scott Croomes, randy.mcclendon@msfc.nasa.gov, Bob Goss, stephen.porter1@jsc.nasa.gov, edgar.o.castro1@jsc.nasa.gov, Bob Crumbley, Teresa Vanhooser, Ann McNair, Sherri Bedwell, Deborah McWhorter, bill.seiser@msfc.nasa.gov, charlotte.hazel@msfc.nasa.gov, Allen Shariett, Jon Holladay, Richard Kuhns. Copy of reports captured in Word format as "UF2 IMC MPLM SHIFT HANDOVER SUMMARY.doc" (RK)

9. We need to make sure we have a copy of the IMC Operations Handbook at the console. (RK)

10. All of the MPLM sensor limits (Flight Rules, Caution and Warning, Malfunction Procedures, hardware acceptance and qualification, MCC display, etc.) need to be defined in one place, maybe in a spreadsheet. Three times we were asked about exceeding limits, and it took some time to track down what they were. First, the cabin pressure at the first environmental check exceeded the Flight Rule upper limit. Second, the cabin air temperature exceeded the low temperature limit, and the crew received an alarm at MPLM power up when docked to ISS. Third, one of

the PDB temperature sensors exceeded a high temperature limit on an Electrical(?) display in the MER. (JH/GB)

11. The ISS equivalent of the STS Annex 4 telemetry data needs to be tracked down and included in Gordon's data CD for the mission. STS Annex 4 also needs to be added to Gordon's CD. (JH/GB)

12. A list of web links to mission documentation may be helpful. The links could be saved to a bookmarks file that could be used for mission support. Gordon downloaded a lot of this information to the mission CD he created, but having the web links may be better because some of the information on the CD would not need to be updated mission to mission to ensure the latest copies. (JH/GB)

13. A console binder with quick reference information maybe helpful with things like shift staffing, phone numbers, timelines, etc. Most of this was sent out before the mission via email; however, hard copies in a console notebook would be helpful if email access is unavailable. (JH/GB)

    Note: this info was on the CD. However it should have been in the binder. (RK)

14. All mission support team members need to attend the pre-mission walk-through training even if they supported all prior missions. New plans and tools were available this mission and word didn't make it to all of the team members. (RK)

15. For cryo barter we should have only one fall back position for deleting heater operations. This flight we coordinated with THOR to give back one heater cycle, and then ended up giving all the up hill operations back during a meeting with FD and THOR. This impacts our credibility with the Flight Director and damages our customer relationship with THOR console. (JH/GB)

16. We need to evaluate cryo value versus protecting NPRA for descent heater operations. Without a rapid turnaround requirement at KSC perhaps cryo is more valuable than the risk of having to perform maintenance on a NPRA. The risk of contamination of a NPRA should be minimal. Air ingested during descent is air at standard atmospheric conditions as a function of altitude. (JH/GB)

17. We need to revisit KSC closeout requirements and procedures. Reference IFI-MER-00805. (RK)

18. We need to revisit the ISS closeout requirements. The requirements currently allow for closeout to fall inside of a box of values that may be too loose. (RK per KP)

19. Everyone on the support team needs to have an MODM account. Some accounts seemed to not allow printing or saving to the hard drive while others did. This would also aid in having print capability to all shifts. (RK)

20. Add sections to the shift plan to indicate who has MODM and Deck Alpha accounts, who needs escort into MCC, and who has rental car. (RK)

21. More IMC training for MSFC folks should be developed. E.g who does what, what the different types of constraints/groundrules are trying to do, what Alenia reps are doing, what the CSR is and does (what do they do?), etc. (RK)

22. Have copy of flight rules, MIP and any other mission related info copied to the CDROM in volume 2 in case individual MODM accounts aren't available or the laptop IP addresses do not work. (RK)

23. Look at getting at least one OSTPV (not sure what acronym means) account on the JSC domain. The MODM accounts that we used were in the JSC-MAS domain. OSTVP provides realtime status and better detailed timelines. It can be customized to show only certain information related to MPLM timelines. (RK)

24. Have everyone leaving their last shift prior to the first landing turn-in headsets or make sure they have time to return to JSC to do so. Possibly have one person collect the headsets for turn-in after the TIG. (RK)

25. To pouch mail items back to MSFC from JSC, you can go to building 1 room 106 (by loading dock) and get items boxed/taped and mailed. Contact for mailroom is John at 281-453-0291 (different building). (RK)

26. The fax numbers for the MER and the IMC should be made part of the contacts list so people at MSFC can get items sent to those supporting the mission at JSC. (CH)

Back Up Information

Multi-Purpose Logistics Module (MPLM)

The three Multi-Purpose Logistics Modules, or MPLMs, which were built by the Italian Space Agency (ASI), are pressurized modules that serve as the International Space Station's "moving vans," carrying laboratory racks filled with equipment, experiments and supplies to and from the station aboard the space shuttle.

The unpiloted, reusable MPLM functions as both a cargo carrier and a space station module when it is flown. Mounted in the space shuttle's cargo bay for launch and landing, they are berthed to the station using the shuttle's robotic arm after the shuttle has docked. While berthed to the station, racks of equipment are unloaded from the module and then old racks and equipment may be reloaded to be taken back to Earth. The Logistics Module is then detached from the station and positioned back into the shuttle's cargo bay for the trip home. When in the cargo bay, the cargo module is independent of the shuttle cabin, and there is no passageway for shuttle crewmembers to travel from the shuttle cabin to the module.

In order to function as an attached station module as well as a cargo transport, the MPLM also includes components that provide some life support, fire detection and suppression, electrical distribution and computer functions. Eventually, the modules also will carry refrigerator freezers for transporting experiment samples and food to and from the station. Although built in Italy, the logistics modules, technically known as Multi-Purpose Logistics Modules are owned by the U.S. and provided in exchange for Italian access to U.S. research time on the station.

Construction of ASI's Leonardo module began in April 1996 at the Alenia Aerospazio factory in Turin, Italy. Leonardo was delivered to Kennedy from Italy in August 1998 by a special Beluga cargo aircraft. The cylindrical module is approximately 6.4 meters (21 feet) long and 4.6 meters (15 feet) in diameter, weighing almost 4.1 metric tons (4.5 tons). It can carry up to 9.1 metric tons (10 tons) of cargo packed into 16 standard space station equipment racks. Of the 16 racks the module can carry, five can be furnished with power, data and fluid to support a refrigerator freezer. Raffaello arrived at Kennedy in August1999. The third module, named Donatello, was delivered to Kennedy on Feb. 1, 2001.

The Italian Space Agency chose the names of the modules because they denote some of the great talents in Italian history: Leonardo da Vinci, an extraordinary inventor-scientist, civil engineer, architect, artist and military planner and weapons designer; Donato di Niccolo DI Betto Bardi, one of the greatest sculptors of all time and one of the founders of modern sculpture; and Raffaello Sanzio, an artist whose work stands alone for its visual achievement of human grandeur, both in clarity of form and ease of composition.

MARSHALL SPACE FLIGHT CENTER
CONTROL BOARD DIRECTIVE (CBD)

1. CBD NUMBER: MP3-00-0067	2. CONTROL BOARD: MPLM Level III CCB	3. DATE: 11/24/2003
4. CHANGE NUMBER: FD24-0034		5. PAGE 1 OF 1
6. PROGRAM CONTROL NUMBER: MP00065	7. RESPONSIBLE INDIVIDUAL(S) ORGANIZATION(S): Bessie LEE/ FD24 / PWI phone: 544-7109 e-mail: bessis.lee@msfc.nasa.gov	

8. CHANGE TITLE: Pressurized Carrier Group Multi Purpose Logistic Module Interface Definition Document Rev. E	9. BASELINE DOCUMENT(S) OR DATABASE AFFECTED: ISS-MPLM-IDD-006
10. CONFIGURATION ITEM (CI)/CSCI NO. AND NOMENCLATURE: ISS-MPLM-IDD-006	11. EFFECTIVITY (CI/CSCI ONLY): MP01

12. BASELINE AFFECTED:

	YES	NO
CONFIGURATION	☒	☐
NON-CONFIGURATION	☐	☒
BUDGET	☐	☒
SCHEDULE	☐	☒
OTHER: ______		

13. IMPACT COST: ☐ YES ☒ NO

☐ COST SPECIFIED IN ATTACHMENT

FY- ____	COST: ____	FY ____	COST: ____
FY- ____	COST: ____	FY ____	COST: ____
FY- ____	COST: ____	TOTAL COST: N/A	

14. IMPACTS:

	YES	NO
WEIGHT	☐	☒
MEMORY	☐	☒
POWER	☐	☒
COST PER FLIGHT	☐	☒
ENVIRONMENTAL	☐	☒
OTHER: ______		

15. CHANGE DISPOSITION:

1.ECR FD24-0034 is approved as written.

2. Pressurized Carriers Group Multi Purpose Logistic Interface Definition Document Rev. E DateNovember 2003, is Hereby baseline.

3.Bessie Lee/PWI shall provide a copy of this document to the MSFC Documentation Repository for file and distribution per the Pressurized Carriers Group Distribution List.

4.All future changes to this Document shall require an ECR.

5.Debbie McWhorter shall put Pressurized Carriers Group Multi Purpose Logistic Module Interface Definition Document Rev. E

16. BOARD MEMBERS	CONCUR YES	CONCUR NO	BOARD MEMBERS	CONCUR YES	CONCUR NO	17. BOARD CHAIRPERSON
Jon Holladay /FD24 [signature]	✓		Additional Distribution:	✓		[signature] 24 Nov '03
						Randy McClendon/FD24 PC/MPLM .
Shawn Reagan/FD24 [signature]	✓					Chairman
						DATE
						18. SECRETARIAT
Kathy Jones/FD24 [signature]	✓					[signature]
				✓		Bessie Lee/FD24/PWI
Victor Hemrick/FD11 [signature]	✓					MPLM/PC CCB Secretariat
						DATE

 Informed

MSFC ENGINEERING CHANGE REQUEST (ECR)
(See Instructions: MSFC Form 2327-2)

1. NUMBER:	2. PCN:	3. DATE:	4. PAGE:
FD24-0034	MP00065	11/05/2003	1 OF 1

5. TO:	6. THRU:	7. FROM:
FD24/Randy McClendon	FD24/Bessie Lee/PWI	FD24/Mike Morlan

8. TITLE OF CHANGE:
Pressurized Carriers Group, Multi Pourpose Logistic Module IDD Rev. E

9. RECOMMENDED PRIORITY:
☐ EMERGENCY ☐ URGENT ☒ ROUTINE

10. NEED DATE:
11/14/2003

11. PROGRAM(S)/PROJECT(S) AFFECTED:
ISS MPLM

12. CONFIGURATION ITEM(S) AFFECTED BY NOMENCLATURE:
MPLM

13. RECOMMENDED EFFECTIVITY(IES):
MP01

14. DOCUMENTATION AFFECTED (Specs, ICD, etc.):
ISS-MPLM-IDD-006

15. RELATED CHANGES (ECR, ECP, CR, etc.) BY NUMBER:
N/A

15A. INITIATING DOCUMENT NUMBER (e.g., DR, Software Trouble Report, etc.):

16. JUSTIFICATION FOR CHANGE (Include effect if not incorporated. If necessary, continue on MSFC Form 2327-1, Continuation Sheet):
To revise ISS-MPLM-IDD-006 to Revision "E"

17. EFFECTS ON:
☐ HARDWARE ☐ FACILITY ☐ SCHEDULE (SEE ENCLOSURE ____ FOR IMPACT ☒ REQUIREMENTS DOCUMENTATION
☐ SOFTWARE ☐ ENVIRONMENT ☐ COST (ESTIMATED COST INCLUDED IN ENCLOSURE ____) ☐ OTHER (SPECIFY): ________

18. DESCRIPTON OF CHANGE (Include reference to enclosure. If necessary, continue on MSFC Form 2327-1, Continuation Sheet.):
To update section 1.1 and to add MPLM Mission History as Appendix "D"

19. MOD KIT INFORMATION:

YES	NO		Enclosure	Paragraph
☐	■	Previously issued modification instructions affected? (Explain)		
☐	■	Proofing of modification instructions and kit installation required? (Explain)		
		Proofing location:		
☐	■	Retest required? (Identify test invalidated by change)		
☐	■	Requalification required? (Include description of test plan for requalification)		

Vehicle/Site & CI Serial No.	Change Period	Mod Kit Delivery Date	Est. M/H for Mod Kit Instl.	Out-of-Service Time

20. SIGNATURE OF ORIGINATOR:	DATE:	TELEPHONE NUMBER:	OFFICE SYMBOL:
[signature]	20 Nov 03	(256) 544-5003	FD24

21. CONCURRENCE

SIGNATURE	ORG. CODE	DATE	SIGNATURE	ORIG. CODE	DATE

22. TECHNICAL APPROVAL

SIGNATURE	ORG. CODE	DATE	SIGNATURE	ORIG. CODE	DATE

PACKAGE NUMBER:	DOCUMENTATION PACKAGE / ROUTING SLIP	SHEET 1 OF 1

PROGRAM/PROJECT: PC/MPLM

CEI NUMBER:	NOMENCLATURE: Interface Definition Document Rev. E
ECR NUMBER: FD24-0034	CCBD NUMBER: MP3-00-0067
PCN NUMBER: MP00065	DATE PREPARED: 11/24/2003

DRAWING / DOCUMENT NUMBER	DRL / EPL NUMBER	EO NUMBER
ISS-MPLM-IDD-006	205	

SUBMITTED BY ENGINEERING AREA:

BASIC RELEASE ☐	;	PARTIAL ☐	COMPLETE ☒
CHANGE RELEASE ☐	;	PARTIAL ☐	COMPLETE ☐

THIS SUBMITTAL CLOSES ACTION ON ABOVE CCBD BY: ☒ YES ☐ NO

PREPARED BY: FD24/Bessie Lee *Bessie Lee*	DATE: 11/24/2003	TRANSMITTAL DATES
SUBMITTED BY: FD24/Bessie Lee *Bessie Lee*	DATE: 11/24/2003	TO RELEASE: 11/24/2003
CONCURRENCE: FD24/Shawn Reagan *Shawn E. Reagan*	DATE: 11/24/2003	TO MSFC REPOSITORY:

REMARKS:

MSFC Form 3418 (Rev. November 2001) Informed

MSFC DOCUMENTATION REPOSITORY - DOCUMENT INPUT RECORD

I. GENERAL INFORMATION

1. APPROVED PROJECT:	2. DOCUMENT/ DRAWING NUMBER:	3. CONTROL NUMBER:	4. RELEASE DATE:	5. SUBMITTAL DATE:
PressurizedCarriers Group/MPLM	ISS-MPLM-~~PLAN-017~~ IDD-006 BL	MP00063	10/09/2003	

6. DOCUMENT/DRAWING TITLE:	7. REPORT TYPE:
Pressurized Carriers Group/Mutli Pourpose Logistics Module Interface Definition Document Rev. E	Plan

8. CONTRACT NUMBER / PERFORMING ACTIVITY:	9. DRD NUMBER:	10. DPD / DRL / IDRD NUMBER:
477-72-61	NA	NA

11. DISPOSITION AUTHORITY (Check One):	12. SUBMITTAL AUTHORITY:	13. RELEASING AUTHORITY:
[X] Official Record - NRRS 8/5/A/1 (c) [ ] Reference Copy - NRRS 8/5/A/3 (destroy when no longer needed)	Mike Morland/FD24	MPLM LEVEL III CCB

14. SPECIAL INSTRUCTIONS:

Send Bessie Lee ~~10~~ 3 copies Bld 4610 rm 4028 (attached)
Send Debbie McWhorter a CD Bld 4610 rm 4028

IF ANY QUESTIONS CALL BESSIE LEE 544-7109

15. CONTRACTOR/SUBMITTING ORGANIZATION, ADDRESS AND PHONE NUMBER:	16. ORIGINATING NASA CENTER:
MSFC	MSFC
	17. OFFICE OF PRIMARY RESPONSIBILITY: Kathy Jones/ FD24

18. PROGRAMMATIC CODE (5 DIGITS):	19. NUMBER OF PAGES:
477-72-61	278 ~~24~~

II. ENGINEERING DRAWINGS

20. REVISION:	21. ENGINEERING ORDER:	22. PARTS LIST:	23. CCBD:
~~B~~ E	NA	N/A	MP3-00-0067

III. REPORTS, SPECIFICATIONS, ETC.

24. REVISION:	25. CHANGE:	26. VOLUME:	27. BOOK:	28. PART:	29. SECTION:

30. ISSUE:	31. ANNEX:	32. SCN:	33. DCN:	34. AMENDMENT:

35. APPENDIX:	36. ADDENDUM:	37. CCBD:	38. CODE ID:	39. IRN:
		MP3-00-0067		

IV. EXPORT AND DISTRIBUTION RESTRICTIONS

- [ ] Privacy Act (see MWI 1382.1)
- [ ] Proprietary (see MPD 2210.1)
- [ ] Patent (see MPG 2220.1)
- [ ] ITAR (see MPG 2220.1)
- [X] EAR (see MPG 2220.1)
- [ ] Other ACI (see NPG 1620.1 and MPG 1600.1) ______
- [ ] No statutory or institutional restrictions applicable -- material may be electronically distributed to user in the NASA domain

V. ORIGINATING ORGANIZATION APPROVAL

40. ORG. CODE:	41. PHONE NUMBER:	42. NAME:	43. SIGNATURE/DATE:
FD24	(256) 544-3559	Randy K.McClendon	Randy K McClendon 24 Nov '03

VI. TO BE COMPLETED BY MSFC DOCUMENTATION REPOSITORY

44. RECEIVED BY:	45. DATE RECEIVED:	46. WORK ORDER:
Eric Donaldson	11-25-03	02-00178-4