7.6 Columbus Payload Accommodation

As part of the ISS, ESA's Columbus module represents an element of a multi–functional, orbital infrastructure that generates and/or distributes the resources required for scientific and technological research in Low Earth Orbit (LEO). Columbus provides the capability for:

- The long–term continuous exposure of payloads to the microgravity environment and the capability for the systematic repetition and evolution of experiments on a more frequent basis;
- Automatic, remotely controlled and interactive investigations involving orbit–based and ground–based crews composed of scientific, engineering and space operations personnel;
- The remote reconfiguration of the Columbus (and potentially the payloads) functional–electrical configuration based on optimised operations and redundancy concepts;
- A successive build–up and complementation of payloads based upon experiment results while using the logistics capabilities of the space transportation systems and the Columbus design features for Orbit Replaceable Units (ORU);
- In–orbit crew intervention for scientific preparatory, technical diagnostic, hardware configuration or recovery purposes when and as required.

Although aimed at basic research in the fields of material, fluid, biological and physiological sciences, the versatility and resources provided makes Columbus a suitable facility for other fields of applied sciences, process engineering and prototyping of automatic experiments.

The Columbus module consists of a cylinder with an inner diameter of 4216 mm and an overall length of 6137.2 mm, closed by a truncated end cone at each end. The cross–section is double symmetric with four identical stand–off envelopes accommodating the routing of utility lines and four identical rack envelopes spaced 90 degrees apart. An overview of the Columbus features and resources are presented in the Columbus Fact Sheet in chapter **9** at the end of the Guide.

In order to simplify the process of preparing and integrating payloads into the Columbus Laboratory, the European Space Agency, for internal purposes only, has defined two classes of user hardware, i.e. Class 1 and Class 2 payloads. Theoretically, the following definitions are applied by ESA to both internal (pressurised) payload hardware and external (unpressurised) payload hardware. For internal payloads the definitions are very clear, but for external payloads however, a precise definition is not so easy to establish. For the latter reason, the Class 1 and Class 2 classification within this guide will only be applied to internal payloads. External payloads will be dealt with in a separate section (see 7.6.3).

Class 1 payloads are large multi-user facilities, which are normally developed by industry for the user(s). Class 2 payloads on the other hand can be provided directly by the user, and range from an individual sample to a complete subrack level payload.
The complete payload lifecycle activities, complexity, cost and development time is significantly different for the two classes of payload - although the general scope and sequence of activities is very similar in each case. The complete payload lifecycle process is generally complex and of long duration for Class 1 (~ 5 years), and simple and of short duration (~ months to a few years) for Class 2.

7.6.1 Class 1 Payloads

Class 1 payloads are any user hardware that interfaces directly with the Columbus laboratory system at the International Standard Payload Rack (ISPR – see 7.6.1.1), or at the Standard Utility Panel interface in case of centre aisle payloads (see 7.6.1.2). In general, the selection of Class 1 payloads is made at Agency Programme level and in close coordination with the Space Station partners in order to avoid duplication of hardware. Once a decision for the development of a Class 1 payload is taken, this payload will be developed by industry under contract and financial coverage of the responsible Agency Programme Directorate. The final technical definition and construction of the Class 1 payload is undertaken in close interaction with the scientific and technical advisory teams of the respective User Programmes.

Within Columbus, pressurised payloads are primarily accommodated in racks. Columbus accommodates 16 racks in four segments of four racks each (Figure 7-24). System equipment requiring access or viewing by the crew is accommodated in the starboard end cone, while the remainder of the system equipment is housed around the perimeter of the port end-cone, and within three of the deck (floor) racks. The remaining 13 racks are available for payloads and storage, 10 have "plumbing and harness" to provide resources to active racks, and 3 provide passive stowage accommodation for payloads and system.

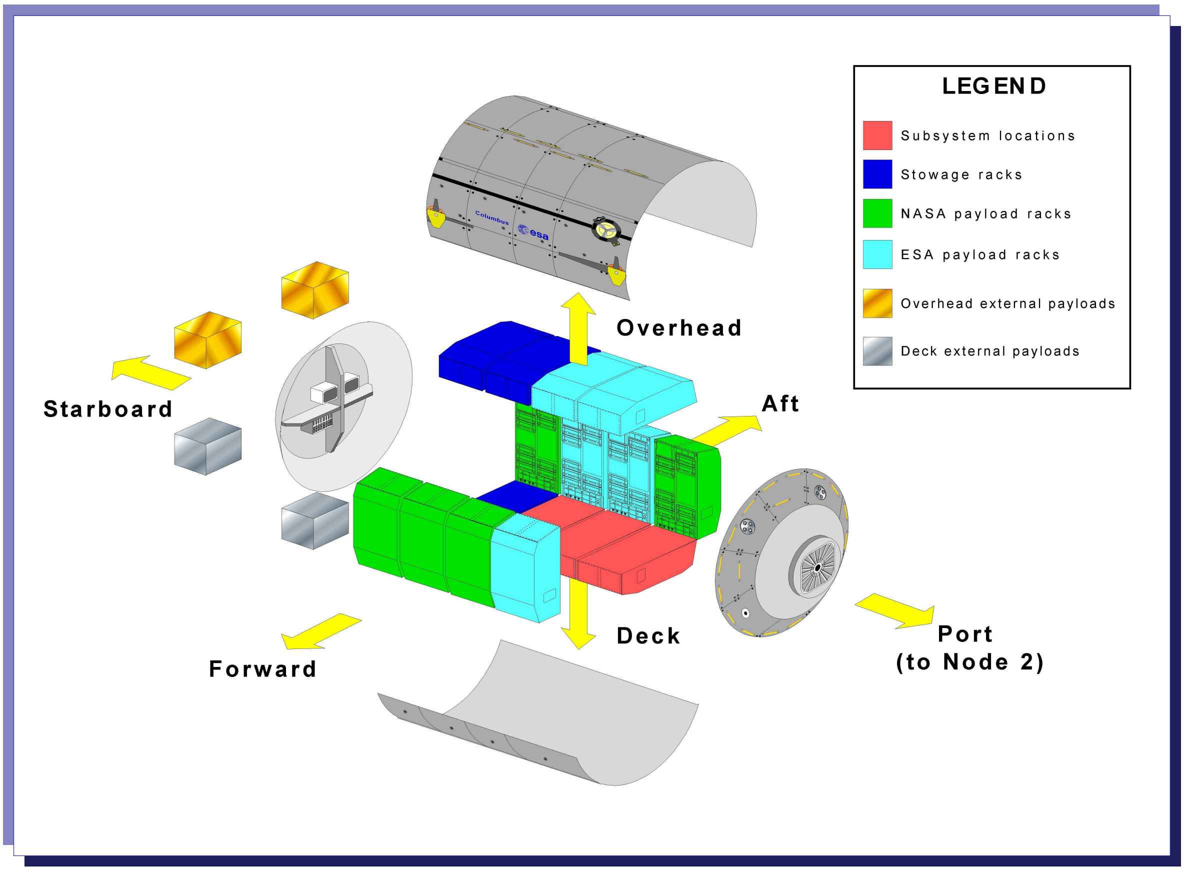

Figure 7-24: Internal layout of Columbus racks

7.6.1.1 The International Standard Payload Rack (ISPR)

To facilitate on-orbit interchangeability between International Partner pressurised modules, internal (or pressurised) payloads are primarily accommodated within an International Standard Payload Rack (ISPR). The exception to this general statement being the Russian segment of the ISS, which does not allow the accommodation of ISPRs. The ISPRs have mechanical mounts at the top and bottom of the rack to enable attachment to the secondary structure of the Columbus Laboratory. The bottom attachment is pivoted, to allow the rack to be tilted forwards approximately 80° for installation, removal or maintenance. Both NASA and JAXA (formerly NASDA) have developed ISPRs that may be utilised by users/payload developers, with interfaces and capabilities that are almost identical. The NASA rack however, has a larger volume for the accommodation of payloads.

The JAXA ISPR (Figure 7-25 and Figure 7-26) is the basic accommodation for European payloads. This is a non-sealed structure made of aluminium. There are removable side and rear panels that may be taken-off during payload integration on the ground or to provide on-orbit access during the payload operations phase. The basic ISPR structure is termed the "six post" configuration, as it has a post at each corner plus one in the centre-front and one in the centre-rear. The centre posts are removable, resulting in a four-post version of the rack. Table 7-23 summarises the major characteristics of the Japanese ISPR for both the 6-post and 4-post versions.

Table 7-23: Characteristics of JAXA International Standard Payload Rack (ISPR)

	6-POST ISPR	4-POST ISPR
Height	2013.4 mm	
Width	1046 mm	
Depth	858 mm	
Payload mass supported	704 kg	418 kg
Internal accommodation volume	1.2 m^3	1.35 m^3

The Japanese ISPR may also be outfitted with standardised components provided by the International Partners – the so-called Standard Payload Outfitting Equipment items (the rack itself is also considered a Standard Payload Outfitting Equipment item).

There are two power ratings of ISPR, a "medium power" 6kW, and a "low-power" 3 kW. The placement of a medium-power rack (6kW) in a low power (3kW) location is not possible, but low-power racks may be placed in any location.

ISPRs are the largest (pressurised) individual entity that can be transported to and from orbit as logistics upload/download. The design of the racks facilitates the ready installation, removal or exchange of sub-rack units on-orbit. The resources available to International Standard Payload Rack payloads are provided through a Utility Interface Panel. This panel (which is part of the Columbus Laboratory) is located beneath the lower front of the ISPR. It is behind the lower stand-off area, and close to the pivot attachment point, only at specific rack locations within the Columbus Laboratory (i.e., the 8 lateral positions and 2 overhead positions). The payload to system interface panel is part of the internal structure of the Columbus Laboratory. The rack utility close-out panel is part of the integrated ISPR. The flexible utility lines (permanently attached to the close-out plate) are mated with the connectors on the Utility Interface Panel during installation of the ISPR in the Columbus Laboratory. These are flexible to provide the capability to tilt the rack for servicing and maintenance without disturbing the interfaces.

The payload/system interface is the Utility Interface Panel itself, so the connectors between the Close-Out Panel and the Utility Interface Panel are payload-provided items. Seat tracks are also present on the front posts of the ISPR, for the temporary attachment of payload equipment, during experiment operations or maintenance activities.

Figure 7-25: International Standard Payload Rack (ISPR): 6-post configuration

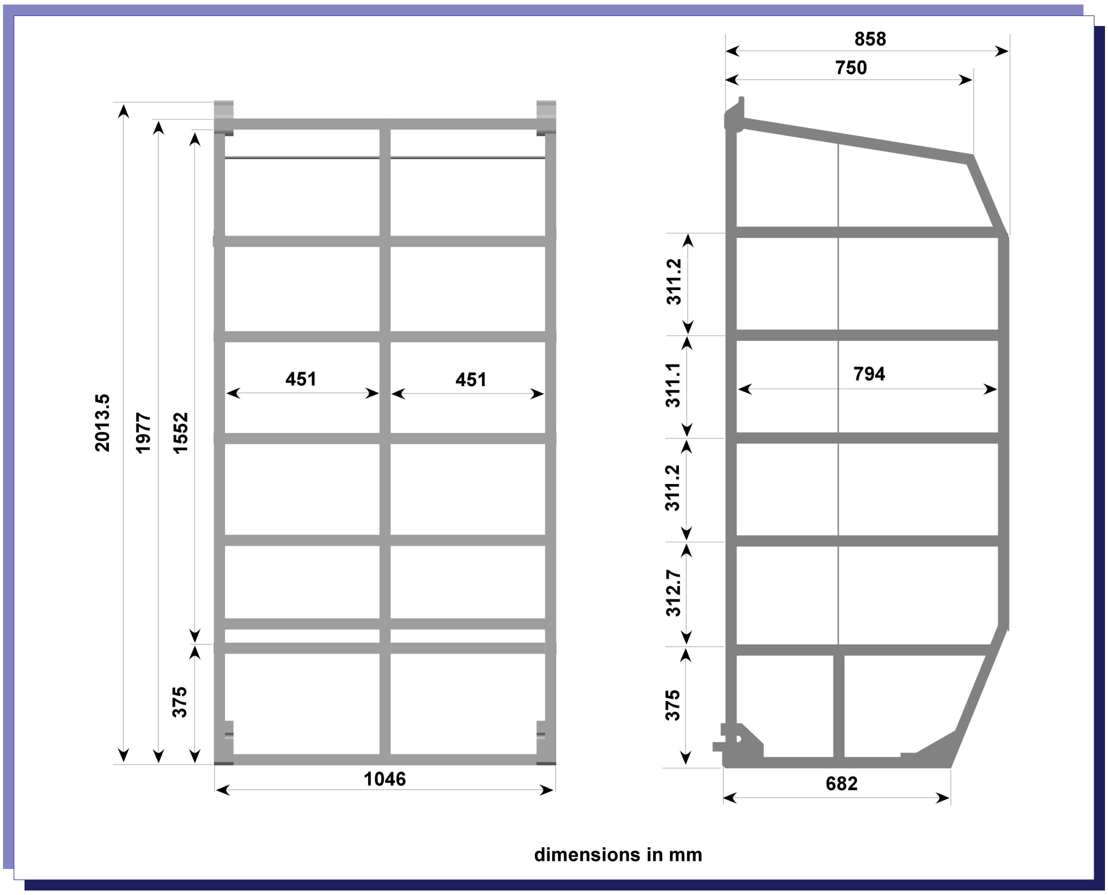

Figure 7-26: ISPR 6-post configuration dimensions – Front and Side View

7.6.1.2 Centre Aisle Payloads

Users have the possibility to mount payload equipment in the centre aisle of the Columbus Laboratory via mechanical attachment to deck rack seat tracks at the location of the deck racks (D1 – D4) of the Columbus floor (see Figure 7-27). The deck panels are removable to allow access to the stowage rack in position D4, or to any of the 3 subsystem racks - D1, D2 and D3 positions, in the underfloor area. Seat tracks are also at the ISPR front post for temporary attachment of payload equipment.

European payloads can be supplied with resources by connection to two Standard Utility Panels (SUPs) located at positions SUP1 and SUP4 in the lower stand-offs. The positions of all four Standard Utility Panels in the stand-off areas adjacent to the deck racks are shown in Figure 7-27.
The Standard Utility Panels include connectors for both payload and system equipment on the same panel. Locations SUP2 and SUP3 are available to American payloads via the United States Payload Bus (as access to the European Columbus payload bus, high rate data and smoke sensor, Emergency Warning and Caution System resources are not available at these positions).

The layout of the Standard Utility Panel is shown in Figure 7-28 and the connector allocations are reported in Table 7-24. Note that there are no water, vacuum, venting or gaseous nitrogen resources provided via the Standard Utility Panel, and any required cooling of aisle-mounted payloads should be performed by the payloads themselves.

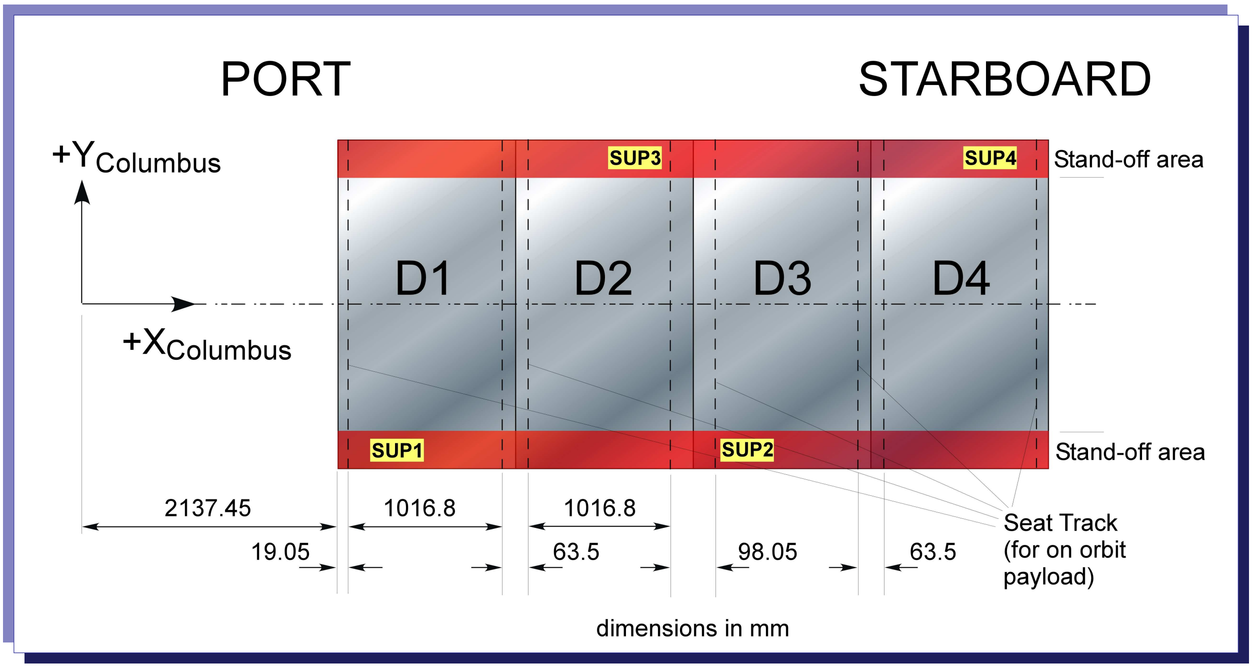

Figure 7-27: Centre Aisle Payload Attachment and Standard Utility Panel (SUP) Locations

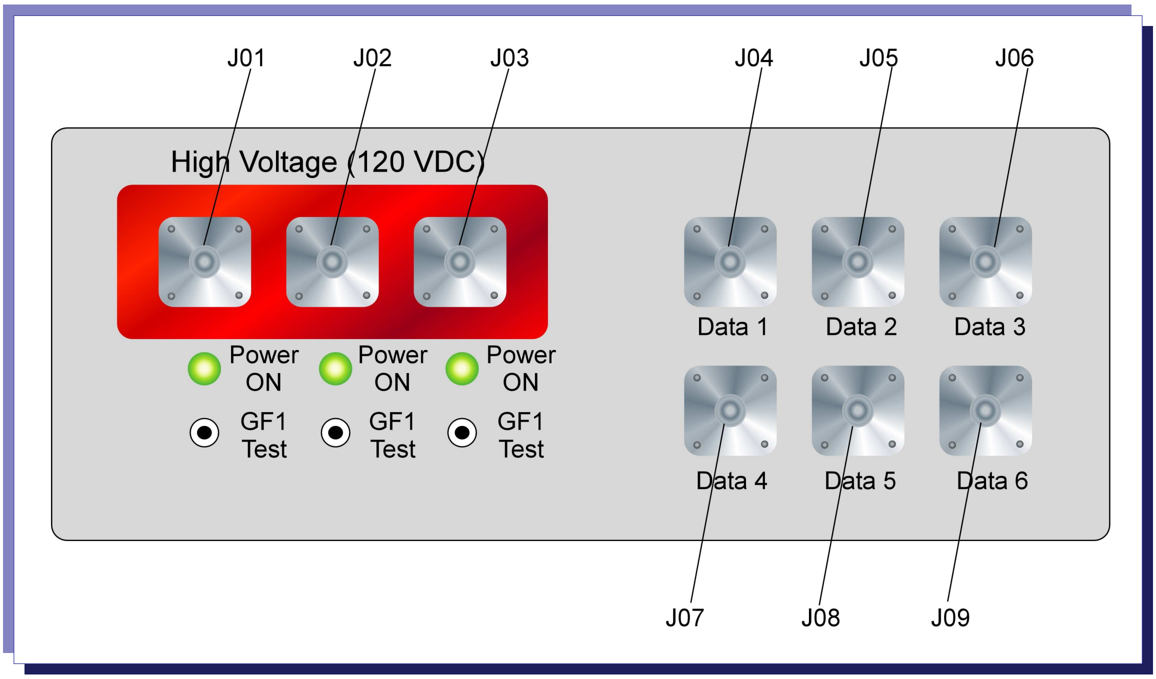

Figure 7-28: SUP panel layout

Table 7-24: Standard Utility Panel connector allocation and function

CONNECTOR	SUP1 & SUP4 LOCATIONS	COMMENTS
J01 – Power	120 Vdc/ Crew Health Care System (CheCS) Bus	Used only by the system
J02 – Power	120 Vdc	Used only by the system
J03 – Power	120 Vdc	Provides power to aisle payloads
J04 – Data 1	Columbus Payload Bus	1533 bus for aisle payload data
J05 – Data 2	Columbus Local Area Network	IEEE 802.3 nominal line
J06 – Data 3	Video/High Rate data	Fibre optic line
J07 – Data 4	Smoke sensor/Emergency, Warning and Caution System	Smoke sensor and Emergency, Warning and Caution System
J08 – Data 5	Video Camera Assembly	This connection is only used by the Columbus system cameras (for 28 Vdc power, sync and video)
J09 – Data 6	Columbus Local Area Network	IEEE 802.3 redundant line

7.6.1.3 Assembly Complete Rack Topology

The following figure (Figure 7-29) shows the overall rack topology at Assembly Complete within all the modules of the non-Russian segment. The different colour codes distinguish between Subsystem, Stowage and Payload Racks. The ESA payload racks in Columbus are also specified. Users must however, keep in mind that due to the dynamic nature of the ISS programme planning, the topology shown represents the situation as at May 2005 and is subject to change.

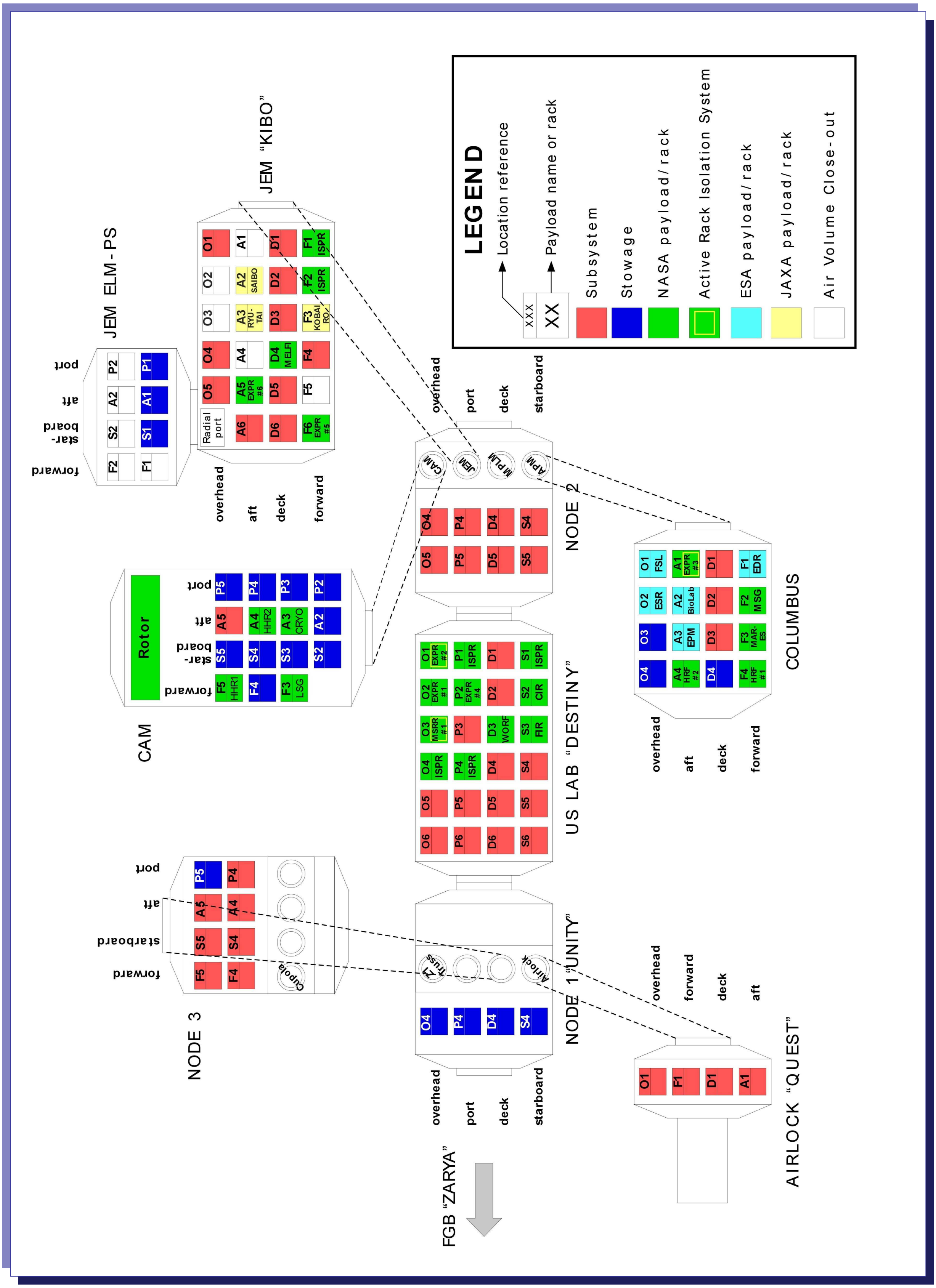

Figure 7-29: Rack configuration at Assembly Complete

7.6.2 Class 2 Payloads

Class 2 payloads are smaller facilities normally provided directly by users (scientists from universities or researchers from industry), which may be sub-units of Class 1 payloads with ISPR internal interfaces, add-on experiments, or smaller instruments accommodated in the European Drawer Rack (EDR). Specific examples of Class 2 payloads would be the Middeck Locker (MDL) and International Subrack Interface Standard (ISIS) drawer used by the EDR for containing experiments or instruments. Other types of Class 2 payloads include experiment samples, dedicated Experiment Containers and Cargo Transfer Bags. The MDL and ISIS drawer are generally referred to as Experiment Container Modules (ECMs). A set of drawers and lockers for the first payload complement will be procured by the European Space Agency, and may be made available to users. Subsequently, users will be required to procure their own drawers/lockers.
The current baseline is that drawers and lockers will normally be transported to the ISS by the Multi Purpose Logistics Module. Lockers requiring power during transportation however, will need to be accommodated in the Space Shuttle middeck area. Conformity to the International Subrack Interface Standard ensures mechanical compatibility with the NASA Express Transport Rack. The American Express Transport Rack can thus be used to upload and download International Subrack Interface Standard drawers. The Middeck Lockers are mechanically compatible with the Space Shuttle Middeck interfaces and the Express Transport Rack, so either the Space Shuttle or the Express Transport Rack can be used to upload and download the Middeck Lockers.

7.6.2.1 Middeck Locker (MDL)

The use of standardised drawers and lockers provides users with a quick turn-around capability, and provides increased flight opportunities for the user community wishing to fly Class 2 payloads. The ISS Middeck Lockers (standard box-shaped containers) were developed by NASA to be compatible with both the Space Shuttle and the ISS. Figure 7-30 shows the basic dimensions and lay out of the MDL, while its characteristics are summarised in Table 7-25.

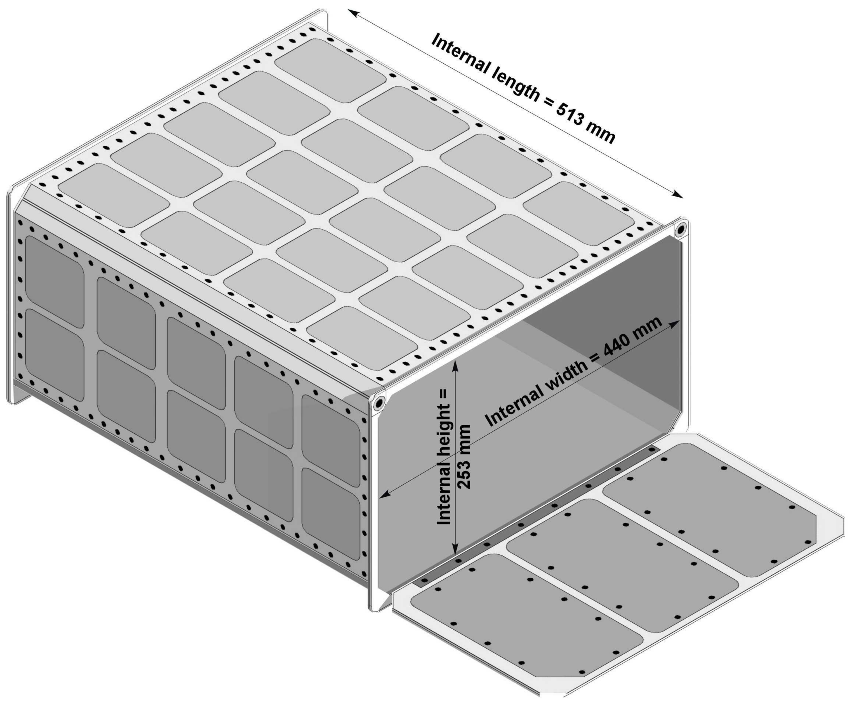

Figure 7-30: Middeck Locker (MDL) Dimensions and Layout

Table 7-25: Middeck Locker Characteristics

PARAMETER	VALUE
Maximum Volume available to users	57 litres
Internal Width	440 mm
Internal Height	253 mm
Internal Length	513 mm
Empty Mass	~ 5.4 kg
Net Mass available to users	28 kg

7.6.2.2 International Subrack Interface Standard (ISIS) Drawer

The ISIS Drawer (Figure 7-31) accommodation is designed to be physically compatible with the drawers of the NASA Express Rack through the adoption of a common rail installation and interface system. In the case of the EDR, the ISIS Drawers are provided by ESA and the baseline foresees the accommodation of 8-PU (8 Panel Unit) ISIS Drawers and the electrical and air cooling interfaces are spaced at 8-PU steps. The Panel Unit is used to determine the height (external) of the drawer, where 1 PU = 44.45 mm. The basic characteristics of the ISIS drawer are given in Table 7-26. The ISIS Drawer receives resources from the EDR system on the rear drawer panel where blind mate connections are implemented for both electrical and air cooling capability; some shared resources will be available in any case from the front of the rack via jumpers.

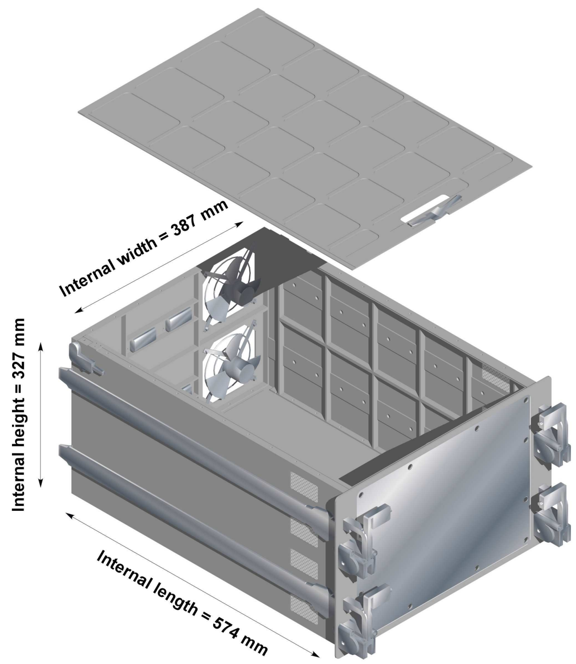

Figure 7-31: International Subrack Interface Standard (ISIS) drawer

Table 7-26: ISIS Drawer Characteristics

PARAMETER	VALUE
Maximum Volume available to users	72.6 litres
Internal Width	387 mm
Internal Height	327 mm
Internal Length	574 mm
Empty Mass (including rails)	~ 18 kg
Net Mass available to users	40 kg

7.6.3 Columbus External Payload Facility (CEPF)

The Columbus module is furnished with attachment locations at the starboard end cone for integrated external payloads requiring space exposure or viewing towards nadir, zenith or the line of flight. The on–orbit attachment locations form part of the Columbus External Payload Facility (CEPF – see Figure 7-32 and Figure 7-33), consisting of two external structures mounted symmetrically and providing a total of four accommodation locations with associated sets of resources.

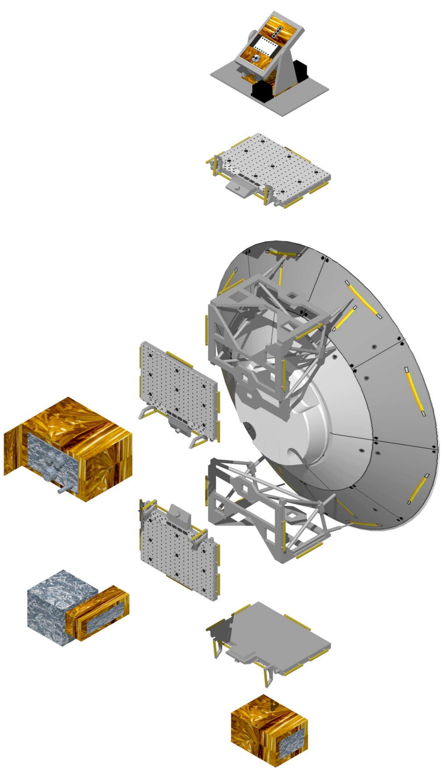

Figure 7-32: Exploded view of Columbus External Payload Facility (CEPF) on the Columbus starboard end cone

The accommodation locations are such that one faces towards the zenith direction (i.e. directly away from the Earth), one towards the nadir direction (i.e. directly towards the Earth), with the remaining two facing towards the starboard side of the ISS (i.e. perpendicular to the ISS velocity vector).
One of the accommodation structures is shown in a simple graphic in Figure 7-34, and consists of the support structure, two Mechanism Support Plates (MSP) and two passive Flight Releasable Attachment Mechanisms (FRAM). Figure 7-35 shows a more detailed view of one CEPF accommodation structure with passive FRAM and MSP.

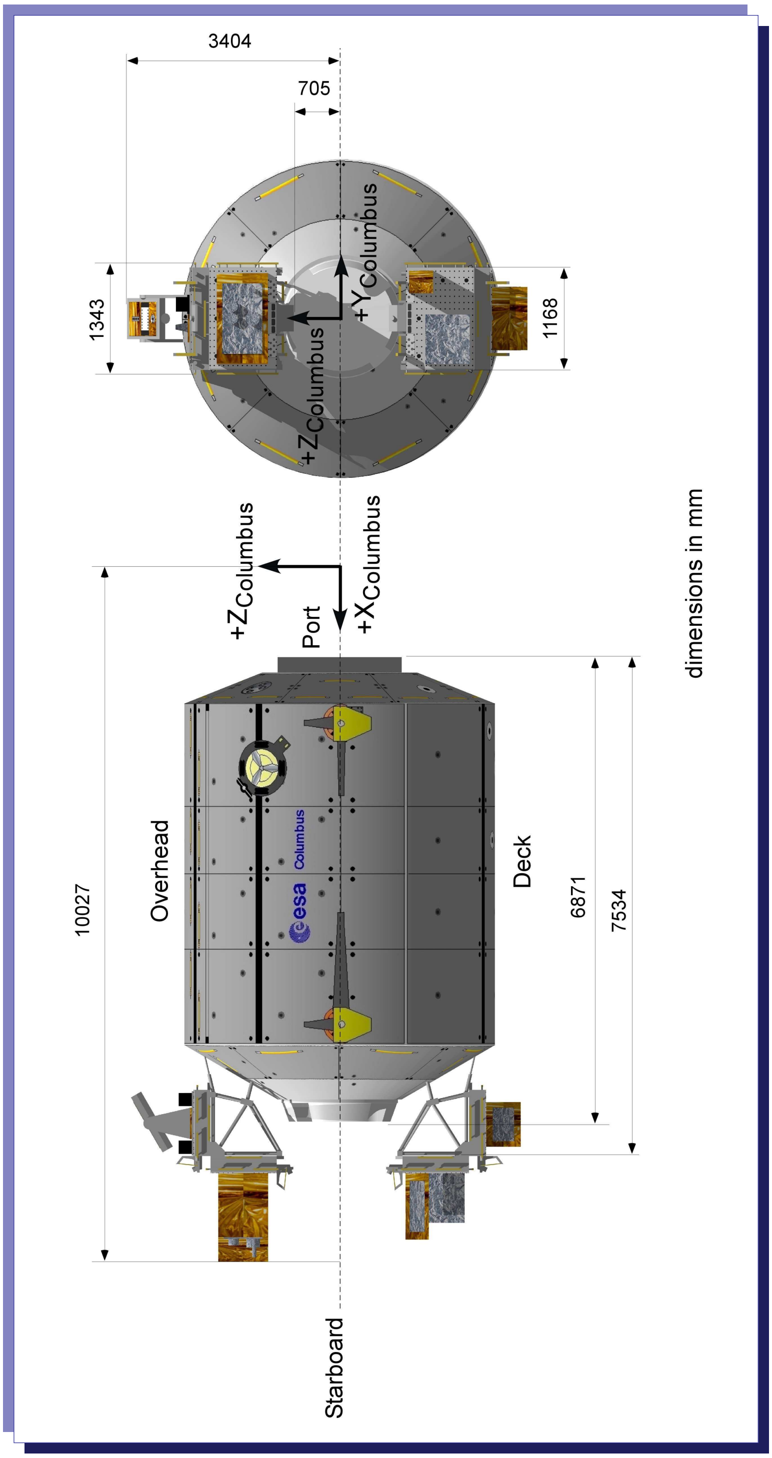

Figure 7-33: Columbus overall envelope with integrated external payloads

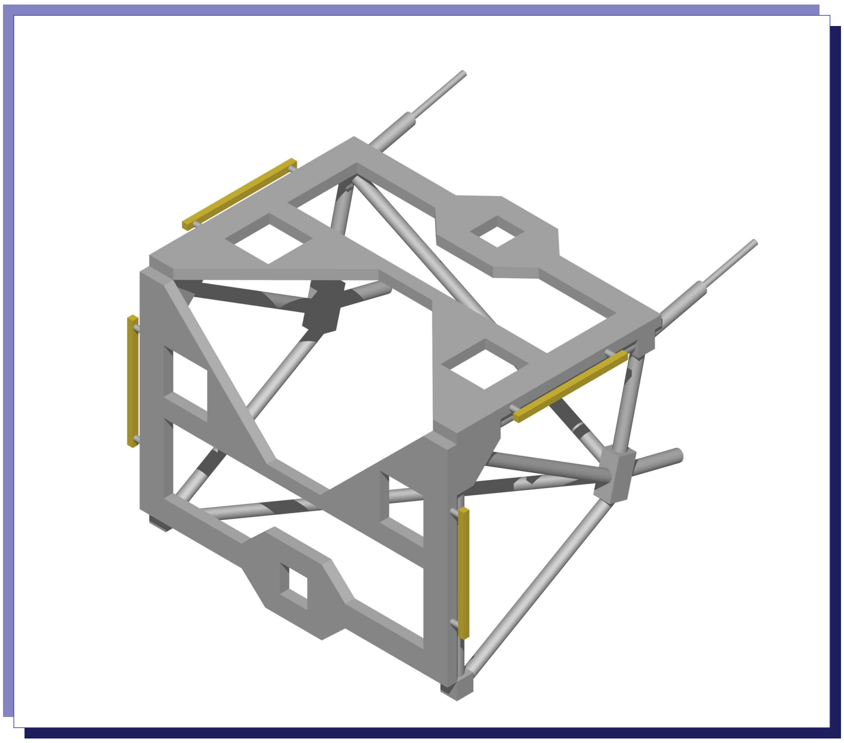

Figure 7-34: CEPF accommodation structure

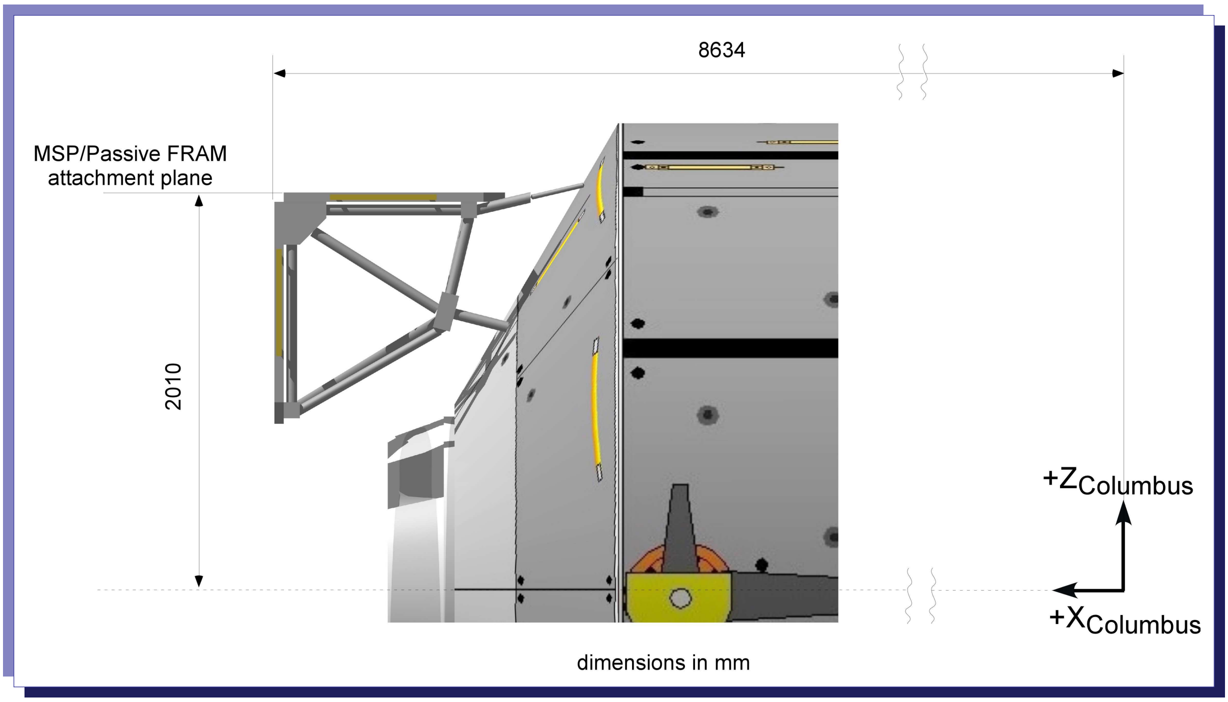

Figure 7-35: Detailed view of CEPF accommodation with passive FRAM and MSP

The primary objective of the FRAM system is to provide a generic means for the accommodation of external payloads. The system consists of an active part and a passive part. The CEPF provides at each of the 4 locations the passive part of the FRAM, while the integrated external payload provides the active part of the FRAM. Figure 7-36 shows the interface plane between an integrated external payload and the Columbus module, with the active and passive FRAM.

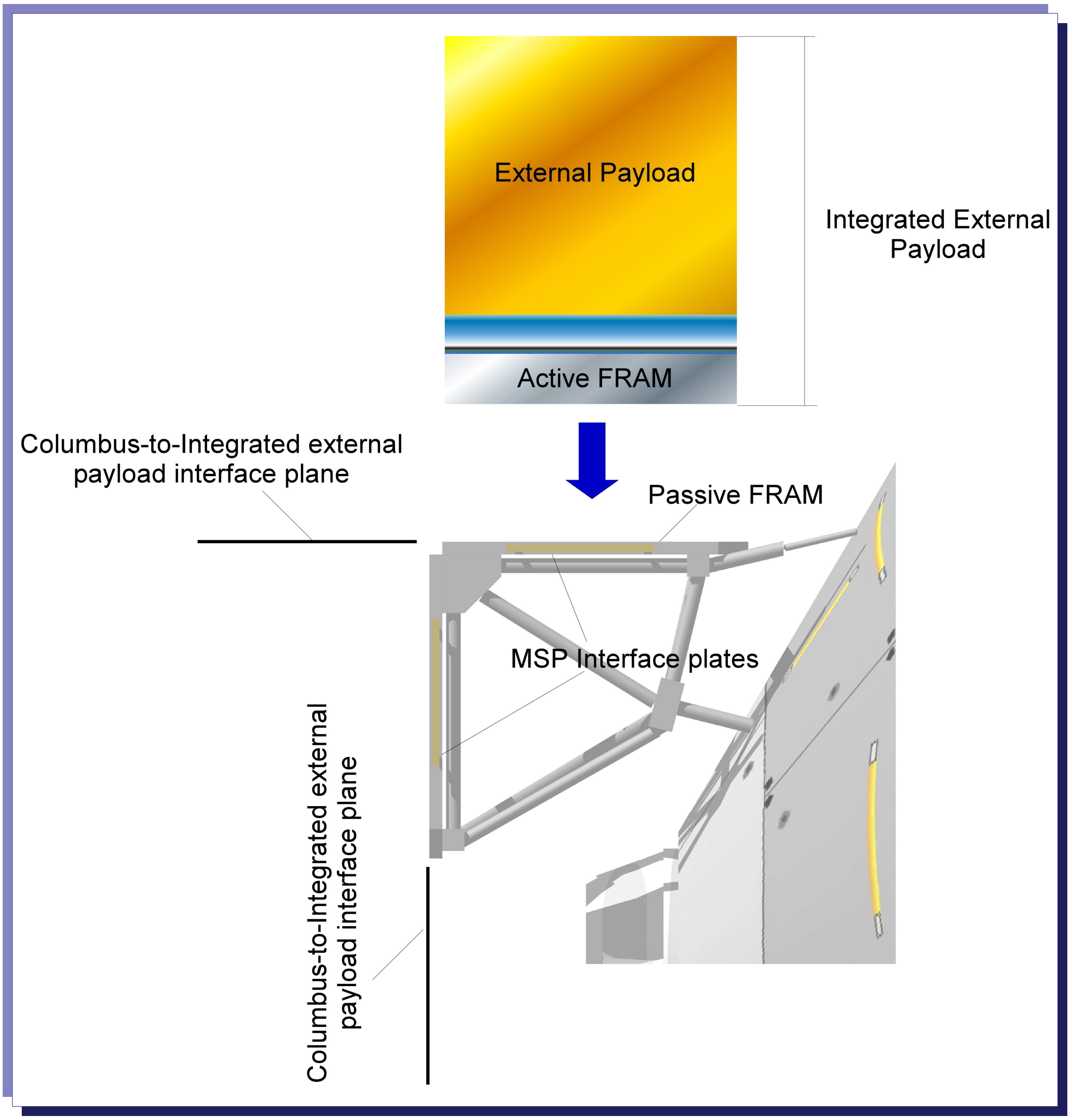

Figure 7-36: External payload/Columbus module interface plane definition

Integrated external payloads will use as a key element, the Columbus External Payload Adapter (CEPA). CEPAs are standardised, removable platforms, which allow the accommodation of external payloads. The CEPA is further described in the next section (7.6.3.1).

7.6.3.1 Columbus External Payload Adapter (CEPA)

The Columbus External Payload Adapter (CEPA) is a mounting plate for Columbus Exposed Facility (CEF) payloads and associated Flight Support Equipment (FSE). It is used in conjunction with the active Flight Releasable Attachment Mechanism (FRAM) to form the CEPA Assembly for transport and stowage aboard the Space Shuttle and Columbus module respectively. Figure 7-37 shows the CEPA Assembly. Each payload with its associated FSE is installed on the CEPA Assembly according to the requirements identified in each payload specification. The CEPA Assembly provides an interface to accommodate a wide variety of CEF payloads for transport to the ISS aboard the Space Shuttle.

In order to accommodate a wide variety of payloads, the CEPA Assembly provides standard mechanical and electrical/data interface features. In addition, the CEPA Assembly provides standardised structural, electrical bonding, and ground support equipment interfaces. The CEPA Plate configuration provides the required interfaces for integration with the active FRAM. Each active FRAM is a moving mechanical assembly which consists of close tolerance, precision machined components, attached to the bottom of an adapter plate. In order to ensure that these components are properly assembled and function as specified, the CEPA Assembly is subjected to acceptance testing consisting of functional, thermal vacuum, and vibration testing. As a result, once acceptance testing is successfully completed, the CEPA Plate should not be disassembled from the active FRAM without successfully repeating the acceptance testing.

Each payload has unique requirements specific to the subject payload. Each CEPA Assembly has a generic interface bolt pattern to allow mounting of payload/payload FSE hardware including EVA aids, heater mats, electrical connector savers and mounting brackets. The payload is integrated to the adapter plate assembly using the payload unique attachments and/or FSE to form the payload integrated assembly. The payload integrated assembly is mounted to a Passive FRAM located on a carrier for launch. Payload specific adapter plates may be developed for use with the active FRAM when it is determined the CEPA Plate configuration cannot meet specified Integrated Payload performance requirements. The CEPA Assembly envelope with dimensions is shown in Figure 7-38.

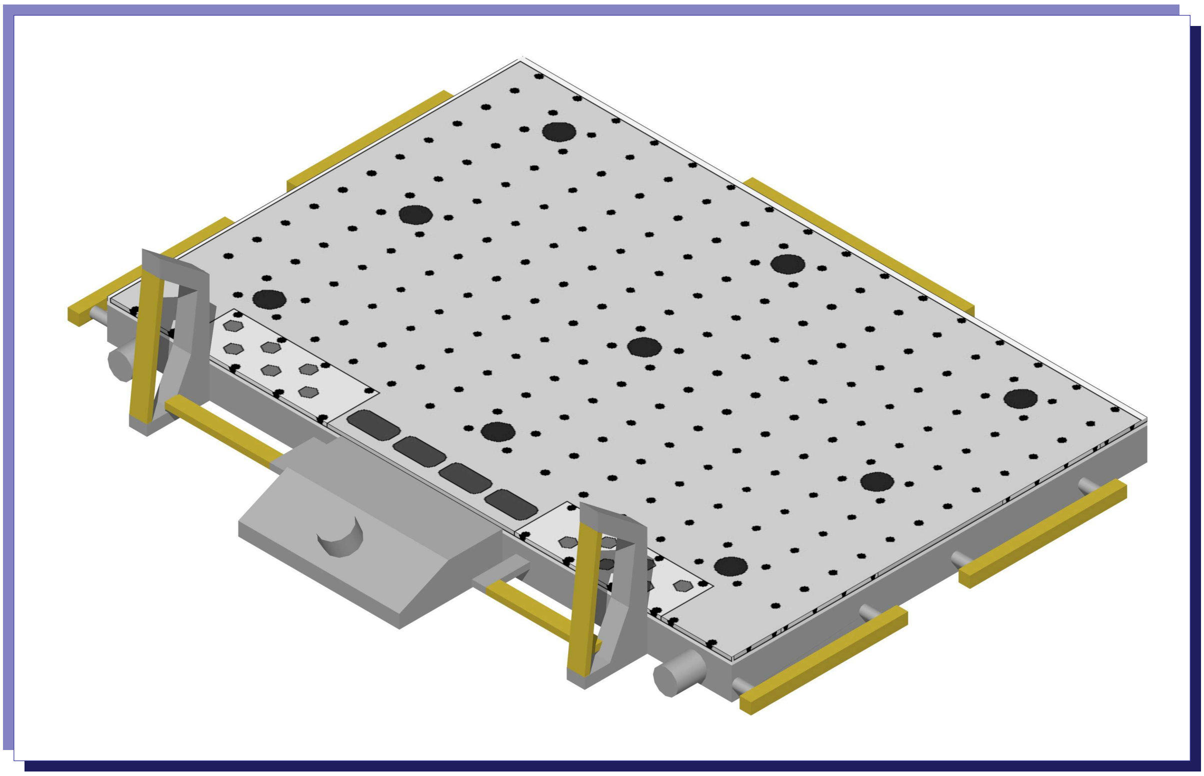

Figure 7-37: Columbus External Payload Adapter (CEPA) Assembly

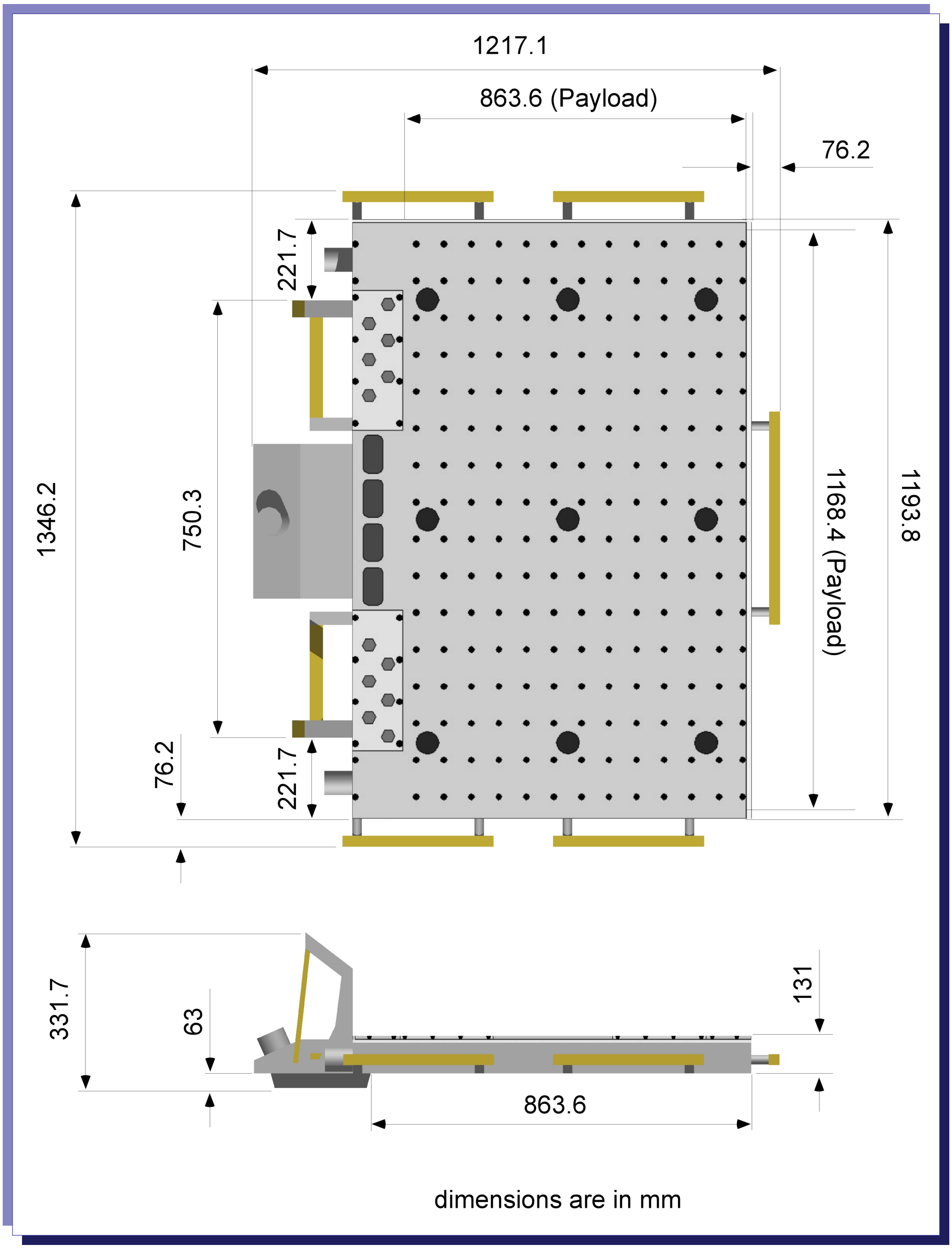

Figure 7-38: CEPA assembly envelope

7.6.3.2 CEPF Integrated External Payload Configuration, Interfaces and Resources

The following table (Table 7-27) summarises the principal Columbus to external payload system interfaces and characteristics. The interfaces of the CEPF include mechanical attach and guidance mechanisms which support the interchangeability by means of Space Station Remote Manipulator System (SSRMS) operations.

Table 7-27: Columbus to external payload system interfaces

INTERFACE/RESOURCE/CONFIGURATION	DESCRIPTION
Integrated external payload on-orbit mass	≤ 290 kg (including CEPA and active FRAM)
Integrated external payload envelope, including active FRAM (Figure 7-39)	1.39 m^3 (width = 1168 mm, height = 1375 mm, depth = 864 mm)
Thermal differences	The integrated external payload shall be thermally conditioned to a temperature in a range between –62 °C to +36 °C to assure the mechanical functionality of the active and passive FRAM design during berthing and unberthing
Power	Columbus will provide a maximum of 1.25 kW per CEPF location; the total for all four external payloads will be limited to 2.5 kW. Each CEPF location is connected to two 120 Vdc power feeders, each with a maximum allocation of 1.25 kW.
Commands to external payload	❑ 3x 28VDC Pulse Command Lines from module per EPF Location ❑ 3x 5VDC Level Command Lines from module per EPF Location
Discrete Data from external payload	❑ 3x Contact status Lines to module per EPF location ❑ 3x Active Driver Inputs to module from each EPF Location
Analogue measurements	❑ 2x Analogue Signals to module from each EPF Location ❑ 2x Analogue Temperature Measurements to module Location from each EPF Location ❑ 2x Analogue Current Measurements to module from each EPF Location
Standard Payload 1553B Bus Interface	Extension of US Lab MIL–STD–1553B payload Data Buses
Specific Columbus Payload 1553B Bus Interface	Extension of Columbus Specific MIL–STD–l553B payload Data Buses supporting 2 remote terminals per payload position
External payload computer serial interface	Connection from Payload Laptop and Programming Panel to External Payload Computer
Columbus specific local area network (LAN)	❑ 2 x TSP (Twisted Shielded Pair cables) connections ❑ ISO/IEC 802–3 (Ethernet standard) ❑ 10Base-T (Twisted Pair wire supporting Ethernet's 10 Mbps) ❑ Columbus Payload Telemetry ❑ Payload–to–Payload communication
US Payload Local Area Network (LAN) (extension into Columbus only, non–redundant)	❑ 2 x TSP (Twisted Shielded Pair cables) connections ❑ ISO/IEC 802–3 (Ethernet standard) ❑ 10Base-T (Twisted Pair wire supporting Ethernet's 10 Mbps) ❑ US Payload Telemetry
Columbus High Rate Data Link	Connection to Columbus Video/Data Processing Unit (VDPU) to transmit payload data with rates up to 100 Mbps

There is no active thermal control capability available to External Payload Facility payloads (such capability must be provided by the payloads themselves). There is also no water, vacuum, venting, gaseous nitrogen (GN2), Emergency Warning and Caution System (EWACS) or NTSC (National Television System Committee) video capability at these locations.

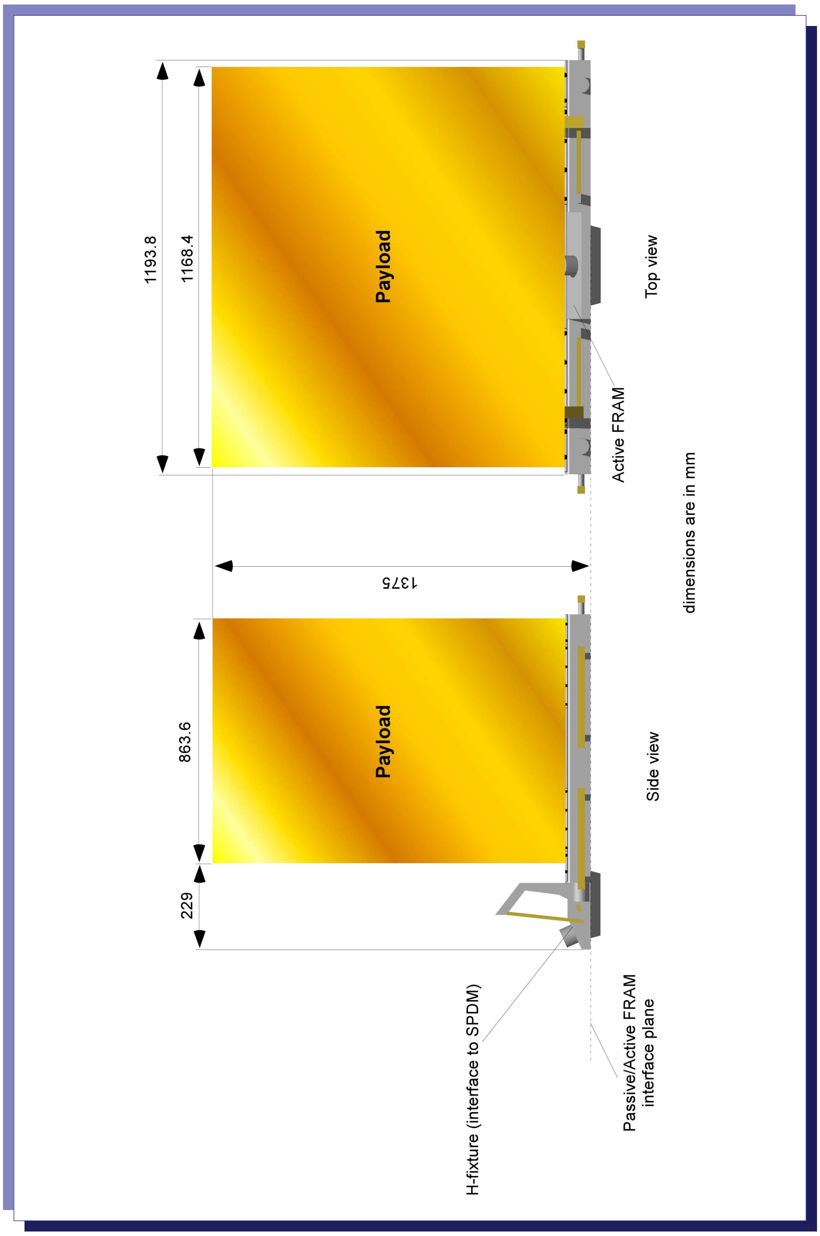

Figure 7-39: CEPF integrated external payload envelope

7.6.4 Other Partner External Accommodations

Besides the European Columbus External Payload Facilities, the ISS also offers other external sites to users. There are a further 14 external sites offered by JAXA and NASA, which are the 10 sites on the Japanese Exposed Facility (F1-F3, A1-A4, U1, U2, O1 – see Figure 7-40) and the 4 sites on the Starboard S3 Truss (S3UI, S3UO, S3LI, S3LO – see Figure 7-41). More information on the JAXA Exposed Facility can be found at the following web site: http://iss.sfo.jaxa.jp/iss/kibo/bakuro_e.html

Users who wish to learn more about the S3 Truss external locations should refer to the following document: SSP57021 Rev. A "Attached Payloads Accommodation Handbook" September 2002.

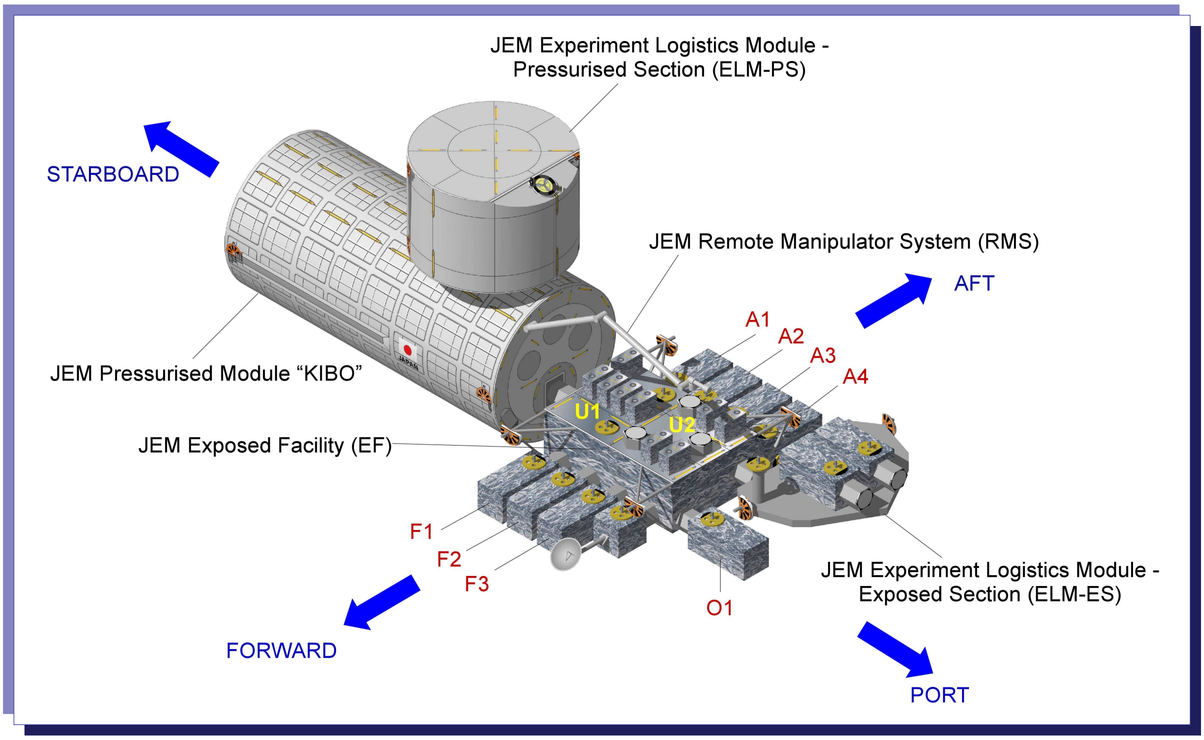

Figure 7-40: External sites configuration on the Japanese Exposed Facility (JEF)

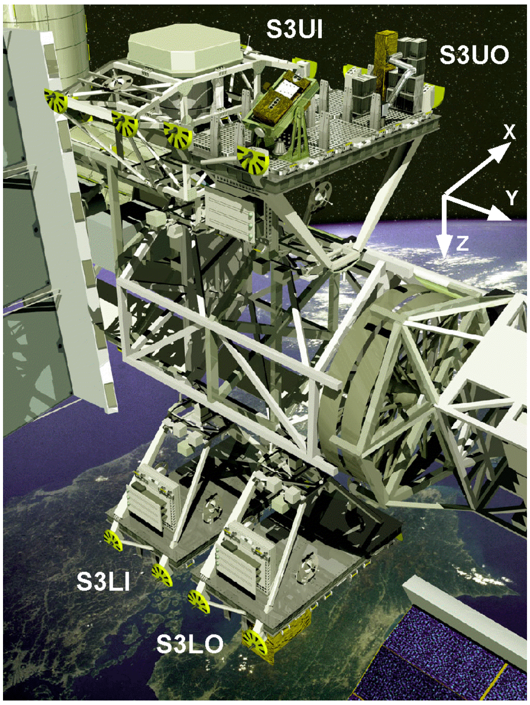

Figure 7-41: External sites configuration on the Starboard Truss (S3) (Image: ESA Ducros)