# Accommodation and Utilisation Resources Capabilities for Payloads

This chapter provides an overview of the resources that are potentially available for European utilisation and describes the accommodation possibilities of European-provided elements and facilities. The actual accommodation and resource requirements for a payload will be agreed and baselined between the payload user and the Agency at the beginning of the payload programme cycle.

## Overall ISS Utilisation Capabilities

The overall utilisation capabilities of the International Space Station are shown in Table 5.

## European Utilisation Capabilities

Europe has acquired, through its contributions to the ISS programme, the following access to user accommodation and utilisation resources:

- 5 ISPRs in the Columbus Laboratory;
- 2 Express Pallet Adapters on the Columbus external payload facility;
- 2.5 kW of electrical power (average);
- 13 h crew time per week.

In addition, a yearly average of 8.3% of TDRSS capability can be acquired by ESA from NASA.

During steady state operations, the average annual up and download requirements of the ESA payloads are:

- 1000 kg of pressurised payload mass upload;
- 780 kg of pressurised payload mass download;
- 600 kg of external payload mass upload;
- 600 kg of external payload mass download.

The utilisation and distribution of these accommodation and resource capabilities is achieved at International Partner level rather than at a specific laboratory or module level. This approach provides each International Partner with wider opportunities for planning to accomplish its specific payload mission objectives.

Table 5. ISS Utilisation Capabilities

| | |
|---|---|
| Number of ISPRs | 37 |
| Additional payload accommodation volume in Russian Research Modules | Volume still unknown |
| Attached sites on the Truss<br>corresponding to Express Pallet Adapters<br>Payload sites on JEM-External Facility<br>Express Pallet Adapters on Columbus-EPF | 4 on S3<br>24<br>10<br>4 |
| Russian Science Power Platform | Payload accommodation still unknown |
| Total average power for utilisation by US segment | 30 k W |
| Crew time (based on crew of 7) | 160 h/week |
| Date uplink<br>Data downlink | 72 kbit/s<br>up to 43 Mbit/s (150 Mbit/s under consideration) |

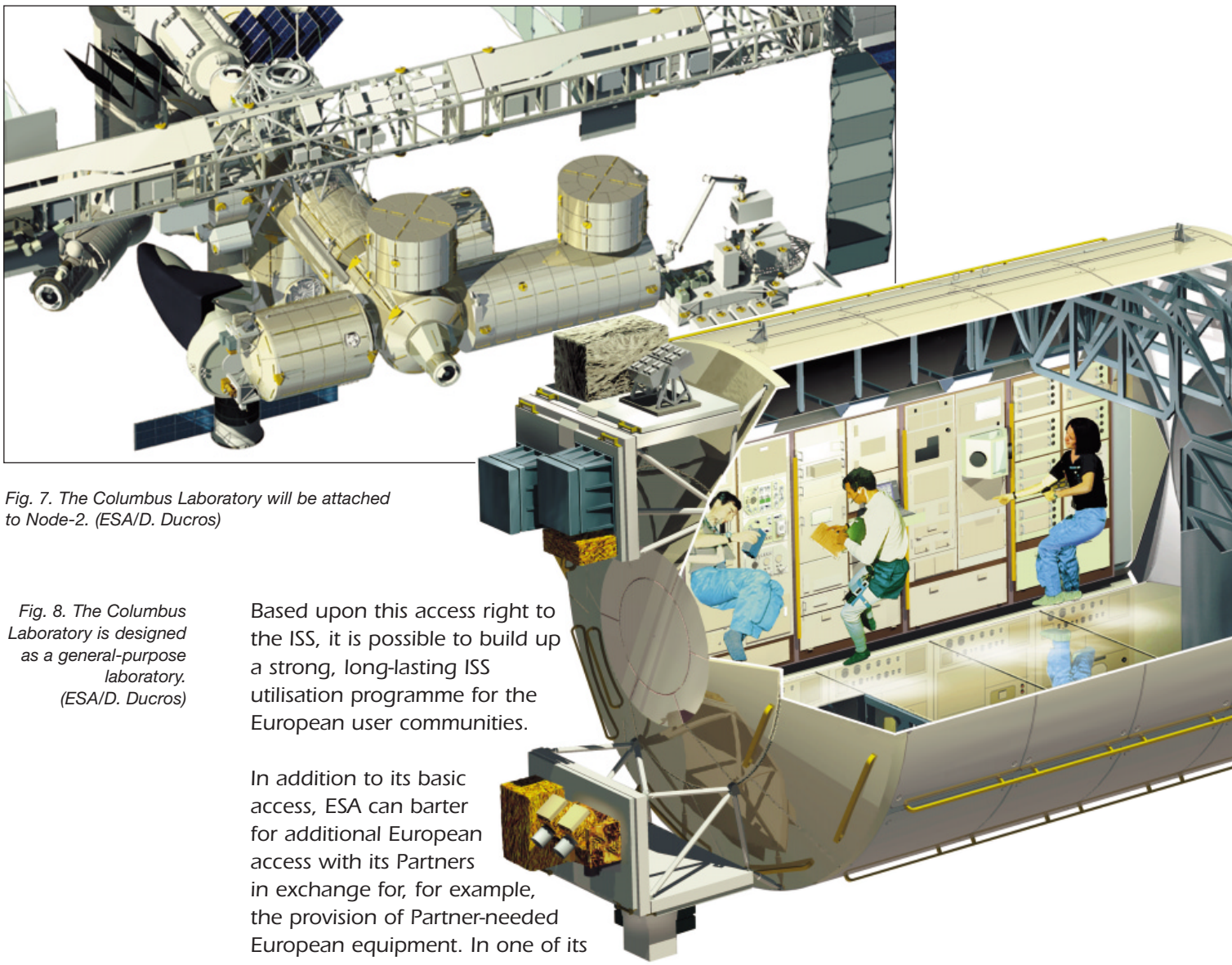


*Fig. 7. The Columbus Laboratory will be attached to Node-2. (ESA/D. Ducros)*

*Fig. 8. The Columbus Laboratory is designed as a general-purpose laboratory. (ESA/D. Ducros)*

Based upon this access right to the ISS, it is possible to build up a strong, long-lasting ISS utilisation programme for the European user communities.

In addition to its basic access, ESA can barter for additional European access with its Partners in exchange for, for example, the provision of Partner-needed European equipment. In one of its early barters, ESA secured access to early opportunities in the US Laboratory and on the attached sites before the Columbus Laboratory becomes available.

## Columbus Laboratory Characteristics

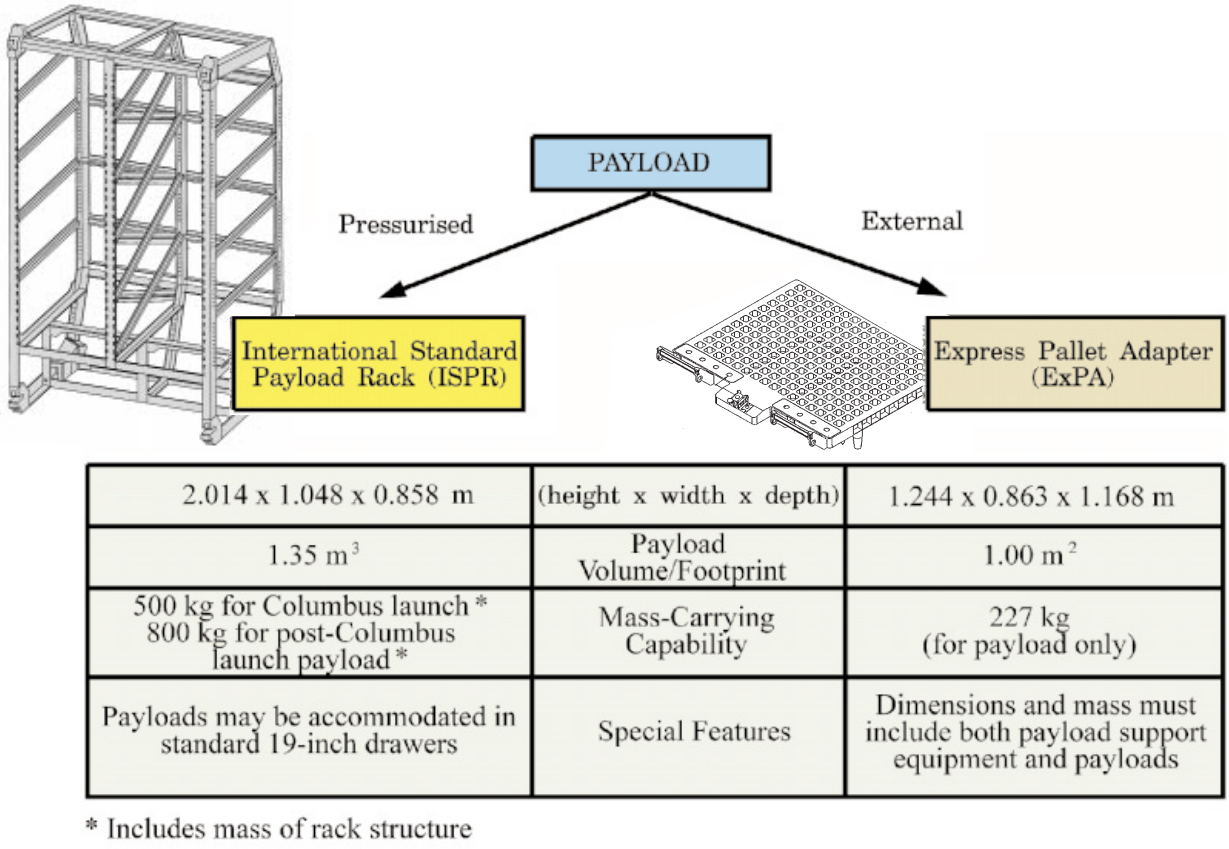
The Columbus Laboratory (Figs. 7/8) is designed as a general-purpose laboratory to accommodate payloads with experiments from life sciences, physical sciences and technology development. It will be launched by the Shuttle and attached to Node-2. External attachment sites are available on the end cone for payloads requiring celestial pointing, Earth pointing or other space environment.

The major characteristics of the Columbus Laboratory are shown in Table 6.

## Basic Accommodation Units

Basic accommodation hardware is available for both pressurised and external payloads. These units can be provided directly to payload developers to allow them to develop, integrate and check out as much of their payloads as possible at their own sites and without the additional effort of developing their own direct-to-ISS element hardware.

The major accommodation characteristics of these units are illustrated in Fig. 9.



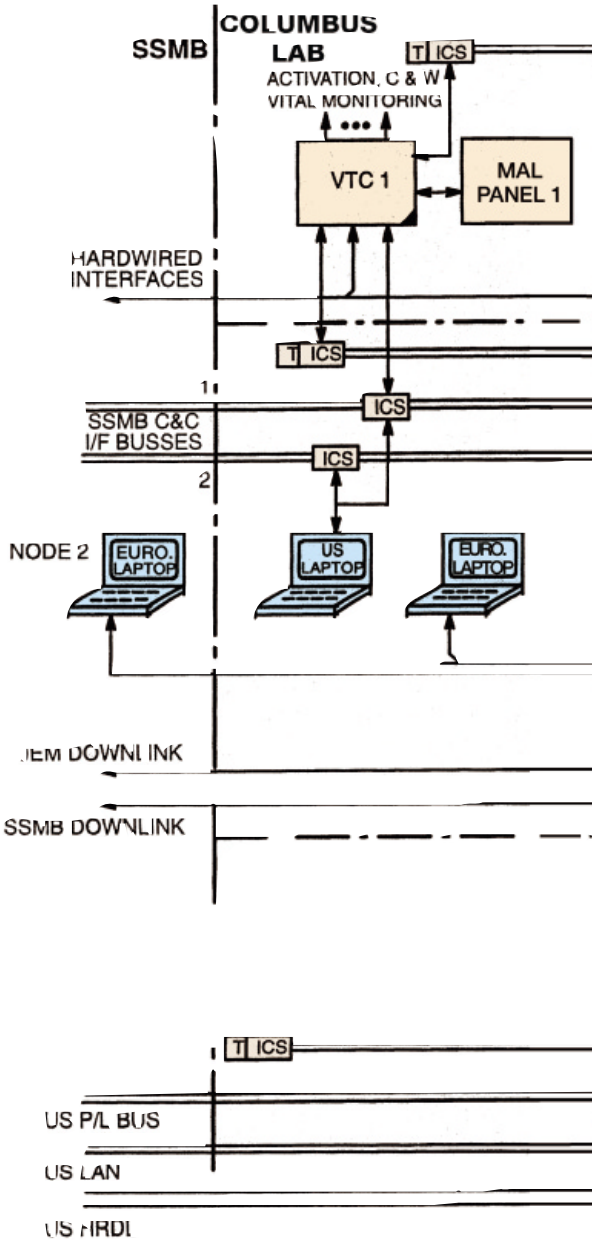

| | | |
|---|---|---|
| 2.014 x 1.048 x 0.858 m | (height x width x depth) | 1.244 x 0.863 x 1.168 m |
| 1.35 $m^3$ | Payload Volume/Footprint | 1.00 $m^2$ |
| 500 kg for Columbus launch * 800 kg for post-Columbus launch payload * | Mass-Carrying Capability | 227 kg (for payload only) |
| Payloads may be accommodated in standard 19-inch drawers | Special Features | Dimensions and mass must include both payload support equipment and payloads |

* Includes mass of rack structure

*Fig. 9. Principal accommodation characteristics of ISPRs and Express Pallet Adapters.*

Table 6. Principal Characteristics of the Columbus Laboratory

| | |
|---|---|
| Launched by Space Shuttle | early 2003 |
| Launch mass<br>Initial payload mass<br>Maximum mass on-orbit | 12.7 t<br>2.5 t (corresponds to 5 ISPRs + payloads)<br>18 t |
| Number of active payload racks<br>Number of stowage racks | 10 ISPRs<br>3 ISPRs |
| Total electrical power available<br>Electrical power available for payloads | 20 k W<br>up to 13.5 k W |
| Thermal control and heat removal | up to 14 k W through medium-temperature water cooling loop<br>Cabin air cooling |
| Earthlike atmosphere<br>Cabin temperature (operating)<br>Vacuum and venting lines to space | 959-1013 mbar<br>16-30¡C |
| Control & Data Handling System<br>Payload bus<br>Payload LAN<br>Video and high-rate data | <br>MIL-STD-1553B<br>IEEE 802.3<br>Fibre optic |
| Communications | Via TDRS system for Ku-band and S-band |




The ISPR basic accommodation units support the large pressurised facility-type payloads in complete racks. A range of European Standard Experiment Drawers (SEDs) and Mid-Deck Lockers (MDLs) within the European Drawer Rack (EDR) is available for smaller pressurised payloads to allow for easier integration and shorter flight access. The technical capabilities of the EDR are described in the 'Multi-User Facilities and Support Equipment' chapter.

## Columbus Resources and Services to Payloads

The Columbus Laboratory provides the following resources and services to payloads.

### Data Management Services (DMS)

DMS (Fig. 10) standard services for payloads include:

- payload data acquisition, processing and routing, including protocol and packet support;
- payload user application software for execution in the Columbus DMS Payload Control Unit (PLCU) for payloads that do not have their own data processing;
- payload (flight) automatic procedure management and execution;
- payload failure management, including telemetry data exception monitoring;
- general services to payloads such as broadcasting, logging file transfer and data reduction.

A payload's DMS requirements for services will be collected during the preparation for flight and the appropriate Columbus DMS software products will be developed to accomplish those requirements.

US payloads in Columbus (nominally five ISPRs) are controlled via the US Lab's DMS extending into Columbus.

### Electrical Power

The Columbus Laboratory is designed to handle up to 20 kW of electrical power at 120 Vdc for systems and payloads. For the Columbus payloads, a maximum of 13.5 kW is available.

The electrical power is provided by the Columbus systems through two Power Distribution Units (PDUs) and distributed as either 6 kW medium- or 3 kW low-power to a payload rack location and 500 W to an aisle payload location.

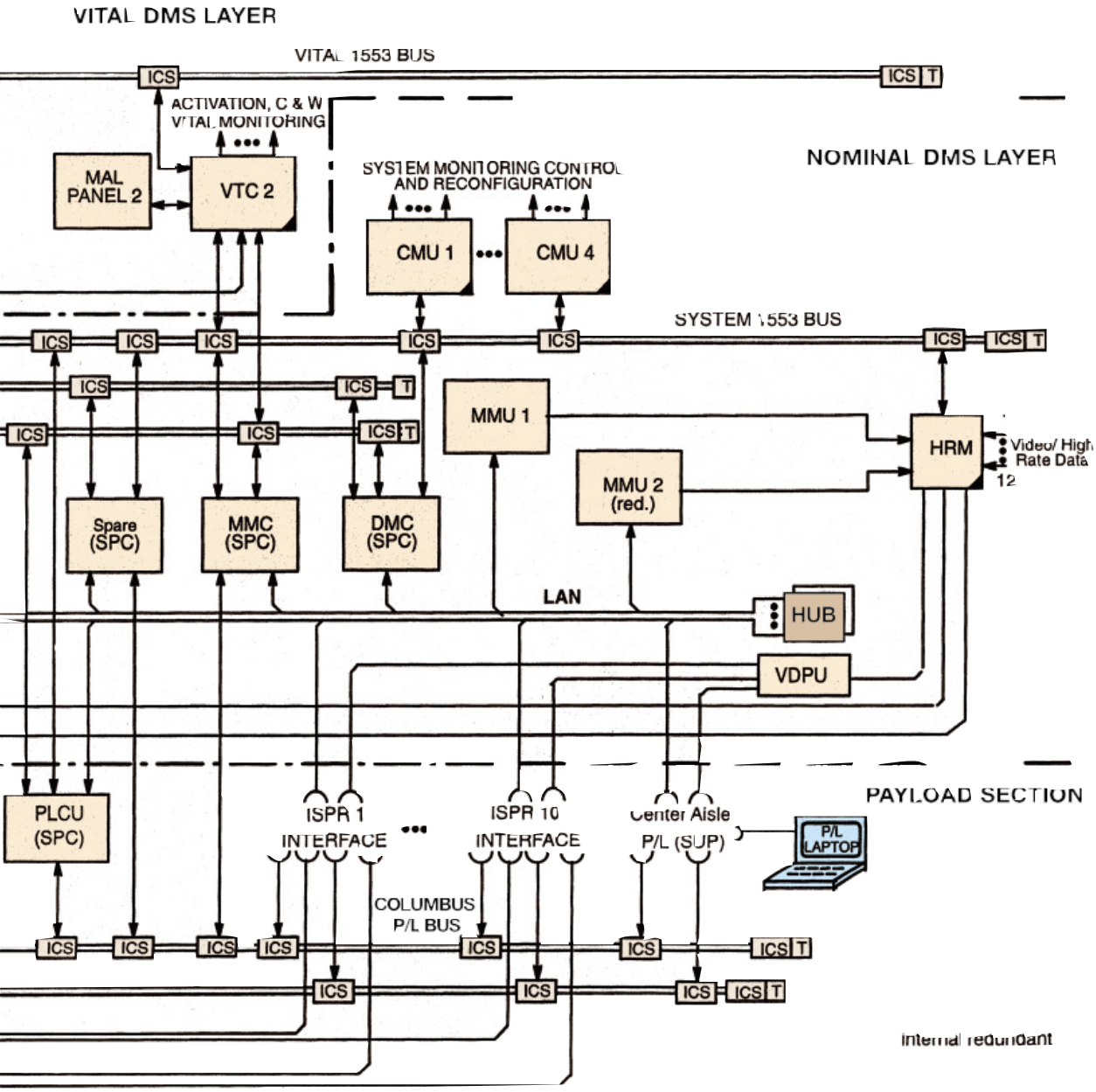



*Fig. 10. Columbus Data Management System Configuration. C&C: Command & Control. C&W: Caution & Warning. CMU: Command & Monitoring Unit. HRDL: High-Rate Data Link. HRM: High-Rate Multiplexer. ICS: Inter Connection System. MAL: Master Alarm Light. MMC: Mission Management Computer. MMU: Mass Memory Unit. SPC: Standard Processor Controller. PLCU: Payload Control Unit. SSMB: Space Station Manned Base. VDPU: Video/Data Processing Unit. VTC: Vital Telemetry/ Telecommand Computer.*

The electrical power provided for the Columbus External Payload Facility is provided through a dedicated Payload Power Switching Box and distributed at 2.5 kW to each adapter location.

Auxiliary power of up to 1.2 kW is provided to the payload racks only, for safing operations when the primary PDU outlets fails.

### *Vacuum and Venting System (VVS)*

A VVS system capability is available at each payload rack location for:

- venting of experiment process chambers;
- venting of cooling and purge gases;
- providing a sustained vacuum.

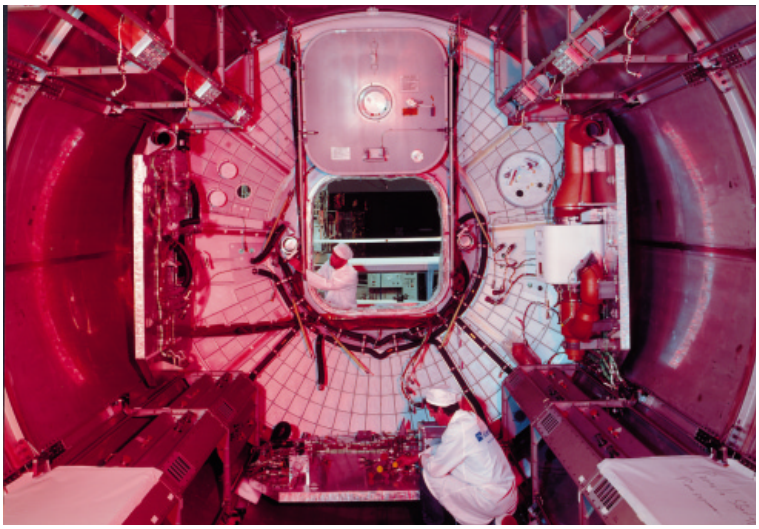
Separation between the vacuum system and the venting system is provided to avoid cross-contamination. Furthermore, venting is operationally timelined in order to minimise potential simultaneous contamination between payloads.

### Cooling Water

Cooling water is provided at each payload rack location from the moderate-temperature cooling system. The payload rack can provide either its own heat exchanger for internal air-cooling or directly use the water-cooling capability. The thermal cooling capability of each rack corresponds to the electrical power available at that rack.

### Nitrogen Gas

Nitrogen gas is available at each payload rack, and may be used for supporting payload-purging operations.



**Video Communications**
US National Television System Committee (NTSC)-format video capability is provided at each payload rack location and aisle outlet. The video may be downlinked or further processed onboard.

**Telemetry and Telecommand Links**
The telemetry and telecommand data links available at each payload rack location are:

- a fibre-optic video communications link that can be used for high-rate data up to 32 Mbit/s;
- a high-rate data link capability for the direct transmission of up to 100 Mbit/s through the US Lab's Automated Payload Switch (APS). This capability is available over the US DMS in Columbus;
- IEEE 802.3 primary and backup Ethernet LANs for payload telemetry access between the Columbus systems and the payload electronics. The 802.3 is used principally for medium-rate telemetry with individual payload rates up to 1.25 Mbit/s;
- MIL-STD-1553B primary and backup data buses for payload telemetry and telecommanding access between the Columbus systems and the payload electronics. The 1553B is principally used for telecommanding and low-rate telemetry, with individual payload rates up to 51.2 kbit/s;

The telemetry and telecommand data links available at each ExPA location are:

- a high-rate digital data link of up to 32 Mbit/s;
- IEEE 802.3 primary and backup Ethernet LANs for payload telemetry access between the Columbus systems and the payload electronics;
- MIL-STD-1553B primary and backup data buses for payload telemetry and telecommanding access between the Columbus systems and the payload electronics.

**Fire Detection and Suppression (FDS)**
Fire detection and suppression capabilities are provided for payload racks. This system allows for the automatic detection of internal payload rack smoke, and subsequent commanding of internal fire suppression measures, as well as automatically applying payload rack power-off. In addition, portable $CO_2$ fire extinguishers can provide manual fire suppression through a special fire suppression port on the front panel of each payload rack.

**Emergency, Warning and Caution and Safing (EWACS)**
Emergency, warning, caution and safing capabilities are provided at each payload rack and aisle payload. EWACS enables payloads to alert the Columbus Laboratory vital systems automatically when a malfunction occurs that requires safing.

**Cabin Air**
Cabin air heat rejection capability is provided within the Columbus Laboratory for up to 500 W from all payloads.

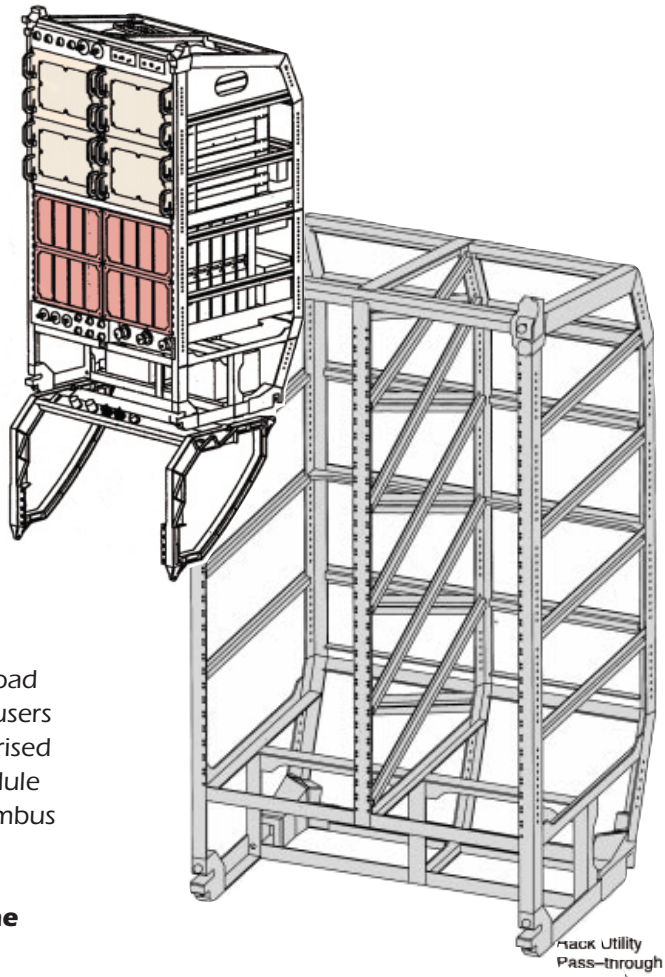


*Fig. 11. The ISPR is the nominal payload accommodation element in the Columbus module.*

*Inset: ISPR configured as a European Drawer Rack*

## Columbus User Accommodation and Payload Interfaces

The user accommodation and payload interfaces for Columbus European users are described here, both for pressurised payloads within the Columbus module and external payloads on the Columbus External Payload Facility (EPF).

### Pressurised Payloads within the Columbus Laboratory module

The International Standard Payload Rack (ISPR; Fig. 11) and the European Drawer Rack (EDR; Figs. 11/27) are the nominal payload accommodation units in the Columbus module.

The Columbus resources available to ISPR payloads are provided through a Utility Interface Panel. This is located under the ISPR and, together with the use of flexible utility lines, allows the ISPR to be tilted without disturbing the interfaces, thus supporting 'all-round' rack servicing and maintenance requirements. The Utility Interface Panel details are shown in Fig. 12.

The resources provided to an ISPR through the Utility Interface Panel are detailed in Table 7.

The European Drawer Rack resources are detailed in the chapter on 'Multi-User Facilities' and Support Equipment.

### Columbus Lab Centre Aisle Payloads

Limited payload equipment may be accommodated on-orbit in the centre aisle. The allowed envelope is shown in Fig. 13.

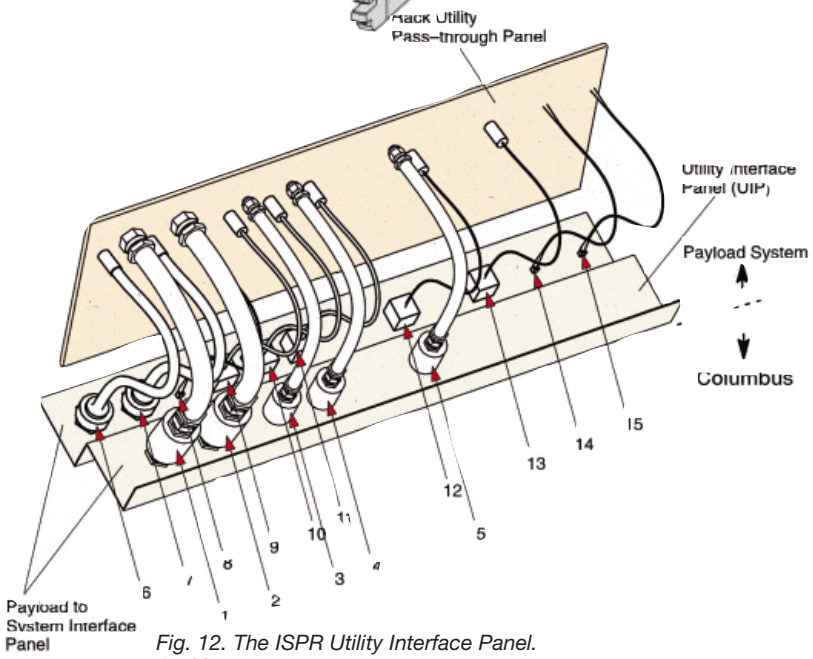



*Fig. 12. The ISPR Utility Interface Panel.*

1. *Vacuum*
2. *Waste gas*
3. *TCS MOD supply*
4. *TCS MOD return*
5. *$GN_2$*
6. *Essential/auxiliary power [J2]*
7. *Main power [J1]*
8. *Video/sync (fibre optic) [J16]*
9. *High Rate Data (fibre optic to Automated Payload Switch) [J7]*
10. *FDS/MAINT (Fire Detection/Power Maintenance Switch) [J43]*
11. *1553B-A (nominal MIL-STD-1553B bus) [J3]*
12. *1553B-B (redundant MIL-STD-1553B bus) [J4]*
13. *EWACS (Payload emergency, warning, safing) [J45]*
14. *LAN-2 (IEEE 802.3 redundant LAN) [J47]*
15. *LAN-1 (IEEE 802.3 nominal LAN) [J46]*

Table 7. Resources Provided to Columbus ISPRs by the Utility Interface Panel

| Resource | Nominally Available | Comments |
|---|---|---|
| Main Power<br>Auxiliary Power | 6 kW or 3 kW @ 120 Vdc<br>1.2 kW @ 120 Vdc | 6kW=medium power, 3kW=low power<br>For back up in case of main power loss |
| Vacuum | 0.13 Pa under a gas load of 0.1 Pa.litre/s | |
| Venting | 1000 hPa to 0.13 Pa within 2 h for a payload chamber of 100 litre | Only 1 ISPR vented at any one time to prevent cross-contamination |
| Cooling Water | Inlet 16-20¡C<br>Outlet <49¡C | Flow rate fixed/calibrated during payload integration between 30 kg/h and 190 kg/h |
| Nitrogen Gas | Max. flow rate 5.43 kg/h. Operating pressure 5170-8270 hPa. Max. pressure 1378 kPa. Temperature 15.6->45¡C | |
| Video | NTSC Standard | Can be configured for high-rate data up to 32 Mbit/s |
| High-Rate Data | Up to 32 Mbit/s | High-rate data to/from US Lab APS |
| Fire Detection System (FDS) | | Payload signals required for credible fire risks (incl. smoke sensor & fans where necessary) and safing commands from Columbus Laboratory vital systems |
| EWACS | | Emergency & Warning signal interfaces and commands with direct link to Columbus Laboratory vital systems |
| 1553B Bus | 51.2 kbit/s data rate | Primarily intended for payload low-rate data and payload commanding |
| 802.3 LAN | <1.25 Mbit/s data rate for all payloads | Primarily intended for payload medium-rate (via HRM) |

Table 8. Resources Provided to Centre Aisle Payloads by the Standard Utility Panel (SUP)

| Resource | Nominally Available | Comments |
|---|---|---|
| Main Power | 500 W @ 120 Vdc | |
| Video | NTSC Standard | Can be configured for high-rate data. Available at only two SUP locations |
| High-Rate Data | Up to 32 Mbit/s | High-rate data to/from US Lab APS but available at only two SUP locations |
| EWACS | | Emergency & Warning signal interfaces and commands with direct link to Columbus Lab vital systems. Available at only two SUP locations |
| 1553B Bus | 51.2 kbit/s data rate | Primarily intended for payload low-rate data and payload commanding. Available at only two SUP locations |
| 802.3 LAN | <1.25 Mbit/s data rate for all payloads | Primarily intended for payload medium-rate (via HRM) data. Nominal and redundant LANs |

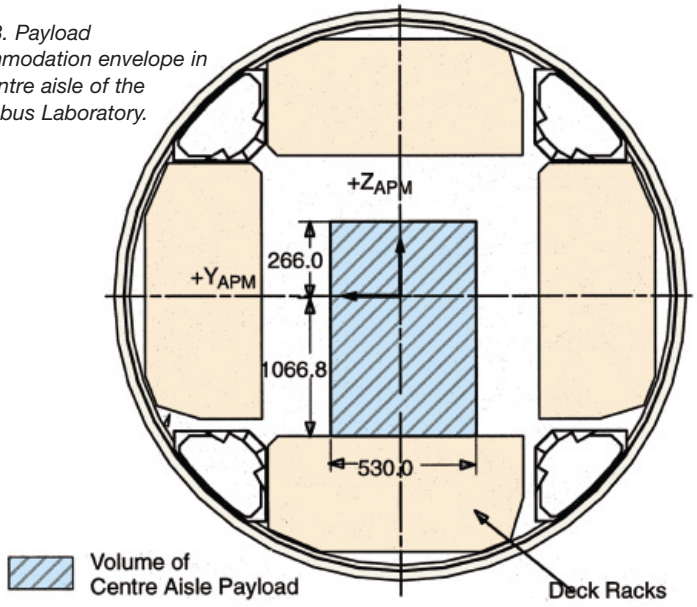



*Fig. 13. Payload accommodation envelope in the centre aisle of the Columbus Laboratory.*

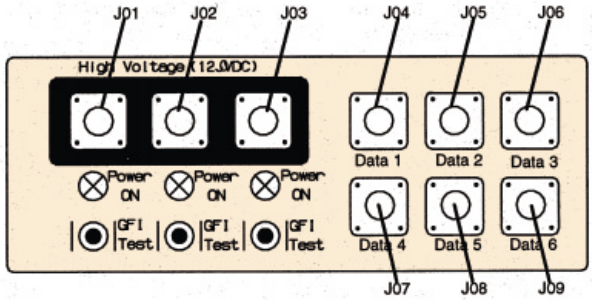



*Fig. 14. Standard Utility Panels provide reduced Columbus resources to aisle payloads.*

Reduced Columbus resources available to aisle payloads are provided at four locations. The Standard Utility Panel is shown in Fig. 14. The resources provided to centre aisle payloads through this Panel are given in Table 8.

**External Payloads on the Columbus Laboratory Starboard End Cone**

Columbus external payload accommodation is provided through four Express Pallet Adapters (ExPAs) mounted on the Columbus Laboratory's External Payload Facility (EPF); see Fig. 15.

The resources provided to Columbus external payload users are a reduced subset of those available to the Columbus pressurised payloads.

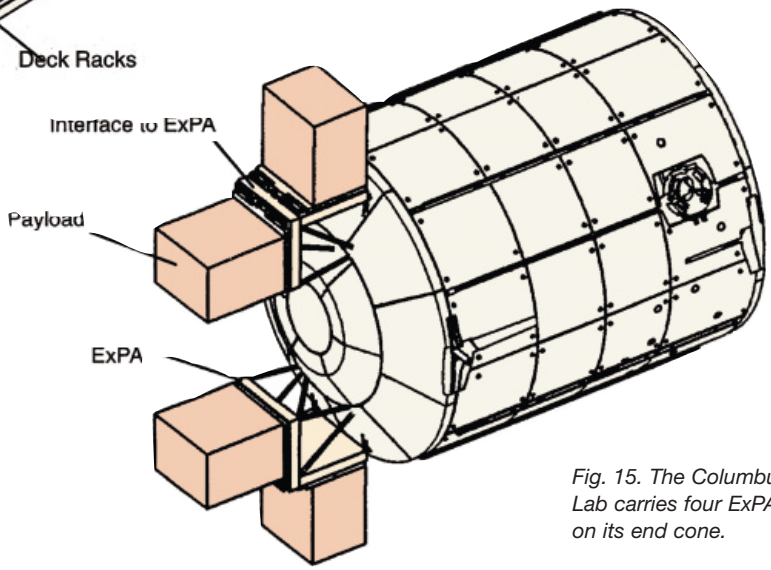



*Fig. 15. The Columbus Lab carries four ExPAs on its end cone.*

The resource planning, allocation and timelining of all European payloads (pressurised and external payloads) are bound together. The resources available for Columbus external payloads are given in Table 9.

Table 9. Resources Available to Columbus External Payloads

| Resource | Nominally Available | Comments |
|---|---|---|
| Main Power | 120 Vdc | 2 feeders to each ExPA. Up to 2.5 kW available at all adapters, but only 2.5 kW may be consumed by all ExPAs |
| Data interfaces | Analog lines<br>Command lines | Interfacing to Command and Monitoring Unit |
| High-Rate Data | Maximum 32 Mbit/s | Redundant pair to each ExPA. Extension of Columbus video/data link |
| 1553B Bus | Selectable. Connected to Network Patch Panel* | Redundant pair to each ExPA |
| 802.3 LAN | Selectable. Connected to Network Patch Panel* | Redundant pair to each ExPA |

*Network Patch Panel provides for ExPA configuration between US Payload/Columbus payload bus and Ethernet LANs

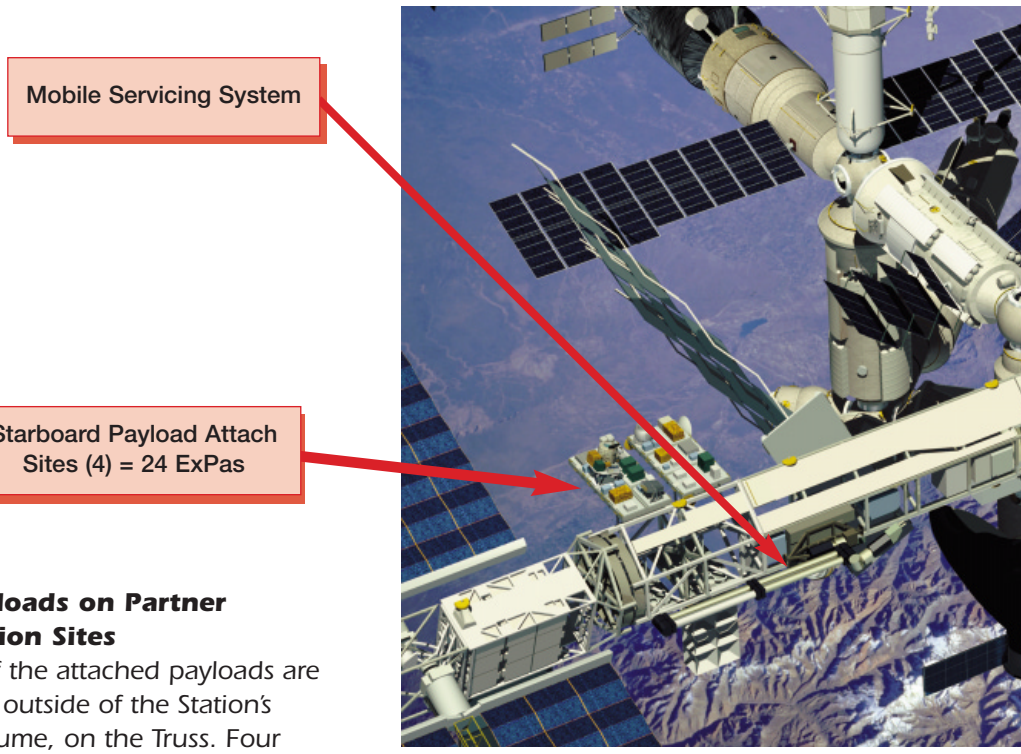



*Fig. 16. Locations for attaching external payloads on the ISS.*

**External Payloads on Partner Accommodation Sites**

The majority of the attached payloads are located on the outside of the Station's pressurised volume, on the Truss. Four locations on the S3 Truss segment offer attached payload accommodation for Express Pallets, and 10 locations on the JEM External Facility house attached payloads. These locations are shown in Fig. 16. An Express Pallet has six robotically replaceable adapters, Express Pallet Adapters (ExPAs), for payloads. An example of an Express Pallet with ExPA's is shown in Fig. 17a/b. The resources available to each ExPA are given in Table 10.

European payload components consisting of several individual payloads may be accommodated on a single ExPA. The ESA-developed Power Distribution Unit (PDU) and External Payload Computer (XPLC) provide the interfaces between these multiple payloads and the ExPA power/data connectors.

The Japanese attached payload sites additionally offer active cooling for payloads.

The Russian Science Power Platform offers further accommodation opportunities for external payloads. However, engineering details are still unknown.

Table 10. Resources Available to Each Express Pallet Adapter

| Resource | Capability | Comments |
|---|---|---|
| Main Power | 28 Vdc<br>120 Vdc | Two outlets per rating.<br>Combined power for each ExPA limited to 2.5 kW max |
| Stay-alive power | 120 W @ 120 Vdc | |
| 1553B Bus | 50 kbit/s | Used for low-rate telemetry and telecommanding. Total rate for all adapters |
| 802.3 LAN | 6 Mbit/s | Used for medium-rate telemetry.<br>6 Mbit/s maximum per Pallet |
| Analog inputs from payloads to ExPA | 6 | Used for monitoring analog payload parameters. For all payloads on an adapter |
| Discrete outputs & inputs between ExPA and payloads | 6 (for input & output) | Used for monitoring discrete payload parameters |
| Field of View | Nadir, zenith, ram, wake & Earth limb | |

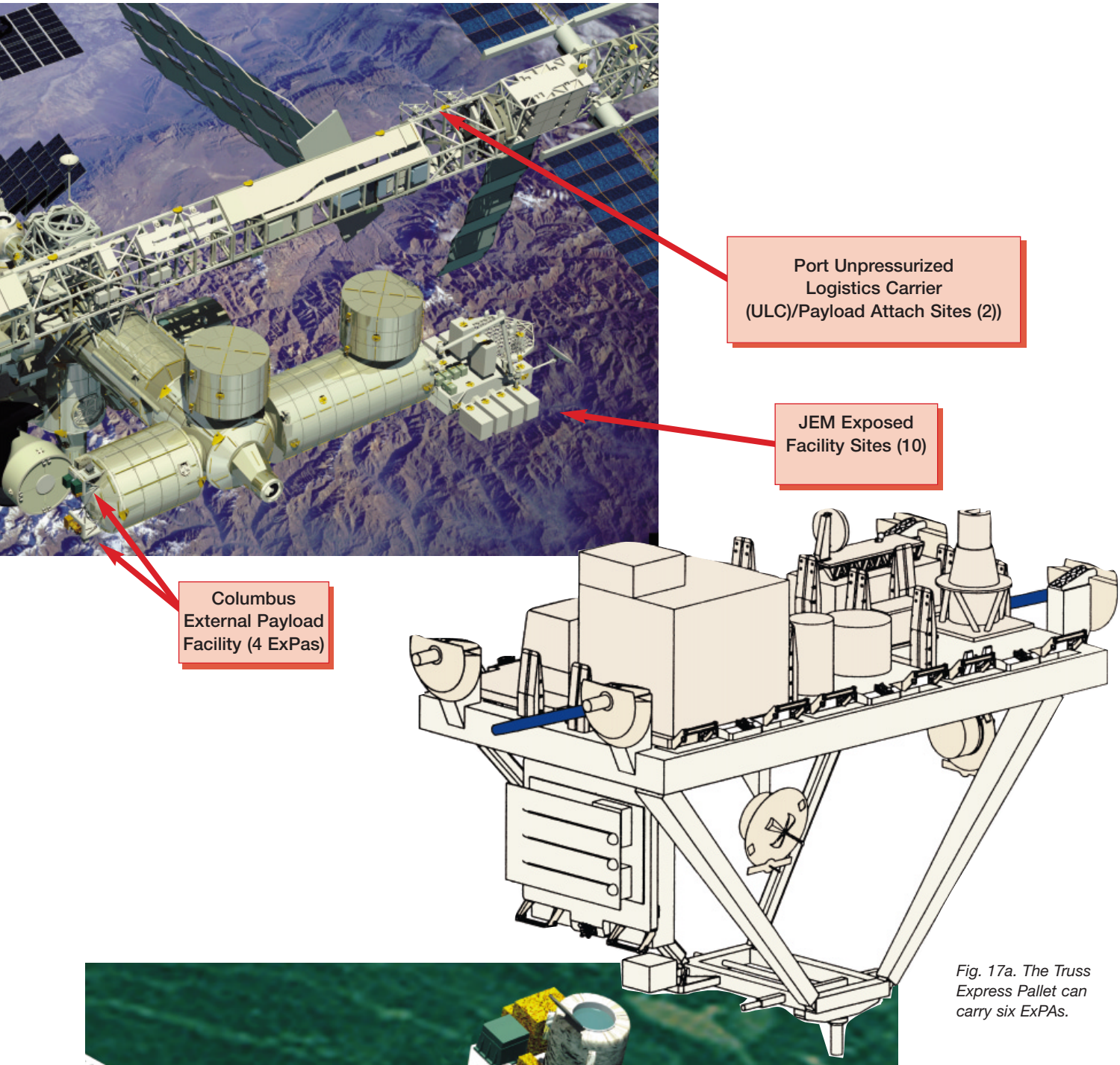



*Fig. 17a. The Truss Express Pallet can carry six ExPAs.*

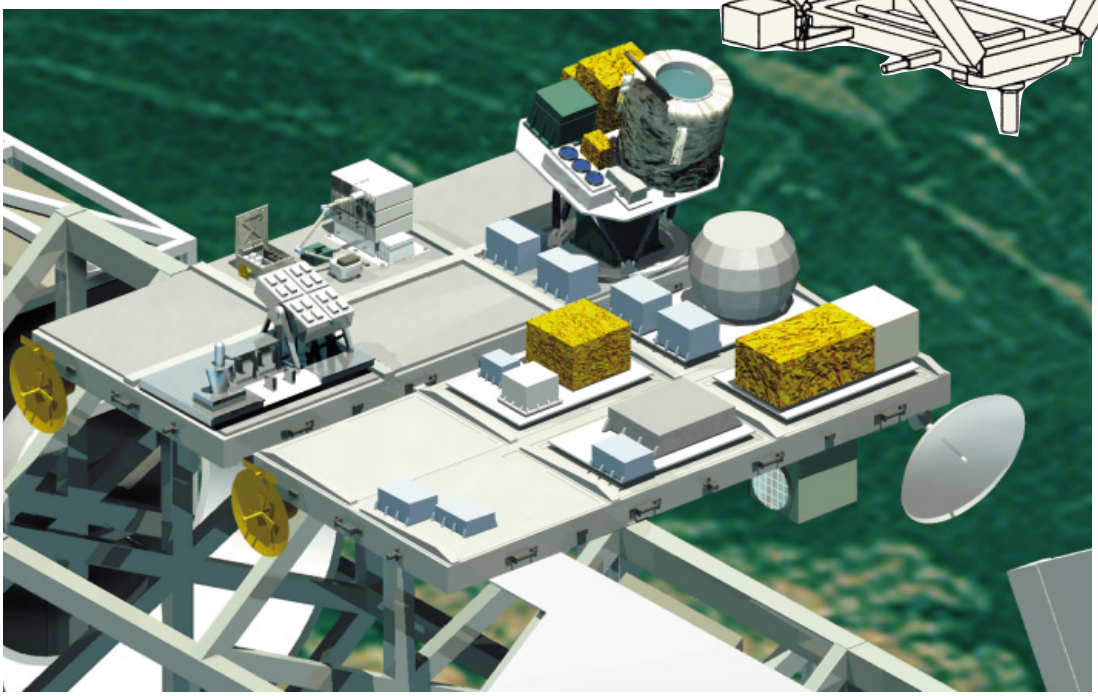


*Fig. 17b. The Express Pallet, carrying six ExPAs, mounted on the ISS Truss. (ESA/D. Ducros)*