International Space Station Capabilities and Payload Accommodations

Rod Jones, Manager, ISS Payloads Office
Current Stage
International Space Station Facts

Spacecraft Mass: 799,046 lb (362,441 kg)
Velocity: 17,500 mph (28,200 kph)
Altitude: 220 miles above Earth
Power: 80 kW continuous
Science Capability: Laboratories from four international space agencies – US, Europe, Japan, and Russia
Assembly Complete Configuration

International Space Station

- MLM - Multi-Purpose Laboratory Module
- European Robotic Arm
- Pressurized Cargo Module
- Heat Reaction Subsystem (HRS) Radiators
- Special Purpose Dextrous Manipulator (DEXTRE)
- EXPRESS Logistics Carrier (ELC)
- Solar Alpha Rotary Joint
- S6 Truss Segment
- Mobile Remote Servicer Base System
- European Lab
- JEM Experiment Logistics Module (ELM)
- Pressurized Mating Adapter

Pressurized Laboratories
External Payload Facilities
The Microgravity Environment

The ISS is equipped with an array of sensors that monitor perturbations to the microgravity state on-orbit.

Even without the Active Rack Isolation System, vibrations are typically within ISS requirements.

While the Station is at its most “quiet” during the eight hours of crew sleep, the Active Rack Isolation System can be effective even during crew exercise.
The ISS provides coverage of 85% of the Earth’s surface and 95% of the world’s populated landmass every 1-3 days, depending on orbital track and field-of-view.
Our Windows on the Earth

**US Laboratory Window**
50-cm diameter
Telescope-quality optical glass

**Service Module Window**
40-cm diameter

**The Cupola**
80-cm diameter
(top window)
## ON Orbit Resources Provided to Payloads

<table>
<thead>
<tr>
<th>Power</th>
<th>30kw average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air to Ground Data</td>
<td>~37.5 Mbps of video (3 lines of video at 12.5 Mbps each)</td>
</tr>
<tr>
<td></td>
<td>~8 Mbps of MRDL data (Science return)</td>
</tr>
<tr>
<td></td>
<td>~5 Mbps for payload still imagery downlink</td>
</tr>
<tr>
<td></td>
<td>~20 Mbps utilized for payload data recorded over LOS</td>
</tr>
<tr>
<td>Internal Racks</td>
<td>13 U.S. Lab</td>
</tr>
<tr>
<td></td>
<td>5 ESA Lab</td>
</tr>
<tr>
<td></td>
<td>6 JAXA Lab</td>
</tr>
<tr>
<td>External Sites</td>
<td>8 Truss ELC Platform Sites</td>
</tr>
<tr>
<td></td>
<td>5 JAXA Platform Sites</td>
</tr>
<tr>
<td></td>
<td>2 ESA Platform Sites</td>
</tr>
<tr>
<td>Crewtime</td>
<td>35 hrs per week (average)</td>
</tr>
</tbody>
</table>
## Upgrades In Work

### Enhanced Processor and Integrated Communications (EPIC) Project

- Phase A will upgrade the three Command and Control (C&C) MDMs and the two Guidance, Navigation, & Control (GN&C) MDMs.
- Phase B will upgrade the two Payload MDMs, and add Ethernet support for the C&C and Payload MDMs.

### Air to Ground High Rate Communications System (HRCS) Project

- Increase data rates internally and on the RF link (300 Mbps downlink, 7/25 Mbps uplink)
- Combine audio and video on orbit
- Provide two way, high quality audio
- Open the door to internet protocol communications
- Open the forward link to multiple users
- Allow for the capability of transmitting & recording HDTV

### On Orbit External Wireless High Rate

- 100 Mbps 2-way Ethernet capability
- 1 Mbps 1553 capability
- Up to 4 antennas attached to EVA handrails on US Lab

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**Rod Jones**  
ISS Payloads Office
What space is available for research?

**Science Rack Topology**

- **DESTINY**
- **COLUMBUS**
- **KIBO**

19 NASA payload science racks at Assembly Complete

Partner

<table>
<thead>
<tr>
<th>Utilization Rack at Assembly Complete</th>
<th>Utilization/Stowage/Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASA</td>
<td></td>
</tr>
<tr>
<td>JAXA</td>
<td></td>
</tr>
<tr>
<td>ESA</td>
<td></td>
</tr>
</tbody>
</table>

National Lab is a capacity within the NASA resource
NASA Science Rack Facilities

On-Orbit

- Microgravity Sciences GloveBox
- 2 Human Research Facility
- 6 ExPRESS Racks
  - ER1
  - ER2A
  - ER3A
  - ER4
  - ER5
  - ER7
- MELFI and MELFI-2
- SpaceDRUMS
  - In ExPRESS 5
- Euro. Modular Cultivation System (EMCS)
  - In ER3A (July 2006)
- Window Observational Research Facility
- Combustion Integrated Rack
  - ER6 (Galley and Research)
- Fluids Integrated Rack
- Materials Science Research Rack
- MELFI-3
  - MELFI-3
- ExPRESS-8
  - MELFI-3
  - ExPRESS-8

ULF-5

More detailed information available at [http://www.nasa.gov/iss-science/](http://www.nasa.gov/iss-science/) Click on “Facilities Catalog”
## Station to Internal Rack Resources

<table>
<thead>
<tr>
<th>Power</th>
<th>3, 6, or 12 kW, 114.5 - 126 voltage, direct current (VDC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td></td>
</tr>
<tr>
<td>Low Rate</td>
<td>MIL-STD-1553 bus 1 Mbps</td>
</tr>
<tr>
<td>High Rate</td>
<td>100 Mbps</td>
</tr>
<tr>
<td>Ethernet</td>
<td>10 Mbps</td>
</tr>
<tr>
<td>Video</td>
<td>NTSC</td>
</tr>
<tr>
<td>Gases</td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Flow= 0.1 kg/min minimum; 517-827 kPa, nominal; 1,379 kPa, maximum</td>
</tr>
<tr>
<td>Argon, carbon dioxide, helium</td>
<td>517-768 kPa, nominal; 1,379 kPa, maximum</td>
</tr>
<tr>
<td>Cooling Loops</td>
<td></td>
</tr>
<tr>
<td>Moderate temperature</td>
<td>16.1 C – 18.3 C</td>
</tr>
<tr>
<td>Flow rate</td>
<td>0 - 45.36 kg/h</td>
</tr>
<tr>
<td>Low temperature</td>
<td>3.3 C – 5.6 C</td>
</tr>
<tr>
<td>Flow rate</td>
<td>233 kg/h</td>
</tr>
<tr>
<td>Vacuum</td>
<td></td>
</tr>
<tr>
<td>Venting</td>
<td>$10^{-3}$ torr in less than 2 h for single payload of 100 L</td>
</tr>
<tr>
<td>Vacuum resource</td>
<td>$10^{-3}$ torr</td>
</tr>
</tbody>
</table>
ExPRESS Rack Accommodations

(Expedite the Processing of Experiments for Space Station)

Middeck Locker
P/N V502-661604

Features
- 4 rear captive fastener attachments
- Friction hinge
- Dual door locks
- Installation tool guides on 4 corners
- Weight — 12 lbs

International Subrack Interface
Standard Drawer
Powered P/N 683-43650
Stowage P/N 683-43656

Features
- 4 PU (Panel Unit)
- Blind Connectors
- Locking Handles
- Weight — 27 lbs
- Rated to at least 37 lbs

EXPRESS 8/2 Configuration
International Standard Payload Rack
Secondary Structure & Subsystems
8/2 Payload Configuration (8 Middeck Lockers, 2 Powered ISIS Drawers)

Peggy Whitson works the Advanced Astroculture (ADVASC) plant growth chamber during Expedition 5 in July 2005

US Lab Module Layout with ISPRs

National Aeronautics and Space Administration
ISS Payloads Office
## ExPRESS Rack Resources

*(Expedite the Processing of Experiments for Space Station)*

<table>
<thead>
<tr>
<th>System</th>
<th>Middeck Locker Locations</th>
<th>ISIS Drawer Locations</th>
<th>Rack-Level Accommodation</th>
</tr>
</thead>
</table>
| **Structural**          | 72 lbs. within cg constraints | 64 lbs. within cg constraints | 8 Mid deck Lockers  
2 ISIS Drawers (4 Panel Unit) |
| **Power**               | 28 Vdc, 0 – 500 W       | 28 Vdc, 0 – 500 W       | 2000 Watts  
28Vdc power |
| **Air Cooling**         | < 200 Watts              | <100 Watts             | 1200 Watts              |
| **Thermal Control**     |                          |                       |                          |
| **System Water Cooling**|                          |                       |                          |
| **Command and Data**    | RS422 Analog            | RS422 Analog           | RS422 Analog            |
| **Handling**            | Ethernet  
5 Vdc Discrete | Ethernet  
5 Vdc Discrete | Ethernet  
5 Vdc Discrete |
| **Video**               | NTSC/RS170A              | NTSC/RS170A             | NTSC/RS170A             |
| **Vacuum Exhaust**      | 1 payload interface per rack | 1 payload interface per rack | 1 payload interface per rack |
| **System**              |                          |                       |                          |
| **Nitrogen**            | 1 payload interface per rack | 1 payload interface per rack | 1 payload interface per rack |
## Cold Stowage Accommodations

<table>
<thead>
<tr>
<th></th>
<th>MELFI</th>
<th>MERLIN</th>
<th>GLACIER</th>
<th>Single and Double Coldbag with ICEPAC’s</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First flight</strong></td>
<td>2006</td>
<td>2007</td>
<td>2008</td>
<td>2006</td>
</tr>
<tr>
<td><strong>On-orbit stowage</strong></td>
<td>Yes</td>
<td>Possible</td>
<td>Possible</td>
<td>No</td>
</tr>
<tr>
<td><strong>Transport</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>On-orbit temperature (°C)</strong></td>
<td>+4, -26, -80</td>
<td>+45 to -20</td>
<td>+4 to -185</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Transport temperature (°C)</strong></td>
<td>N/A</td>
<td>+45 to -5</td>
<td>+4 to -160</td>
<td>+4 to -32</td>
</tr>
<tr>
<td><strong>Useable volume (L)</strong></td>
<td>175</td>
<td>19</td>
<td>30</td>
<td>6.8/18.7</td>
</tr>
<tr>
<td><strong>External volume</strong></td>
<td>1 rack</td>
<td>1 MLE</td>
<td>2 MLE</td>
<td>0.5/1 MLE</td>
</tr>
</tbody>
</table>
## External Research Accommodations

<table>
<thead>
<tr>
<th>Common Attachment System (CAS) Site</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass capacity</strong></td>
<td>1360 - 8618 kg (3000 - 19000 lb)</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>3 kW each on two lines (primary, auxiliary)</td>
</tr>
<tr>
<td><strong>Thermal</strong></td>
<td>Passive</td>
</tr>
<tr>
<td><strong>Low-rate data</strong></td>
<td>1 Mbps (MIL-STD-1553)</td>
</tr>
<tr>
<td><strong>High-rate data</strong></td>
<td>100 Mbps (shared)</td>
</tr>
<tr>
<td><strong>Sites available to NASA</strong></td>
<td>6 sites</td>
</tr>
</tbody>
</table>
Recent ISS Assembly Science Facilities

*NASA Express Logistics Carriers (ELCs)*

S3 Truss

P3 Truss

ELC1, ELC3, & ELC4

2 payload sites per ELC
## External Research Accommodations

<table>
<thead>
<tr>
<th>ELC Single Adapter Resources</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass capacity</strong></td>
<td>227 kg (500 lb)</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td>1 m³</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>750 W, 113 – 126 VDC; 500 W at 28 VDC per adapter</td>
</tr>
<tr>
<td><strong>Thermal</strong></td>
<td>Active heating, passive cooling</td>
</tr>
<tr>
<td><strong>Low-rate data</strong></td>
<td>1 Mbps (MIL-STD-1553)</td>
</tr>
<tr>
<td><strong>Medium-rate data</strong></td>
<td>6 Mbps (shared)</td>
</tr>
<tr>
<td><strong>Sites available per ELC</strong></td>
<td>2 sites</td>
</tr>
<tr>
<td><strong>Total ELC sites available</strong></td>
<td>8 sites</td>
</tr>
</tbody>
</table>
Recent ISS Assembly Science Facilities

Japanese Experiment Module - Kibo

- 5 external payload sites allocated to NASA on the JEM Exposed Facility
- 6 internal active payload rack locations allocated to NASA inside the JEM Pressurized Module
### External Research Accommodations

<table>
<thead>
<tr>
<th>JEM-EF Resources</th>
<th></th>
</tr>
</thead>
</table>
| **Mass capacity** | 550 kg (1,150 lb) at standard site  
2,250 kg (5,550 lb) at large site |
| **Volume**       | 1.5 m³           |
| **Power**        | 3-6 kW, 113 – 126 VDC |
| **Thermal**      | 3-6 kW cooling   |
| **Low-rate data**| 1 Mbps (MIL-STD-1553) |
| **High-rate data**| 43 Mbps (shared) |
| **Sites available to NASA** | 5 sites |
## External Research Accommodations

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass capacity</td>
<td>230 kg (500 lb)</td>
</tr>
<tr>
<td>Volume</td>
<td>1 m³</td>
</tr>
<tr>
<td>Power</td>
<td>2.5 kW total to carrier (shared)</td>
</tr>
<tr>
<td>Thermal</td>
<td>Passive</td>
</tr>
<tr>
<td>Low-rate data</td>
<td>1 Mbps (MIL-STD-1553)</td>
</tr>
<tr>
<td>Medium-rate data</td>
<td>2 Mbps (shared)</td>
</tr>
<tr>
<td>Sites available to NASA</td>
<td>2 sites</td>
</tr>
</tbody>
</table>

**Columbus External Resources**
ISS Visiting Vehicles Post-Shuttle

Cygnus (Orbital)

Dragon (SpaceX)

ATV (ESA)

Progress/Soyuz (Energia)

HTV (JAXA)
ATV

**Upmass**
- Internal
  - Powered: None
  - Late Load
    - Up to 28 bags (not CTBE) of late access
  - Racks
    - Up to 8 passive racks
- External
  - None
- On Dock
  - Cargo: L-14 weeks
  - Late Load: L-4 weeks

**Downmass**
- Internal
  - Disposal only
- External
  - None
HTV

Upmass
- Internal
  Powered: None
  Late Load
    » Maximum 3 CTBE (0.5 or 1.0 CTB), each <20 kg
    » Additional possible if negotiated in advance.

Racks
  » Up to 8 passive racks
  » Forward Bay: ISPR compatible
  » Aft Bay racks fixed: HTV Resupply Rack

- External
  Exposed Pallet (on following chart)

- On Dock
  Cargo: L-6 months
  Late Load: L-6 weeks

Downmass
- Internal
  Disposal only

- External
  Disposal only
HTV External Pallet Configurations

Fig. 3.3.2-1 Type I-a: HCAM Type EF Payload (x 3)

Fig. 3.3.2-2 Type I-b: HCAM Type EF Payload (x 2) and FRAM Type EF Payload (x 1)

Fig. 3.3.2-3 Type I-b: HCAM Type EF Payload (x 2) and FRAM Type Cargo (x 1)

Fig. 3.3.2-4 Type I-c: HCAM Type EF Payload (x 2) and Battery Transportation Demonstration (x 1)

Fig. 3.3.2-5 Type III-a: FRAM Type Cargo (x 4)

Fig. 3.3.2-6 Type III-b: FRAM Type EF Payload (X1) and FRAM Type Cargo (X4)

Fig. 3.3.2-7 Type III-c: Non-FRAM Type Cargo (X6)

NASA M-Size Cargo (Non-FRAM Type) (x 6)
Progress

Upmass
- Internal
  Powered: Special allowance only
  Late Load
  Racks: None
  Items up to 8-10 kg in vehicle containers
  Larger items installed in special transport frames
- External
  None

Downmass
- Internal
  Disposal only
- External
  None
Soyuz

Upmass
- Internal
  - Powered: Special allowance only
  - Late Load
  - Racks: None
  - Items up to 5 kg in vehicle containers
  - Larger items installed in special transport frames
- External
  - None

Downmass
- Internal
  - Items up to 5 kg in container under crew seat
  - Special container available for larger items if only two crew on return
- External
  - None
Dragon

**Upmass**
- **Internal**
  - Powered: Double MLE
  - Late Load: T-12 hrs for powered MLE; TBD days for nominal
  - Racks (SpaceX-designed)
    - ~3300 kg mass
- **External**
  - Trunk capability

**Downmass**
- **Internal**
  - Powered: Double MLE
  - ~1700 kg return
  - Early destow at dock available
  - Fast boat return available
- **External**
  - Disposal only
Cygnus

Upmass
- Internal
  Powered: Double MLE
  Late Load: TBD
  Racks
    » 2000 kg mass (standard)
    » 2700 kg mass (expanded)
- External
  None

Downmass
- Internal
  Disposal only
- External
  None

2000 kg mass (standard)
2700 kg mass (expanded)
References

- Attached Payload Interface Requirements Document, SSP 57003
- **Common Interface Requirements Document**, SSP 50835
- **ATV-2 Cargo Summary** (24 Sep 2009)
- **HTV Cargo Accommodation Handbook**, JFX-99102
- **Requirements for International Partner Cargo Transported On Russian Progress and Soyuz Vehicles**, Π32928-103
- SpaceX Introduction For Payloads (OZ3, Jan 2010)
- **Cygnus Fact Sheet** (Orbital, 2009)
Backup

Science Facilities Overview
Science Facilities On Orbit

2 Human Research Facility (HRF) Racks - Biomedical investigations, including ultrasound, body mass measurement, metabolic gas analysis, pulmonary monitoring, ambulatory blood pressure measurement, Holter monitor, and experiment unique hardware

- **Microgravity Sciences Glovebox (MSG)**
  Principally materials and fluid physics experiments to date

Expedition 12 crewmember Bill McArthur activating the SLAMMD in the HRF 2 rack

Expedition 13 crewmember Jeff Williams performing the PFMI experiment in the Microgravity Science Glovebox
Science Facilities On Orbit

- 7 Multi-User (EXPRESS) Racks - Middeck locker scale instruments in various research disciplines such as biotechnology and plant research

- 2 Minus Eighty-degree Laboratory Freezer for ISS (MELFI) - Provides thermal conditioning at +4°C, -26°C and -80°C
Science Facilities On Orbit

- **Space Dynamically Responding Ultrasound Matrix System (SpaceDRUMS)**

- **Window Observation Research Facility (WORF) (2009)**
  - Facility to support visual and multispectral remote sensing using Lab Optical Window

- **Combustion Integrated Rack (CIR) (2008)**
  - Facility dedicated to research in combustion science
Science Facilities On Orbit

- **Materials Science Research Rack (MSRR)** (2009)
  - Facility to support ESA Microgravity Science Lab furnace
- **Fluids Integrated Rack (FIR)** (2009)
  - Facility dedicated to fluid physics research, with Light Microscope Module
- **Muscle Atrophy Research Exercise System (MARES)** (2009)
  - Facility for musculoskeletal, biomechanical, neuromuscular and neurological physiology measurements
ELC1 Configuration

ELC1 Top Side

ELC1 Keel Side
ELC2 Configuration

ELC2 Top Side

ELC2 Keel Side
ELC3 Configuration

Top Side

Keel Side

Empty Payload Site

SAS

CTC

Anticipated (ULFY/HTV2)

HPGT

ATTA

National Aeronautics and Space Administration

ISS Payloads Office
ISS Payload Integration Process

Hardware development time varies per payload 36 months to days
ISS Payload Control Centers

Payload Operations Center (POIC) - Huntsville

POIC: Responsible for execution of on-orbit NASA research

Mission Control Center—Houston
MCC-H: Responsible for flight command and control of overall vehicle

Mission Control Center—Moscow
MCC-M: Responsible for flight command and control of Russian segment.
Payload Ops Integration Center Interfaces

MCC-H, 4 IP Control Centers, 4 Telescience Support Centers, 49 Telescience Resource Kit (TReK) clients
ISS Transition From Assembly to Utilization

Cumulative ISS Utilization Crewtime by All Partners

Total Utilization Hours Operated (Cumulative)

Year

Assembly Complete
Six Crew On-orbit