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
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><strong>Air to Ground Data</strong></td>
<td></td>
</tr>
<tr>
<td>~37.5 Mbps of video (3 lines of video at 12.5 Mbps each)</td>
<td></td>
</tr>
<tr>
<td>~8 Mbps of MRDL data (Science return)</td>
<td></td>
</tr>
<tr>
<td>~5 Mbps for payload still imagery downlink</td>
<td></td>
</tr>
<tr>
<td>~20 Mbps utilized for payload data recorded over LOS</td>
<td></td>
</tr>
<tr>
<td><strong>Internal Racks</strong></td>
<td></td>
</tr>
<tr>
<td>13 U.S. Lab</td>
<td></td>
</tr>
<tr>
<td>5 ESA Lab</td>
<td></td>
</tr>
<tr>
<td>6 JAXA Lab</td>
<td></td>
</tr>
<tr>
<td><strong>External Sites</strong></td>
<td></td>
</tr>
<tr>
<td>8 Truss ELC Platform Sites</td>
<td></td>
</tr>
<tr>
<td>5 JAXA Platform Sites</td>
<td></td>
</tr>
<tr>
<td>2 ESA Platform Sites</td>
<td></td>
</tr>
<tr>
<td><strong>Crewtime</strong></td>
<td></td>
</tr>
<tr>
<td>35 hrs per week (average)</td>
<td></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
What space is available for research?

*Science Rack Topology*

19 NASA payload science racks at Assembly Complete

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

On-Orbit

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>Low Rate</td>
</tr>
<tr>
<td></td>
<td>High Rate</td>
</tr>
<tr>
<td></td>
<td>Ethernet</td>
</tr>
<tr>
<td></td>
<td>Video</td>
</tr>
<tr>
<td>Gases</td>
<td>Nitrogen</td>
</tr>
<tr>
<td></td>
<td>Argon, carbon dioxide, helium</td>
</tr>
<tr>
<td>Cooling Loops</td>
<td>Moderate temperature</td>
</tr>
<tr>
<td></td>
<td>Flow rate</td>
</tr>
<tr>
<td></td>
<td>Low temperature</td>
</tr>
<tr>
<td></td>
<td>Flow rate</td>
</tr>
<tr>
<td>Vacuum</td>
<td>Venting</td>
</tr>
<tr>
<td></td>
<td>Vacuum resource</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 683-43666
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)

Rod Jones
ISS Payloads Office
National Aeronautics and Space Administration
# 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>
<tbody>
<tr>
<td>Structural</td>
<td>72 lbs. within cg constraints</td>
<td>64 lbs. within cg constraints</td>
<td>8 Mid deck Lockers 2 ISIS Drawers (4 Panel Unit)</td>
</tr>
<tr>
<td>Power</td>
<td>28 Vdc, 0 – 500 W</td>
<td>28 Vdc, 0 – 500 W</td>
<td>2000 Watts 28Vdc power</td>
</tr>
<tr>
<td>Air Cooling</td>
<td>≤ 200 Watts</td>
<td>&lt;100 Watts</td>
<td>1200 Watts</td>
</tr>
<tr>
<td>Thermal Control System Water Cooling</td>
<td>500 Watts (2 positions per rack)</td>
<td>500 Watts (2 positions per rack)</td>
<td>2 positions per rack</td>
</tr>
<tr>
<td>Command and Data Handling</td>
<td>RS422 Analog Ethernet 5 Vdc Discrete</td>
<td>RS422 Analog Ethernet 5 Vdc Discrete</td>
<td>RS422 Analog Ethernet 5 Vdc Discrete</td>
</tr>
<tr>
<td>Video</td>
<td>NTSC/RS170A</td>
<td>NTSC/RS170A</td>
<td>NTSC/RS170A</td>
</tr>
<tr>
<td>Vacuum Exhaust System</td>
<td>1 payload interface per rack</td>
<td>1 payload interface per rack</td>
<td>1 payload interface per rack</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1 payload interface per rack</td>
<td>1 payload interface per rack</td>
<td>1 payload interface per rack</td>
</tr>
</tbody>
</table>

Rod Jones  
ISS Payloads Office  
National Aeronautics and Space Administration
# 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>

**Notes:**
- MELFI MERLIN GLACIER
- First flight 2006
- On-orbit stowage Possible Possible No
- Transport No Yes Yes Yes
- Power Yes Yes No
- On-orbit temperature (°C) +4, -26, -80 +45 to -20 +4 to -185 N/A
- Transport temperature (°C) N/A +45 to -5 +4 to -160 +4 to -32
- Useable volume (L) 175 19 30 6.8/18.7
- External volume 1 rack 1 MLE 2 MLE 0.5/1 MLE
Truss Attach Site Usage

National Aeronautics and Space Administration
**External Research Accommodations**

### Common Attachment System (CAS) Site

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass capacity</td>
<td>1360 - 8618 kg (3000 - 19000 lb)</td>
</tr>
<tr>
<td>Power</td>
<td>3 kW each on two lines (primary, auxiliary)</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>High-rate data</td>
<td>100 Mbps (shared)</td>
</tr>
<tr>
<td>Sites available to NASA</td>
<td>6 sites</td>
</tr>
</tbody>
</table>
Recent ISS Assembly Science Facilities

NASA Express Logistics Carriers (ELCs)

ELC1, ELC3, & ELC4

S3 Truss

P3 Truss

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

### Columbus External Resources

<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>

---

Rod Jones
ISS Payloads Office
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

ATV-2 Racks with M-01 bags
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: Non-FRAM Type Cargo (x 6)

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)
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
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, П32928-103
- 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
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

SASA

CTC
Anticipated (ULF5/HV2)

SASA

HPGT

4TA
ELC4 Configuration

Top Side

Keel Side

HRSR

Empty Payload Site

Future FHRC Site (via HTV2)

Future CTC-4 (via HTV2)

Empty ORU Site

Empty Payload Site
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

White Sands Complex, New Mexico

Payload Ops Control Center
Huntsville

Space Shuttle
TDRSS
ISS

Global Customer Support

Mission Control Center
Houston

International Partner
Facilities
Russia
Europe
Japan
Italy
Canada

GRC
ARC
JSC
MSFC

Payload User Sites
TReK

National Aeronautics and Space Administration

SS Payloads Office
ISS Transition From Assembly to Utilization

Cumulative ISS Utilization Crewtime by All Partners

Year

Total Utilization Hours Operated (Cumulative)

Assembly Complete
Six Crew On-orbit
Average Weekly Actuals Provided as Compared to Minimum Requirements, Subscriptions, and Allocations

POC: Rod Jones/OZJ

Increment 19 & 22: USOS utilization avg crew time to date = 29.3 hrs in 16.2 work wks (vs. 29.5 hrs in 14.2 work wks last month; USOS Voluntary Science crew time to date = 32.1 hrs; NASA = 19.2 hrs, ESA = 1.1 hrs, CSA = 4.3 hrs, JAXA = 7.0 hrs (last month, JAXA was estimated at 6.3 hrs, is now retroactively corrected)

Actuals Provided -- includes all Scheduled, Task-List, and Voluntary Science hours (IMC), docked ops utilization not included/shown*

Plus # Hours Per Week Average Reserve Crewtime (from Annex 5 PTP or MPCB Approval)

INCREMENT

- Generic Groundrules, Requirements & Constraints (GGR&C) Minimum Requirement
- L-12 Month Increment Definition and Requirements Document Subscription (or Requirement)
- L-12 Month Increment Definition and Requirements Document (IDRD) Allocation
- L-1 Month Most Recent to Launch On-Orbit Operations Summary (OOS) (or most-current-to-launch IDRD until final pre-flight OOS release)
- Actuals Provided -- includes all Scheduled, Task-List, and Voluntary Science hours (IMC); docked ops utilization not included/shown*

Legend:

- Generic Groundrules, Requirements & Constraints (GGR&C) Minimum Requirement
- L-12 Month Increment Definition and Requirements Document Subscription (or Requirement)
- L-12 Month Increment Definition and Requirements Document (IDRD) Allocation
- L-1 Month Most Recent to Launch On-Orbit Operations Summary (OOS) (or most-current-to-launch IDRD until final pre-flight OOS release)
- Actuals Provided -- includes all Scheduled, Task-List, and Voluntary Science hours (IMC); docked ops utilization not included/shown*

Plus # Hours Per Week Average Reserve Crewtime (from Annex 5 PTP or MPCB Approval)

Status: YELLOW
Based on increase in Incrs 23 & 24 latest crewtime allocation as per L-1 Final Preflight OOS; last month