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
International Space Station (ISS) External Research Facilities

ELC2 (ULF6, 2011)
AMS

ELC3

Kibo External Facility
5 sites NASA, 10 sites total

ELC1

ESP-3

ELC4 (ULF5)

Keel Side

Columbus
External Payload Facility
(2 sites NASA, 4 sites total)

Keel Side

Keel Side

Keel Side

Keel Side

Keel Side
### ELC Single Adapter Resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass capacity</td>
<td>227 kg (500 lb)</td>
</tr>
<tr>
<td>Volume</td>
<td>1 m³</td>
</tr>
<tr>
<td>Power</td>
<td>750 W, 113 – 126 VDC; 500 W at 28 VDC/adapter</td>
</tr>
<tr>
<td>Thermal</td>
<td>Active heating, passive cooling</td>
</tr>
<tr>
<td>Low-rate data</td>
<td>*1 Mbps (MIL-STD-1553)</td>
</tr>
<tr>
<td>Medium-rate data</td>
<td>*6 Mbps (shared) - Return link (payload to ISS) only</td>
</tr>
<tr>
<td>Sites available per ELC</td>
<td>2 sites</td>
</tr>
<tr>
<td>Total ELC sites available</td>
<td>8 sites</td>
</tr>
</tbody>
</table>

Research Payload ExPA (see next chart)
Japanese Experiment Module - *Kibo*
JEM EF External Research Accommodations

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, two way)

Medium-rate data
- 1EEE-802.3(10BASE-T, two way)

High-rate data
- 43 Mbps (shared, one way downlink)

Sites available to NASA
- 5 sites

*Ethernet bus is tested to 100BASE-T capacity.
*Upgrade to 100BASE-T is being worked by JAXA
### Columbus EF Overview

#### Location Viewing

<table>
<thead>
<tr>
<th>Location</th>
<th>Viewing</th>
<th>Payload Size</th>
<th>Power</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOZ</td>
<td>Zenith</td>
<td>226 kg + CEPA</td>
<td>1.25 kW at 120 VDC</td>
<td>Ethernet, 1553</td>
</tr>
<tr>
<td>SOX</td>
<td>Ram</td>
<td></td>
<td>2.5 kW max</td>
<td></td>
</tr>
<tr>
<td>SDX</td>
<td>Ram</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDN</td>
<td>Nadir</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*All 4 locations are allocated to Utilization*
Earth Venture 2 ISS Feasibility Assessment Process

(1) Contact the Technology Demonstration Office (TDO) (in Space Station Payloads Office, NASA JSC) start a dialogue and arrange an assessment telecon or meeting (George Nelson, george.nelson-1@nasa.gov, 281-244-8514.

(2) Background information provided to an ISS assessment team, lead by TDO representative (Al Holt or Dave Hornyak). Information on proposed payload (charts) should include:

• Description of payload concepts and preliminary design approaches.
• Include estimate launch/on-orbit mass, on-orbit volume/dimensions, power, data downlink requirements, need for active cooling, and your assessment of where the payload could be located.
• Any mass or volume/dimensions which exceed standard operational payload envelopes for a particular site will require a waiver – small deviations can often be accommodated.
• We will assess your overall design approach and let you know where your payload exceeds standard envelopes, and options related to them.
Earth Venture 2 ISS Feasibility Assessment Process

(3) To complete the assessment a follow-up telecon may be needed, e-mail exchanges are to be expected.

(4) Once the ISS assessment team has reviewed all potential ISS accommodations and interfaces, and has identified and briefly discussed these with proposer, the generation of a draft feasibility assessment letter can be initiated.

(5) Draft of the ISS feasibility assessment letter will be sent to the proposer for any comments near the end of an internal review of the letter.

(6) Letter is approved and signed by the Space Station Payloads Office manager Rod Jones
   - Signed letter is then scanned in and sent by e-mail to the proposer with the original sent by regular mail.
Manifesting Process & Opportunities

- When a payload is selected or funded, contact is made with the Space Station Payloads Office, and for Earth Venture 2 payloads, with the Technology Demonstration Office.

- Technical Interchange Meetings or telecons are set up to provide a further assessment of the ISS’s capability to support the payload and to provide answers to payload sponsors’ questions.
  - These TIMs are initially led by a representative of the Technology Demonstration Office, until a Strategic Payload Integration Manager can be assigned.

- Around the same time, a request is made to add the payload to the Multi-Increment Payload Resupply and Outfitting Manifest (strategic plan for unpressurized or external payloads)
  - A particular external payload site is selected at that point
  - Expected launch readiness for the payload is used to locate the payload on the timeline

- Strategic Payload Integration Manager is assigned to begin leading TIM activities or strongly support TDO led TIM activities.
All TBDs except TBD-ESA-1 and TBD-ESA-2 (highlighted in gold) represent NASA opportunities that have not yet been named (minimum of 1 Columbus opportunity and 3 ELC opportunities)
### External Manifesting and ISS Locations

**JEM-EF**

*(draft through 2015 shown)*

#### UNPRESSURIZED FACILITY LAUNCH / DISPOSAL PLANS AND ON-ORBIT TOPOLOGY

<table>
<thead>
<tr>
<th>Site</th>
<th>Location Number</th>
<th>Viewing</th>
<th>Calendar Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ram</td>
<td>MAXI(^1)</td>
<td>MAXI(^2)</td>
<td>MAXI(^3)</td>
<td>MAXI(^4)</td>
<td>MAXI(^5)</td>
<td>MAXI(^6)</td>
</tr>
<tr>
<td>2</td>
<td>Wake</td>
<td>SEDAP(^1)</td>
<td>SEDAP(^2)</td>
<td>SEDAP(^3)</td>
<td>SEDAP(^4)</td>
<td>SEDAP(^5)</td>
<td>SEDAP(^6)</td>
</tr>
<tr>
<td>3</td>
<td>Wake</td>
<td>HREP(^1)</td>
<td>HREP(^2)</td>
<td>HREP(^3)</td>
<td>HREP(^4)</td>
<td>HREP(^5)</td>
<td>HREP(^6)</td>
</tr>
<tr>
<td>4</td>
<td>Wake</td>
<td>MCE(^1)</td>
<td>MCE(^2)</td>
<td>MCE(^3)</td>
<td>MCE(^4)</td>
<td>MCE(^5)</td>
<td>MCE(^6)</td>
</tr>
<tr>
<td>5</td>
<td>Wake</td>
<td>SEDAP(^1)</td>
<td>SEDAP(^2)</td>
<td>SEDAP(^3)</td>
<td>SEDAP(^4)</td>
<td>SEDAP(^5)</td>
<td>SEDAP(^6)</td>
</tr>
<tr>
<td>6</td>
<td>Wake</td>
<td>CALET(^1)</td>
<td>CALET(^2)</td>
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<td>CALET(^4)</td>
<td>CALET(^5)</td>
<td>CALET(^6)</td>
</tr>
<tr>
<td>7</td>
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<td>CALET(^1)</td>
<td>CALET(^2)</td>
<td>CALET(^3)</td>
<td>CALET(^4)</td>
<td>CALET(^5)</td>
<td>CALET(^6)</td>
</tr>
<tr>
<td>8</td>
<td>Wake</td>
<td>CALET(^1)</td>
<td>CALET(^2)</td>
<td>CALET(^3)</td>
<td>CALET(^4)</td>
<td>CALET(^5)</td>
<td>CALET(^6)</td>
</tr>
<tr>
<td>9</td>
<td>Wake</td>
<td>CALET(^1)</td>
<td>CALET(^2)</td>
<td>CALET(^3)</td>
<td>CALET(^4)</td>
<td>CALET(^5)</td>
<td>CALET(^6)</td>
</tr>
<tr>
<td>10</td>
<td>Zenith</td>
<td>S3 Upper Inboard</td>
<td>SEDAP(^1)</td>
<td>SEDAP(^2)</td>
<td>SEDAP(^3)</td>
<td>SEDAP(^4)</td>
<td>SEDAP(^5)</td>
</tr>
<tr>
<td>11</td>
<td>Zenith</td>
<td>S3 Upper Inboard</td>
<td>SEDAP(^1)</td>
<td>SEDAP(^2)</td>
<td>SEDAP(^3)</td>
<td>SEDAP(^4)</td>
<td>SEDAP(^5)</td>
</tr>
</tbody>
</table>

### Notes:

- All TBDs (highlighted in gold) represent NASA opportunities that have not yet been named (minimum of 3 sites with flight opportunities).
- Location/site numbers are color-coded to match the illustration on page 5.
A payload’s RPO sponsor initially responds to the RPWG “Call for Payloads” with a list of candidate payloads and resource requirements for consideration. This starts the manifesting process.

- **Flight & Increment-specific Utilization Allocations (ISS Program Office)**
  - (Up/downmass, Crewtime, Power, etc)

- **Payload-specific Resource Definition and Two-pagers (RPO)**
  - ISS Payloads Office
  - Feasibility Assessments (Integration Organizations)

- **Payload-prioritization (ISS Program Scientist)**

- **Research Planning Working Group (RPWG)**
  - Increment-specific Research Plan

- **Launch Schedules (Shuttle, Russians, ESA, JAXA, ISS Program Office)**

- **ISS Payloads Control Board**

- **Payload Tactical Plan (PTP)**

~ Increment minus 16 months

~ Increment minus 19 months
Payload Integration Process

- Once the payload development activity reaches a point where weekly telecons are needed, a Payload Integration Manager is assigned.

- The Payload Integration Manager leads the Technical Interchange Meetings from then on, and acts the central point of contact for interaction with other offices in the Space Station Program Office and ISS analytical services.
NASA Payload Integration Manager (PIM)

- Functions as the Payload Developer’s primary interface to the ISS Program
- Serves as payload advocate while protecting ISS Program Requirements
- Ensures payload requirements are accurately defined and documented
- Facilitates payload integration product development, delivery schedules, and communications with the ISS Program
ISS Standard Payload Integration Process

- NASA PIMs provide integration leadership during all phases of the payload’s life cycle
  - Strategic – ISS integration requirements, products, and schedule development to ensure that an ISS compatible payload is built; support manifest process (payload data collection and feasibility assessments)
  - Tactical – represent PD interests to Increment and Flight-specific teams to ensure that integration and operations requirements are addressed; provide oversight for payload CoFR and verification submittals
  - Operations – assist with operations issue resolution between the PD and the Increment Payload Manager; maintains payload insight; and coordinates payload resupply or return requirements; assure payload CoFR and verification submittals during payload lifetime on-orbit
  - Post-flight – coordinate vehicle deintegration requirements; return of payload material from the landing site to the PD; and Lessons Learned submittals
Integration Products

Payload Integration Manager Schedule

**STRATEGIC**

- PDR: Safety Phase 0/I
  - Export Classification Letter
  - Prelim Design Data Package
  - Safety Data (Phase 0-I)
  - Training Strategy TIMs
- CDR: Safety Phase II
  - Payload Integration Agreement (PIA)
  - Critical Design Data Package
  - Safety Data (Phase II)
  - ICD/Verification Requirements
  - Resource Requirements Definition
  - Procedures & Displays DS (P)

**TACTICAL**

- PayloadManifested: Safety Phase III
  - Safety Data Pack
  - C&DH DS (P)
  - KSC Support Rqmts DS
  - KSC Technical Rqmts DS
  - Ground Data Services DS
  - Procedures & Displays (U)
  - Payload Planning DS (P)
  - Manifest/Stowage DS (P)
  - Drawing DS (P)
- Safety Phase III: CoFR
  - Manifest/Stowage DS (U)
  - Drawing DS (U)
  - Integration Data Pack (IDP)
  - C&DH DS (F)
  - Procedures & Displays (F)
- Payload Pre-Ship: CoFR
  - C&DH DS (U)
  - Payload Trainer H/W & S/W
  - Training Plans & Courseware
  - Payload Planning DS (F)
- Key:
  - P – Preliminary
  - U – Update
  - F – Final

ISS Payload Integration Process Overview

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ISS Payload Integration Process Overview

1/11/11
Tactical Timeframe Overview

TYPICAL TACTICAL TIMEFRAME

~L-16 to L-12M
- Manifest and Stowage, Drawings, KSC Data Sets
- Training Units Delivered, Planning Data Set, Operations Data Set
- Initial Procedure Development

~L-12 to L-6M
- Phase III Safety Review
- Crew Training
- Baseline Datasets: Command & Data Handling, Manifest and Stowage, Drawing, Procedures and Displays
- ISS Interface Verification

~L-6 to L-1M
- Payload Rack Checkout Unit (PRCU) Testing at KSC
- Payload Turnover for Launch Vehicle Integration
  - Shuttle Middeck
  - Multipurpose Pressurized Logistics Module (MPLM)
  - Soyuz/Progress
  - ATV
  - HTV
  - COTS

Note: EXPRESS Sub-rack payloads will have a compressed integration cycle
For technical questions associated with International Space Station Payloads:

Dr. George Nelson  
Venture 2 ISS Payload POC  
Space Station Payload Office  
Mail Stop OZ  
NASA Johnson Space Center  
Houston, TX 77058  
Tel: 281-244-8514  
Email: george.nelson-1@nasa.gov

Customer Service Helpline: The International Space Station Payloads Office has both a phone and an email customer service helpline that Payload Developers and others interested in doing research can contact to get assistance. The phone is staffed during regular business hours, or messages may be issued after hours, and a representative will return the call on the next business day. Phone: 281-244-6187, email: jsc-iss-payloads-helpline@mail.nasa.gov.”
ISS External Accommodations
Dexterous End Effector

SSRMS attachment which the ground team or on-orbit crew can use robotically to install, remove and replace payloads and failed components
JEM RMS Payload Support
Express Logistics Carriers Overview

Payload Locations Circled

ELC-1
Port lower
2 Nadir payload sites

ELC-2
Starboard upper
2 Zenith payload sites
Express Logistics Carriers Overview

<table>
<thead>
<tr>
<th>Outboard Side</th>
<th>Inboard Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA$A</td>
<td>P/L PFRAM</td>
</tr>
<tr>
<td>P/L PFRAM</td>
<td>P/L PFRAM</td>
</tr>
<tr>
<td>HPGT</td>
<td>ATA</td>
</tr>
<tr>
<td>SPDM Arm</td>
<td>ASA</td>
</tr>
<tr>
<td>CTC-6</td>
<td>HRS Radiator</td>
</tr>
<tr>
<td>FHRC</td>
<td>P/L PFRAM</td>
</tr>
<tr>
<td>PFRAM</td>
<td>CTC-2</td>
</tr>
</tbody>
</table>

Payload Locations Circled

ELC-3
Port upper
2 Zenith payload sites

ELC-4
Starboard lower
2 Nadir payload sites
<table>
<thead>
<tr>
<th><strong>Express Pallet Adapter (ExPA) Assembly</strong></th>
<th><strong>ExPA overall Mass</strong></th>
<th>255 lb</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ExPA overall dimension</strong></td>
<td>46.05&quot; x 47&quot; x 13.06&quot; (H)</td>
<td></td>
</tr>
<tr>
<td><strong>ExPA payload carrying capability</strong></td>
<td>34&quot; x 46&quot; x 49&quot; (H) and 500 lb</td>
<td></td>
</tr>
</tbody>
</table>
| **Payload electrical interface**         | Power(120VDC & 28VDC): Four NATC connectors  
Data (1553, Ethernet): Six NATC connectors |
| **Payload thermal interface**            | Active heating, passive cooling |
| **Payload structural interface**         | 2.756" X 2.756" Grid with 250-28 UNF Locking Inserts and 1.625" diameter Shear Boss Provisions |
| **EVA compatibility**                    | EVA handrail provisions |
| **EVR compatibility**                    | All EVR interfaces on ExPA |
Japanese Experiment Module Exposed Facility (JEM EF) Overview

- ELM-PS
- JEM-RMS
- JEM-EF
- EF Payloads
- ICS-EF
- ELM-ES
- Airlock
- RAM

to ISS Node 2
JEM EF EFU Location Overview

1. **Pressurized Module**
   - FOV obstruction
   - 1

2. **6 kW; Ethernet, 1553, Video**
   - Currently unoccupied; reserved for ICS back-up

3. **3 kW; Ethernet, 1553, Video**
   - Good zenith viewing

4. **3 kW; Ethernet, 1553, Video**

5. **3 kW; Ethernet, 1553, Video**

6. **3 kW; Ethernet, 1553, Video**

7. **3 kW; Ethernet, 1553, Video**

8. **3 kW; Ethernet, 1553, Video**

9. **Only location with Port view**
   - 9

10. **EPMP Berthing location**

11. **3 kW; Ethernet**

12. **3 kW; Ethernet, 1553, Video**

- Slight obstruction from camera mount; obstructed during EP berthing
- FOV obstruction
- Good zenith viewing
- 6 kW; Ethernet, 1553, Video
- Currently unoccupied; reserved for ICS back-up
- 3 kW; Ethernet, 1553, Video
- Dedicated to ICS
- 3 kW; Ethernet, 1553, Video

* * Capability for 2.5 MT payload
## JEM-EF Detailed Accommodations by Site

<table>
<thead>
<tr>
<th>Location</th>
<th>Viewing</th>
<th>Payload Size</th>
<th>Description / Notes</th>
<th>Power</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ram, Nadir, Zenith</td>
<td>500 kg</td>
<td>Ram field of View (FOV) obstruction by JEM module</td>
<td>6 kW</td>
<td>Ethernet, 1553, Video</td>
</tr>
<tr>
<td>3</td>
<td>Ram, Nadir, Zenith</td>
<td>500 kg</td>
<td>Clear view</td>
<td>3 kW</td>
<td>Ethernet, 1553, Video</td>
</tr>
<tr>
<td>5</td>
<td>Ram, Nadir, Zenith</td>
<td>500 kg</td>
<td>ICS System back-up site (negotiable?)</td>
<td>3 kW</td>
<td>Ethernet, 1553, Video</td>
</tr>
<tr>
<td>7</td>
<td>Ram, Nadir, Zenith</td>
<td>500 kg</td>
<td>ICS-dedicated</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>Port, Zenith, Nadir</td>
<td>2.5 MT</td>
<td>Best volumetrically for large payloads (up to 2.5 MT), but not necessarily the best viewing</td>
<td>3 kW</td>
<td>Ethernet, 1553, Video</td>
</tr>
<tr>
<td>2</td>
<td>Wake, Nadir, Zenith</td>
<td>2.5 MT</td>
<td>Can hold large payloads, but has an FOV obstruction by JEM module</td>
<td>6 kW</td>
<td>Ethernet, 1553, Video</td>
</tr>
<tr>
<td>4</td>
<td>Wake, Nadir, Zenith</td>
<td>500 kg</td>
<td>Clear view</td>
<td>3 kW</td>
<td>1553, Video</td>
</tr>
<tr>
<td>6</td>
<td>Wake, Nadir, Zenith</td>
<td>500 kg</td>
<td>Clear view</td>
<td>3 kW</td>
<td>Ethernet, 1553, Video</td>
</tr>
<tr>
<td>8</td>
<td>Wake, Nadir, Zenith</td>
<td>500 kg</td>
<td>Obstruction during EP berthing, slight obstruction from camera mount</td>
<td>3 kW</td>
<td>1553, Video</td>
</tr>
<tr>
<td>10</td>
<td>Wake, Nadir, Zenith</td>
<td>500 kg</td>
<td>EPMP berthing site</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>Zenith only</td>
<td>500 kg</td>
<td>Good Zenith viewing</td>
<td>3 kW</td>
<td>Ethernet</td>
</tr>
<tr>
<td>12</td>
<td>Zenith only</td>
<td>500 kg</td>
<td>Temporary stowage location</td>
<td>3 kW</td>
<td>Ethernet</td>
</tr>
</tbody>
</table>
ISS Cargo Vehicles

ATV (ESA)
- Cargo Capacity: 5,500 kg

Cygnaus (Orbital Sciences Corp)
- Cargo Capacity: 2,000 kg

HTV (JAXA)
- Cargo Capacity: 5,500 kg

Progress
- Cargo Capacity: 2,250 kg
  (Roscosmos, The Russian Federal Space Agency)

Dragon (SpaceX)
- Cargo Capacity: 3,100 kg ascent
### Payload Allowable Up-Mass & Volume Summary Table

<table>
<thead>
<tr>
<th>Attach Payload Location</th>
<th>Allowable Payload Weight (including Flight Support Equipment)</th>
<th>Accommodation Weight (including adapter plate)</th>
<th>Total Weight</th>
<th>Payload Volume (W x H x L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTV Exposed Pallet (JEM EF Payload)</td>
<td>979 Lb (445 Kg)</td>
<td>121 Lb (55 Kg)</td>
<td>1100 Lb (500 Kg)</td>
<td>31.5” x 39.4” x 72.8” (800mm x 1000mm x 1850 mm)</td>
</tr>
<tr>
<td>HTV Exposed Pallet (ExPA, CEPA Payload)</td>
<td>See ExPA &amp; CEPA payload specification for ELC &amp; CEF</td>
<td>See ExPA &amp; CEPA payload specification for ELC &amp; CEF</td>
<td>*See ExPA &amp; CEPA payload specification for ELC &amp; CEF</td>
<td>*See ExPA &amp; CEPA payload specification for ELC &amp; CEF</td>
</tr>
<tr>
<td>ELC (ExPA)</td>
<td>490 Lb (222 Kg)</td>
<td>250 Lb (114 Kg)</td>
<td>740 Lb (336 Kg)</td>
<td>34” x 49” X 46” (863mm x 1244mm x 1168 mm)</td>
</tr>
<tr>
<td>Columbus (CEPA)</td>
<td>388 Lb (176Kg)</td>
<td>250 Lb (114 Kg)</td>
<td>638 Lb (290 Kg)</td>
<td>34” x 49” X 46” (863mm x 1244mm x 1168 mm)</td>
</tr>
<tr>
<td>JEM-EF</td>
<td>979 Lb (445 Kg)</td>
<td>121 Lb (55 Kg)</td>
<td>1100 Lb (500 Kg)</td>
<td>31.5” x 39.4” x 72.8” (800mm x 1000mm x 1850 mm)</td>
</tr>
</tbody>
</table>

* Location constraint applies in HTV Exposed Pallet
## 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 |
ISS as a Platform for Earth Science

All geographic locations between 51.6 North and South latitude can be observed NADIR pointing.
Provides coverage of 85% of the Earth’s surface and 95% of the world’s populated landmass every 1-3 days.
ISS coverage in 24 hrs for a 70°-swath optical payload. (Courtesy of ESA)

Processing lighting (changes with subsequent passes)
Well-suited for test bed concepts with hardware change out and upgrades
ISS Attitude Torque Equilibrium Attitude (TEA) & Wobble Oscillation Description

For Stage configurations (i.e.; no Orbiter or Orbiter sized vehicle docked on the ISS) in the foreseeable future, the predicted TEA ranges are:
- Roll: -1.0 ~ +3.0 deg
- Pitch: -7.0 ~ +2.0 deg

Momentum Manager Controller Peak to Peak Attitude Wobble Oscillation

<table>
<thead>
<tr>
<th>Performance Descriptions</th>
<th>Peak to Peak Attitude Oscillations Per Orbit</th>
<th>Peak Attitude Variation from Steady-State Orbit: Average Attitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Roll (X) (deg)</td>
<td>Pitch (Y) (deg)</td>
</tr>
<tr>
<td>Non-Micro-Gravity (Assembly Stages) Non-Propulsive (Momentum Manager) Attitude Control Performance Requirement</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Micro-Gravity (Assembly Complete) Non-Propulsive (Momentum Manager) Attitude Control Performance Requirement</td>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Typical Steady-State Performance of Minimum CMG momentum oscillation Momentum Manager Controller</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Typical Steady-State Performance of Minimum Attitude oscillation Momentum Manager Controller</td>
<td>1.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Typical Steady-State Performance of Minimum CMG momentum &amp; Attitude oscillation Blended Momentum Manager Controller</td>
<td>1.6</td>
<td>0.7</td>
</tr>
</tbody>
</table>
ISS quiescent mode = No thruster firings, dockings, EVA, or robotics operations

• Typical response, not worst case

• Maximum per octave band
  - SDMS S3B1N on-orbit accelerometer data.
  - Snapshot of 3 10-minute data takes
  - All data taken on March 16, 26, and 27, Stbd SARJ Rotating, exercise, 3 crew.

ULF-4 analysis concluded peak ELC rotations on the order of 0.03 degrees (quiescent mode)

Data provided by Boeing, June 2010
The International Space Station provides an exceptionally clean environment to external payloads and science assets.

External contamination control requirements limit contaminant deposition to 130Å/year on external payloads and ISS sensitive surfaces.

- Specified levels are lower than any previous space station (Mir, Skylab, Salyut) by several orders of magnitude.

Measurements of contaminant deposition on ISS returned hardware have demonstrated that requirements are met at ISS payload sites.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Side</th>
<th>Requirement (130Å/year)</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISSE 2</td>
<td>ram</td>
<td>520 Å (4 years)</td>
<td>50 Å</td>
</tr>
<tr>
<td></td>
<td>wake</td>
<td>520 Å (4 years)</td>
<td>500 Å</td>
</tr>
<tr>
<td>Node 1 nadir</td>
<td>nadir</td>
<td>390 Å (3 years)</td>
<td>50 Å</td>
</tr>
</tbody>
</table>

Data provided by Boeing, June 2010
Back Up Charts

OTHER
References

• **ISS Program Scientist Toolbox:** [http://iss-science.jsc.nasa.gov/index.cfm](http://iss-science.jsc.nasa.gov/index.cfm)
• **ISS National Laboratory Office:**
• **Advanced Avionics Development Office:**
• **Attached Payload Interface Requirements Document**, SSP 57003
• **FRAM (ELC) Attached Payload Launch Vehicle IRD**, SSP 57012
• **ATV-2 Cargo Summary** (24 Sep 2009)
• **HII Transfer Vehicle Cargo IRD**, HTV-CG-001 Rev D
• **Requirements for International Partner Cargo Transported On Russian Progress and Soyuz Vehicles**, П32928-103
• **Cygnus Fact Sheet** (Orbital, 2009)
• **JEM EF Attached Payload Accommodation Handbook**, NASDA-ESPC-2857B_Cargo IRD
• **Columbus EF Payload Accommodations**, COL-RIBRE-SPE-0165-1C_Columbus External Payloads IRD
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACES</td>
<td>Atomic Clock Ensemble in Space</td>
</tr>
<tr>
<td>AMS</td>
<td>Alpha Magnetic Spectrometer</td>
</tr>
<tr>
<td>ASI</td>
<td>Italian Space Agency</td>
</tr>
<tr>
<td>ASIM</td>
<td>Atmospheric Space Interactions Monitor</td>
</tr>
<tr>
<td>ATA</td>
<td>Ammonia Tank Assembly</td>
</tr>
<tr>
<td>BCDU</td>
<td>Battery Charge Discharge Unit</td>
</tr>
<tr>
<td>CALET</td>
<td>Calorimetric Electron Telescope</td>
</tr>
<tr>
<td>C&amp;DH</td>
<td>Command and Data Handling</td>
</tr>
<tr>
<td>CEF</td>
<td>Columbus Exposed Facility</td>
</tr>
<tr>
<td>CEPA</td>
<td>Columbus External Payload Adapter</td>
</tr>
<tr>
<td>CMG</td>
<td>Control Moment(um) Gyro(scope)</td>
</tr>
<tr>
<td>COL-EPF</td>
<td>Columbus Exposed Payload Facility</td>
</tr>
<tr>
<td>CSA</td>
<td>Canadian Space Agency</td>
</tr>
<tr>
<td>CTC</td>
<td>Cargo Transport Container</td>
</tr>
<tr>
<td>DPP</td>
<td>Dextre Pointing Package</td>
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<tr>
<td>ELC</td>
<td>External Logistics Carrier</td>
</tr>
<tr>
<td>ELM-ES</td>
<td>Experiment Logistics Module-Exposed Section</td>
</tr>
<tr>
<td>ELM-PS</td>
<td>Experiment Logistics Module – Pressurized Section</td>
</tr>
<tr>
<td>EF</td>
<td>Exposed Facility</td>
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<tr>
<td>EFU</td>
<td>Exposed Facility Unit</td>
</tr>
<tr>
<td>EPF</td>
<td>Exposed Payload Facility</td>
</tr>
<tr>
<td>EPMP</td>
<td>Exposed Pallet – Multi-Purpose</td>
</tr>
<tr>
<td>ESA</td>
<td>European Space Agency</td>
</tr>
<tr>
<td>EuTEF</td>
<td>European Technology Exposure Facility</td>
</tr>
<tr>
<td>EVA</td>
<td>Extravehicular Activity</td>
</tr>
<tr>
<td>EVR</td>
<td>Extravehicular Robotics</td>
</tr>
<tr>
<td>ExPA</td>
<td>EXPRESS Pallet Adapter</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>FHRC</td>
<td>Flex Hose Rotary Coupler</td>
</tr>
<tr>
<td>FOV</td>
<td>Field of View</td>
</tr>
<tr>
<td>FSE</td>
<td>Flight Support Equipment</td>
</tr>
<tr>
<td>HPGT</td>
<td>High Pressure Gas Tank</td>
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<tr>
<td>HREP</td>
<td>Hyperspectral Imager for the Coastal Ocean (HICO)/Remote Atmospheric and Ionospheric Detection System (RAIDS) Experiment Payload</td>
</tr>
<tr>
<td>HRS</td>
<td>Heat Rejection Subsystem</td>
</tr>
<tr>
<td>HTV</td>
<td>H-II Transfer Vehicle (Japanese resupply vehicle)</td>
</tr>
<tr>
<td>ICS-EF</td>
<td>Inter-Satellite Communication System – Exposed Facility</td>
</tr>
<tr>
<td>ISS</td>
<td>International Space Station</td>
</tr>
<tr>
<td>JAXA</td>
<td>Japan Aerospace Exploration Agency</td>
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<tr>
<td>JEM</td>
<td>Japanese Experiment Module</td>
</tr>
<tr>
<td>JEM-EF</td>
<td>Japanese Experimental Module-Exposed Facility</td>
</tr>
<tr>
<td>JEM-PM</td>
<td>Japanese Experimental Module-Pressurized Module</td>
</tr>
<tr>
<td>Kg</td>
<td>kilogram</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>LEE</td>
<td>Latching End Effector MAXI Monitor All-sky X-ray Image</td>
</tr>
<tr>
<td>MCE</td>
<td>Multi-mission Consolidated Equipment</td>
</tr>
<tr>
<td>MIM</td>
<td>Multi-Increment Manifest</td>
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<tr>
<td>MiPROM</td>
<td>Multi-Increment Payload Resupply and Outfitting Manifest</td>
</tr>
<tr>
<td>MISSE</td>
<td>Materials International Space Station Experiment</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>NTA</td>
<td>Nitrogen Tank Assembly</td>
</tr>
<tr>
<td>ODAR</td>
<td>Obsolescence Driven Avionics Re-Design</td>
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<tr>
<td>OPALS</td>
<td>Optical Planetary Access Link for Space Station</td>
</tr>
<tr>
<td>PCU</td>
<td>Plasma Contactor Unit</td>
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<tr>
<td>PFRAM</td>
<td>Passive Flight Releasable Attach Mechanism</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
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<tr>
<td>PIU</td>
<td>Power Interface Unit</td>
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<tr>
<td>P/L</td>
<td>Payload</td>
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<tr>
<td>PRELSE</td>
<td>Platform for Retrievable Experiments in a Leo Space Environment</td>
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<tr>
<td>R2D2</td>
<td>Robotic Refueling Dexterous Demonstration using Dextre</td>
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<td>RMS</td>
<td>Remote Manipulator System</td>
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<tr>
<td>SAGE III</td>
<td>Stratospheric Aerosol and Gas Experiment III w/ Hexapod</td>
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<tr>
<td>SARJ</td>
<td>Solar Array Rotary Joint</td>
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<tr>
<td>SASA</td>
<td>S-Band Antenna Support Assembly Testbed</td>
</tr>
<tr>
<td>SCAN</td>
<td>Space Communication And Navigation Testbed</td>
</tr>
<tr>
<td>SDN</td>
<td>Starboard Deck Nadir</td>
</tr>
<tr>
<td>SDX</td>
<td>Starboard Deck X-Direction</td>
</tr>
<tr>
<td>SEDA</td>
<td>Space Environmental Data Acquisition Equipment</td>
</tr>
<tr>
<td>SMILES</td>
<td>Superconducting Sub-Millimeter Wave Limb Emission Sounder</td>
</tr>
<tr>
<td>SOLAR</td>
<td>Solar Observatory Grouping</td>
</tr>
<tr>
<td>SOX</td>
<td>Starboard Overhead X-Direction</td>
</tr>
<tr>
<td>SOZ</td>
<td>Starboard Overhead Zenith</td>
</tr>
<tr>
<td>SPDM</td>
<td>Special Purpose Dexterous Manipulator</td>
</tr>
<tr>
<td>Stbd</td>
<td>Starboard</td>
</tr>
<tr>
<td>Sx</td>
<td>SpaceX (US commercial resupply vehicle)</td>
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<tr>
<td>TBD</td>
<td>To Be Determined</td>
</tr>
<tr>
<td>TBR</td>
<td>To Be Resolved</td>
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<td>TEA</td>
<td>Torque Equilibrium Attitude</td>
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<td>TUS-RA</td>
<td>Trailing Umbilical System-Reel Assembly</td>
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<td>ULF</td>
<td>Utilization &amp; Logistics Flight</td>
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<td>U.S.</td>
<td>United States</td>
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<tr>
<td>USOS</td>
<td>U.S. Operational Segment</td>
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</table>
Facility to support visual and multispectral remote sensing using Lab Optical Window

US Laboratory Window
50-cm diameter
Telescope-quality optical glass
NADIR view

Window Observational Research Facility (WORF)
Service Module Window
40-cm diameter
NADIR view
**Middeck Locker**

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

**International Sub rack Interface Standard Drawer**

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

**Sub Rack size payload capability with standard utilities such as power, data, cooling and gases**

**EXPRESS 8/2 Configuration**

**International Standard Payload Rack**

**Secondary Structure & Subsystems**

**8/2 Payload Configuration (8 Middeck Lockers, 2 Powered ISIS Drawers)**

**ExPRESS Rack**
### 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</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>Water Cooling</td>
<td>RS422 Analog</td>
<td>RS422 Analog</td>
<td>RS422 Analog</td>
</tr>
<tr>
<td>Command and Data Handling</td>
<td>Ethernet 5 Vdc Discrete</td>
<td>Ethernet 5 Vdc Discrete</td>
<td>Ethernet 5 Vdc Discrete</td>
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<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>
Payload Operations Integration Center Interfaces

Payload/ Kuband & Ancillary Telemetry
Planning Products, Voice, Ops Mgmt.

Payload Ops Control Center Huntsville

Payload/ Kuband & Vehicle Telemetry

Vehicle Telemetry, Voice, Video
Commands, Uplinks

Mission Control Center Houston

White Sands Complex, New Mexico

Space Shuttle

TDRSS

ISS

Global Customer Support

International Partner Facilities

Russia

Europe

Japan

Italy

Canada

GRC

ARC

JSC

MSFC

NASA Telescience Support Centers

Payload User Sites TReK

MCCH to International Partner Services

Commands, Uplinks, Voice

Vehicle Telemetry, Voice, Video

Payload Operations Integration Center Interfaces

49 Telescience Resource Kit (TReK) Clients
Operations Timeframe Overview

TYPICAL OPERATIONS TIMEFRAME

~L+2 days up through 6 months or more on-orbit

- Certification of Flight Readiness
- Launch
- On-Orbit Operations
- Landing
- Post-Landing Payload Processing

- CoFR documentation addresses both hardware Launch and Stage operations

Requirements Documentation and Verification Paperwork

- Hardware De-integration
- Sample Return
ISS Requirements & Agreements

Station Program Implementation Plan (SPIP)

Integration Timeline

Agency to Agency
- Other Requirements (Safety, OpNom, etc.)
  - SPIA (Standard PIA)
  - IRD’s (Interface Requirements Documents)
  - IDD’s (Interface Definition Documents)
  - CoFR (Certification of Flight Readiness)

Program to Payload
- PIA (Payload Integration Agreement)
  - Schedule Template
  - PIM Schedules
  - Status Reports
  - Stoplights
  - ICD’s (Interface Control Document)
    - Applicability Matrix
    - Verification Requirements
  - Verification Data
  - Data Sets
  - Lean Integration Data Package

Payload to Program
- SPIA (Standard PIA)
- PIM Schedules
- Status Reports
- Stoplights
- ICD’s (Interface Control Document)
  - Applicability Matrix
  - Verification Requirements
- Verification Data
- Data Sets
- Lean Integration Data Package

Management CoFR Reporting

Continuing on-orbit tasks
- Recertification
- RCAR
- CoFR

Other Requirements
- Safety, OpNom, etc.
- SPIA (Standard PIA)
- PIA (Payload Integration Agreement)
- ICD’s (Interface Control Document)
- Verification Data
- Data Sets
- Lean Integration Data Package

ISS Payload Integration Process Overview

1/11/11
ISS Requirements & Agreements

• Requirements ensure safety, interface, and operations compatibility

Safety Requirements Documents
• NSTS 1700.7B, “Safety Policy and Requirements for Payloads using the Space Transportation System”
• NSTS 1700.7B, ISS Addendum, “Safety Policy and Requirements for Payloads Using the International Space Station”
• NSTS/ISS 13830, “Payload Safety Review and Data Submittal Requirements for Payloads Using the ISS”
• NSTS/ISS 18798, “Interpretations of NSTS/ISS Payload Safety Requirements”
• KHB 1700.7, “Space Shuttle Ground Safety Handbook”
• SSP 52005, “Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures”
• SSP 57025, “ISS Payload Interface System Fault Tolerance Document”

Standard Requirements Documents (partial listing)
• SSP 52000-PDS, “Payload Data Sets Blank Book”
• SSP 52054, “ISS Program Payloads Certification of Flight Readiness Implementation Plan, Generic”
• SSP 57000, “Pressurized Payloads Interface Requirements Document”
• SSP 57003, “Attached Payload Interface Requirements Document”
• SSP 57061, “Standard Payload Integration Agreement for Attached Payloads”
• SSP 57072, “Standard Payload Integration Agreement for Pressurized, Small, and ExPRESS/WORF Rack Payloads”

• IP requirements also exist for integration into partner modules, elements, or facilities.

Joint Agreements are required in the following disciplines

• Safety Requirements
• Physical Interface Requirements
• Human Factors and Labeling Requirements
• Electrical/Thermal Interface Requirements
• Command and Data Downlink Requirements
• Operational Requirements
• Crew Training Requirements
• Transportation to/from Orbit Requirements
• Ground Data Services
• EVA/EVR Requirements