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

- ELC4 (ULF5)

- ESP-3

- Keel Side

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

- Kibo
  - External Facility
  - 5 sites NASA, 10 sites total

(ULF6, 2011)
## External Research Accommodations
### Express Logistic Carrier

<table>
<thead>
<tr>
<th>ELC Single Adapter Resources</th>
<th>NASA payload sites per ELC</th>
<th>(2)</th>
</tr>
</thead>
</table>

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

- **Research Payload ExPA**
  - Proposed C&DH Enhancement to each Research Payload site
  - 100 Mbps Two Way wireless LAN

(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

<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>
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.
(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)
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.

Research Planning Working Group (RPWG)

Payload-specific Resource Definition and Two-pagers (RPO)

ISS Payloads Office Feasibility Assessments (Integration Organizations)

Payload-prioritization (ISS Program Scientist)

Flight & Increment-specific Utilization Allocations (ISS Program Office)

(Up/downmass, Crewtime, Power, etc)

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

~ Increment minus 19 months

Increment-specific Research Plan

ISS Payloads Control Board

Payload Tactical Plan (PTP)

~ Increment minus 16 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

<table>
<thead>
<tr>
<th>STRATEGIC</th>
<th>TACTICAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDR</td>
<td>Safety Phase III</td>
</tr>
<tr>
<td>Safety Phase 0/I</td>
<td>Payload Pre-Ship</td>
</tr>
<tr>
<td>CDR</td>
<td>CoFR</td>
</tr>
<tr>
<td>Safety Phase II</td>
<td>Payload Manifested</td>
</tr>
</tbody>
</table>

**Key:**
- P – Preliminary
- U – Update
- F – Final

- Export Classification Letter
- Prelim Design Data Package
- Safety Data (Phase 0-I)
- Training Strategy TIMs
- Payload Integration Agreement (PIA)
- Critical Design Data Package
- Safety Data (Phase II)
- ICD/Verification Requirements
- Resource Requirements Definition
- Procedures & Displays DS (P)
- 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)
- C&DH DS (U)
- Payload Trainer H/W & S/W
- Training Plans & Courseware
- Payload Planning DS (F)
- Interface Control Document (ICD) (U)
- Payload Verification Plan (PVP) (U)
- Requirements Exceptions
- CoFR Endorsement

ISS Payload Integration Process Overview

1/11/11
ISS Payload Integration Process Overview

1/11/11

Strategic Timeframe Overview

TYPICAL STRATEGIC TIMEFRAME

Preliminary Design Review

Export Classification Letter

ISS Design Support Teams

Payload Integration Agreement (PIA) Development

Develop Product Delivery Schedule

Begin Technical Interchange Meetings

Phase 0/I Safety Review

Hardware Interface Control Document (ICD), Ops Nomenclature

Critical Design Review

Phase II Safety Review

PIA Update (if req’d), Baseline Hardware ICD

Payload Development and Verification

Payload Displays, Software ICD Development

Payload Tactical Plan (Inc/Flt Assignment)

Resource Requirements Definition

Identifies the initial processes for the Payload Integration activity
ISS Payload Integration Process Overview

Tactical Timeframe Overview

TYPICAL TACTICAL TIMEFRAME

~L-16 to L-12M

Manifest and Stowage, Drawings, KSC Data Sets

~L-12 to L-6M

Phase III Safety Review

~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

Training Units Delivered, Planning Data Set, Operations Data Set

Crew Training

Baseline Datasets: Command & Data Handling, Manifest and Stowage, Drawing, Procedures and Displays

ISS Interface Verification

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

**Payload Locations Circled**

**ELC-3**
Port upper
2 Zenith payload sites

**ELC-4**
Starboard lower
2 Nadir payload sites
<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExPA overall Mass</td>
<td>255 lb</td>
</tr>
<tr>
<td>ExPA overall dimension</td>
<td>46.05” x 47” x 13.06” (H)</td>
</tr>
<tr>
<td>ExPA payload carrying capability</td>
<td>34” x 46” x 49” (H) and 500 lb”</td>
</tr>
<tr>
<td>Payload electrical interface</td>
<td>Power(120VDC &amp; 28VDC): Four NATC connectors Data (1553, Ethernet): Six NATC connectors</td>
</tr>
<tr>
<td>Payload thermal interface</td>
<td>Active heating, passive cooling</td>
</tr>
<tr>
<td>Payload structural interface</td>
<td>2.756” X 2.756” Grid with 250-28 UNF Locking Inserts and 1.625” diameter Shear Boss Provisions</td>
</tr>
<tr>
<td>EVA compatibility</td>
<td>EVA handrail provisions</td>
</tr>
<tr>
<td>EVR compatibility</td>
<td>All EVR interfaces on ExPA</td>
</tr>
</tbody>
</table>
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**
     - 2
       - 6 kW; Ethernet, 1553, Video
   - 4
     - 3 kW; Ethernet, 1553, Video
   - 6
     - 3 kW; Ethernet, 1553, Video
   - 8
     - 3 kW; Ethernet, 1553, Video

2. **JEM-EF**
   - **FOV obstruction**
     - Slight obstruction from camera mount; obstructed during EP berthing
   - **Good zenith viewing**
     - 11
     - 3 kW; Ethernet
   - **Currently unoccupied; reserved for ICS back-up**
     - 5
     - 3 kW; Ethernet, 1553, Video
   - **Dedicated to ICS**
     - 7
     - 3 kW; Ethernet, 1553, Video
   - **Temporary Parking**
     - 12
     - 3 kW; Ethernet
   - **EPMP Berthing location**
     - 10

3. **Other Locations**
   - **Only location with Port view**
     - 9
     - 3 kW; Ethernet, 1553, Video
   - **Capability for 2.5 MT payload**

---

**Notes:**
- 6 kW; Ethernet, 1553, Video
- 3 kW; Ethernet, 1553, Video
- 3 kW; Ethernet
- 3 kW; Ethernet, 1553, Video
- 3 kW; Ethernet, 1553, Video
- 3 kW; Ethernet

---

**ISPP OZ 3/Chang**
<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>
Columbus EF
ISS Cargo Vehicles

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

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

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

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

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 |
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 as a Platform for Earth Science

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
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: $-1.0 \sim +3.0 \text{ deg}$
Pitch: $-7.0 \sim +2.0 \text{ deg}$
Yaw: $-15 \sim +15 \text{ deg}$.  

### 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 ($\alpha$) (deg)</td>
<td>Pitch ($\gamma$) (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</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Momentum Manager Controller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Steady-State Performance of Minimum Attitude oscillation</td>
<td>1.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Momentum Manager Controller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Steady-State Performance of Minimum CMG momentum &amp; Attitude oscillation Blended</td>
<td>1.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Momentum Manager Controller</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ISS Quiescent Mode Truss Vibratory Environment
For External Payload Pointing Instrument
Data measured on ISS S3 truss

- 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
- ISS National Laboratory Office:
- Advanced Avionics Development Office:
  http://iss-www.jsc.nasa.gov/nwo/avionics/aado/home/web/
- 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>Acronyms</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) Gyroscope</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>
</tr>
<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>
</tr>
<tr>
<td>EFU</td>
<td>Exposed Facility Unit</td>
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<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>Full Form</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>
</tr>
<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>
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<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 EffectorMAXI 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>
</tr>
<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>
</tr>
<tr>
<td>OPALS</td>
<td>Optical Planetary Access Link for Space Station</td>
</tr>
<tr>
<td>PCU</td>
<td>Plasma Contactor Unit</td>
</tr>
<tr>
<td>PFRAM</td>
<td>Passive Flight Releasable Attach Mechanism</td>
</tr>
</tbody>
</table>
Acronyms (Continued)

PIU Power Interface Unit
P/L Payload
PRELSE Platform for Retrievable Experiments in a Leo Space Environment
R2D2 Robotic Refueling Dexterous Demonstration using Dextre
RMS Remote Manipulator System
SAGE III /Hexapod Stratospheric Aerosol and Gas Experiment III w/ Hexapod
SARJ Solar Array Rotary Joint
SASA S-Band Antenna Support Assembly Testbed
SCAN Space Communication And Navigation Testbed
SDN Starboard Deck Nadir
SDX Starboard Deck X-Direction
SEDA Space Environmental Data Acquisition Equipment
SMILES Superconducting Sub-Millimeter Wave Limb Emission Sounder
SOLAR Solar Observatory Grouping
SOX Starboard Overhead X-Direction
SOZ Starboard Overhead Zenith
SPDM Special Purpose Dexterous Manipulator
Stbd Starboard
Sx SpaceX (US commercial resupply vehicle)
TBD To Be Determined
TBR To Be Resolved
TEA Torque Equilibrium Attitude
TUS-RA Trailing Umbilical System-Reel Assembly
ULF Utilization & Logistics Flight
U.S. United States
USOS U.S. Operational Segment
Facility to support visual and multispectral remote sensing using Lab Optical Window
Windows on the Earth

Service Module Window
40-cm diameter
NADIR view
**ExPRESS Racks** *(Expedite the Processing of Experiments for SpaceStation)*

**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)
<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><strong>Structural</strong></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><strong>Power</strong></td>
<td>28 Vdc, 0 – 500 W</td>
<td>28 Vdc, 0 – 500 W</td>
<td>2000 Watts 28Vdc power</td>
</tr>
<tr>
<td><strong>Air Cooling</strong></td>
<td>≤ 200 Watts</td>
<td>&lt;100 Watts</td>
<td>1200 Watts</td>
</tr>
<tr>
<td><strong>Thermal Control System Water Cooling</strong></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><strong>Command and Data Handling</strong></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><strong>Video</strong></td>
<td>NTSC/RS170A</td>
<td>NTSC/RS170A</td>
<td>NTSC/RS170A</td>
</tr>
<tr>
<td><strong>Vacuum Exhaust System</strong></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><strong>Nitrogen</strong></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>
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 Payload Integration Process Overview

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ISS Requirements & Agreements

Station Program Implementation Plan (SPIP)

- SPIA (Standard PIA)
- IRD’s (Interface Requirements Documents)
- IDD’s (Interface Definition Documents)
- CoFR (Certification of Flight Readiness)

Integration Timeline

- Schedule Template
- PIA (Payload Integration Agreement)
- ICD’s (Interface Control Document)
- Verification Data
- Lean Integration Data Package

Integration Agreements

Program to Payload

Other Requirements (Safety, OpNom, etc.)
- PIM Schedules
- Status Reports
- Stoplights
- Verification Requirements
- Data Sets
- Management CoFR Reporting

Payload to Program

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)

Integration Agreements

- CoFR Checklists
- CoFR Letters

Continuing on-orbit tasks
- Recertification
- RCAR
- CoFR

Integration Timeline

- PIA (Payload Integration Agreement)
- ICD’s (Interface Control Document)
- Verification Data
- Data Sets
- Lean Integration Data Package

Management CoFR Reporting

ISS Payload Integration Process Overview

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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 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