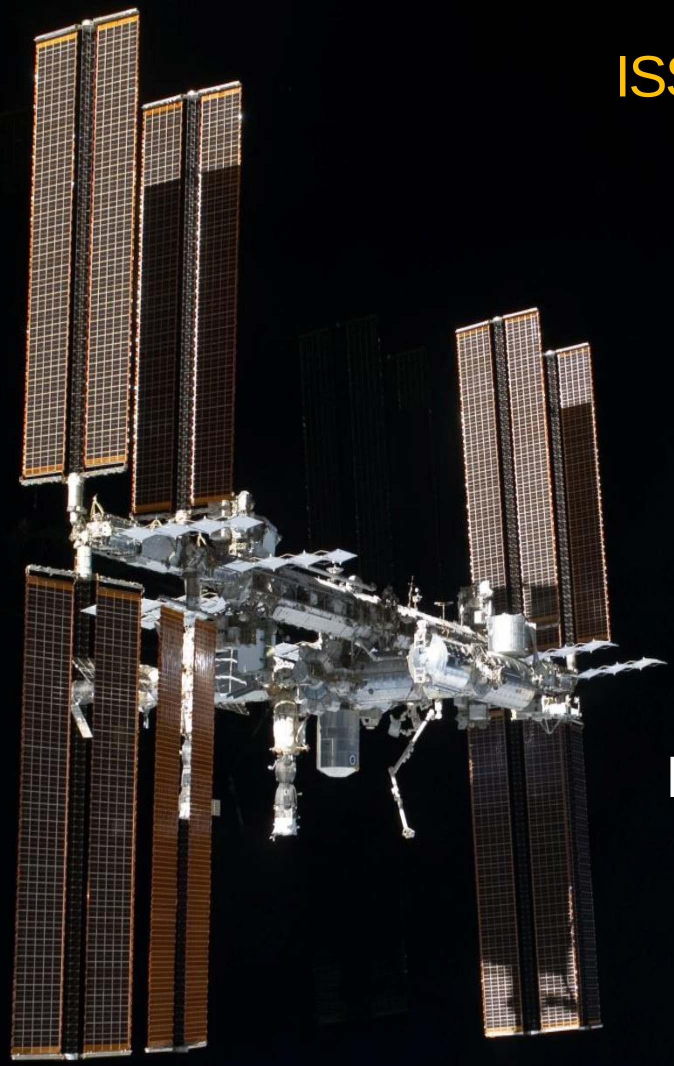
ISS Research Capability for Hosting Space Science Instruments



Kenol Jules

ISS Research Integration Office

NASA Johnson Space Center

Houston

Heliophysics Explorers Program 2019 Medium-Class Explorer (MIDEX) Pre-Proposal Conference (PPC)

July 23, 2019

International Space Station

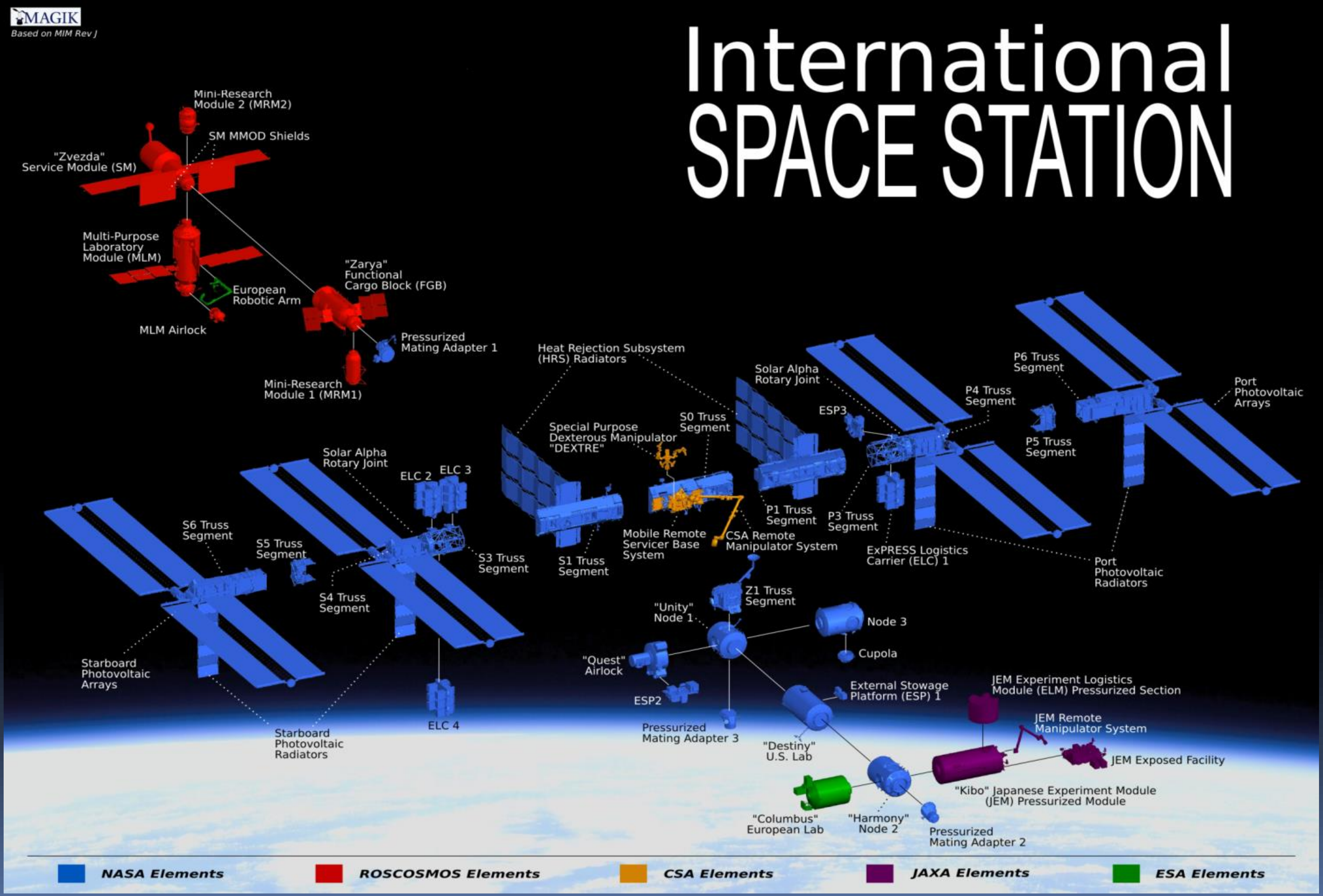
Created by a partnership of 5 space agencies

10 years and over 100 missions to assemble

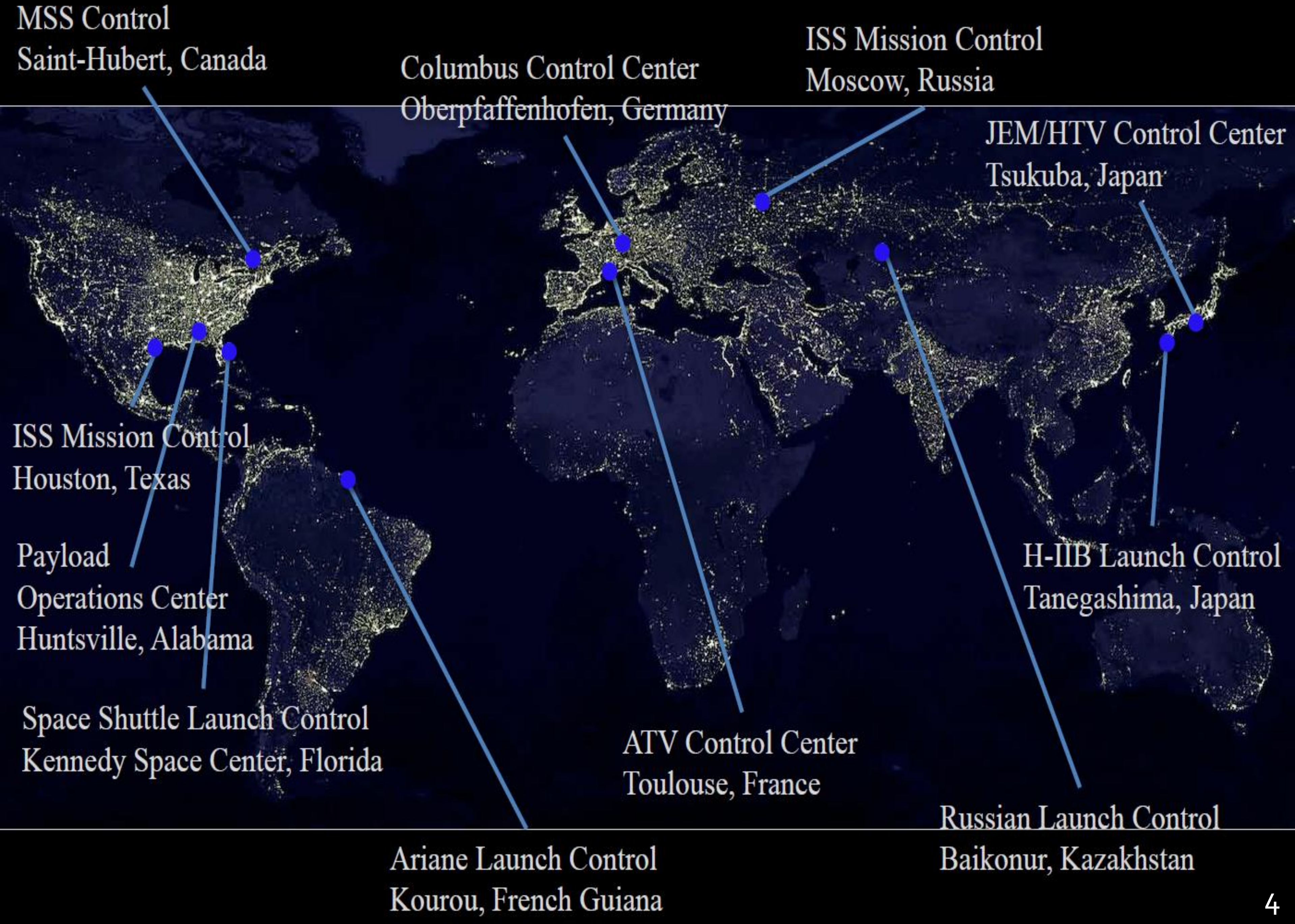
A laboratory for **Microgravity** and **Heliophysics** research at a scale that has not been achieved before and that no one agency or country could sustain

Creating knowledge that improves life here on earth and provides a stepping stone for humans to push further into space

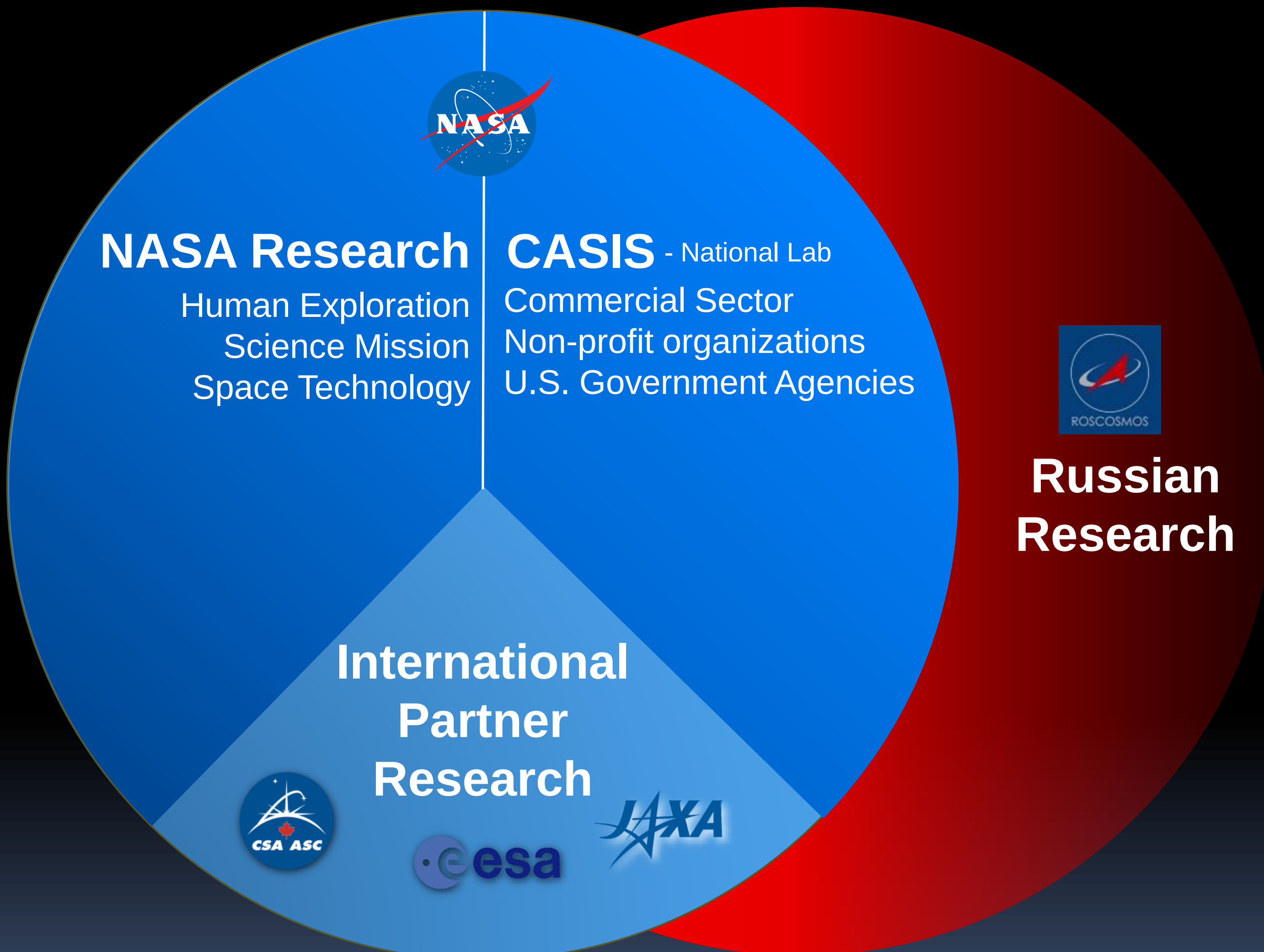
A collaboration of 5 space agencies



Global Ground-Based Infrastructure



Research Sponsors on ISS



Biology and Biotechnology, Earth, Space Science, Educational Activities, Human Research, Physical & Material Sciences and Technology Demonstration

International Space Station Key Features

- Sustainable microgravity and space research platform for long term studies
- Permanent Crew presence
- Access to vacuum of space
- External (space) and internal research
- Automated, human, and robotic operated research
- Exposure to the thermosphere
- Earth observations at high altitude and velocity
- Habitable environmentally controlled environment
- Nearly continuous data and communication link to anywhere in the world
- Payload to orbit and return capability (for some external payloads)
- Modularity and maintainability built into the design ensures mission life, allows life extension, vehicle evolution and technology upgrades

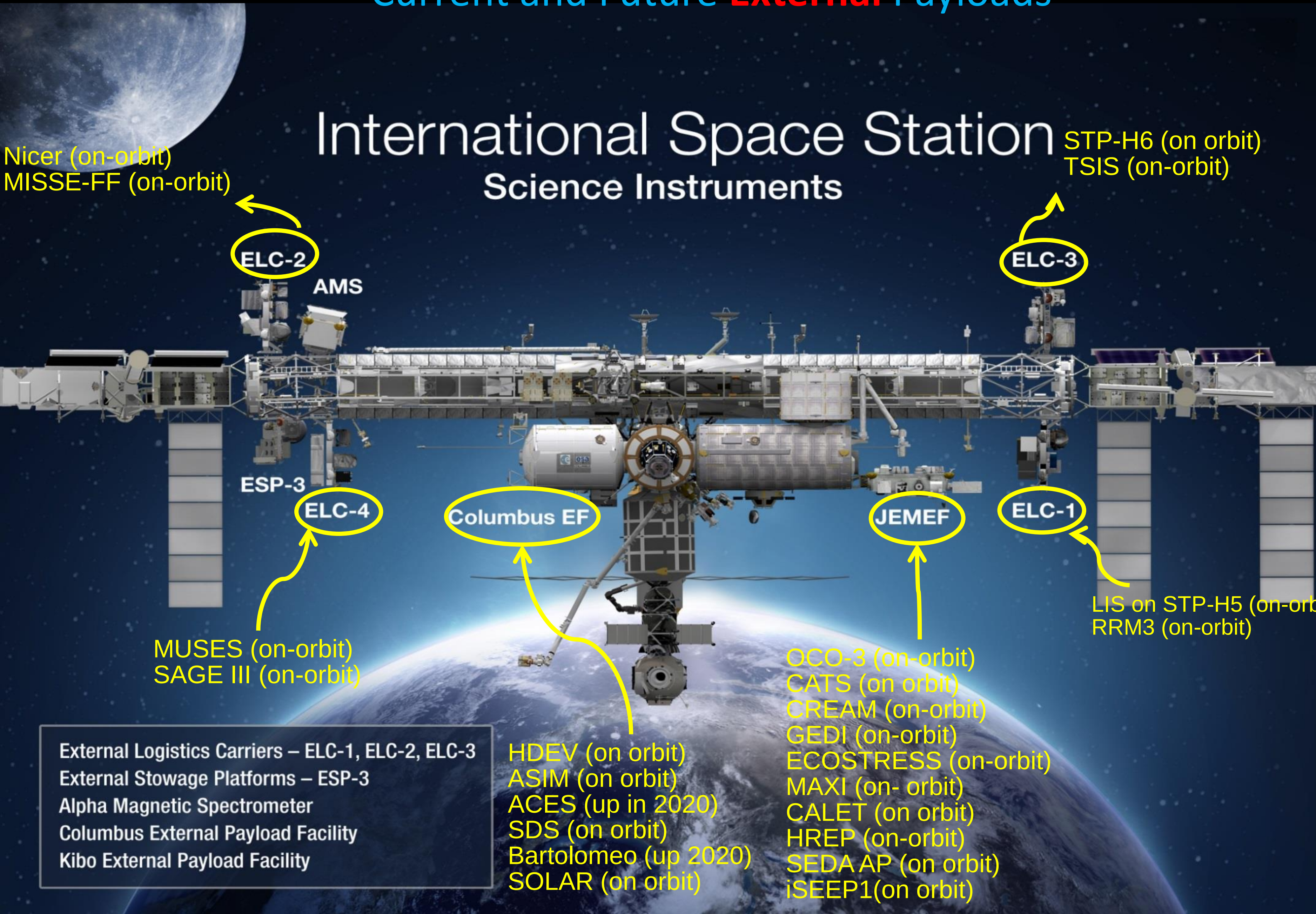
ISS Payload Philosophy

Our goal is to fly and operate a payload as soon as it is ready

To operate the ISS like a laboratory to enable the flexibility for investigators to adapt their research plan based on new and unexpected findings

To continue to make the integration and operation of payloads on ISS as simple and ground lab like as possible

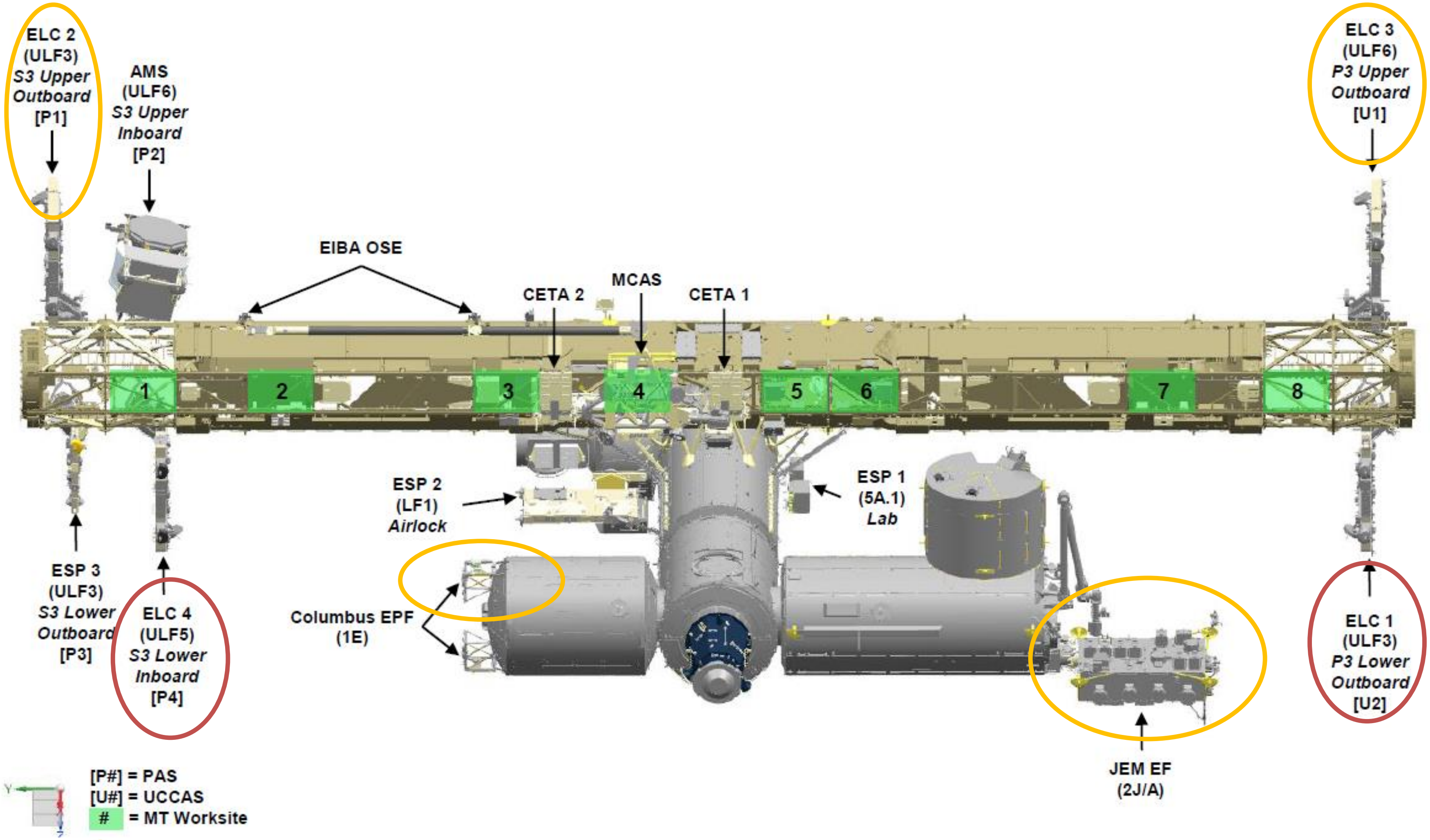
Current and Future External Payloads



External Sites

The Japan Aerospace Exploration Agency (JAXA) has demonstrated small satellite deployment from the Japanese Experiment Module "Kibo" of the International Space Station (ISS) in order to enhance the capability of Kibo's utilization and to offer more launch opportunities to small satellites.

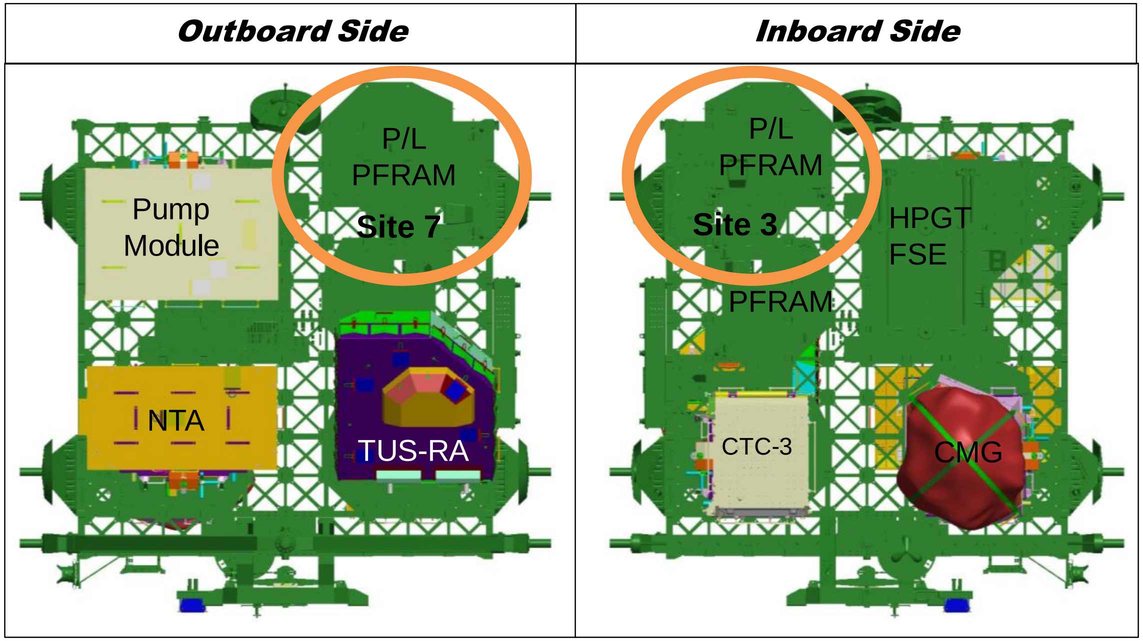
ISS External Attached Sites for Heliophyscis Experiments



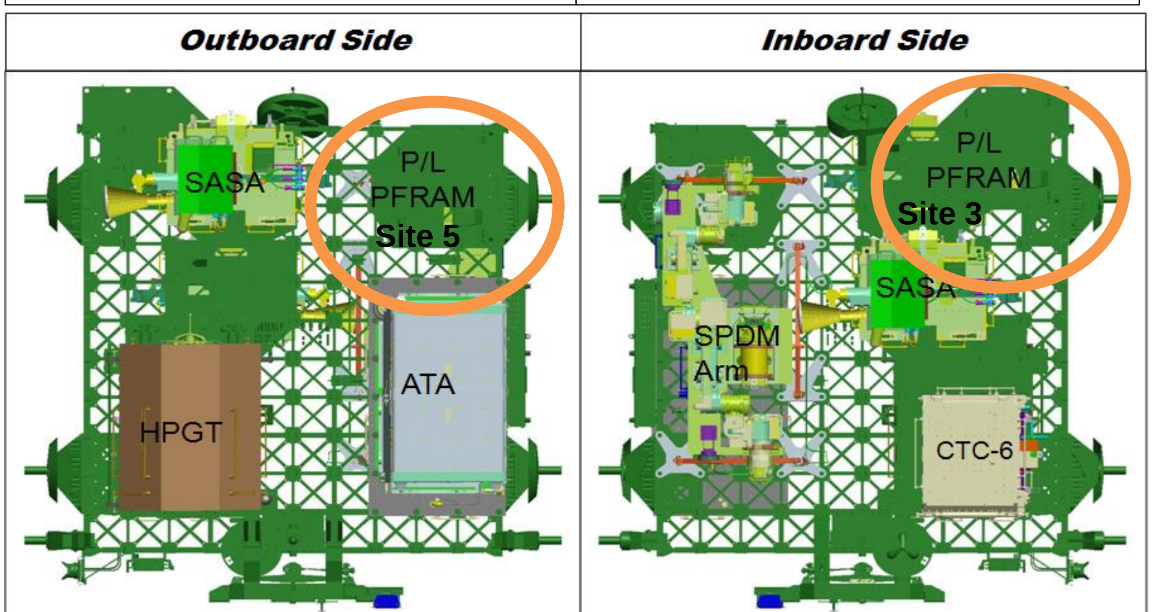
Best External Sites For Heliophysics Instruments

Express Logistics Carriers Overview

Payload Locations Circled

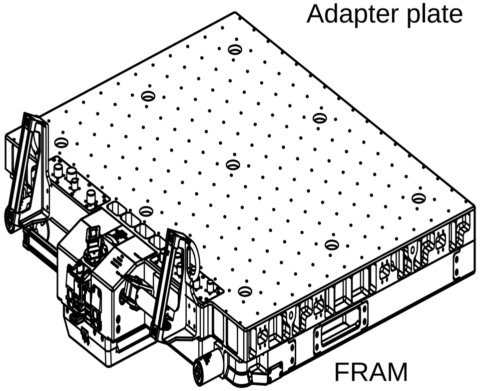


ELC-2 (Both Ram)
Starboard upper
2 Zenith payload sites

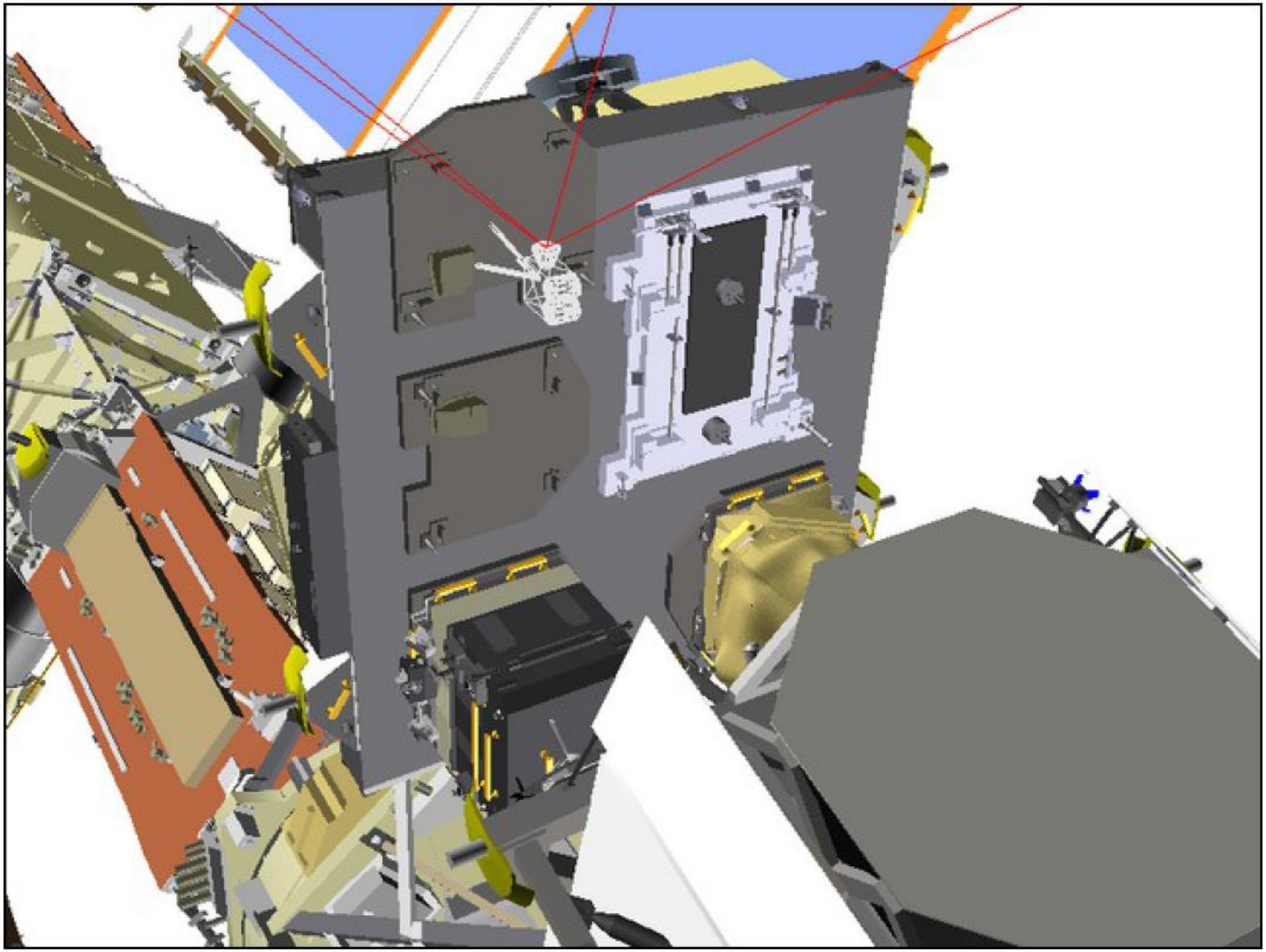


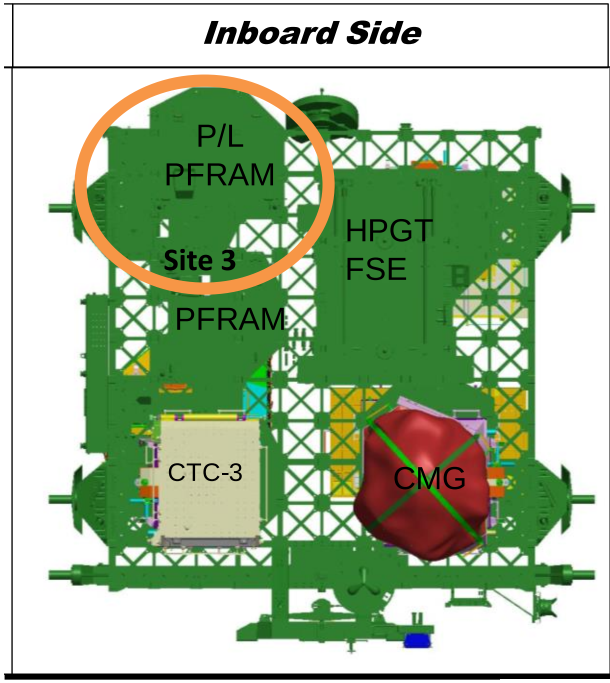
ELC-3 (3-Ram;5-Wake)
Port upper
2 Zenith payload sites

Express Pallet Adapter (ExPA) Assembly (GFE)

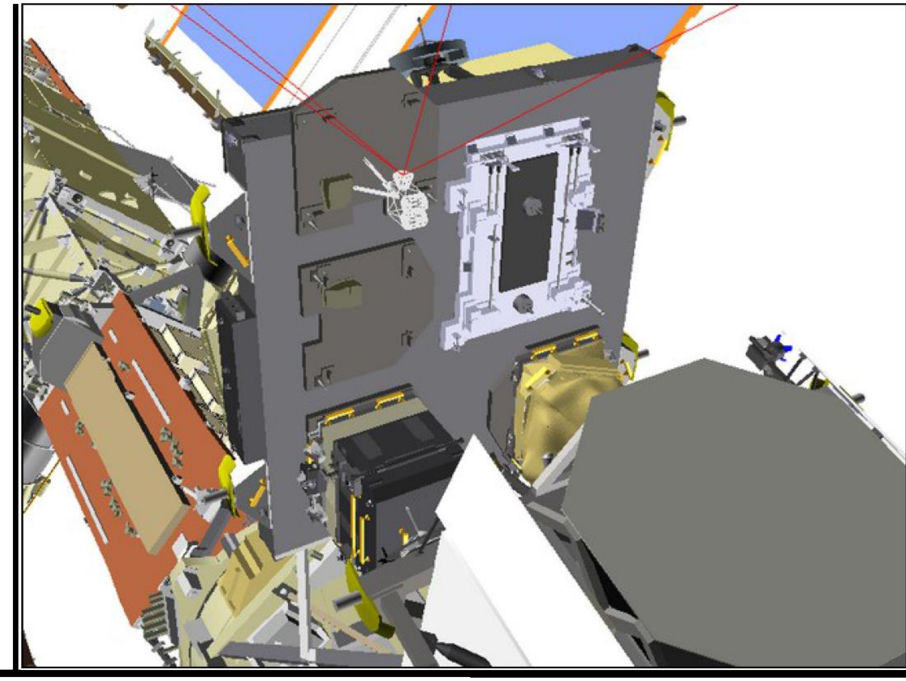
Express Pallet Adapter (ExPA) Assembly		
	ExPA overall Mass	255 lb
	ExPA overall dimension	46.05” x 47” x 13.06” (H)
	ExPA payload carrying capability	34” x 46” x 49” (H) and 500 lb”
	Payload electrical interface	Power(120VDC & 28VDC): Four NATC connectors Data (1553, Ethernet): Six NATC connectors
	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

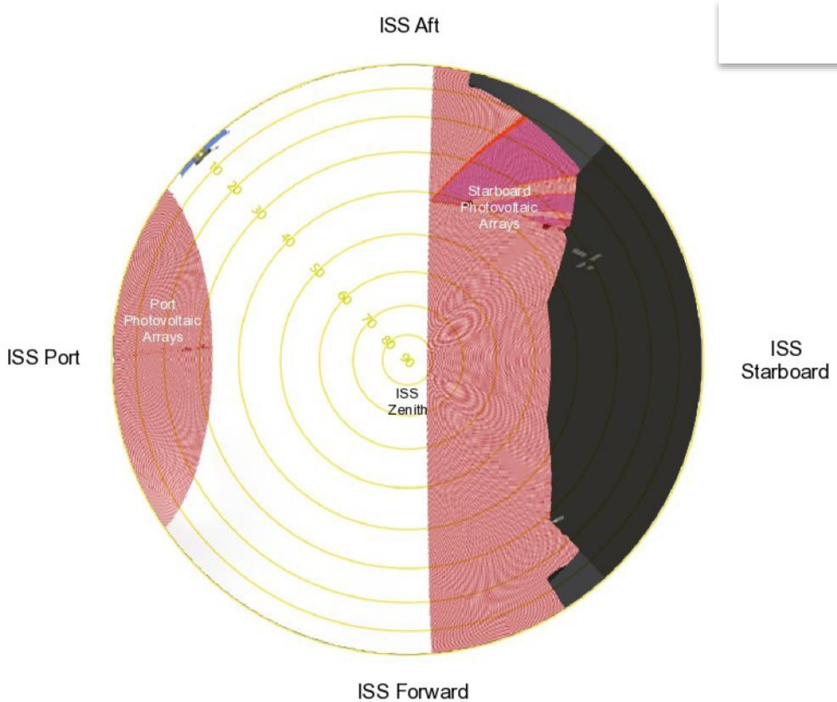
Placement of "Eye" Point for Sensor Viewing for Field of View Analysis

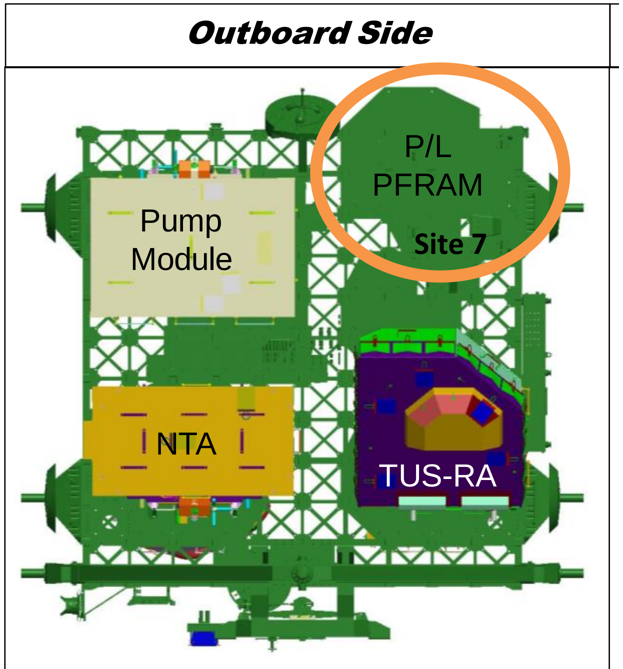




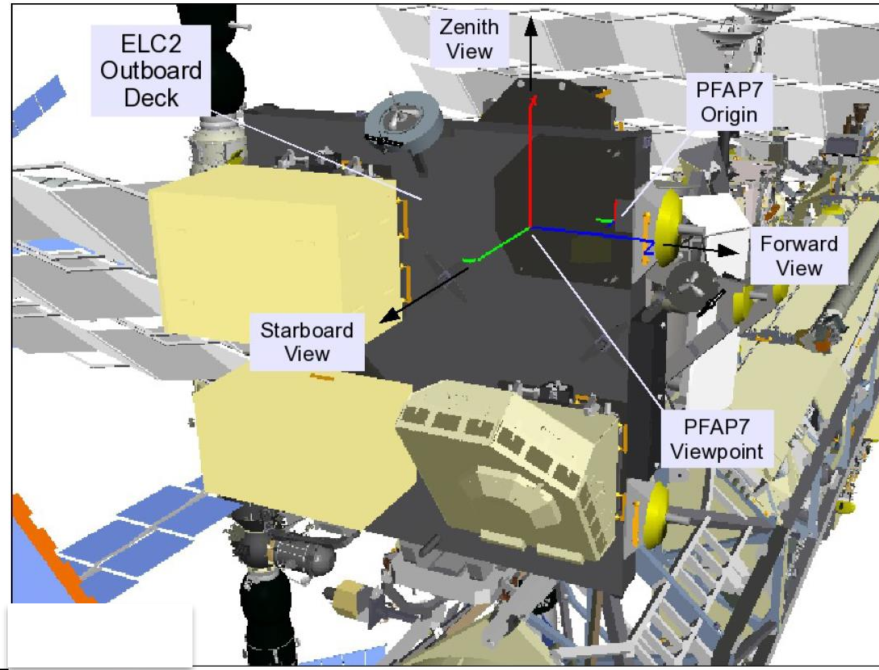
ELC-2 (Ram)/Site 3
Starboard upper
Zenith site

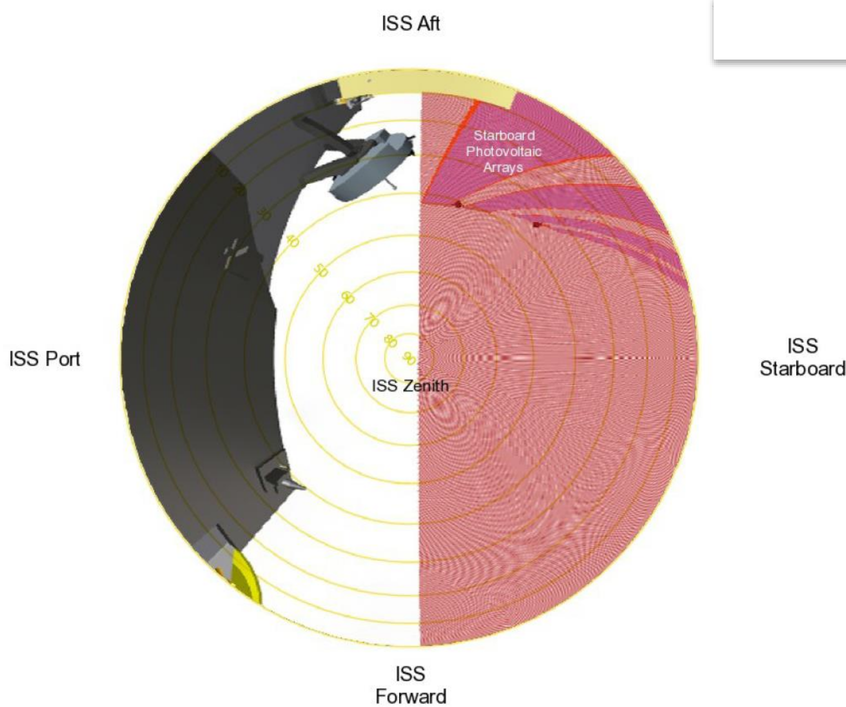


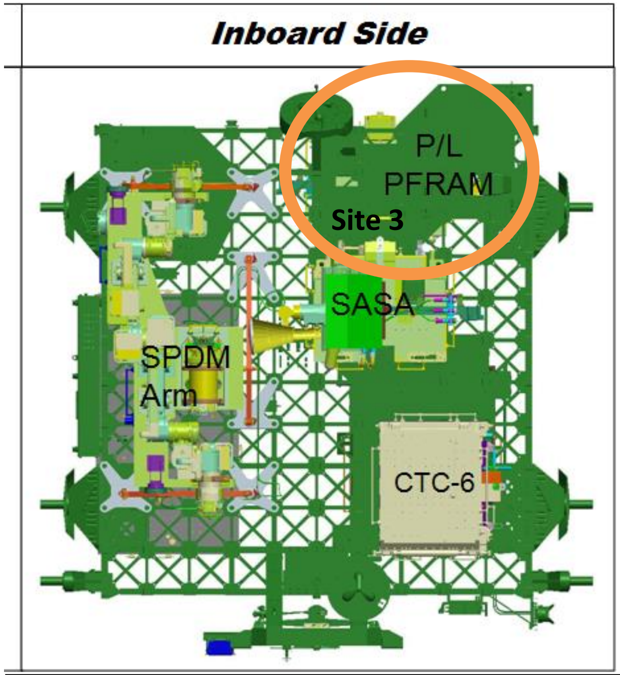




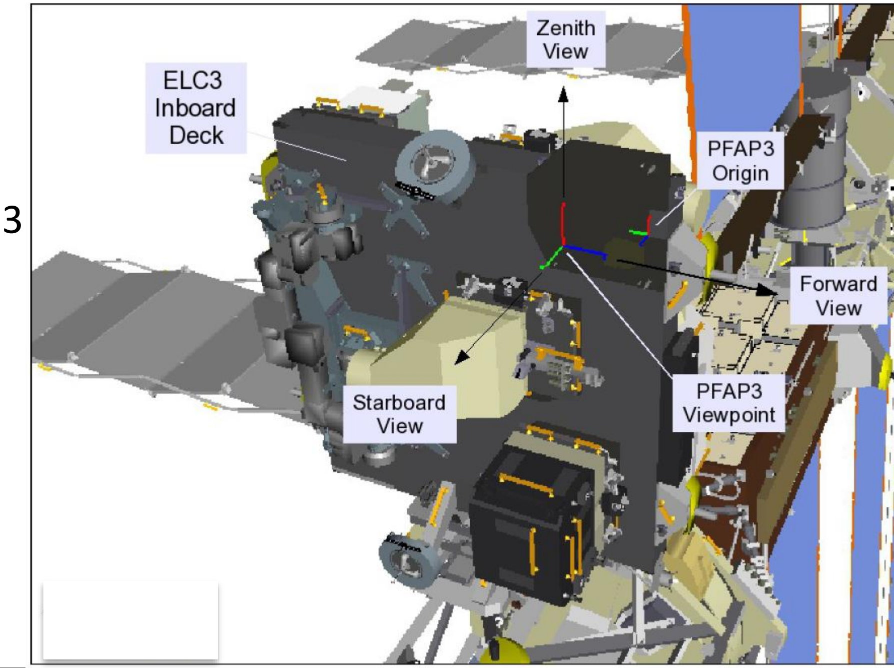
ELC-2 (Ram)/Site 7
Starboard upper
Zenith site

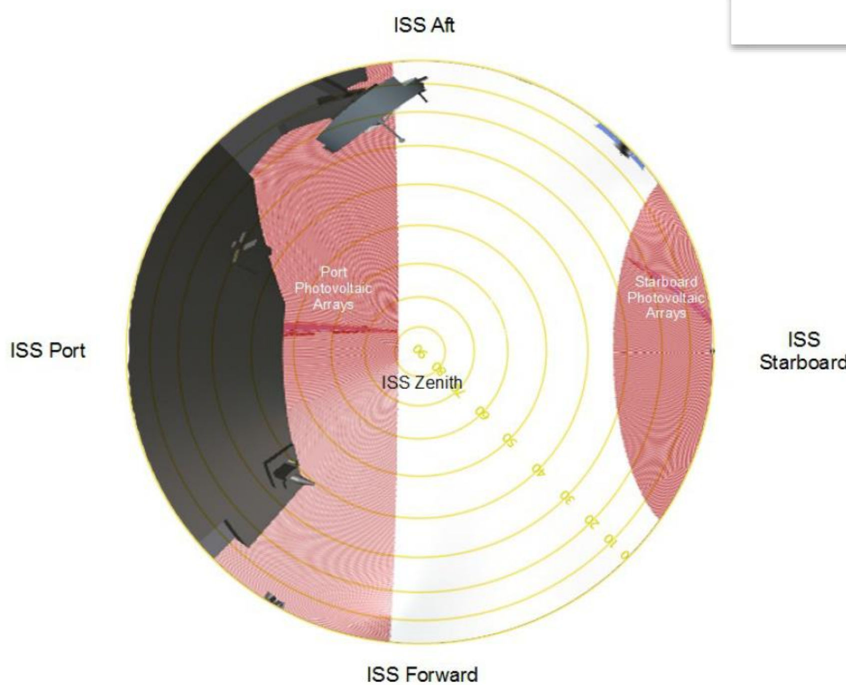


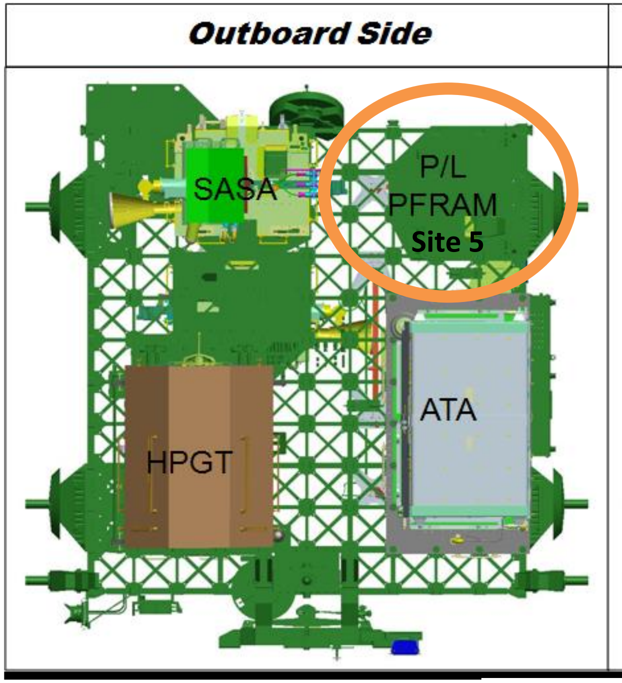




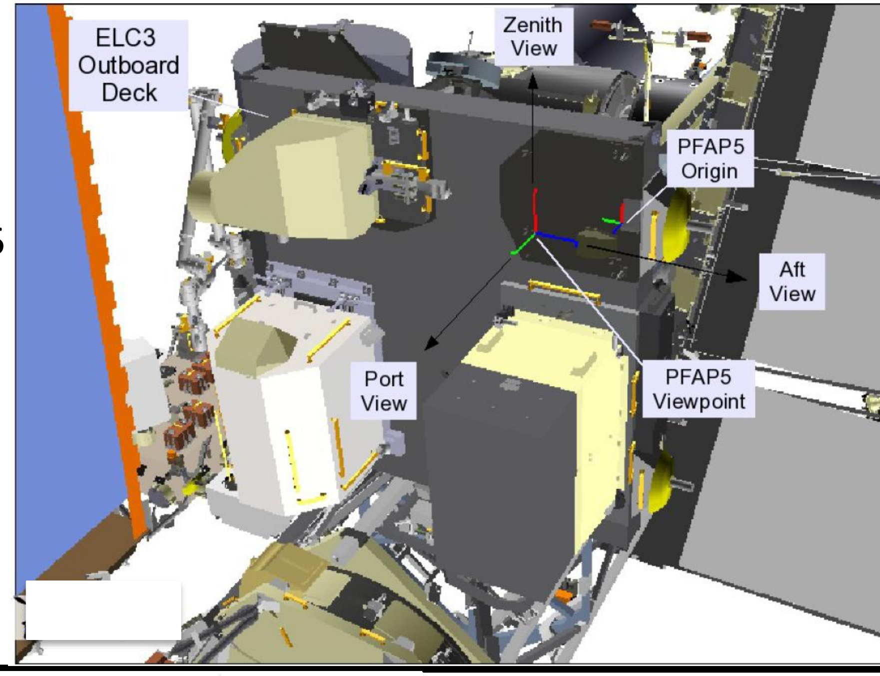
ELC-3 (Ram)/Site 3
Port upper
Zenith site

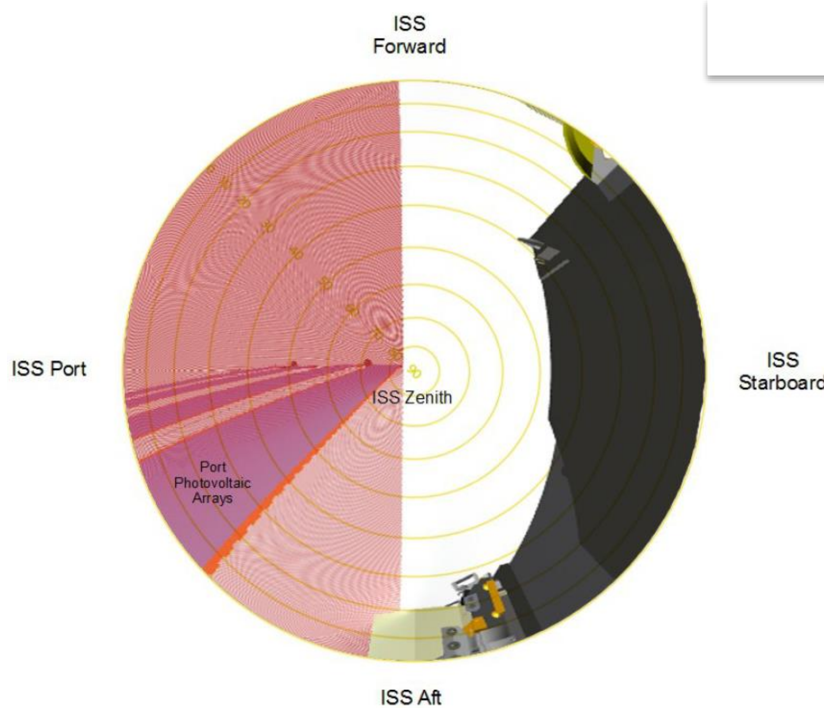






ELC-3 (Wake)/Site 5
Port upper
Zenith site



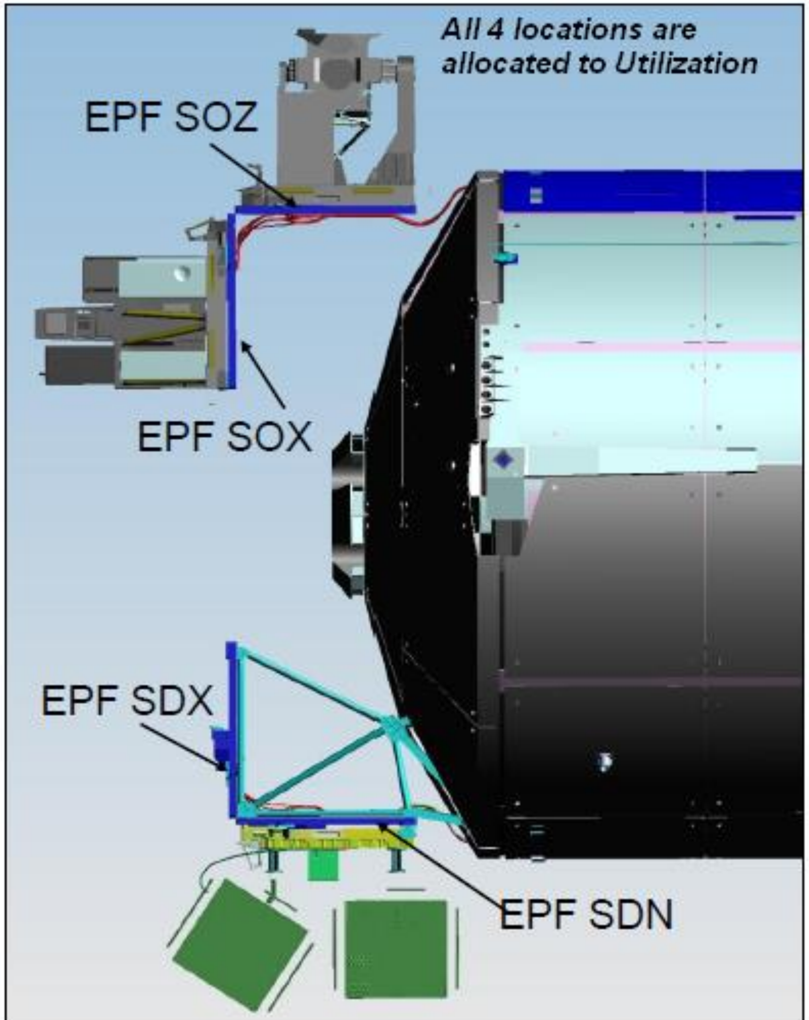


Columbus External Research Accommodations

Columbus External Resources

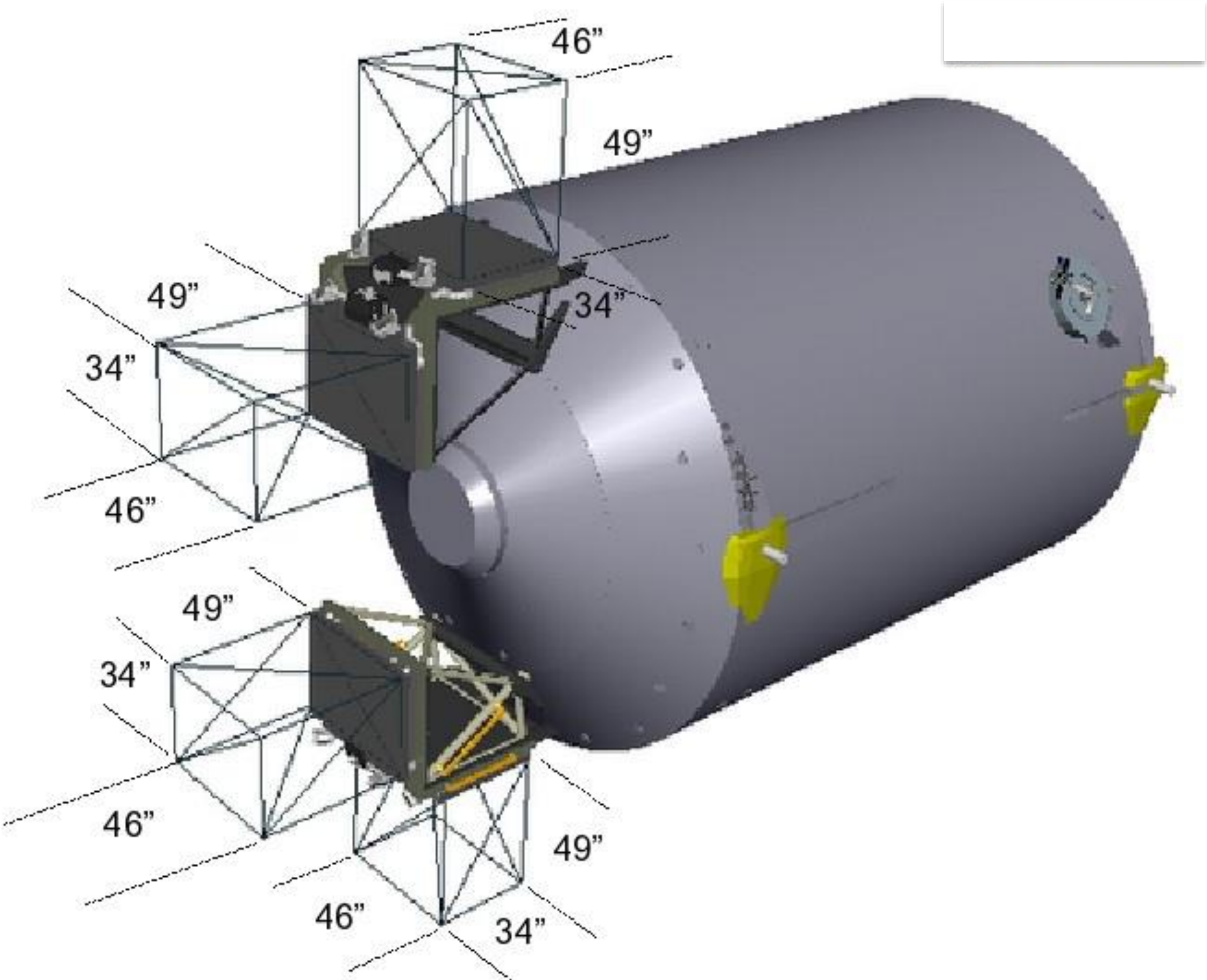
Mass capacity	230 kg (500 lb)
Volume	1 m^3
Power	2.5 kW total to carrier **(shared)**
Thermal	Passive
Low-rate data	1 Mbps (MIL-STD-1553)
Medium-rate data	2 Mbps (shared)
Sites available to NASA	2 sites

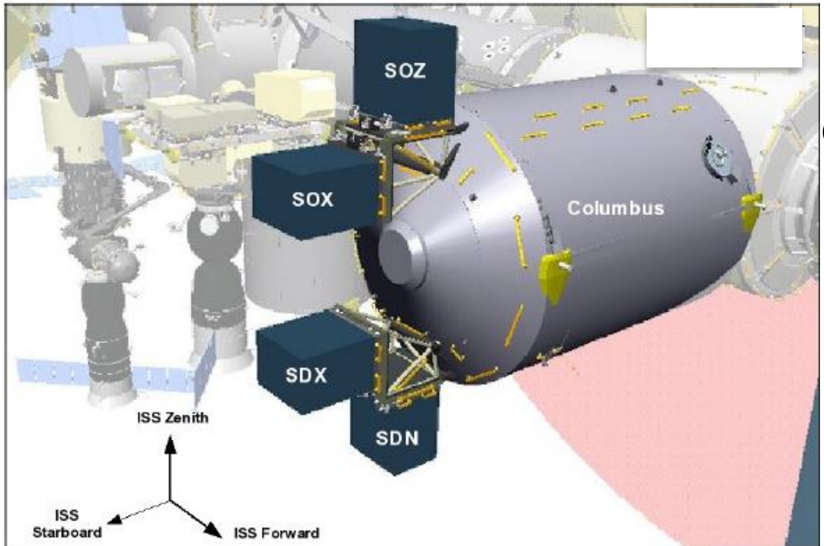
Columbus EF Overview



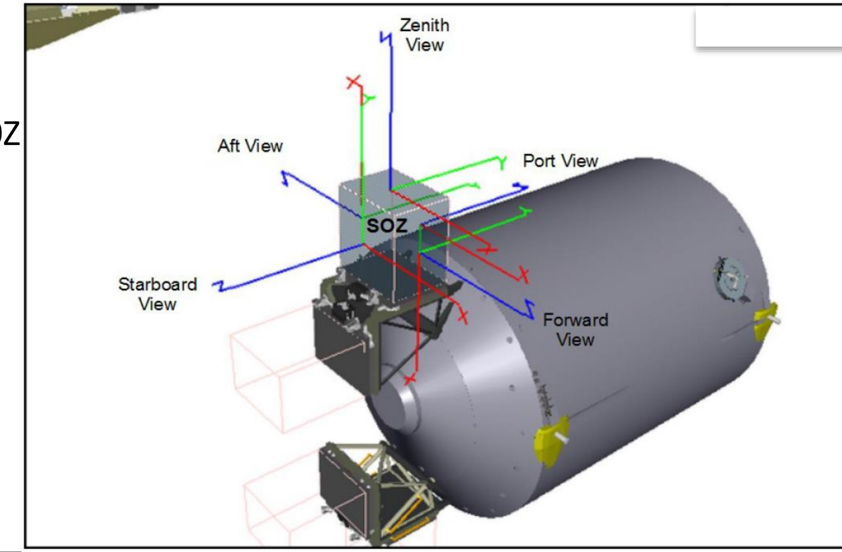
Location	Viewing	Payload Size	Power	Data
SOZ	Zenith	226 kg + CEPA	1.25 kW at 120 VDC 2.5 kW max (**Shared**)	Ethernet, 1553
SOX	Ram			
SDX	Ram			
SDN	Nadir			

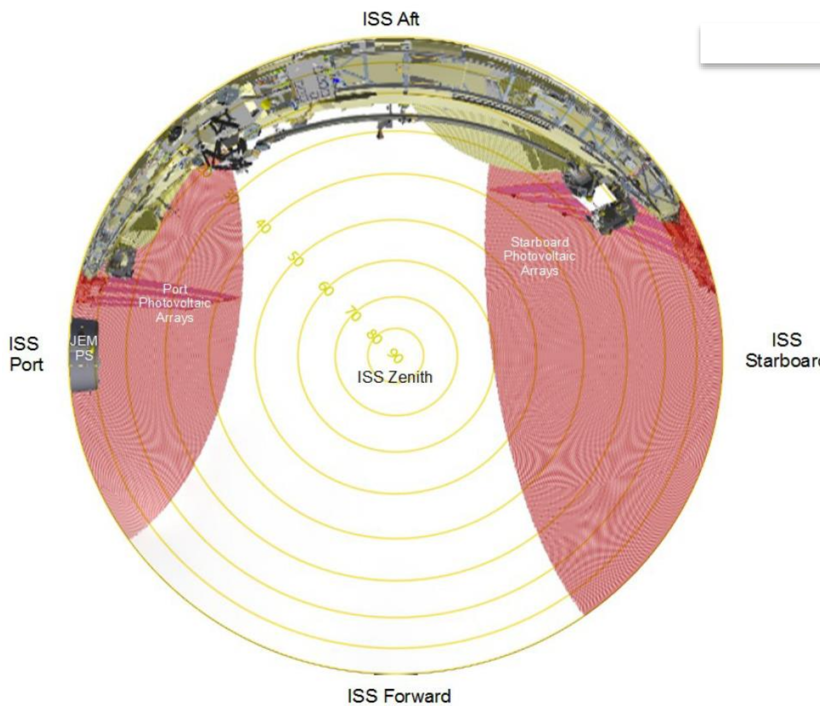
Columbus External Payload Envelope Dimensions

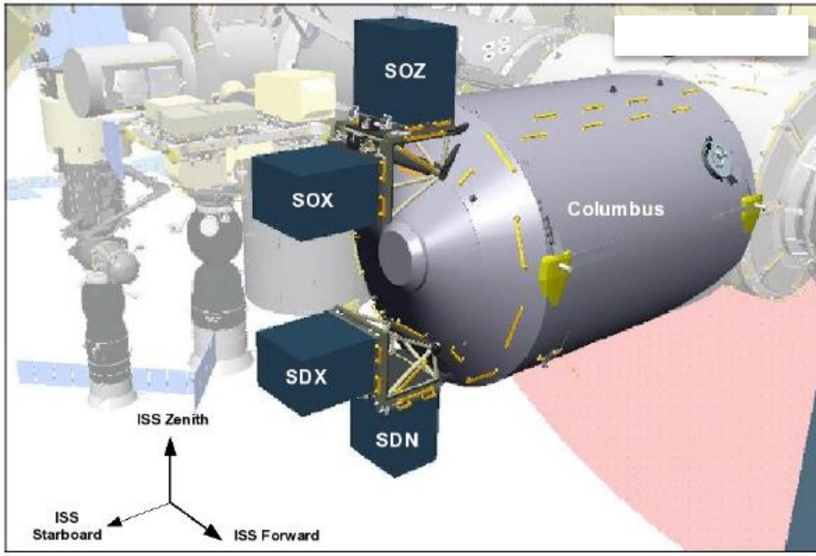




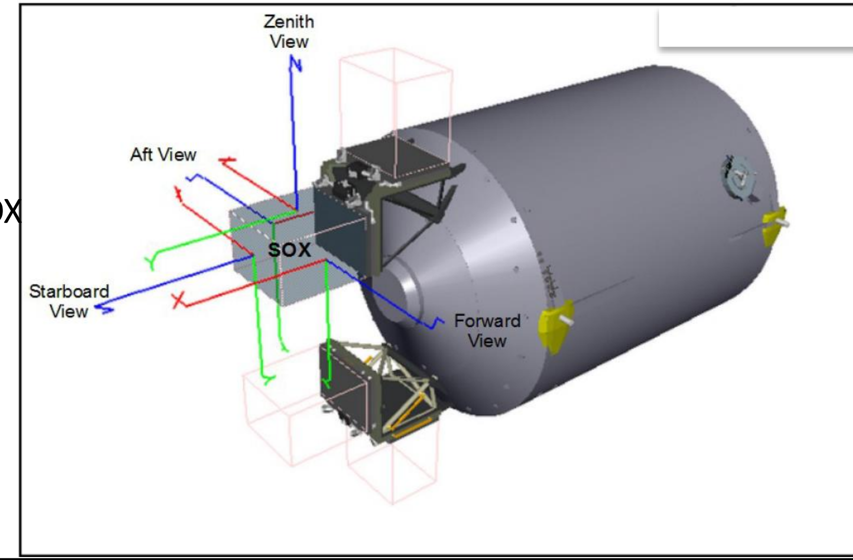
Columbus/S0Z
Overhead
Zenith site

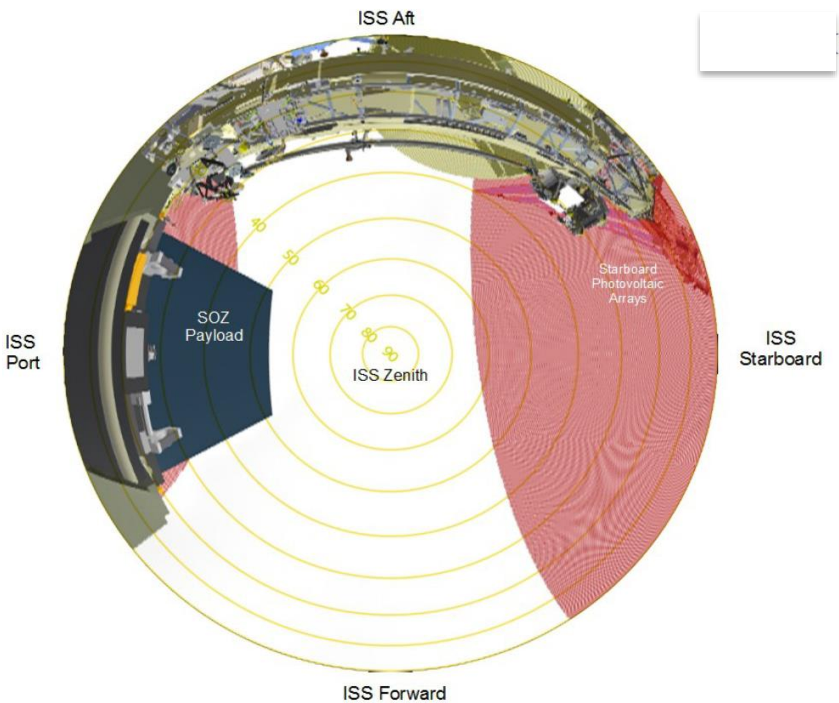




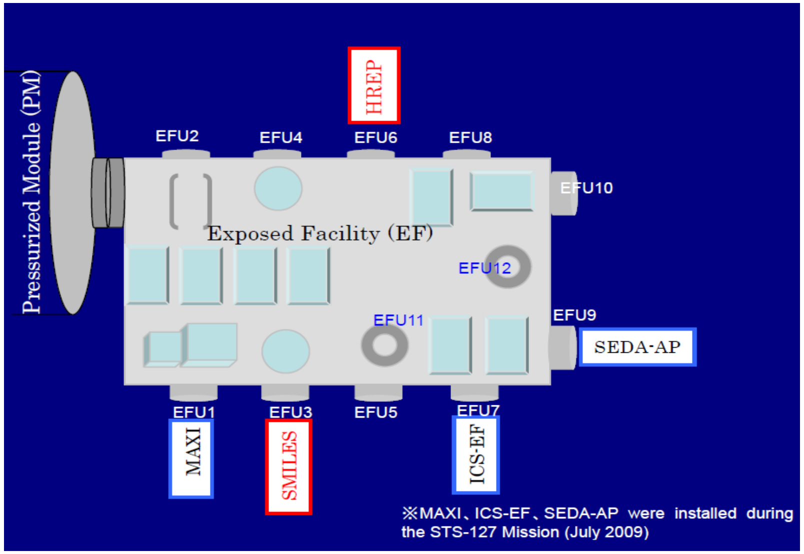


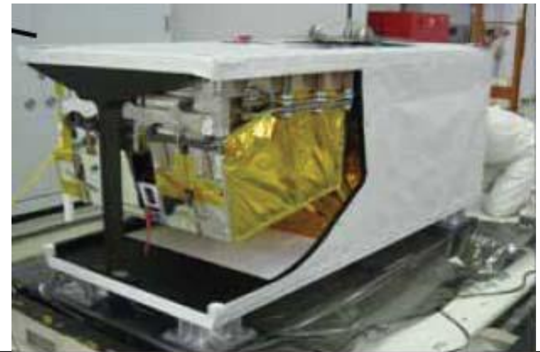
Columbus/SOX
Overhead
Zenith site



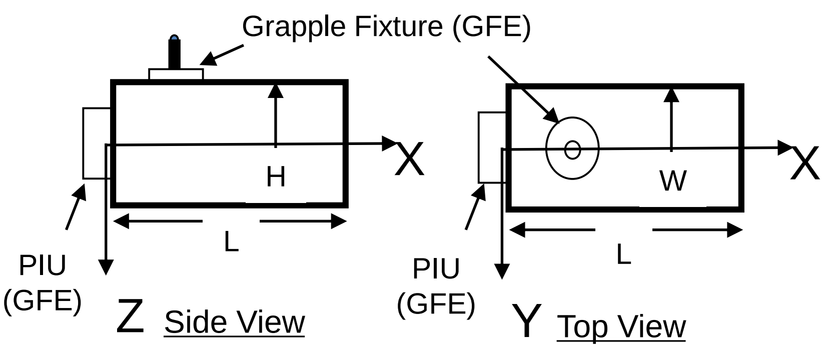


JEM EF External Research Accommodations





NASA/DOD HREP payload

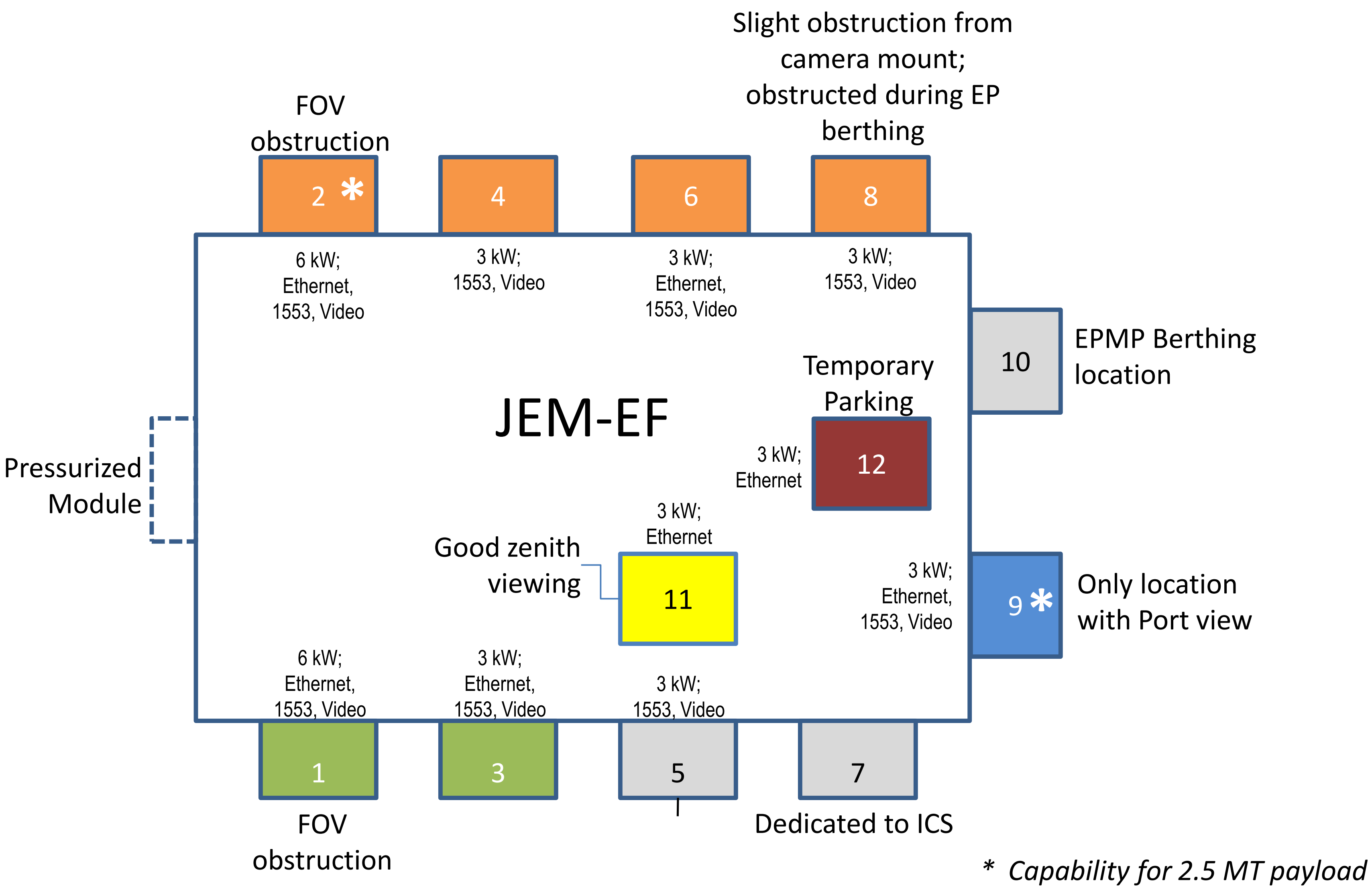


Axis	mm	ft	inch
W	800	2	7.50
H	1000	3	3.37
L	1850	6	0.83

Mass capacity	550 kg (1,150 lb) at standard site 2,250 kg (5,550 lb) at large site
Volume	1.5 m^3
Power	3-6 kW, 113 – 126 VDC (**Shared resource**)
Thermal	3-6 kW cooling (**Shared resource**)
Low-rate data Medium-rate data	1 Mbps (MIL-STD-1553, two way) 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**

JEM EF EFU Location Overview



Both power and active cooling are shared resource for all operating payloads during an increment

ISSP Management JEM-EF Power & Flow Design Limit Directive

- Due to the JEM-EF system constraint to meet the external payload complement needs for power and fluid flow rate during the 2019-2024 timeframe to allow all of the payloads located on that platform to operate continuously at the same time, ISSP is directing PDs to design their instruments to perform within the limitation of the JEM-EF system capability in order to minimize payloads real time operation timelining

- *JEM-EF system can support the following resource utilization per payload during the 2019-2024 timeframe:
  - Maximum fluid flow per payload: **151 kg/hr**
  - Maximum Power draw per payload: **500 W**
  - Maximum accumulator volume: **2L**

* Deviation from these values above will significantly increase the likelihood of that payload complement to be timeline during real time operations of that increment, which means less continuous on-orbit operation of all the payloads in that increment at the same time

ISSP Management ELC Power Design Limit Directive

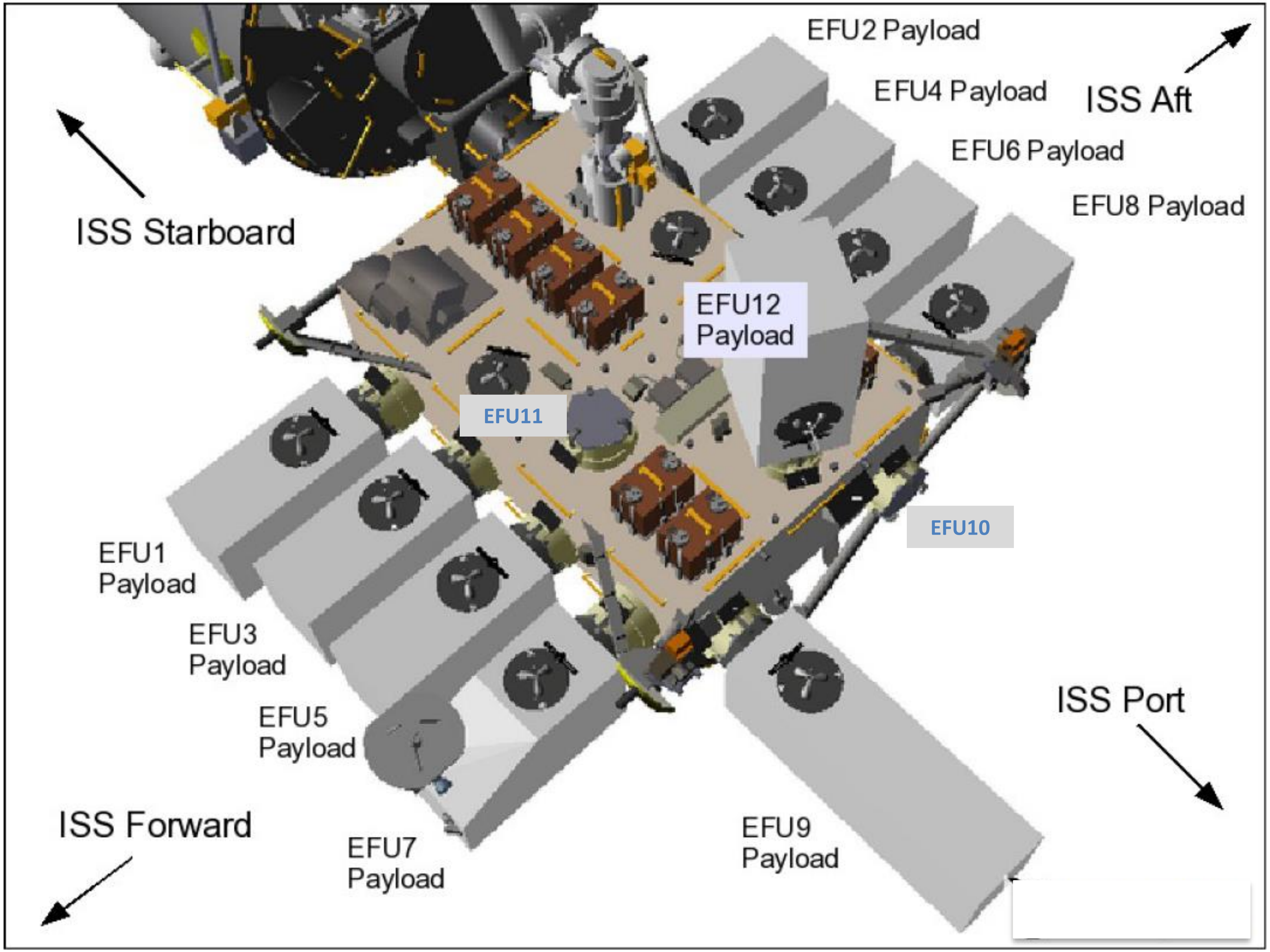
- Due to a design flaw uncovered recently in the ELC 28 dc power interface, which limits the Experiment Control Module (ECM) in the EXPRESS Carrier Avionics (ExPCA) to operate 40 degrees Celsius when two instruments are operating simultaneously on that ELC, the ISS Program recommends that all future ELC proposed instruments be designed to interface with the ISS 120 Vdc power interface.

- Payload Developers (PDs), however, still have the option to design their instruments to interface with the 28 Vdc power feed at the risk of that payload being operations constraint (timeline constraint) whenever the 40 degrees Celsius limit is reached, which will trigger a power shed situation to balance total power draw across that ELC. This is being done to prevent total loss of science operation on that ELC if the ECM fails. Current analysis shows that when two payloads operating on the ELC simultaneous and both are using the 28 dc power, the 40 degrees Celsius limit is reached faster compared to if one is using the 28 dc power and the other the 120 Vdc power interface.

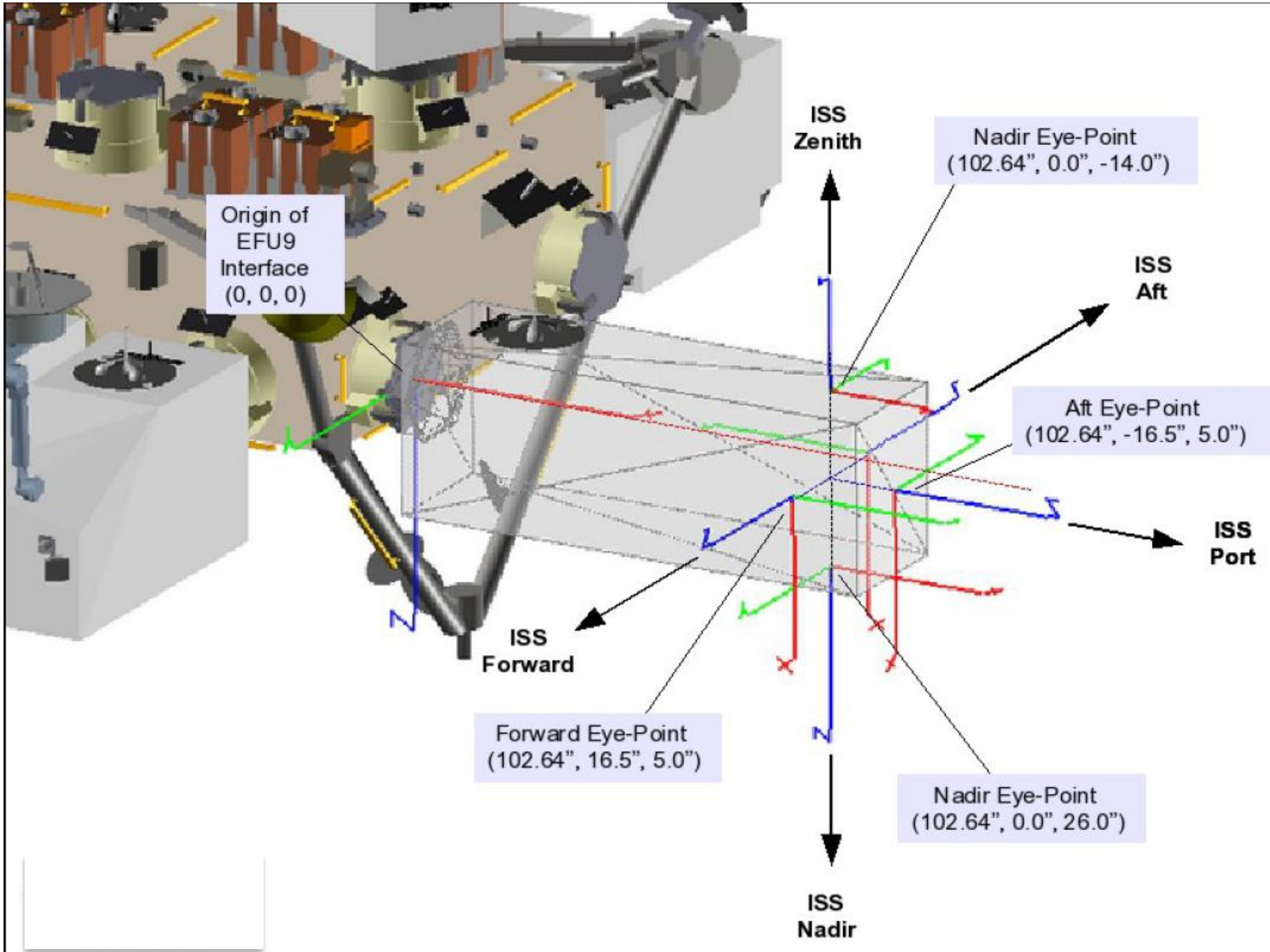
JEM-EF Detailed Accommodations by Site

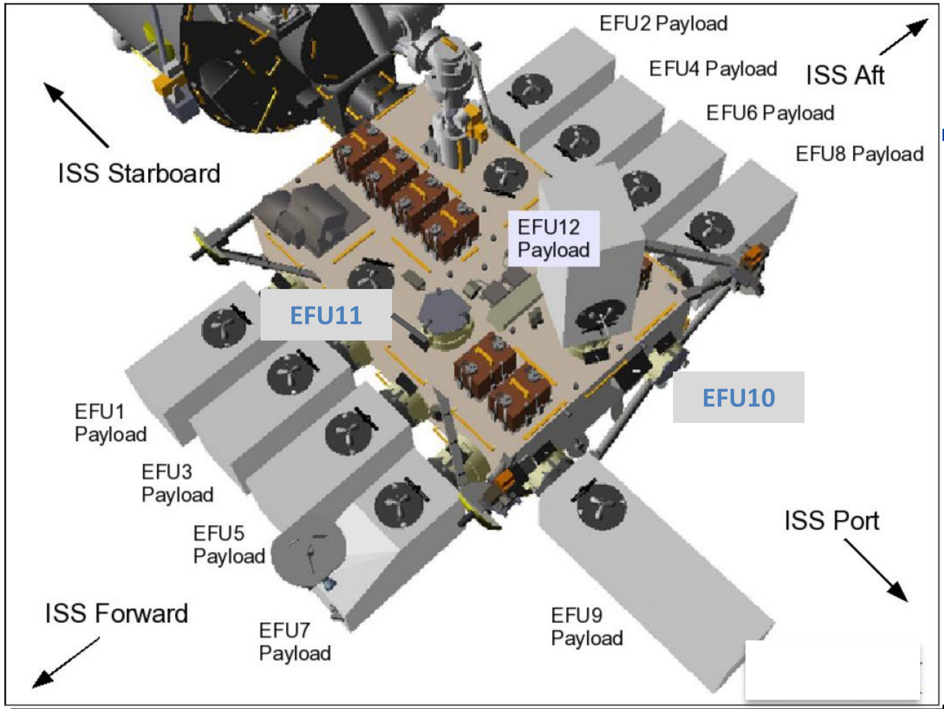
Location	Viewing	Payload Size	Description / Notes	Data
1	Ram, Nadir, Zenith	500 kg	Ram field of View (FOV) obstruction by JEM module	Ethernet, 1553, Video
3	Ram, Nadir, Zenith	500 kg	Clear view	Ethernet, 1553, Video
5	Ram, Nadir, Zenith	500 kg	ICS System back-up site (negotiable?)	1553, Video
7	Ram,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

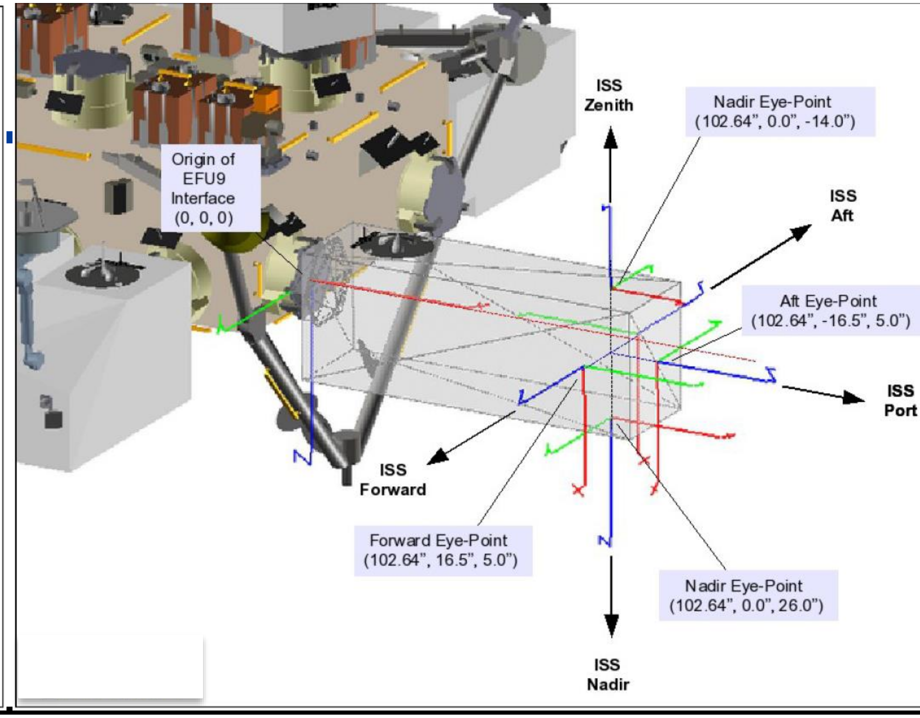
JEM-EF External Sites Locations

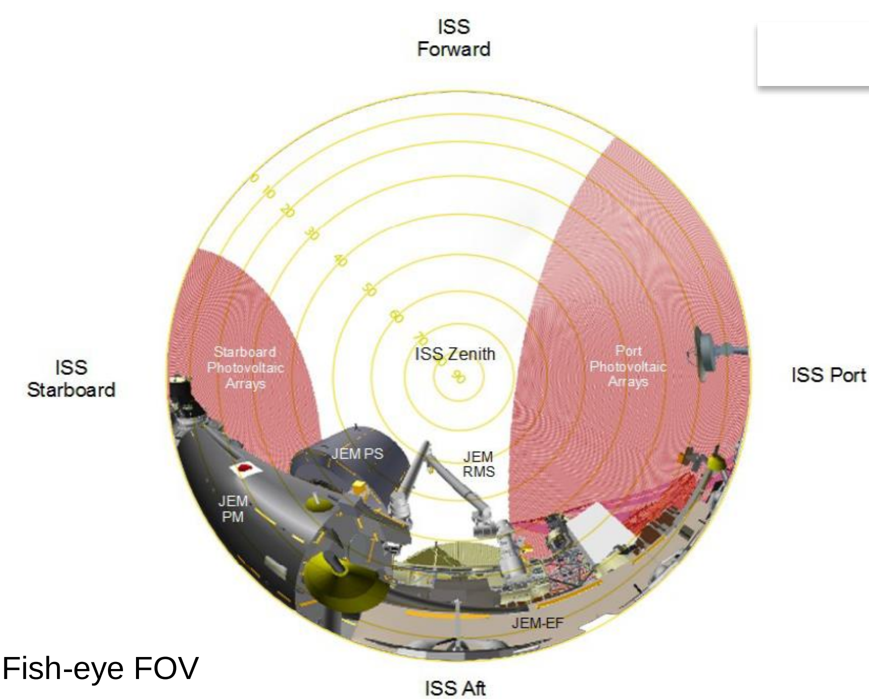


Placement of Eye-Point for Sensors Located on a Generic EFU Payload Box

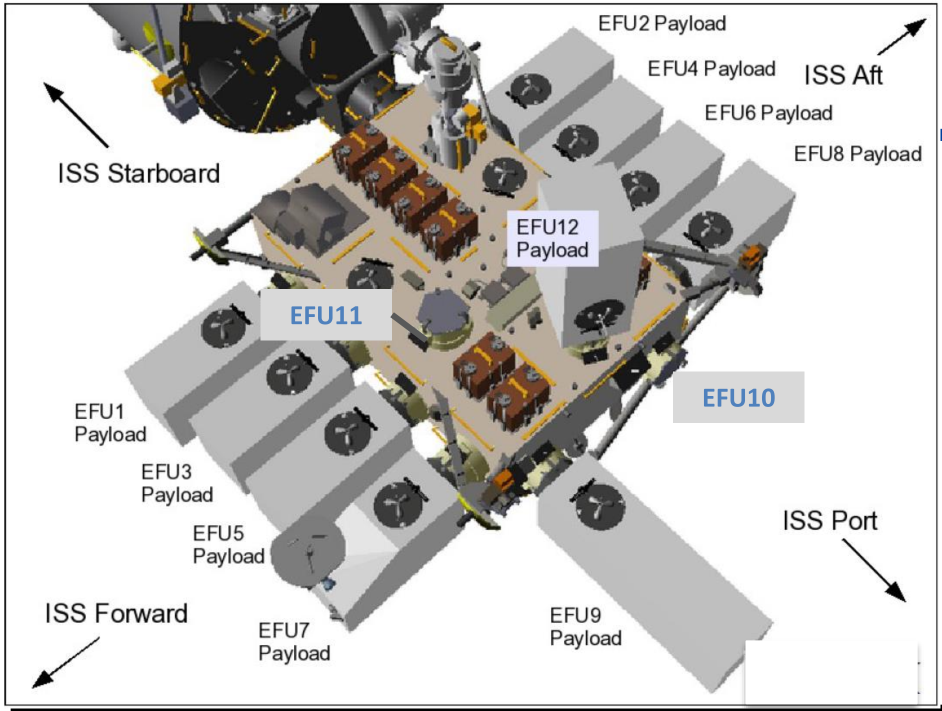


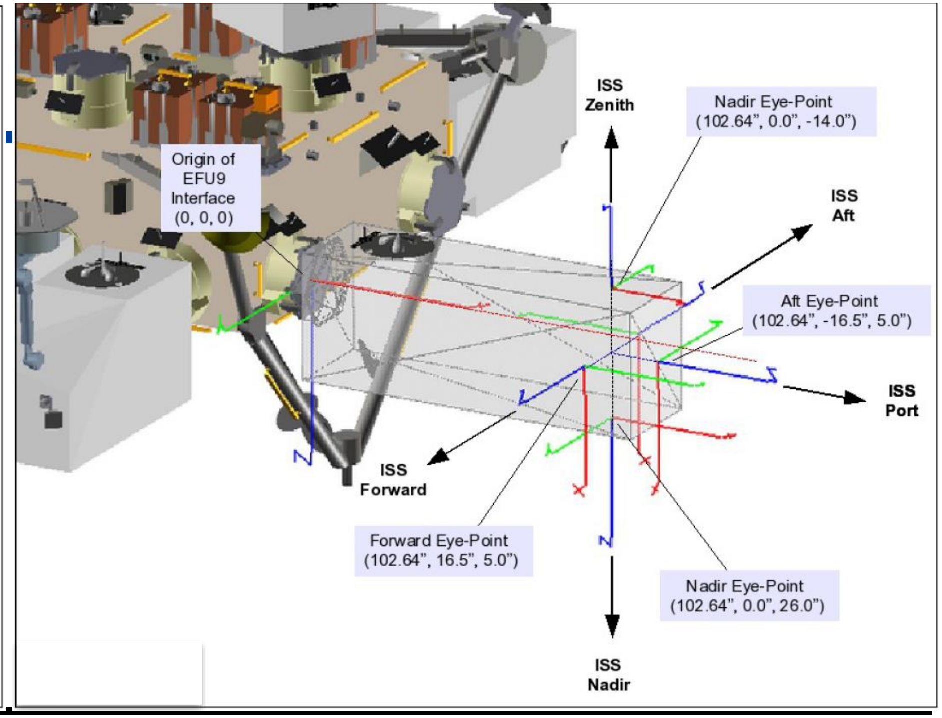


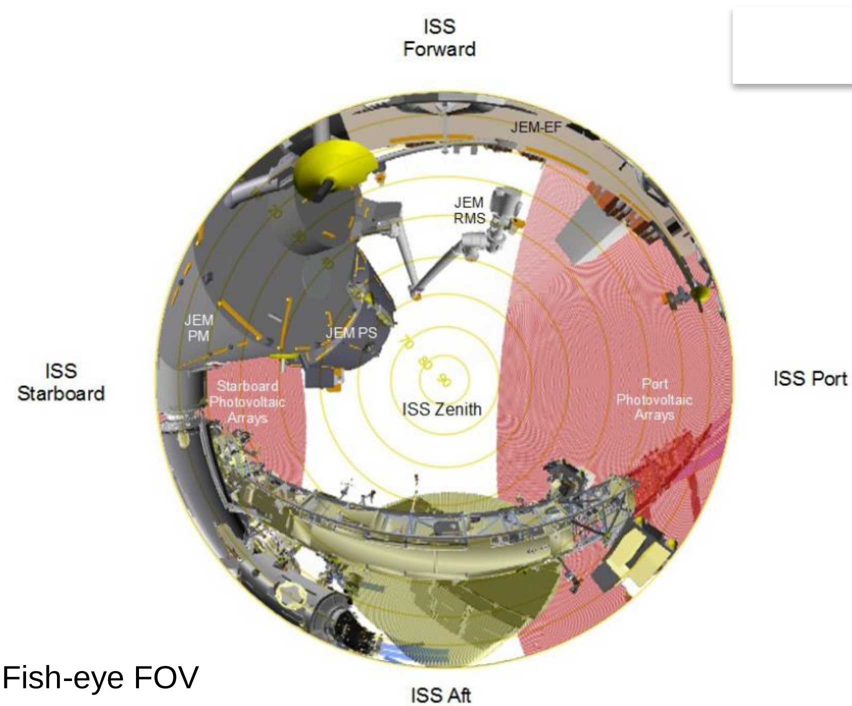




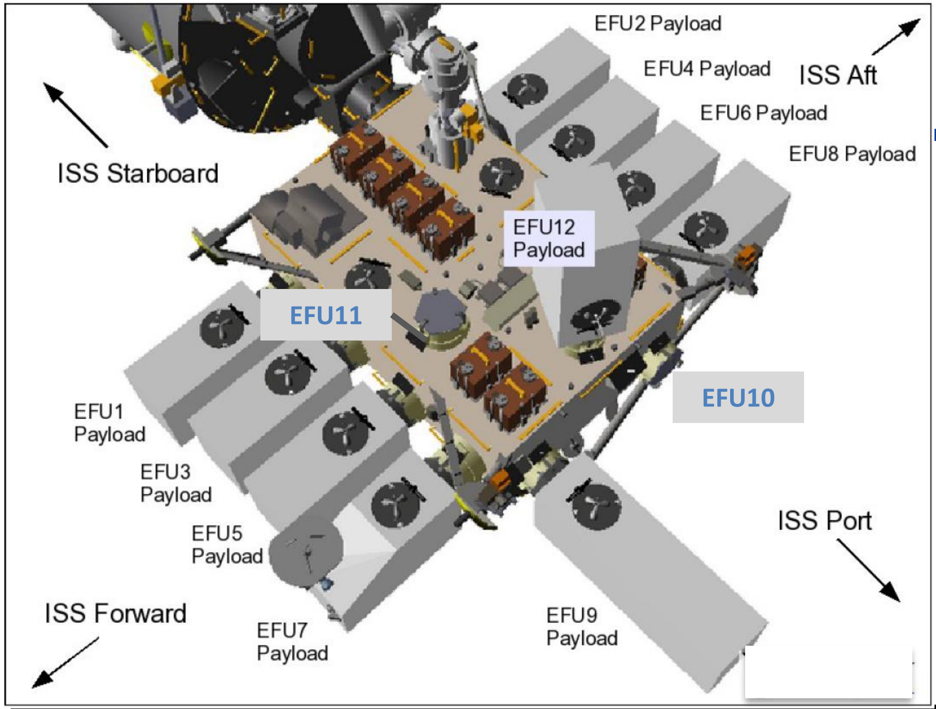
JEM EFU 1 Payload Zenith Face Fish-eye FOV

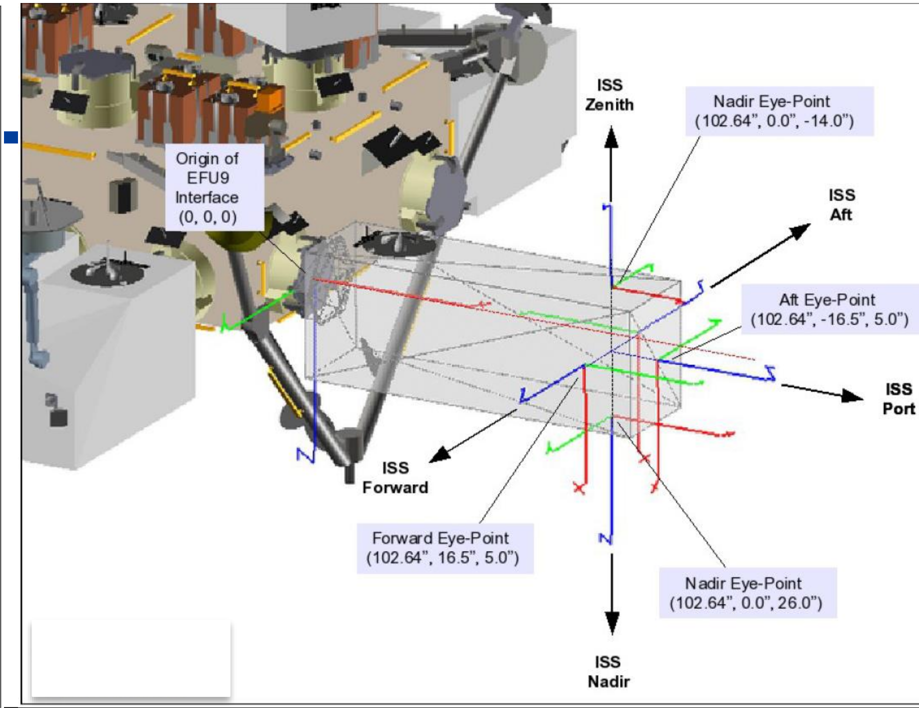


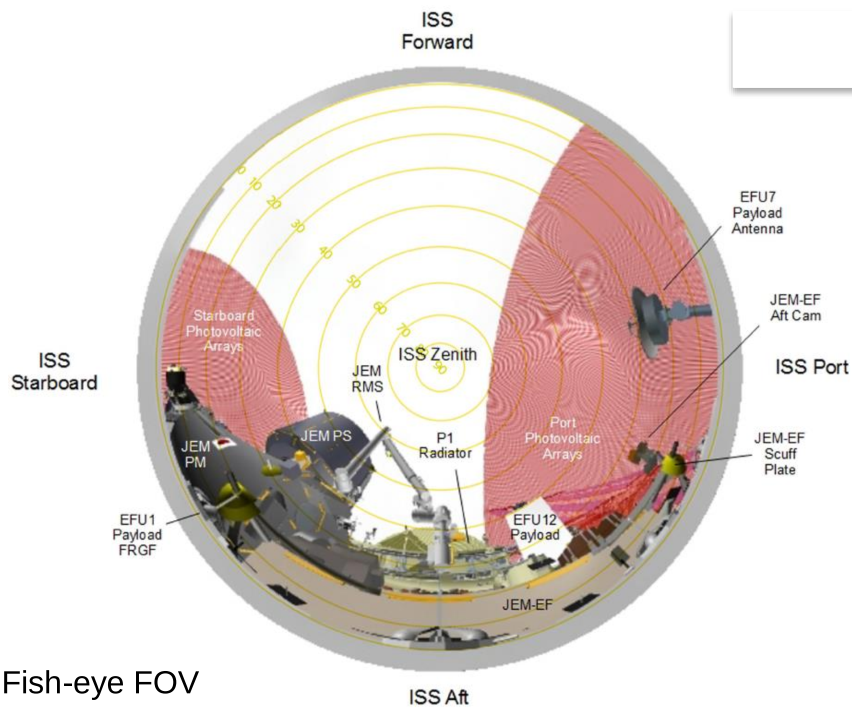




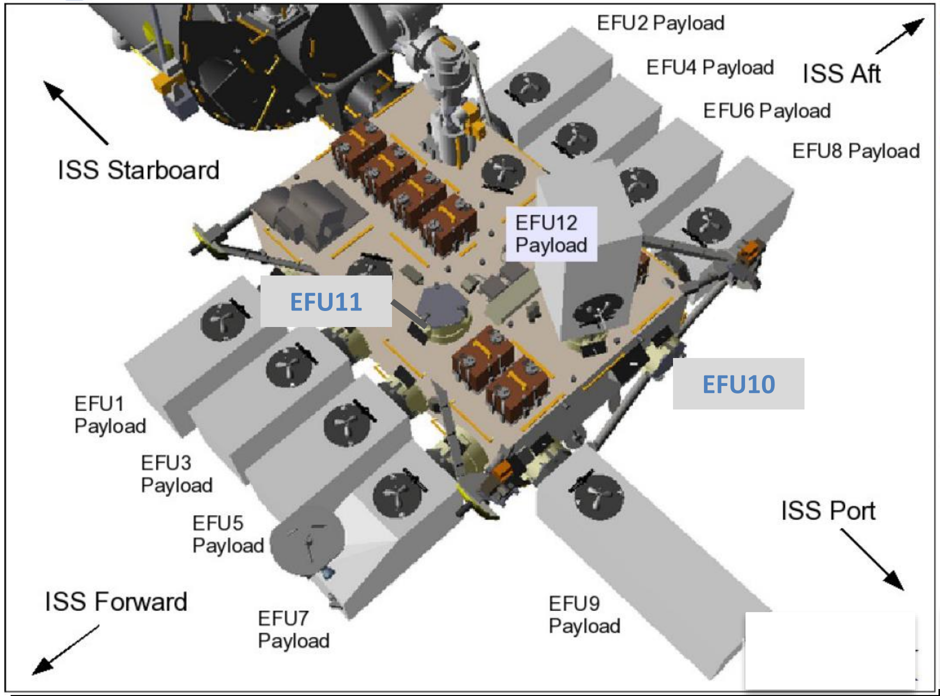
JEM EFU 2 Payload Zenith Face Fish-eye FOV

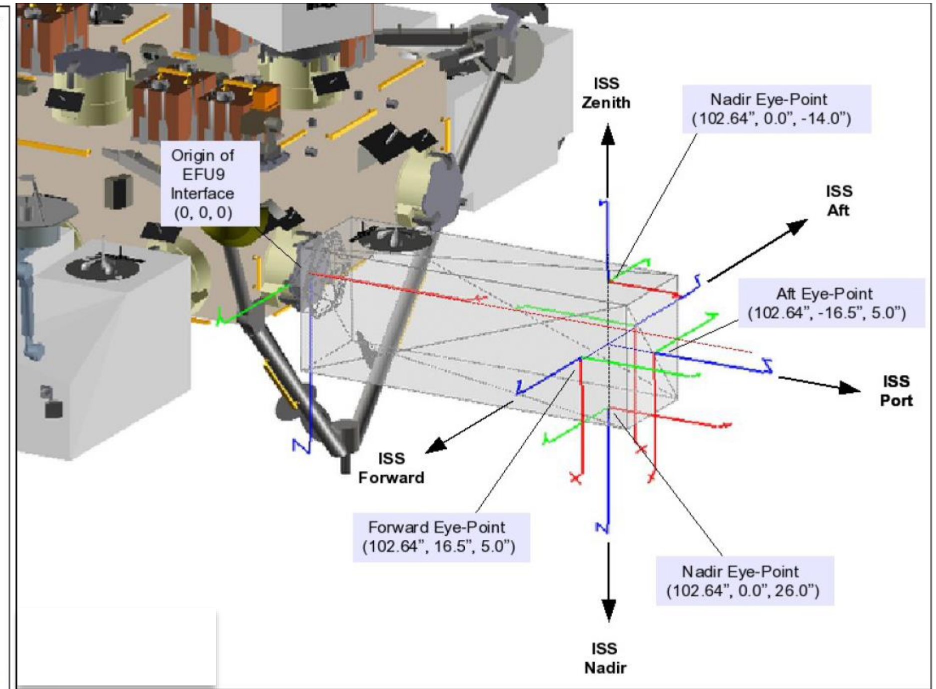


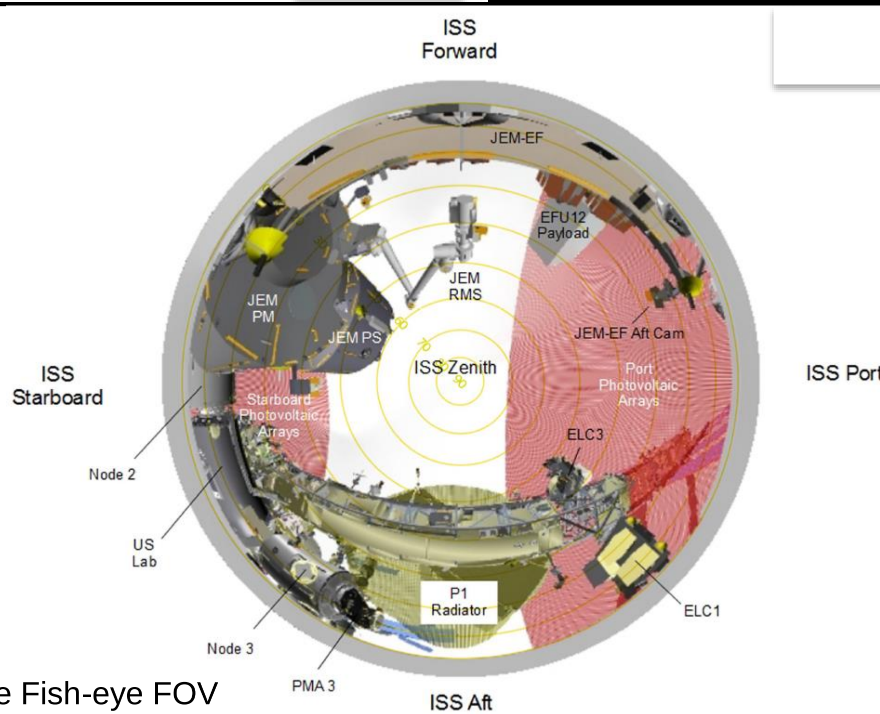




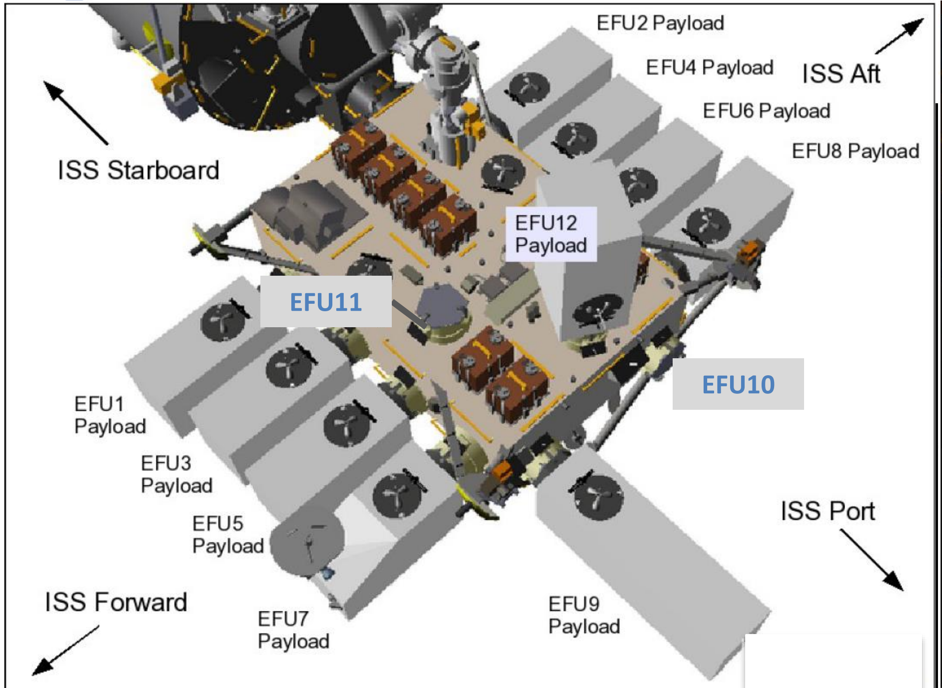
JEM EFU 3 Payload Zenith Face Fish-eye FOV

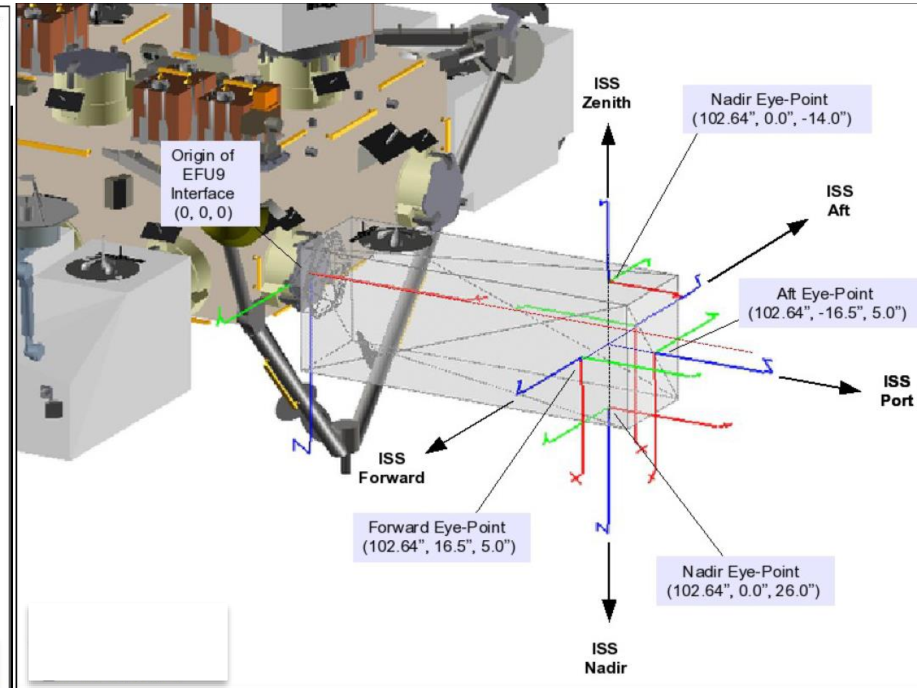


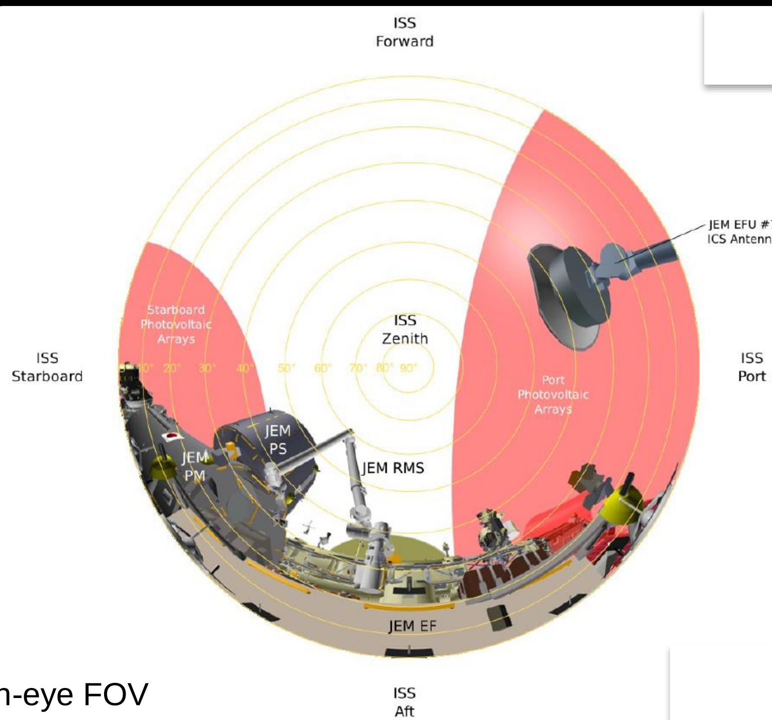




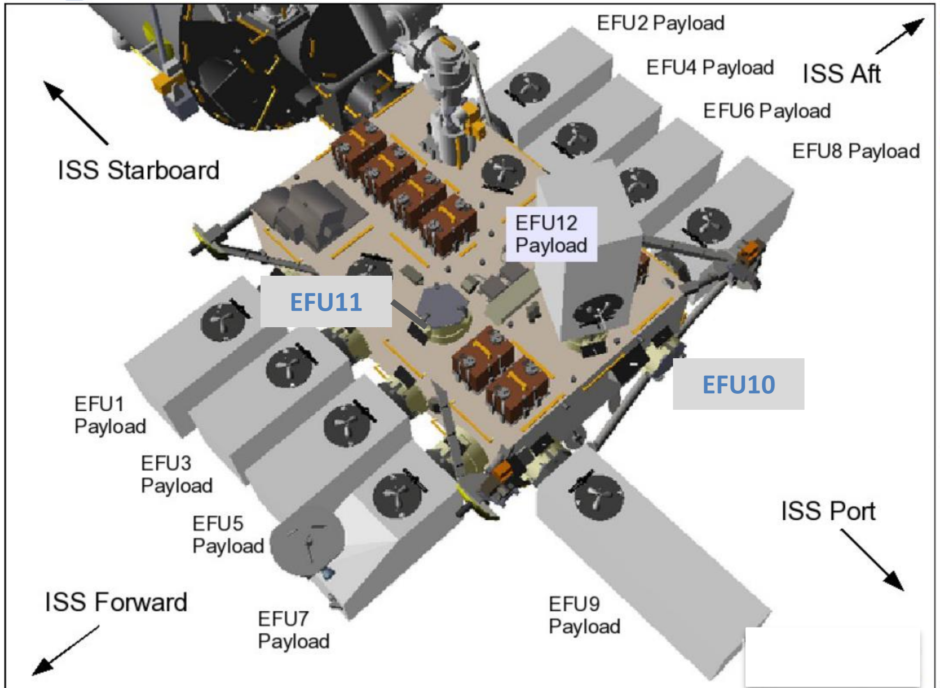
JEM EFU 4 Payload Zenith Face Fish-eye FOV

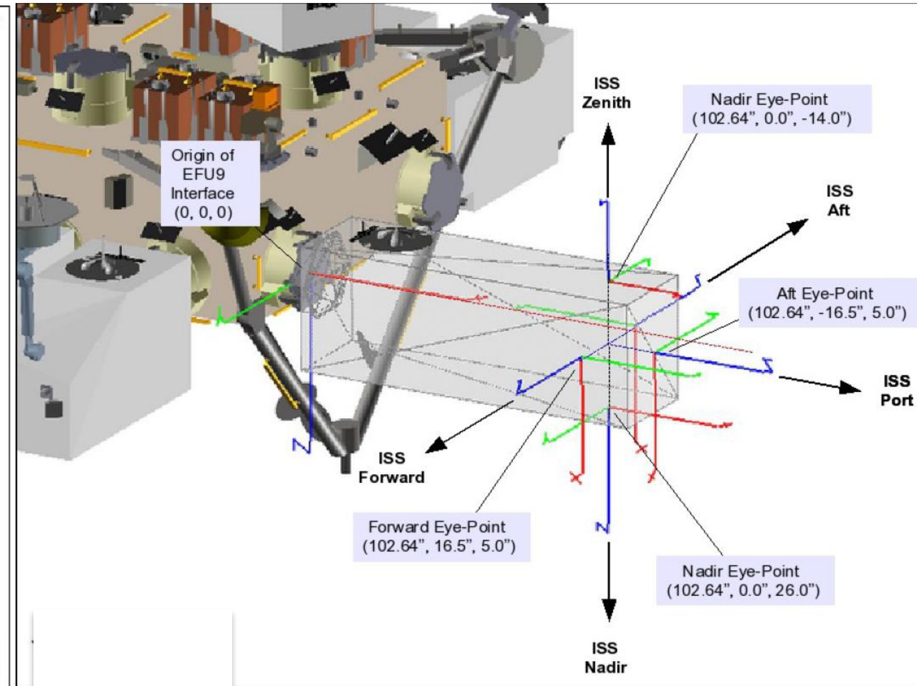


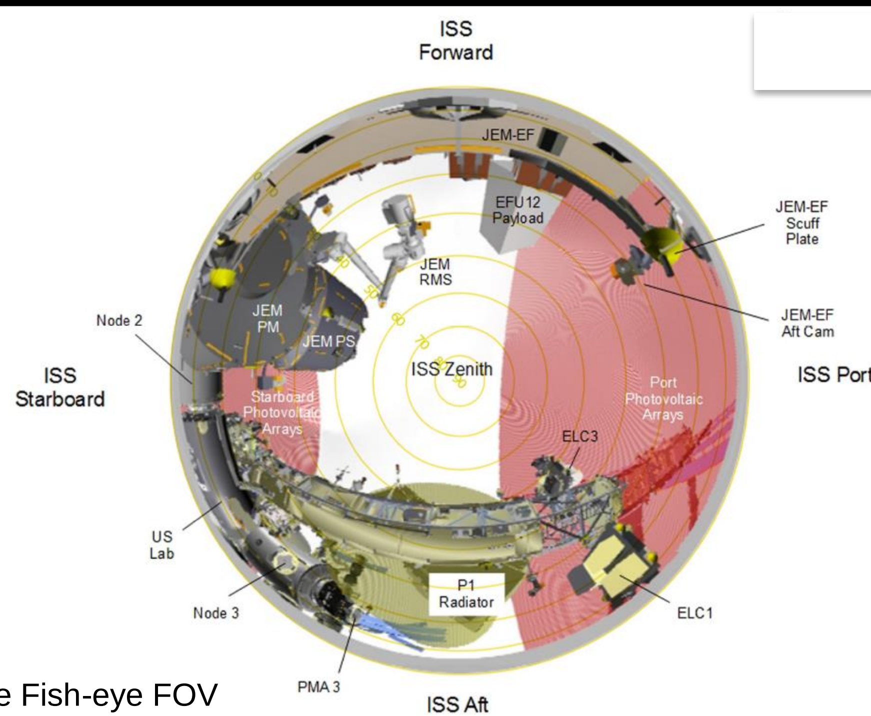




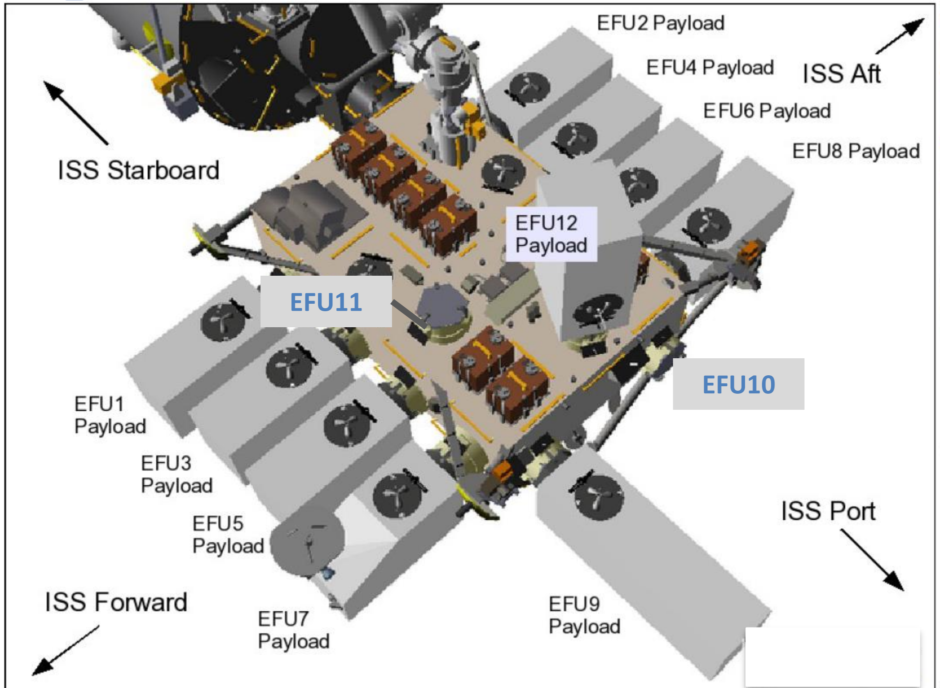
JEM EFU 5 Payload Zenith Face Fish-eye FOV

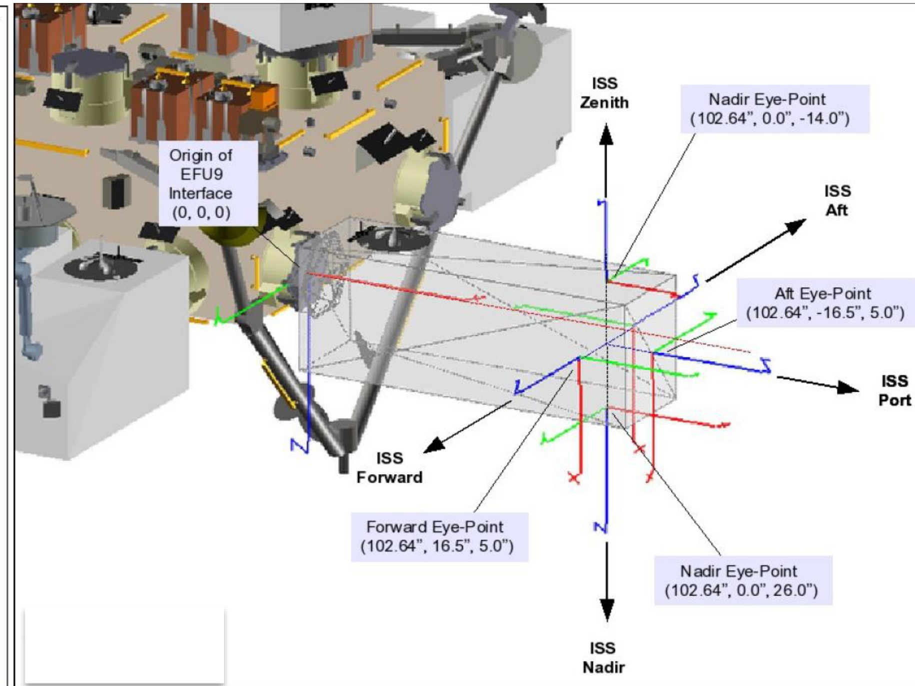


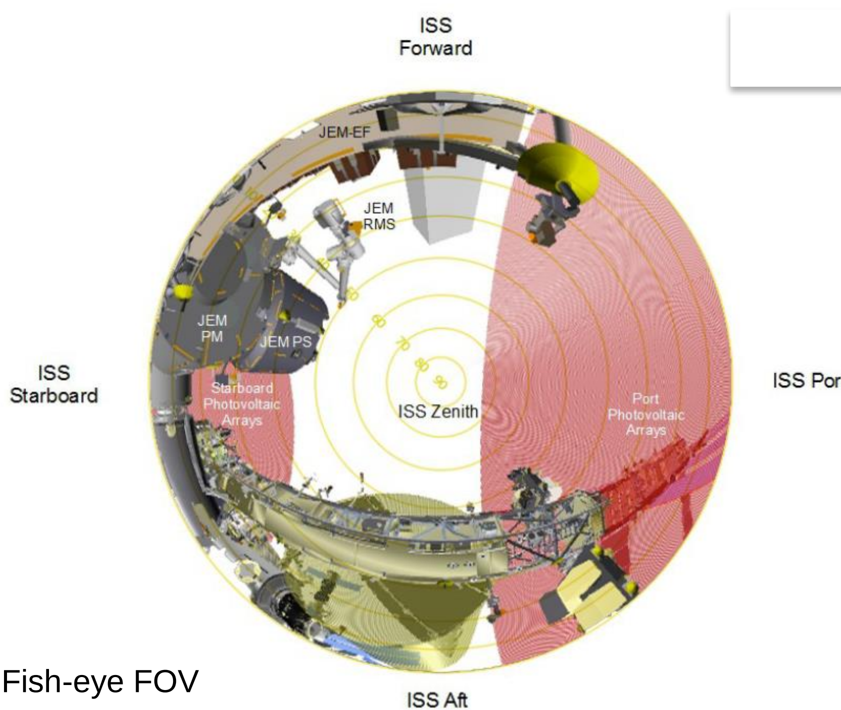




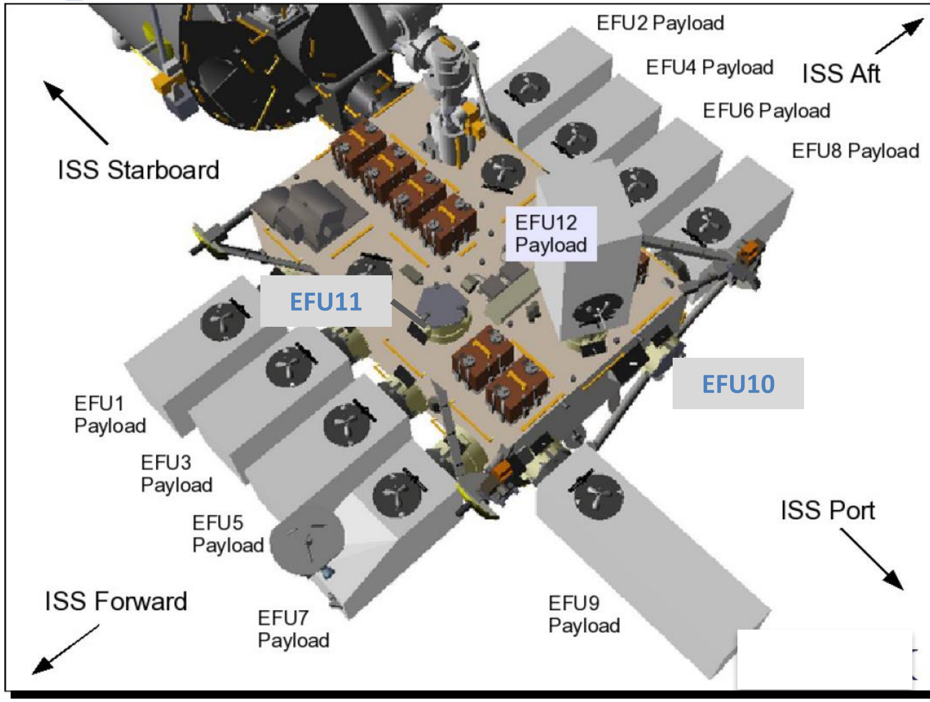
JEM EFU 6 Payload Zenith Face Fish-eye FOV

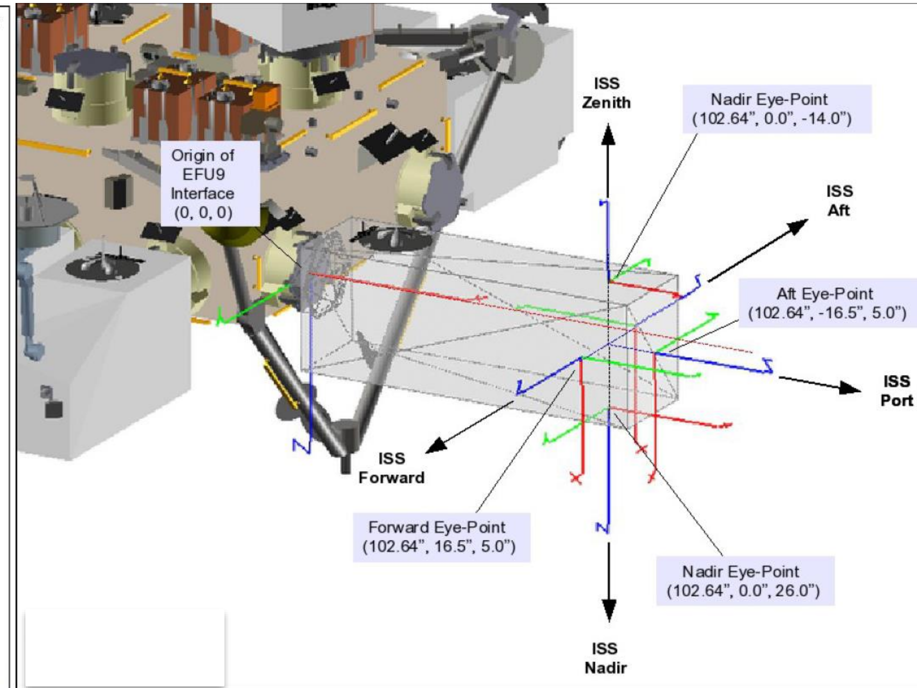


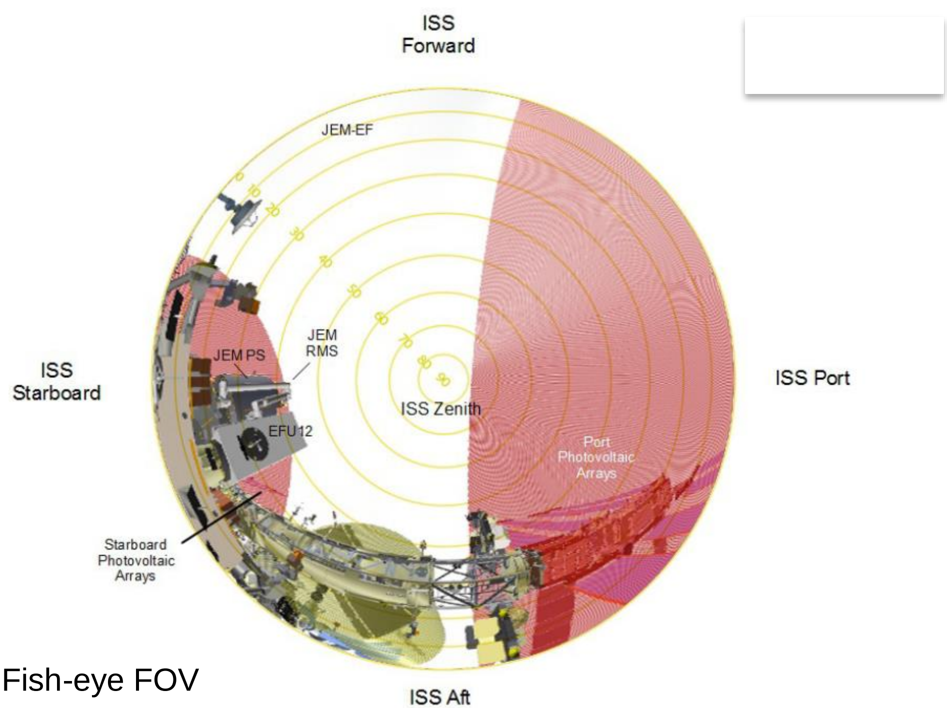




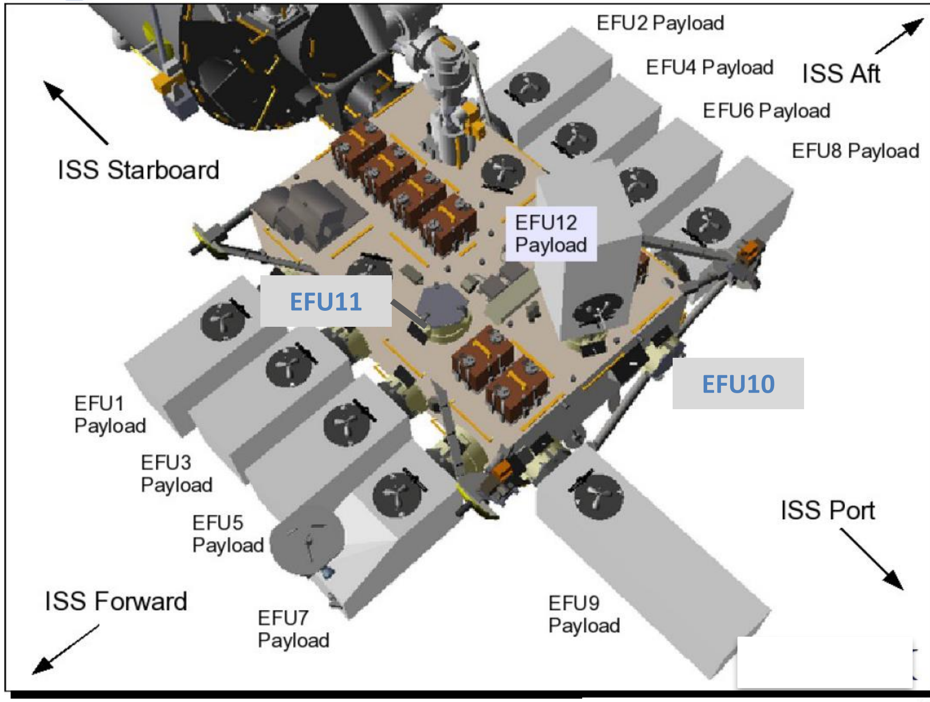
JEM EFU 8 Payload Zenith Face Fish-eye FOV

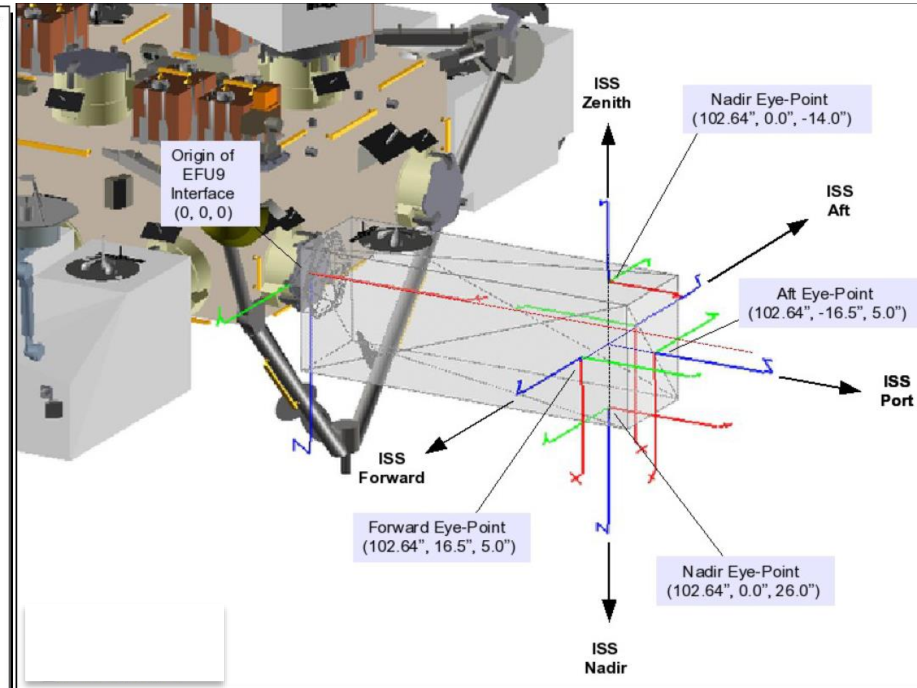


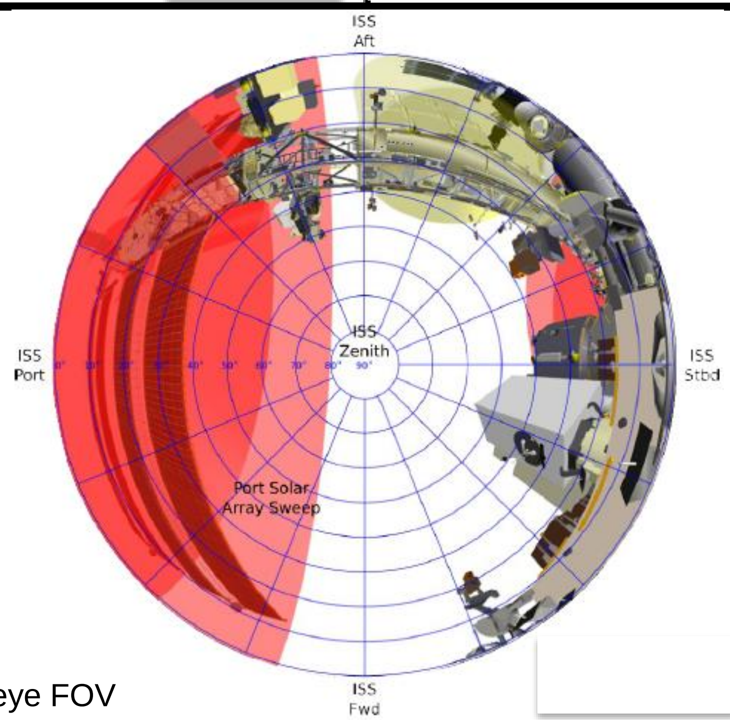




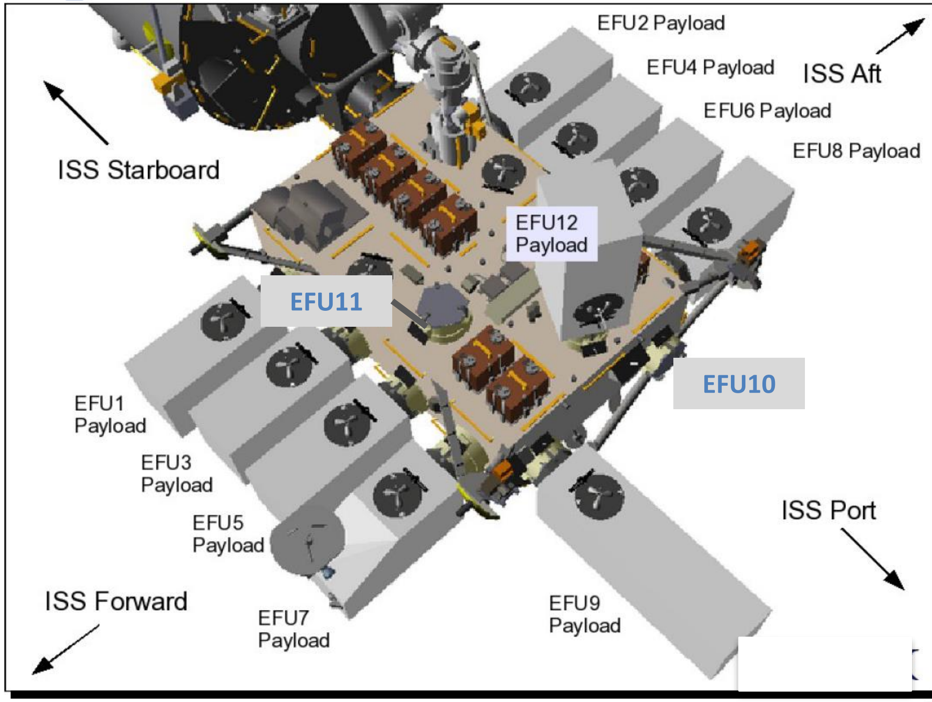
JEM EFU 9 Payload Zenith Face Fish-eye FOV

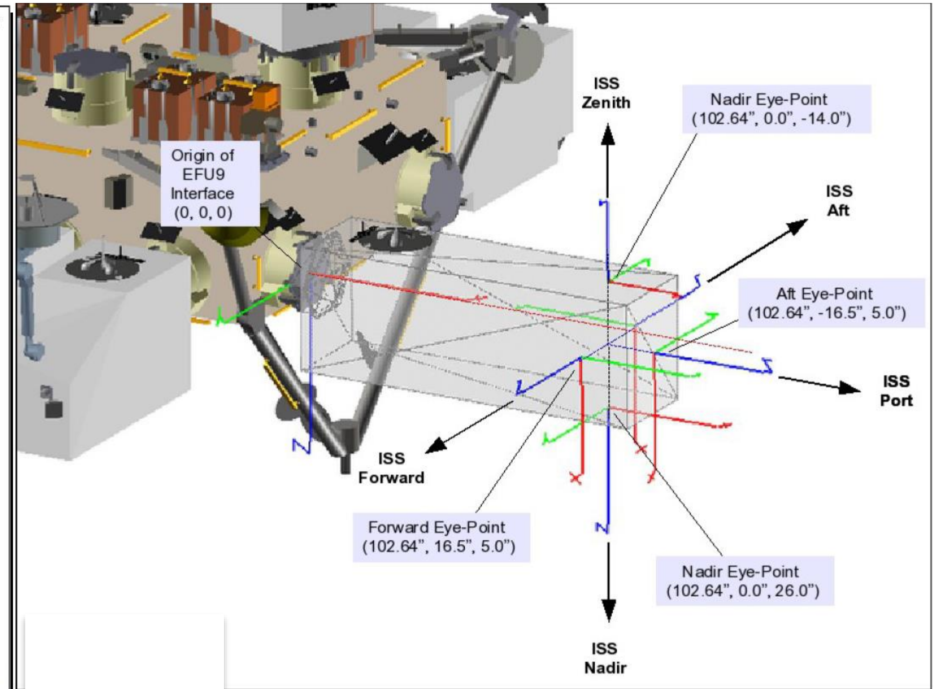


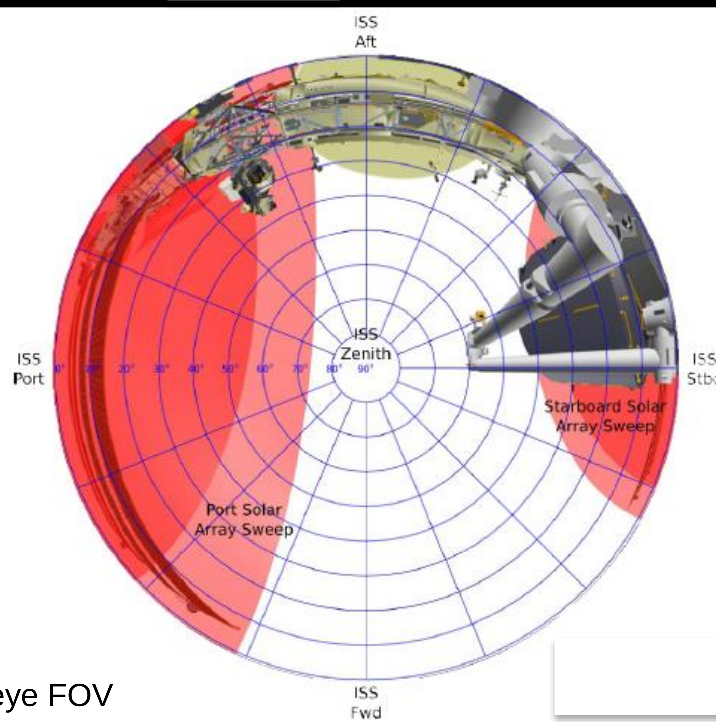




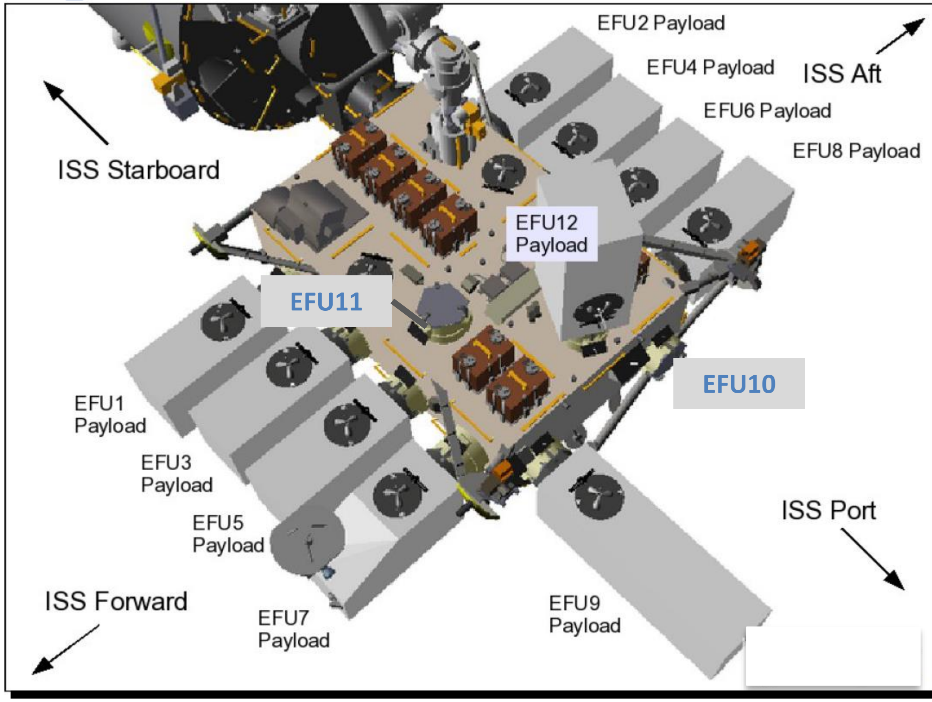
JEM EFU 10 Payload Zenith Face Fish-eye FOV

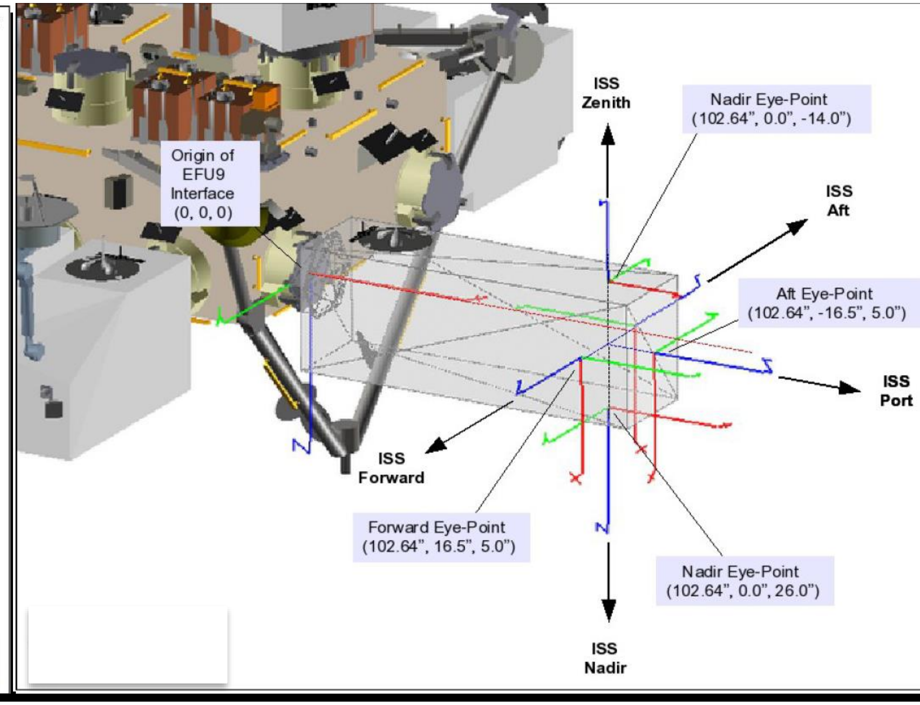


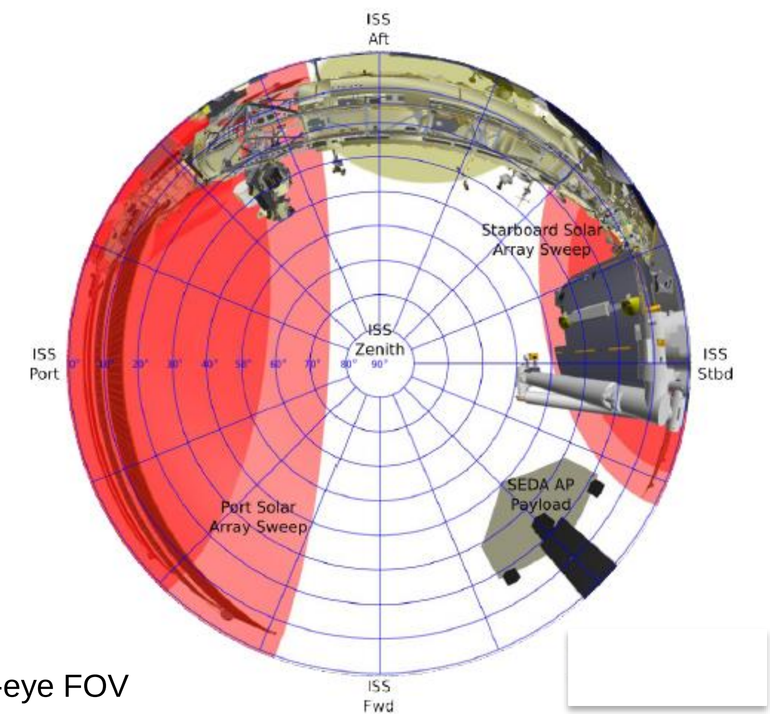




JEM EFU 11 Payload Zenith Face Fish-eye FOV







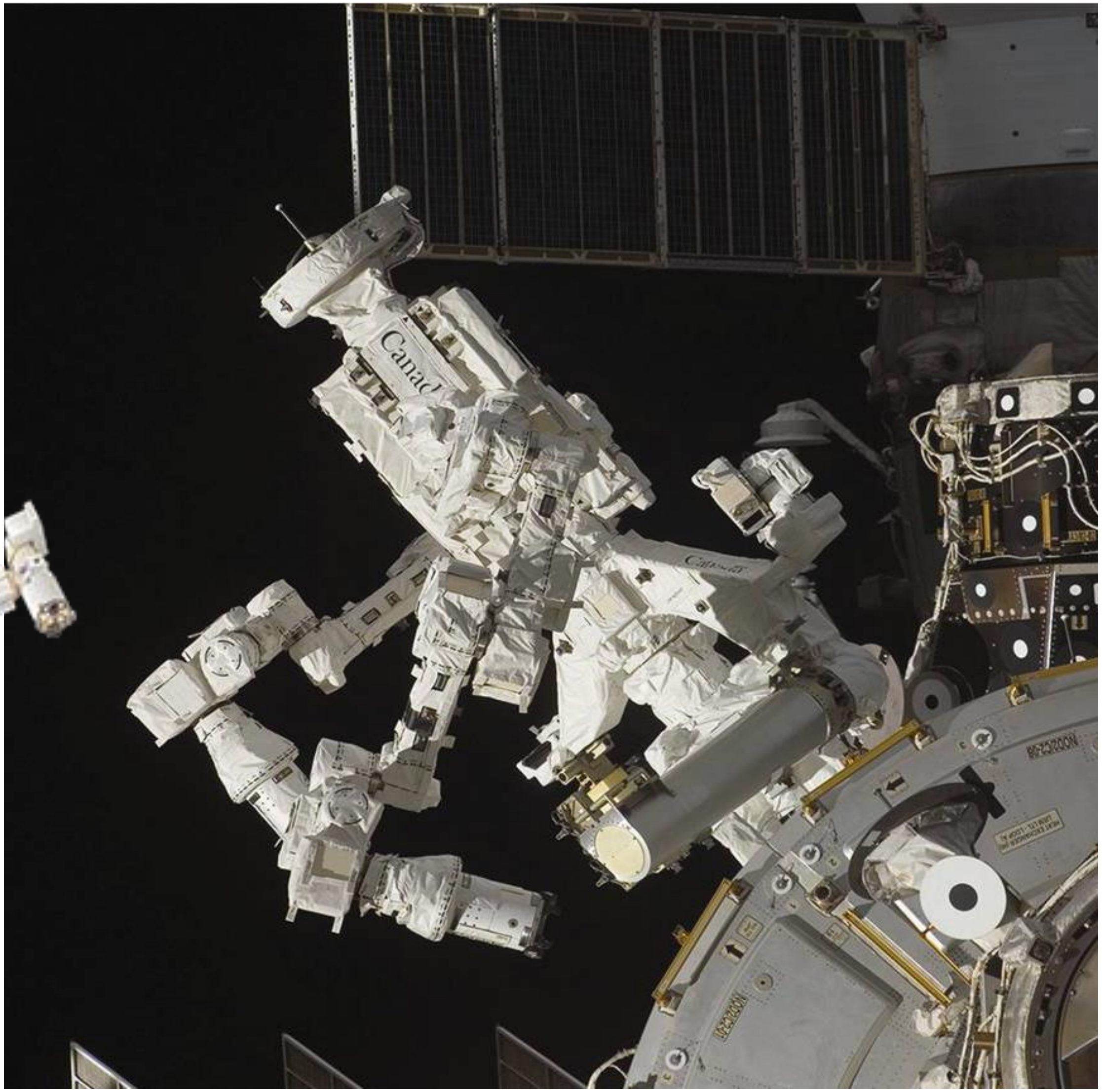
JEM EFU 12 Payload Zenith Face Fish-eye FOV

Payload Allowable Up-Mass & Volume Summary Table

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

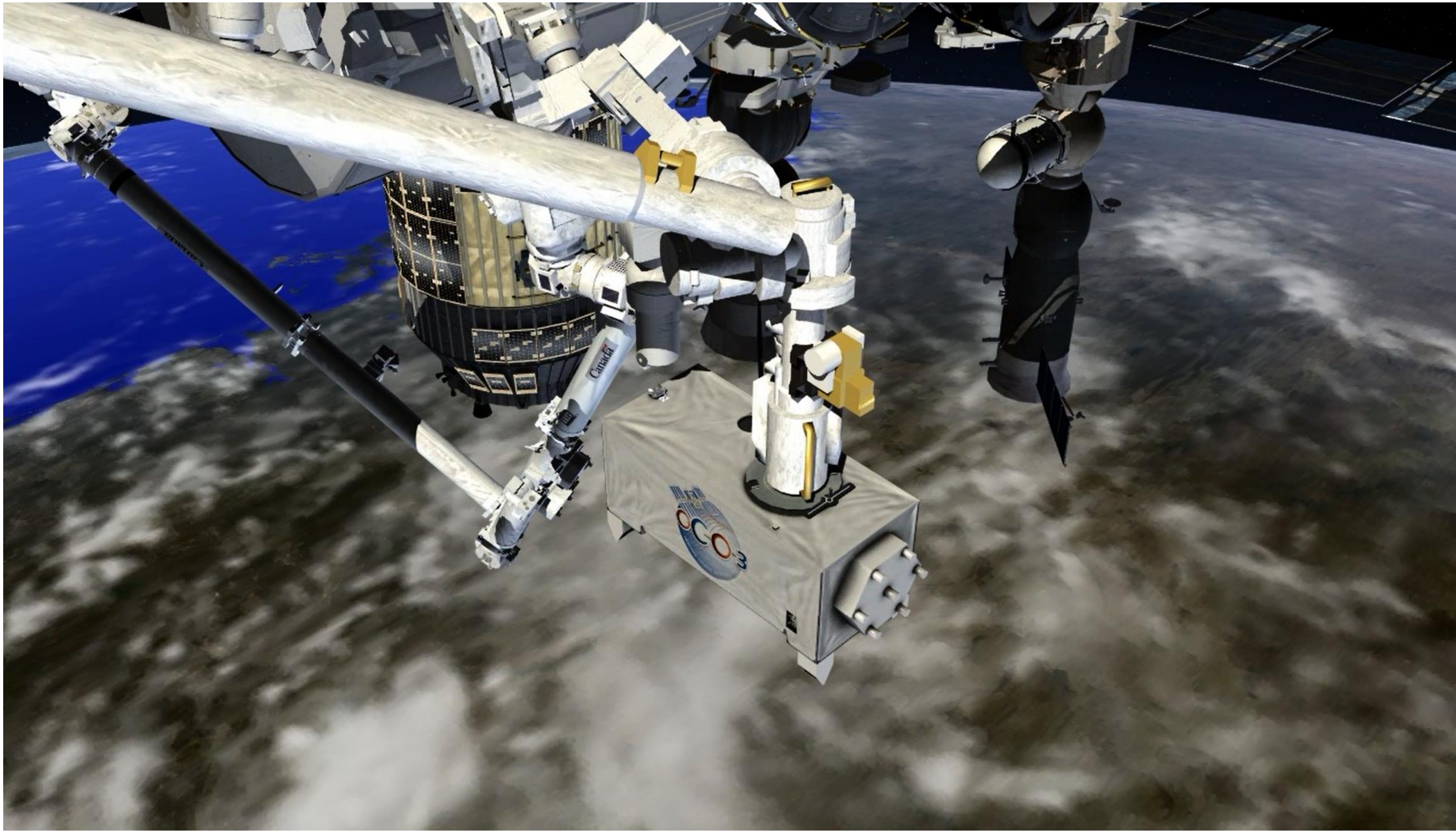
* Location constraint applies in HTV Exposed Pallet

Dexterous End Effector

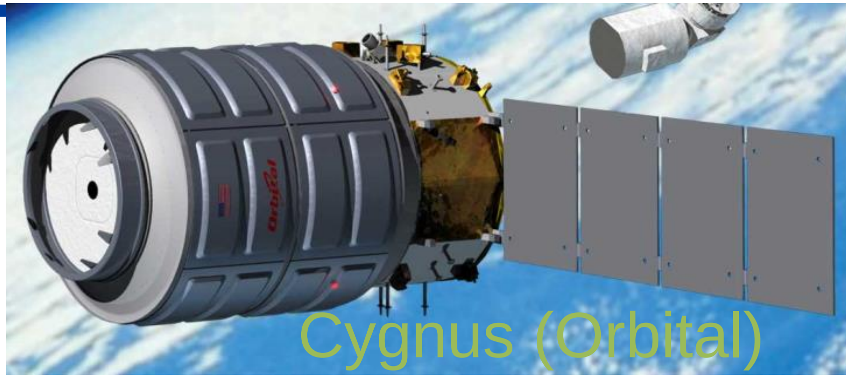


SSRMS attachment which the ground team or on-orbit crew can use robotically to install, remove and replace payloads and failed components

Robotic Installation of Instrument to ISS



ISS Visiting Vehicles Post-Shuttle



Progress/Soyuz (Energia)

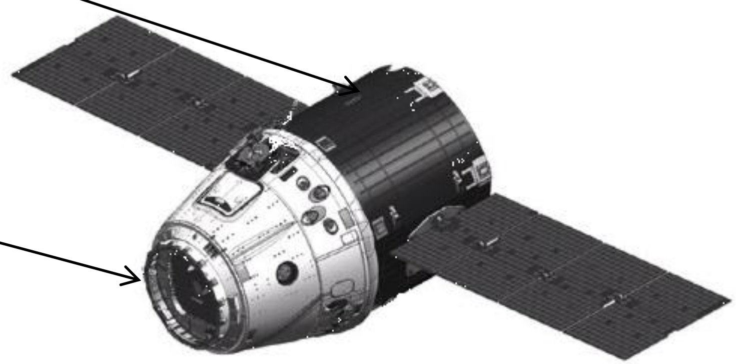
HTV (JAXA)

SpaceX Dragon Launch Vehicle

- **<u>Space X Dragon Launch Vehicle</u>**
  - The Commercial Resupply Contract (CRS) is a vehicle to provide up-mass to ISS using commercial services Space X “Falcon 9” rocket and Dragon spacecraft
  - Trunk behind Dragon for unpressurized cargo (no return capability – disposal only)
  - Dragon Trunk Capacity is ~ 1700 Kg.
  - Total Dragon cargo heater power is 200 watts (**shared** between payloads in the launch vehicle trunk)

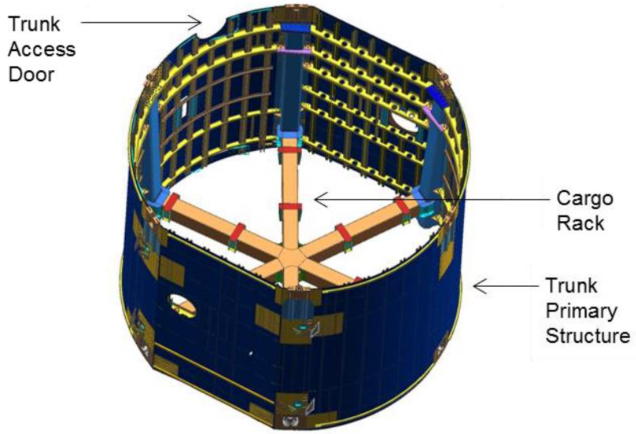
Dragon Dispose Trunk

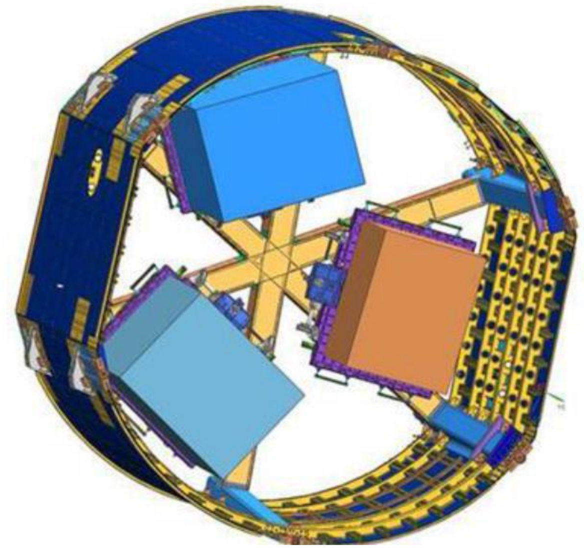
Dragon Return Capsule

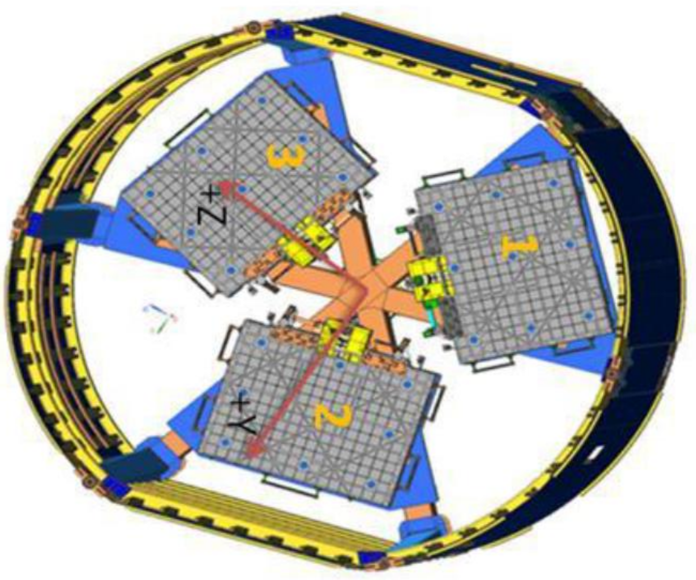


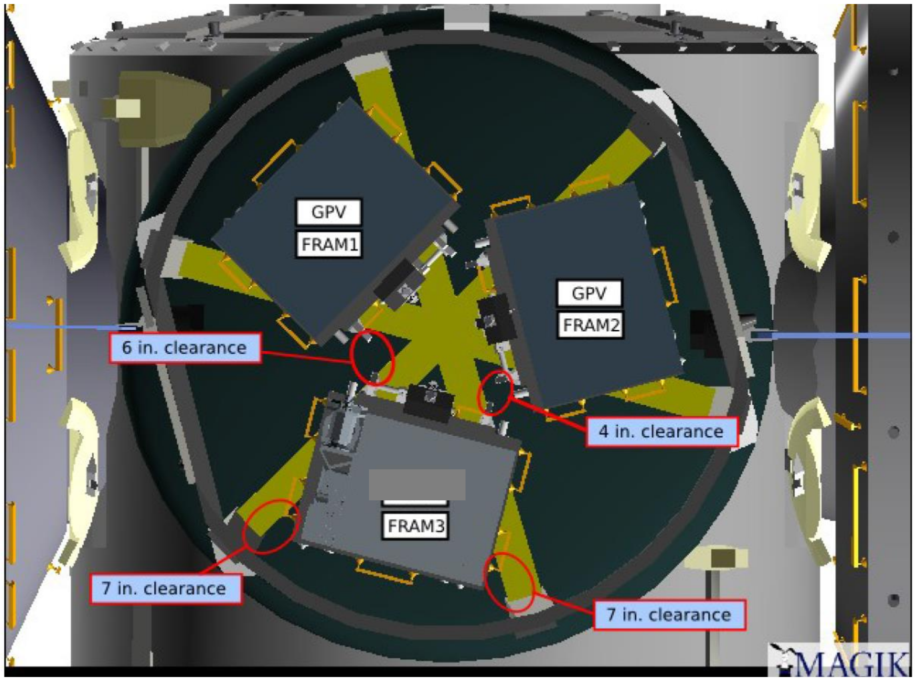
Dragon

SpaceX Dragon External Payload Trunk FRAM Lay-out

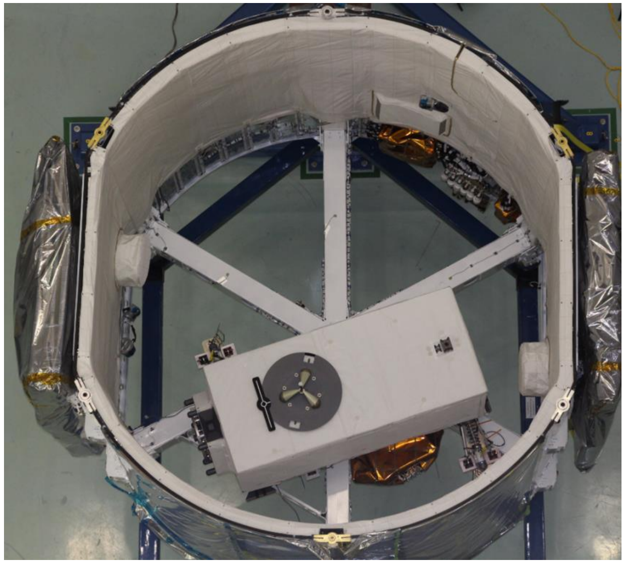


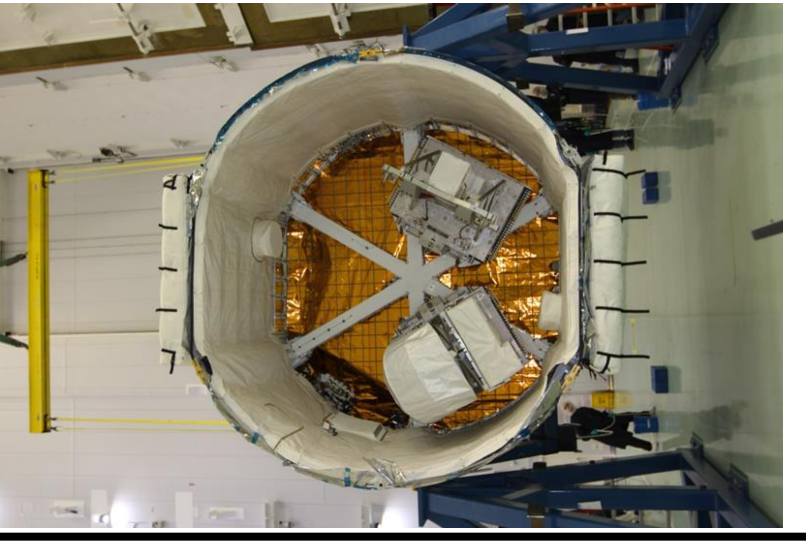


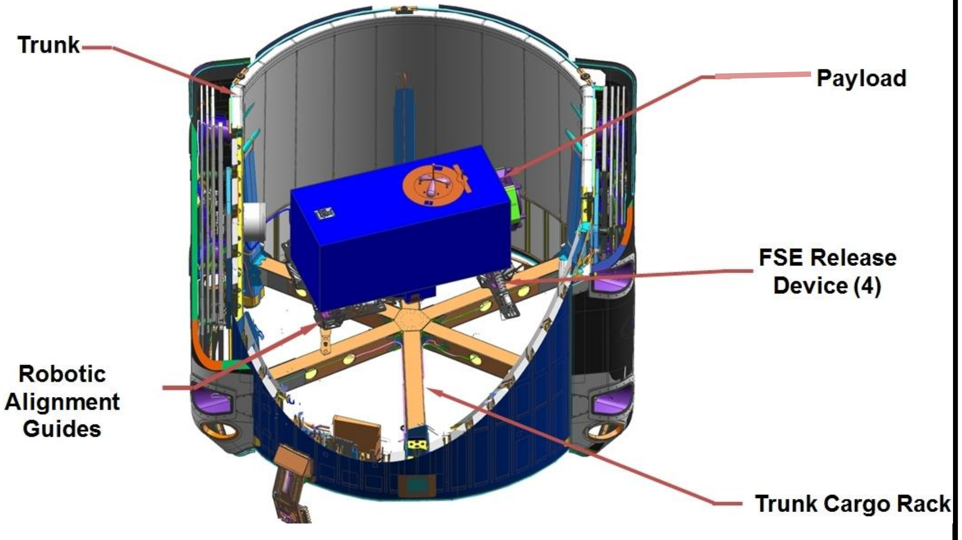


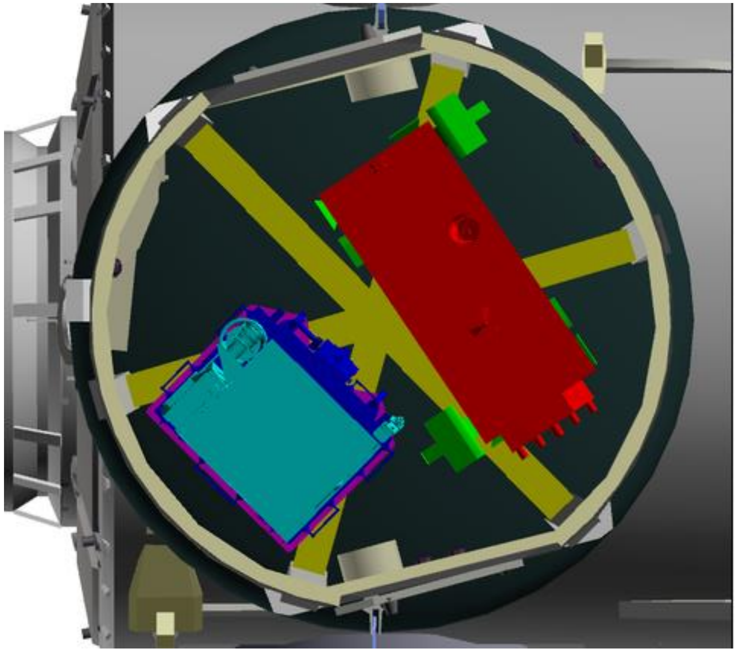


SpaceX Dragon External Payload Trunk JEM-EF Lay-out





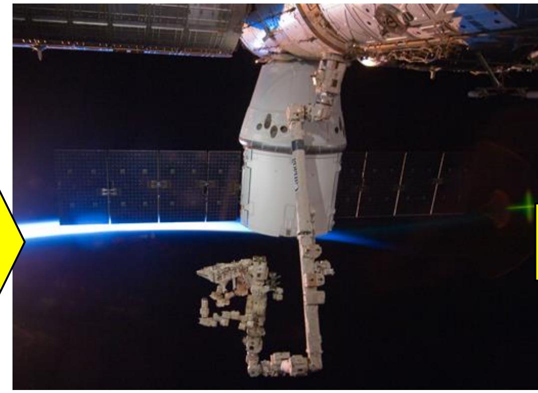




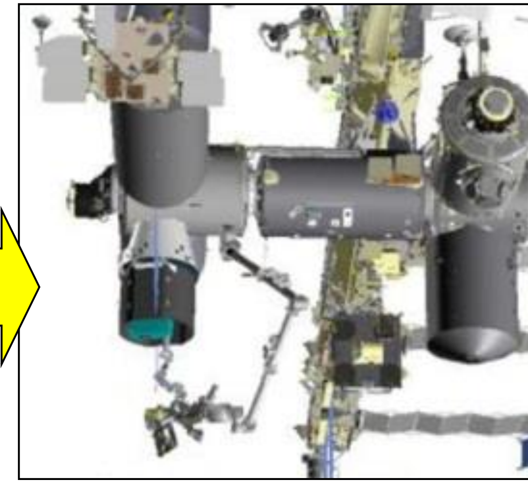
Launch and Installation

Dragon Launch

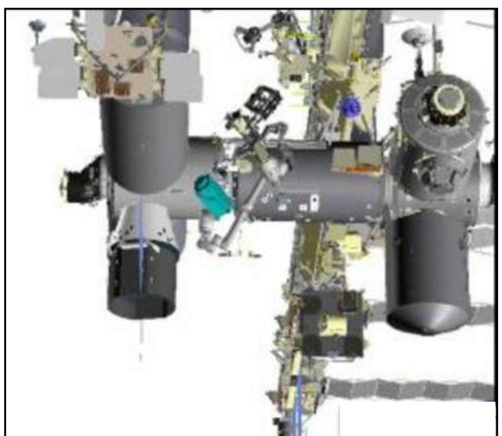
Dragon travels in lower rendezvous orbit for 2-3 days



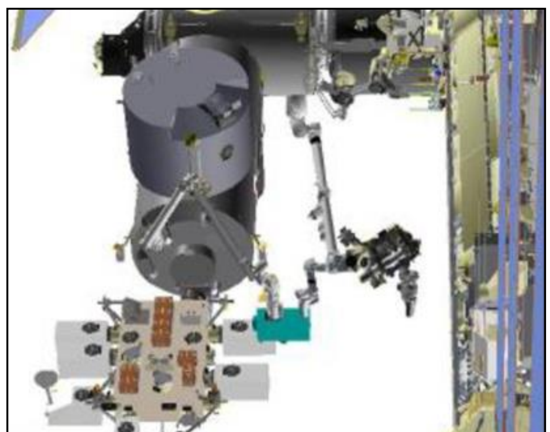
Dragon rendezvous with ISS; captured and berthed at Node 2



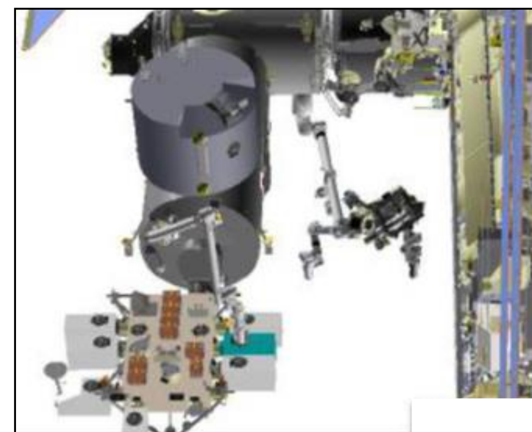
Instrument is removed from Dragon trunk by the SSRMS



Instrument is moved over to JEM



Instrument is handed off to JEM-RMS



Instrument is berthed at EFU

ISS Feasibility Accommodation Assessment Evaluation Criteria

- In performing the accommodation feasibility assessments, the ISS Integration Research office (RIO/OZ) looks at whether or not the proposed instrument meets the standard interfaces or requires significant non-standard integration re/work
- For example, the volumes are defined for each platform but there are specific dimensions that make up those volumes
  - Working with the proposer, we will evaluate the dimensions and determine if the instrument is within the standard dimensions or exceeds those dimensions in one or more areas
  - If it exceeds the standard interfaces, we will provide an evaluation of how simple or hard it will be to accommodate those non-standard interfaces
  - The proposers will be made aware of any non-standard interfaces to determine if they can modify their design to stay within the standard interfaces
  - A lot of times, non-standard interfaces CAN be accommodated but it requires additional work during the integration process

Nominal Data Required From Proposer Team

- Payload Upmass (Includes both instrument and ISS Interface Hardware
- Volumetric Dimensions (both static and dynamic)
- Power consumption (includes peak power)
- Data rates (includes any data latency requirements)
- Pointing/viewing needs
- Lifetime required on orbit
- Instrument readiness date (date payload is ready to fly to ISS)
- Return plan

Heliophysics Explorers ISS Feasibility Assessment Process

1. Contact the Space Station Research Integration Office (RIO/OZ) at the NASA Johnson Space Center to start a dialogue and arrange for a feasibility assessment telecon:

    - Kenol Jules (Kenol.jules-1@nasa.gov, 281-244-5516)

2. Provide background information on the AO that your team is responding to, HQ Program Scientist (PS) and Program Executive (PE) names and your instrument technical information, such as:
    - Description of instrument concept and preliminary design approach
    - Estimate of launch/on-orbit mass, on-orbit volume/dimensions, power, data downlink requirements, need for cooling, and your preliminary assessment of possible ISS site locations for your proposed instrument
    - Any mass or volume/dimensions that exceed ISS standard operational instrument envelopes for a particular site will require a waiver---small deviations can often be accommodated
    - RIO will assess your overall design approach and let you know the suitability of your proposed design concept for accommodation on ISS. If your design concept has envelope exceedances, we will let you know possible options related to them.

Science Mission Explorer ISS Feasibility Assessment Process

3. To complete the assessment several follow-up telecons may be needed, email exchanges and additional data requests are to be expected
4. Once the ISS assessment team has reviewed all potential ISS accommodations and interfaces issues and had had discussions about them with the proposer team, a draft preliminary ISS accommodation feasibility letter will be generated by RIO
5. The draft feasibility letter will be reviewed with the proposer team for any comment. The content of the letter focuses on the issues identify by the assessment team, which were discussed with the proposer team and it is solely based on the information provided by the proposer at that time
6. The feasibility letter is signed by the RIO manager and issued to the proposer team
7. The whole *process can take 6 to 10 weeks*, depending on the complexity and maturity of the design concept from the proposer team

Science Mission Explorer ISS Feasibility Assessment Process

8. Once the proposals are submitted to NASA, the ISS specific proposals will be reviewed again (in depth this time around) by the ISS RIO in order to issue a final ISS accommodation feasibility letter to the PS, using information provided in the proposals
9. When a proposal is selected for funding, SMD will initiate contact with RIO, which in turn will initiate contact with the proposer team or vice versa to start discussion leading to the instrument integration process to be flown to ISS
10. An authorization to proceed (ATP) will be provided to the ISS office by SMD to official assigned that instrument on ISS at a specific site, launch vehicle with readiness to fly date
11. An ISS integration team will be activated to support the integration process of that instrument on ISS
12. Once the proposer/PI/PD team is under contract with SMD, an ISS kick-off meeting will be held at the Johnson Space Center to start the ISS integration process

[redacted] *Las Vegas at night. Visible are the Las Vegas Strip, seen in contrast with McCarran Airport. Frenchman Mountain and Nellis Air Force Base are dark against the rectilinear grid of the city.*

Questions?

Contact Information:

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NASA Johnson Space Center

Email: Kenol.jules-1@nasa.gov

Tel.: 281-244-5516