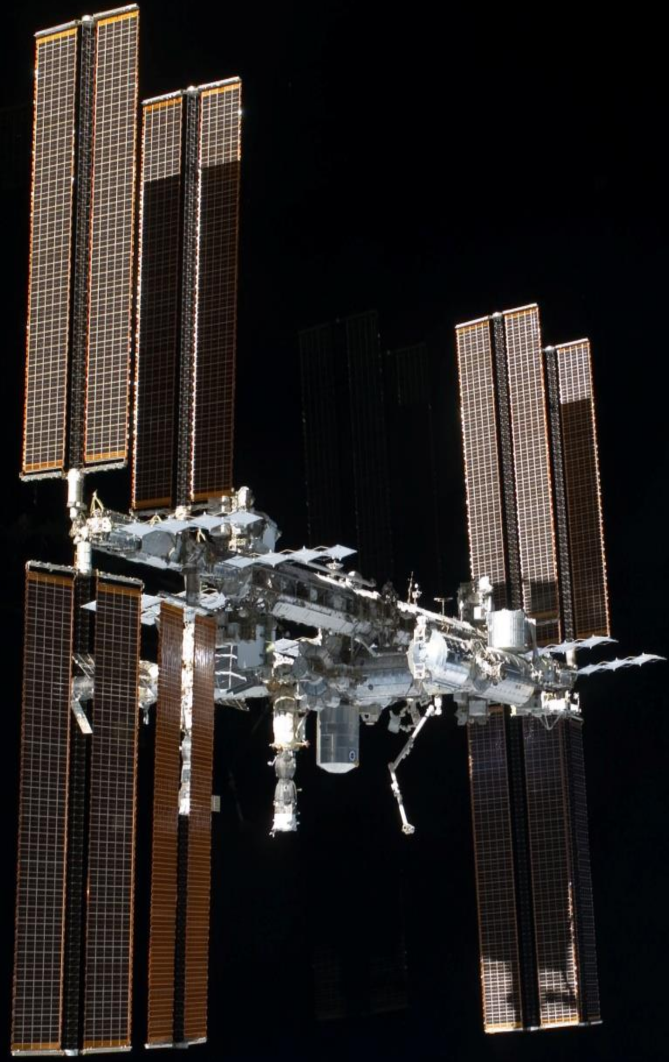


ISS Research Capability for Hosting Space Science Instruments

Steve Huning
Research Portfolio Manager
ISS Research Integration Office
NASA Johnson Space Center

2022 ESD EVI-6 Pre-proposal Conference

May 6, 2022

International Space Station

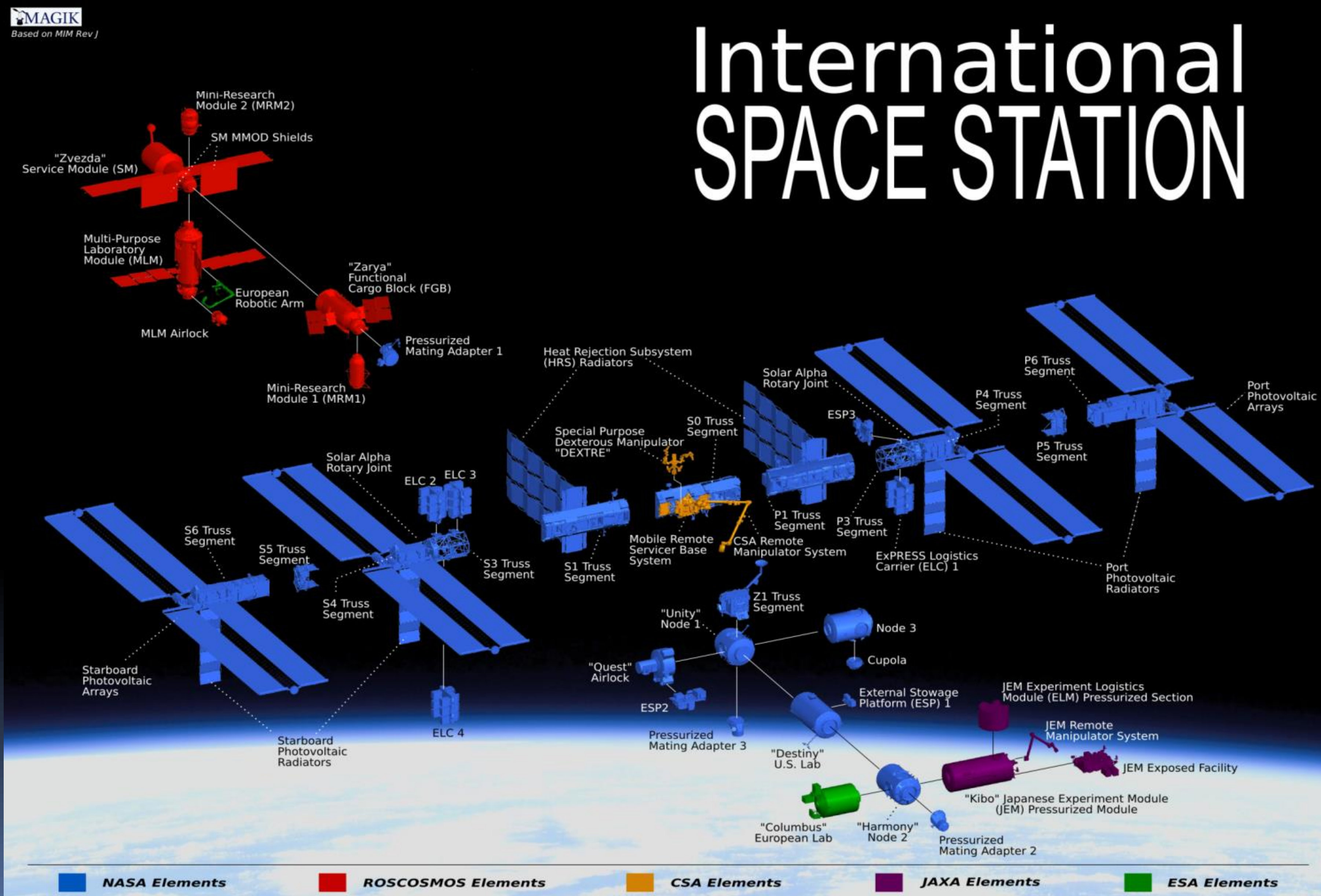
Created by a partnership of 5 space agencies

10 years and over 100 missions to assemble

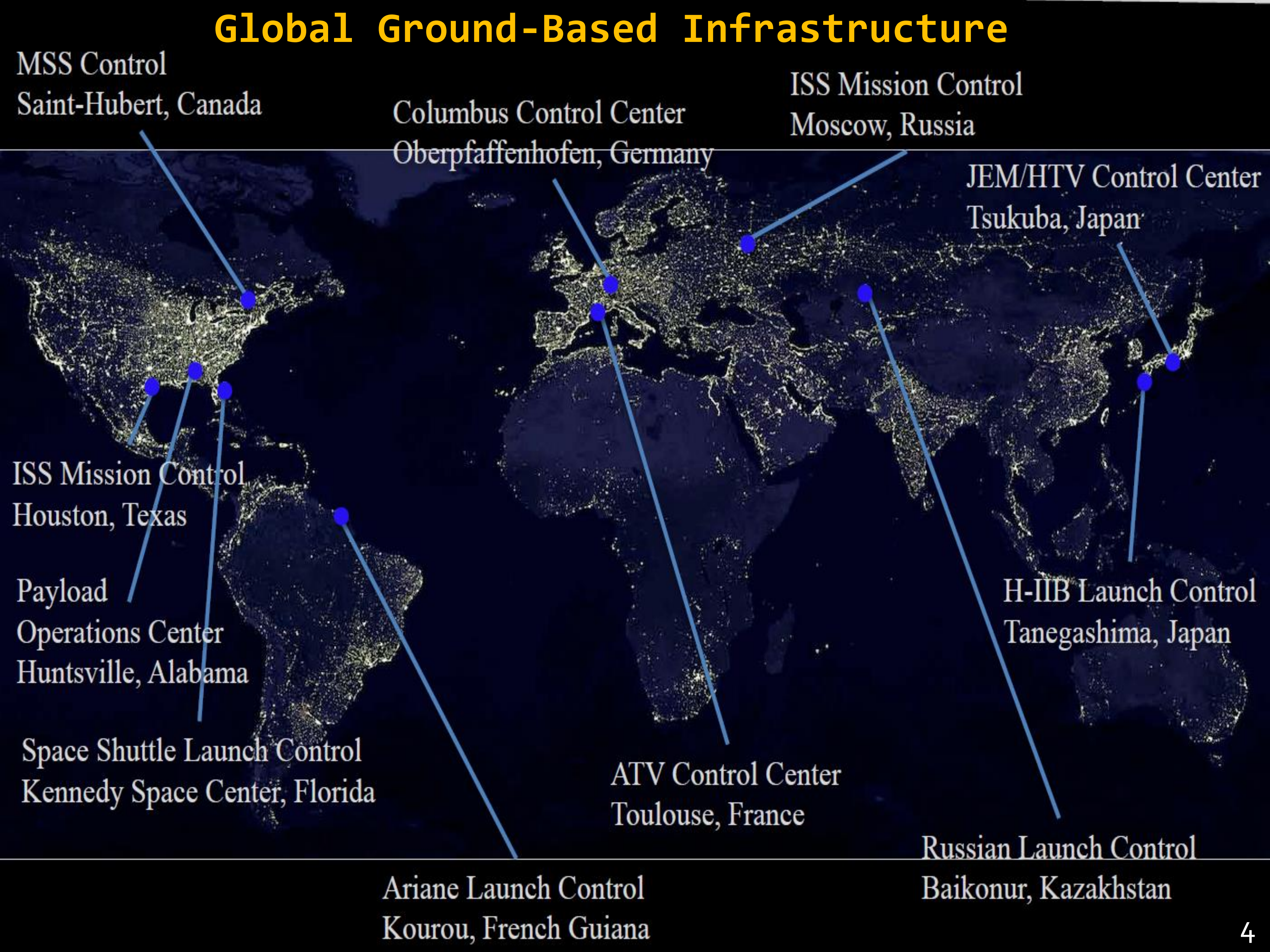
A laboratory for **Microgravity** and **Earth Science** research at a scale that has not been achieved before and that no one agency or country could sustain

Creating knowledge that improves life here on earth and provides a steppingstone 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

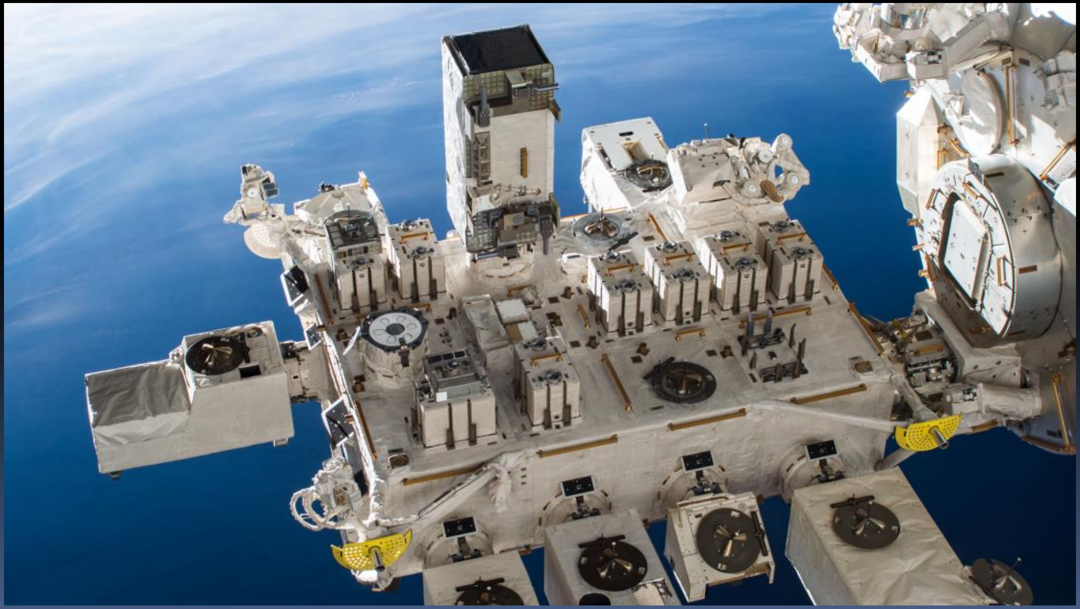
- Sustainable microgravity and space research platform for long term studies
- Permanent Crew presence
- Access to the vacuum of space
- External and internal research
- Automated, human, and robotic operated research
- Exposure to the thermosphere
- Earth observations at high altitude and velocity
- 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

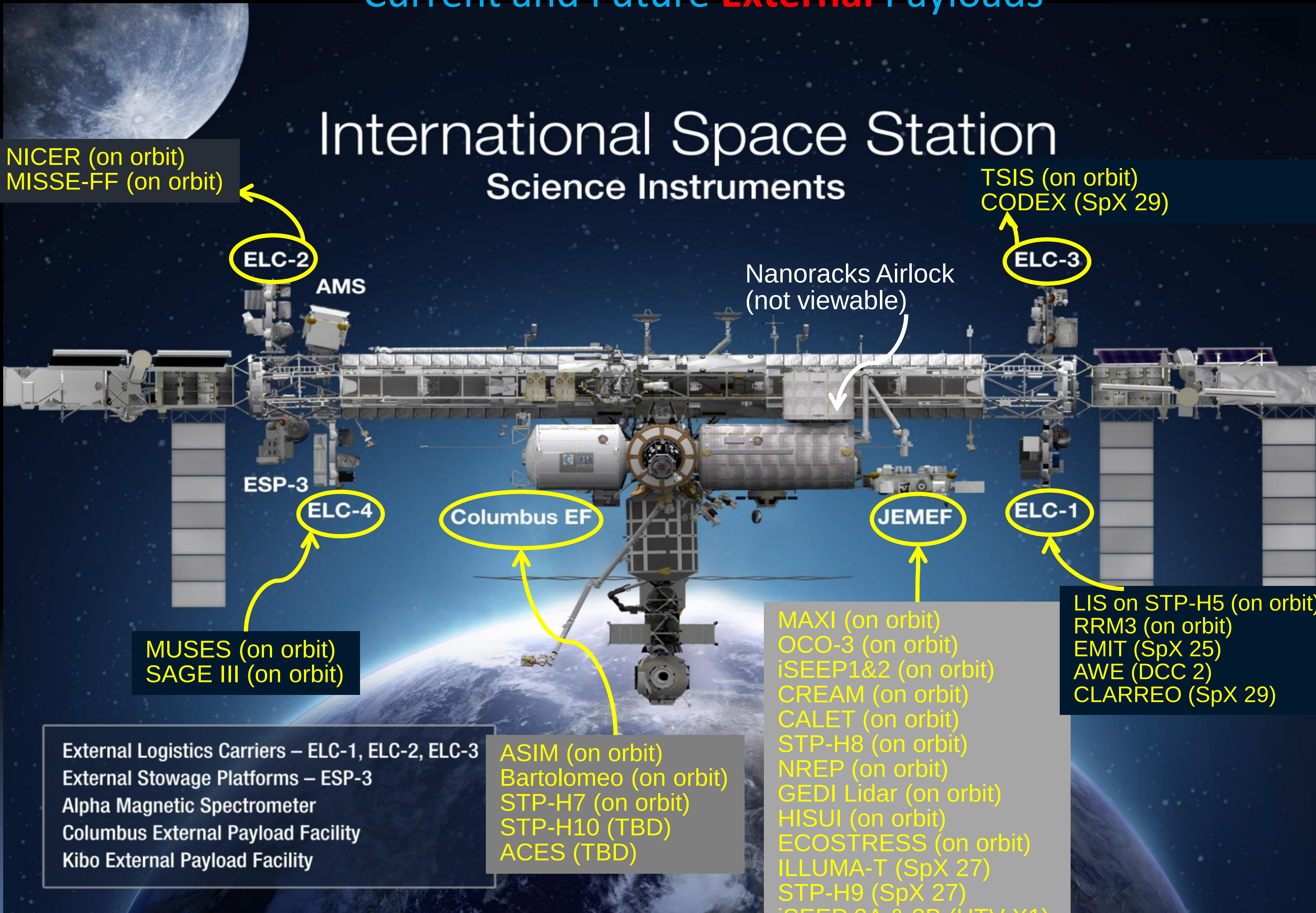
To continue to make the integration and operation of payloads on ISS as simple and ground lab like as possible



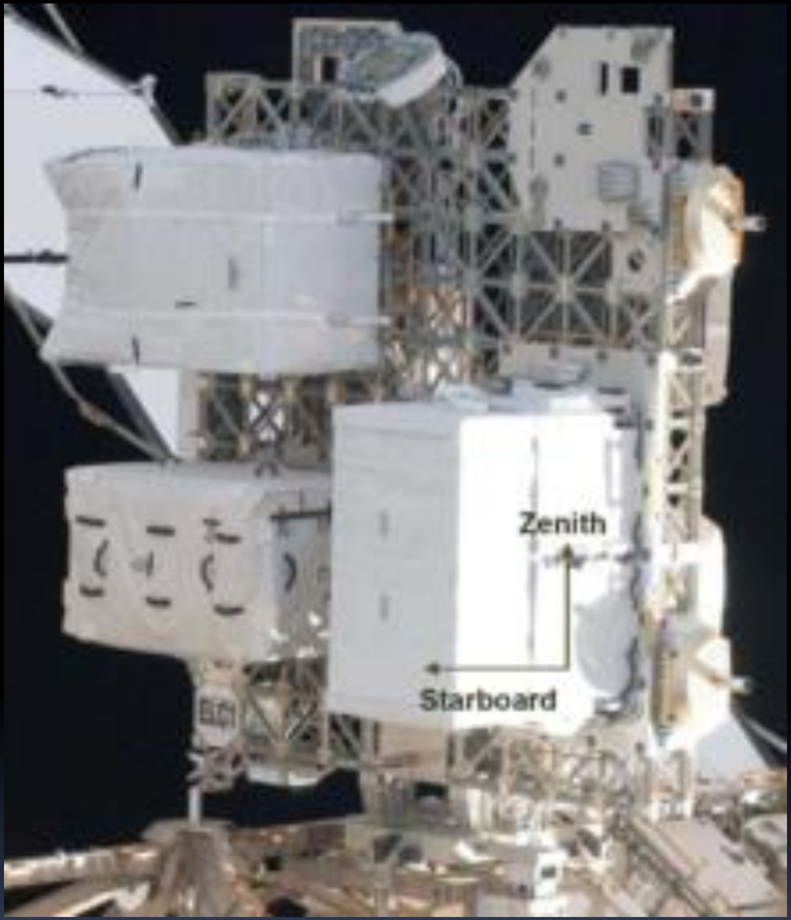
Biden-Harris Administration committed to extend ISS operations through 2030

- International Partners on board with extending to 2030 and are working through the details to finalize with their Agencies / Government
  - https://blogs.nasa.gov/spacestation/2021/12/31/biden-harris-administration-extends-space-station-operations-through-2030/
  - Video: https://www.youtube.com/watch?v=a-flzdifn54

Current and Future External Payloads



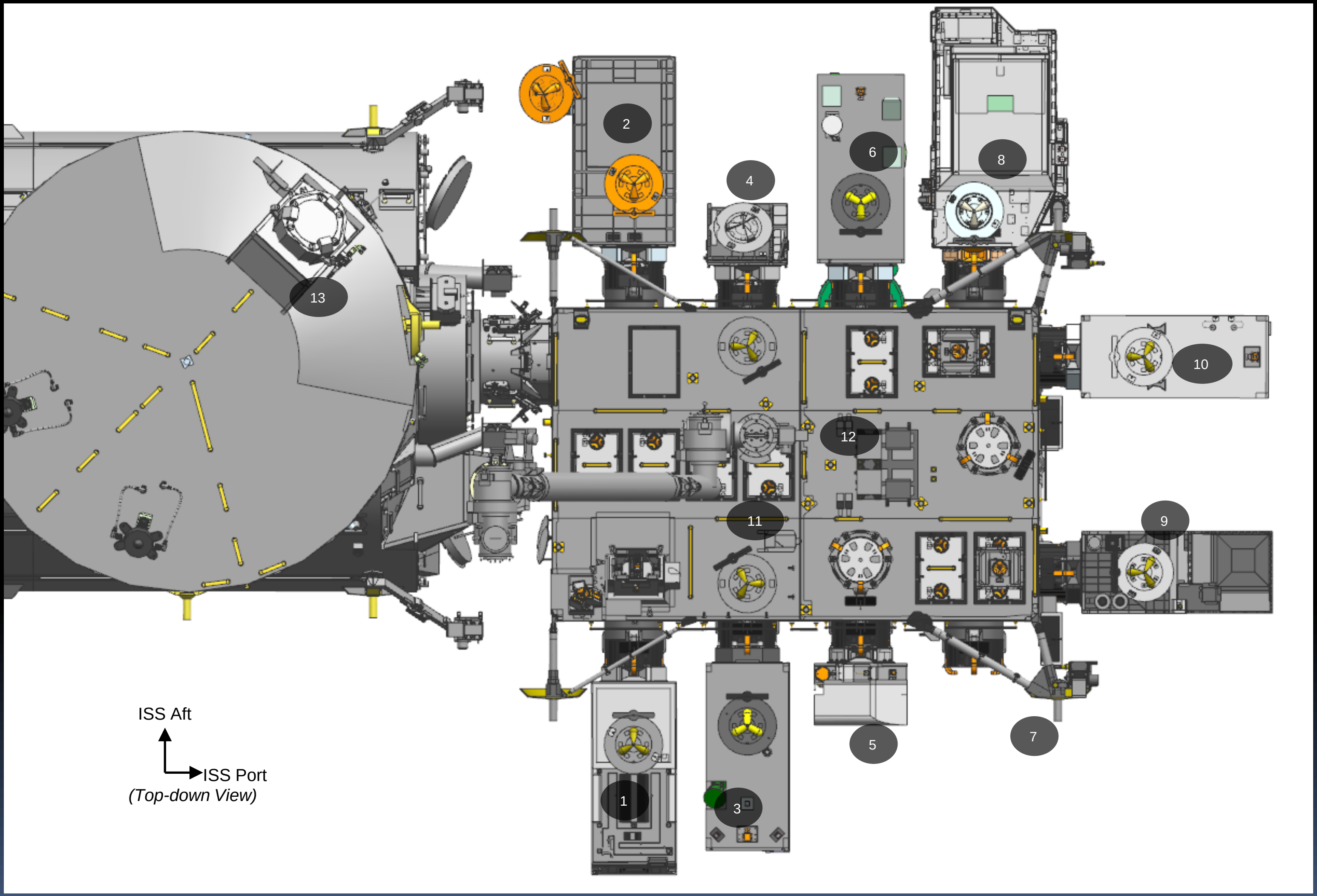
External Logistics Carriers (ELCs)



4 ELCs are attached to the ISS truss

- Each provide 2 payload sites – 8 total
- Port/Starboard & Upper/Lower locations
- Inboard / Outboard / RAM/ Nadir/ Wake / Zenith views

JEM EF Payloads and EFUs

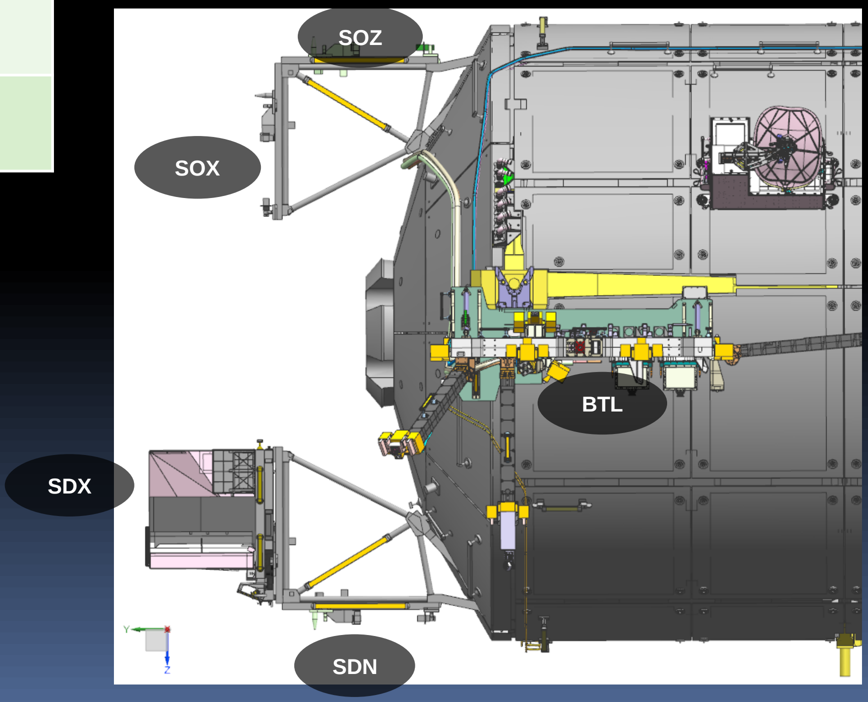


12 JEM EF external payload sites available

Columbus Exposed Payload Facility

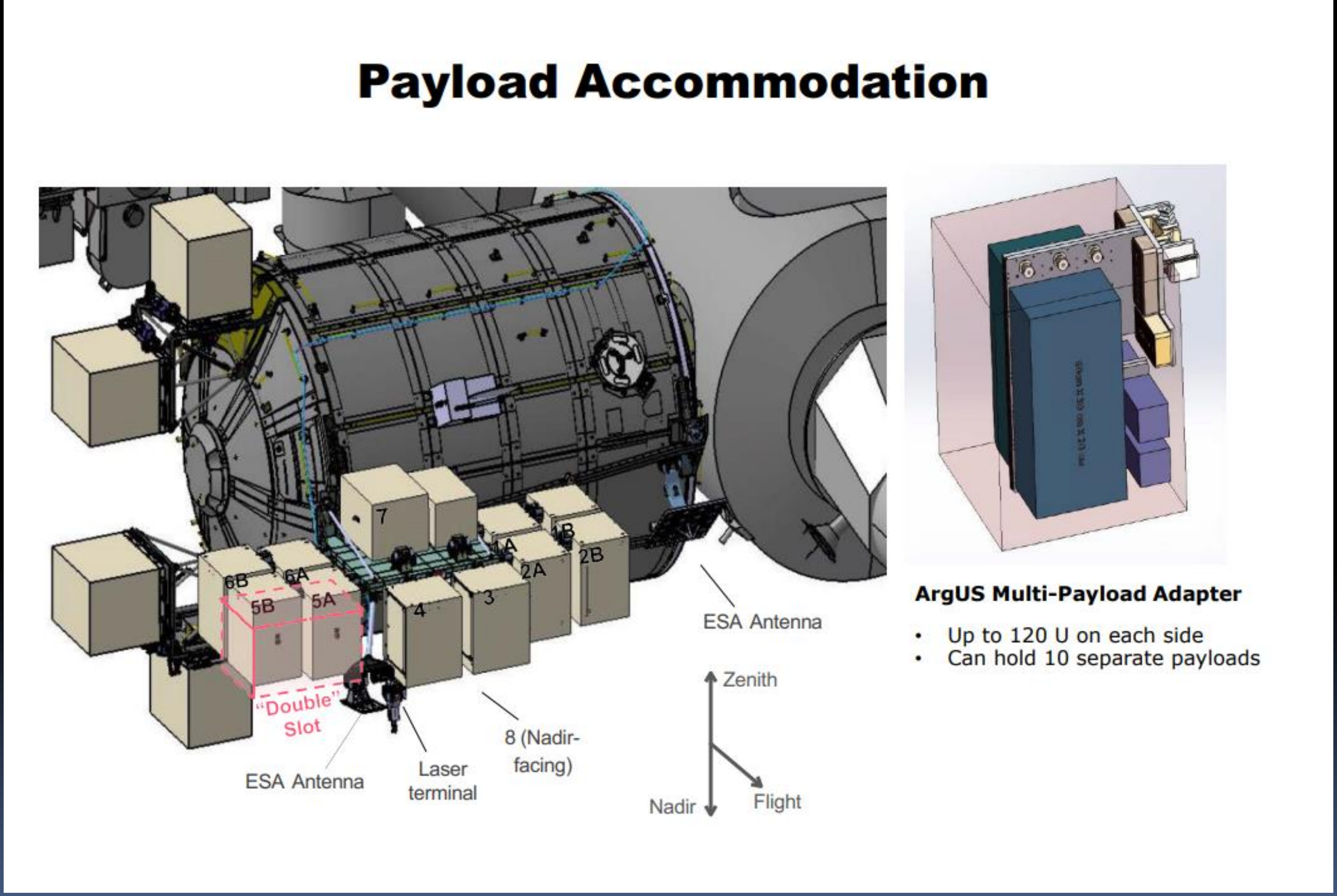
Year	SOZ	SOX	SDX	SDN	BTL
Past	SOLAR (↑1E, ↓NG-12)	SDS (↑SpX-13, ↓NG-12)	RapidScat (SpX-4:SpX-13) ASIM (↑SpX-14)	HDEV (↑SpX-3, ↓NG-13)	BARTOLOMEO (↑SpX-20)
2021			ASIM / STP-H7 (↑SpX-24)	ASIM	m-NLP (↑NG-17) (slot BCP 3)
2022			STP-H7	ASIM	m-NLP (slot BCP 3, TBD)
2023			STP-H7	ASIM (TBD)	
2024			STP-H7 / ASIM (TBD)	ASIM / ACES (TBD)	

4 FRAM based and 12 Gold-2 Payload sites available



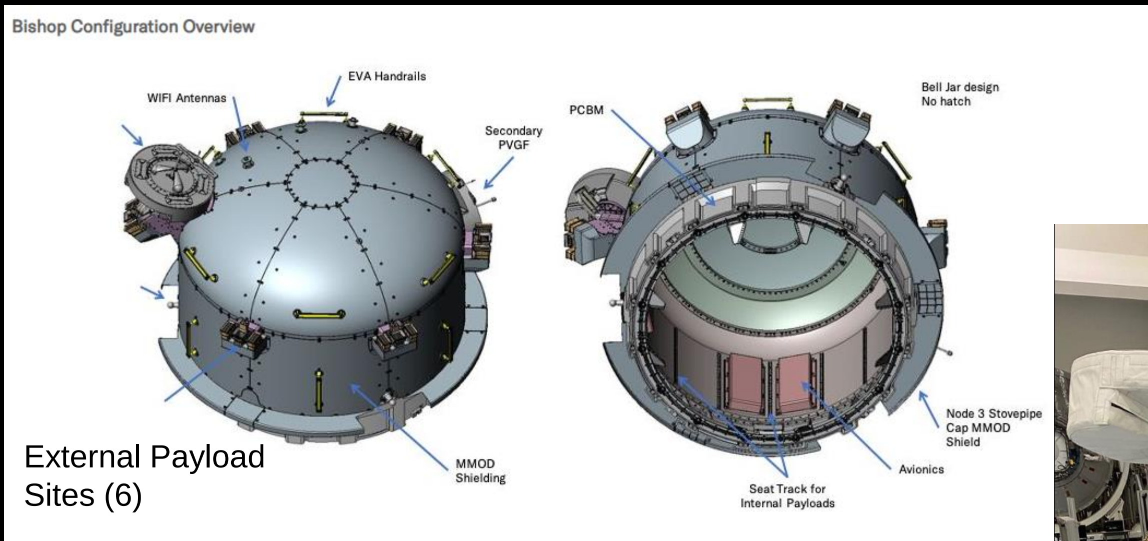
Bartolomeo (Commercial)

https://airbusus.com/leo-human-spaceflight-commercialization/



https://www.issnationallab.org/wp-content/uploads/2018/11/Airbus-Bartolomeo-Platform.pdf

Bishop Airlock (Commercial)

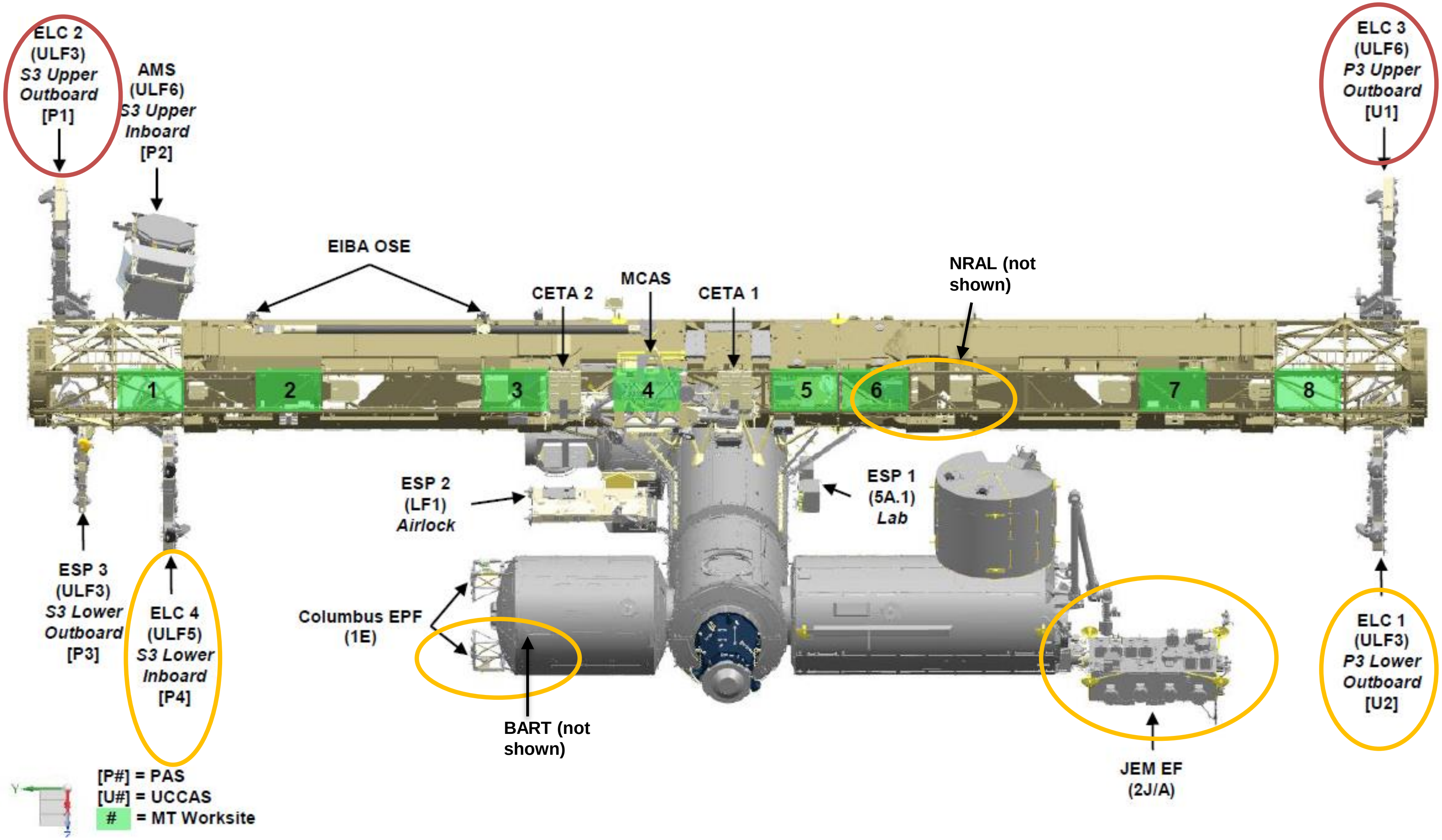


6 Gold-2 payload sites available

GOLD-2

https://nanoracks.com/bishop-airlock/

ISS External Attached Sites for Earth Science Experiments



Best External Sites For Earth Science Instruments

Cubesat Deployers

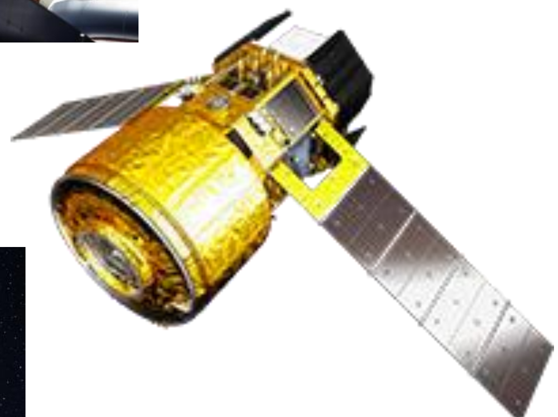
JAXA and Nanoracks have demonstrated small satellite deployment from the ISS to offer more launch opportunities to small satellites.

ISS Visiting Vehicles

Dragon (SpX)

Cygnus (Northrup Grumman)

HTV-X1 (JAXA)
NET: 1/2023

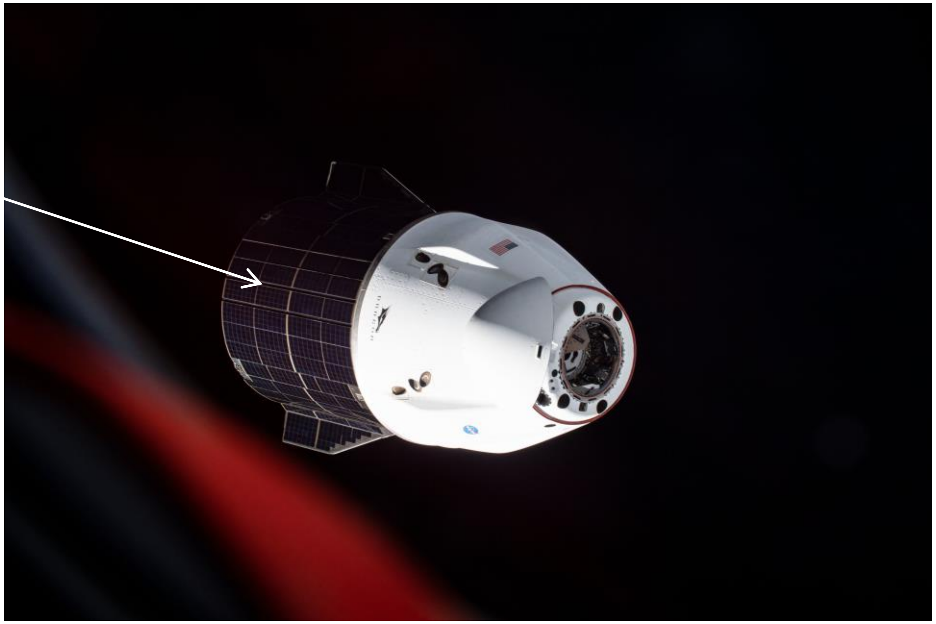


Dream Chaser (Sierra Nevada)
NET: 2/2023

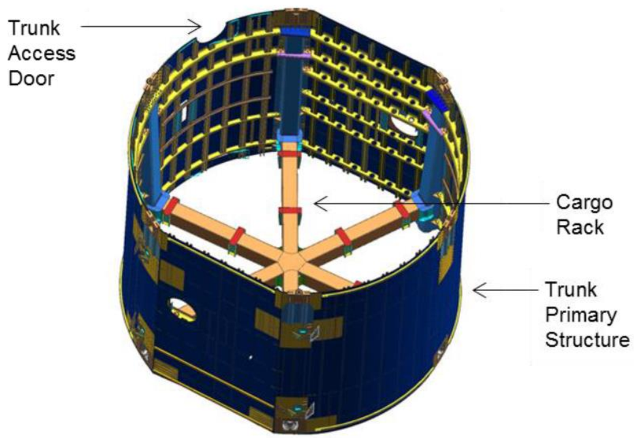
Progress & Soyuz (Energia)

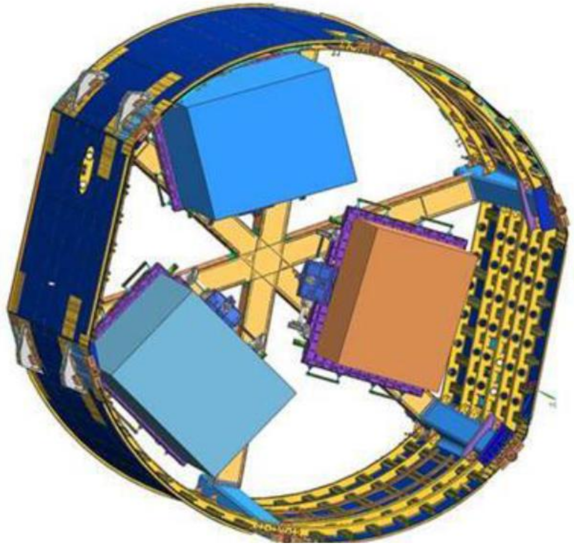
- **<u>Space X Dragon Launch Vehicle</u>**
  - The Commercial Resupply Contract (CRS) provides up-mass to ISS using the commercial Space X Falcon 9 rocket and Dragon spacecraft
  - Dragon trunk utilized for unpressurized cargo (no return capability – disposal only)
  - Dragon Trunk Capacity is ~ 1700 Kg.
  - Total Dragon cargo heater power is 300 watts (**shared** between payloads in the launch vehicle trunk)

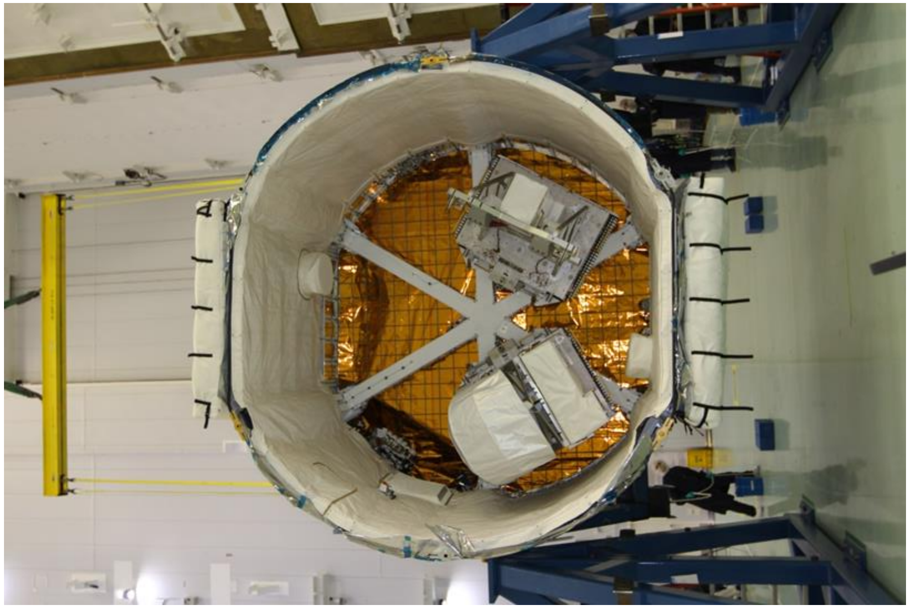
Dragon Disposable Trunk

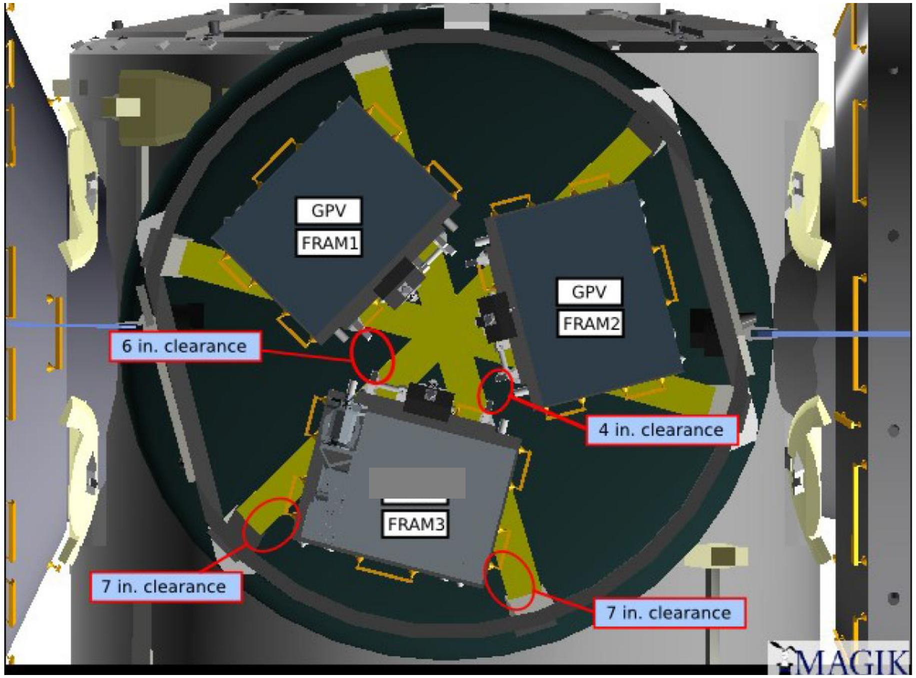


SpaceX Dragon External Payload Trunk FRAM Lay-out (CRS-1 trunk shown)

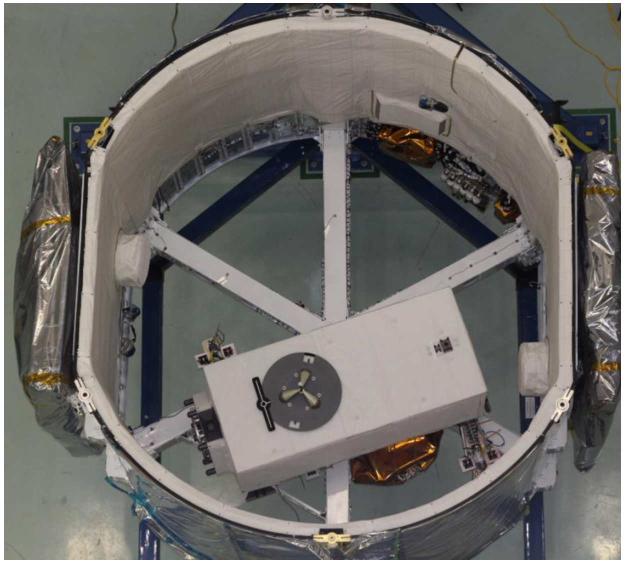


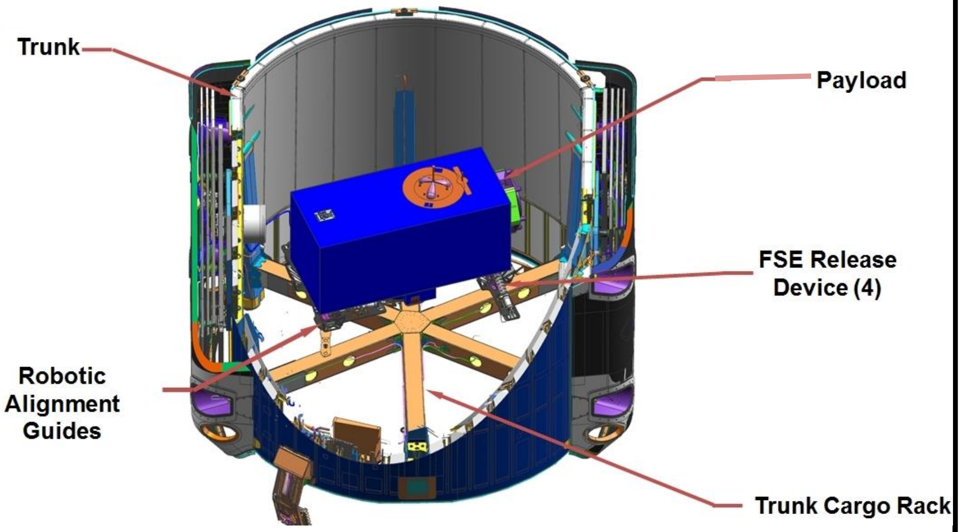


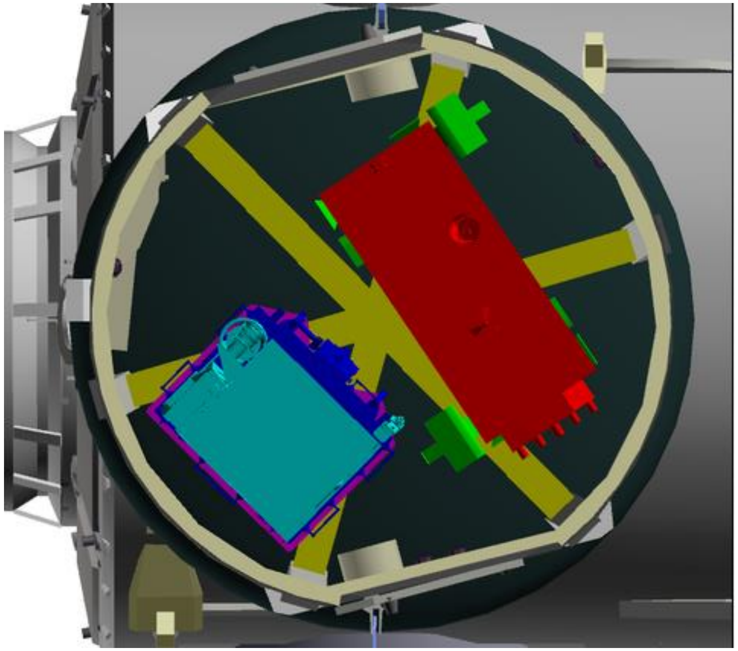




SpaceX Dragon External Payload Trunk JEM-EF Lay-out (CRS-1 trunk shown)





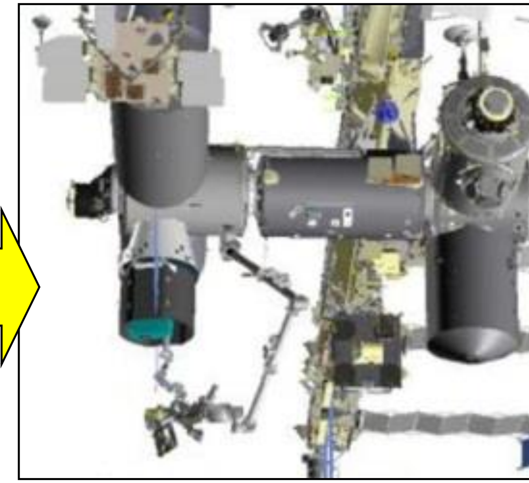


Launch and Installation (JEM EF Payload)

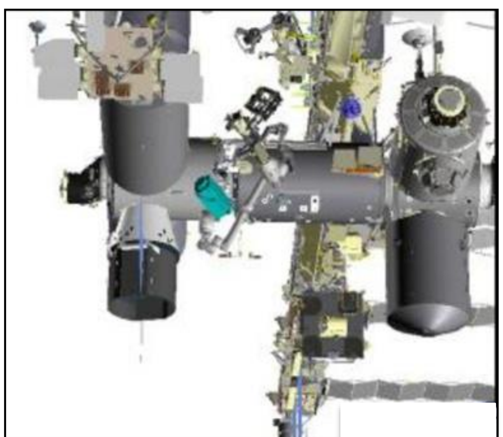
Dragon Launch

Dragon travels in lower rendezvous orbit for 1-2 days

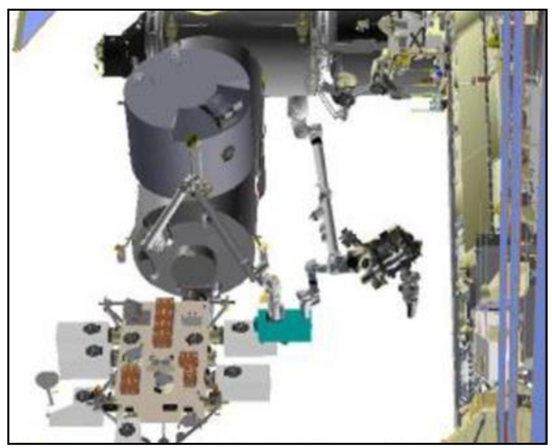
Dragon rendezvous and docks to Node 2



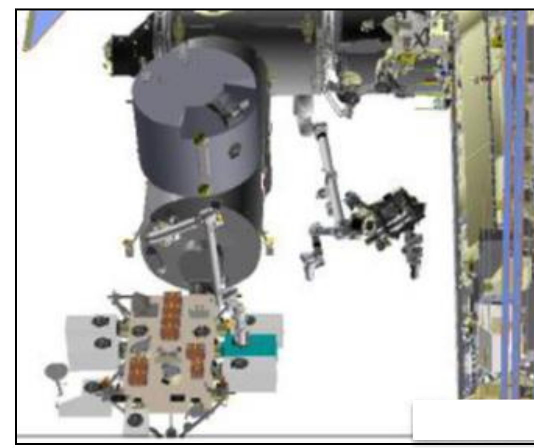
Payload removed from CRS-1 Dragon trunk by the SSRMS



Payload relocated to JEM External Facility (EF)



Payload handed off to JEM-RMS

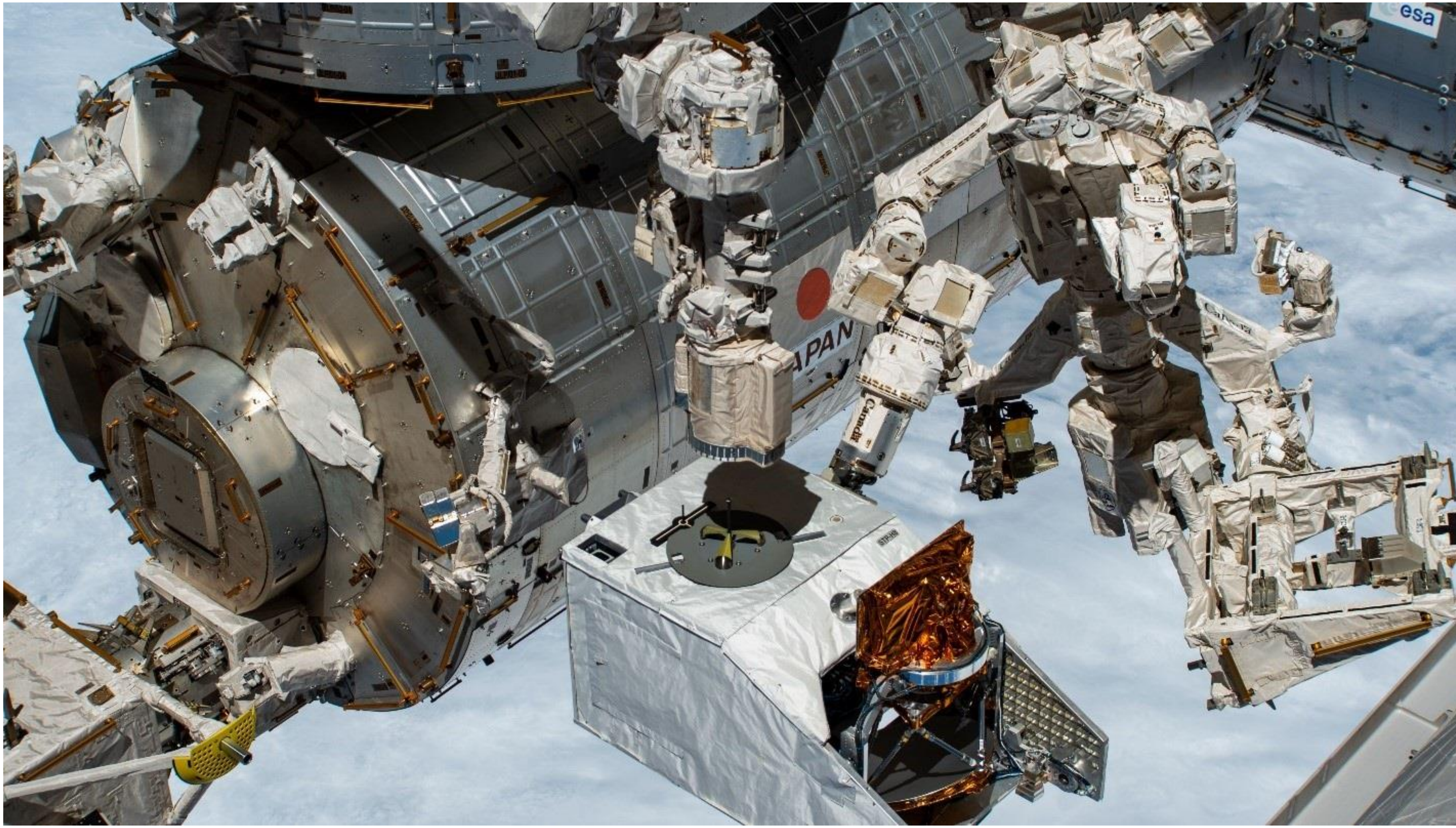


Payload berthed to JEM EF Unit

Special Purpose Dexterous Manipulator (SPDM)

SPDM attached to SSRMS and used by the ground team or on-orbit crew to robotically install, remove and replace payloads and failed components

SPDM to JEM RMS Handoff of ISS Payload prior to installing on JEM EF



ISS Feasibility Assessment

- The ISS Integration Research office (RIO) will assess the payload needs to determine if they are compliant with ISS resources and meet standard interface requirements
- Nominal Data needed from Proposer Team
  - Payload Upmass (Include both instrument and ISS Interface Hardware
  - Volumetric Dimensions (both static and dynamic)
  - Power consumption (include peak power, on orbit and launch vehicle survival power)
  - Data rates (include any data latency requirements)
  - Pointing/viewing needs
  - Lifetime required on orbit
  - Instrument readiness date (date payload is ready to be turned over to the launch vehicle)
  - Return plan

ISS Resource Requested	Units	CBE	NTE/MPV	Proposal Team Comments	ISS Comments
Flight Hardware Readiness	Date/ year				
Site	N/A				
Mass	Kg				
Peak Power	Watt				
Average Power	Watt				
On-Orbit Survival Power	Watt				
Launch Vehicle Survival Power @120V	Watt				
Average Data	Mbps				
Peak Data	Mbps				
Data Volume	GB/da y				
Volume at Launch	LxWx H, m3				
Volume During on-orbit Operation	LxWx H, m3				
Cooling Flow	Kg/hr				
FOV	N/A				
Data Interface	N/A				
Site Occupancy Length	# of years				
Data Latency Day/hr/min					
Other/Ancillary	N/A				
CBE: current best estimate; MEV: maximum expected value; MPV: maximum possible value (MPV=NTE)					

Feasibility Assessment Process

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

    - Steven Huning
      steven.w.huning@nasa.gov
      832.248.1034

2. Provide the Mission of Opportunity that your team is supporting, 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

3. To complete the assessment several follow-up telecons, emails and data requests may be needed

Feasibility Assessment Process

4. ISS RIO will assess your design approach and let you know the suitability of your proposed design for accommodation on ISS. If your design has envelope exceedances, we will let you know possible options to resolve.

5. A draft feasibility letter will be generated and reviewed with the proposer team for comments. The letter is solely based on the information provided by the proposer at that time.

6. The final feasibility letter is signed by the RIO manager and provided to the proposer team

7. The entire process should take 6 to 10 weeks, depending on the complexity and maturity of the design from the proposer team

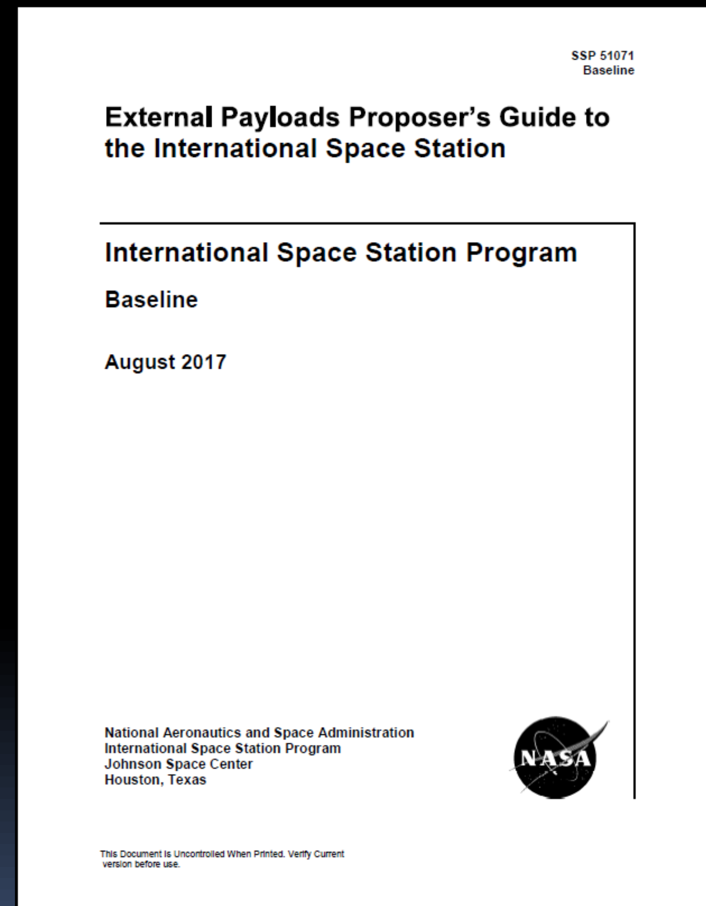
8. When a proposal is selected for funding, SMD will inform the ISS RIO via an Authorization to proceed (ATP), to start the integration process

8. An ISS integration team will be developed to support the integration process of that instrument on ISS. This team will help your team throughout the design, test, safety approval and verification, launch, and operations processes.

External Payloads Proposer's Guide to the International Space Station

- Provides proposers who are new to the Station environment an overview of the capabilities, accommodations, and requirements for operating research on ISS
- The Guide is intended as a one-stop shop for developing proposals for operating external payloads on ISS

https://www.nasa.gov/mission_pages/station/research/facilities_external_payloads_proposer_guide


SSP 51071
Baseline

External Payloads Proposer's Guide to the International Space Station

International Space Station Program

Baseline

August 2017

National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center
Houston, Texas

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[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:

Steve Huning

NASA Johnson Space Center

Email: steven.w.huning@nasa.gov

Tel.: 832.248.1034

BACKUP

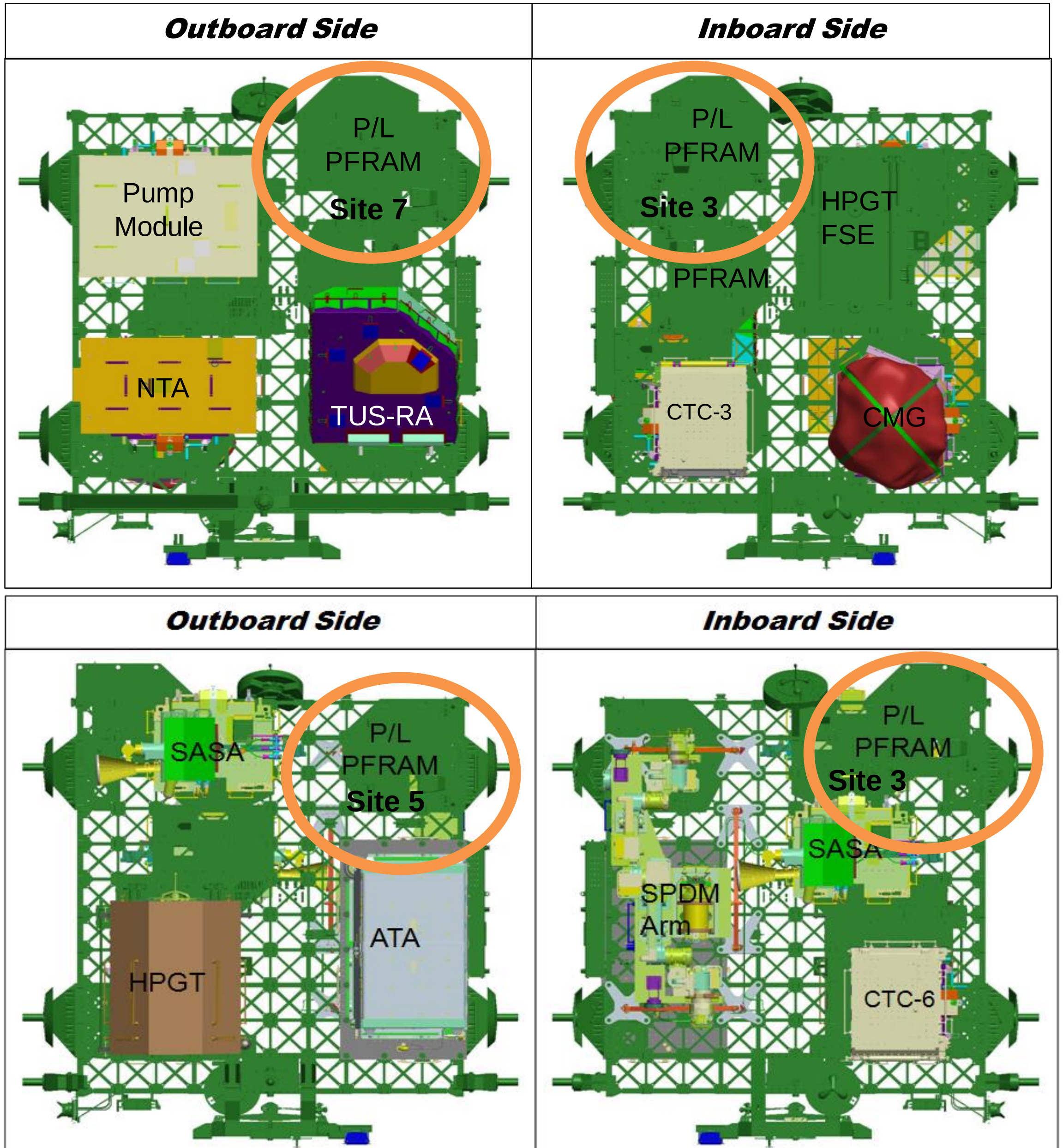
Payload Allowable Up-Mass & Volume Summary Table

Attached Payload Location	Allowable Payload weight	Flight Support Equipment weight	Total Weight	Payload Volume (W x H x L)
ELC (ExPA)	500 lbs (227 kg)	250 lbs (114kg)	750 lbs (340 kg)	34 x 49 x 46 in (863 x 1244 x 1168 mm)
Columbus (CEPA)	521 lbs (236 kg)	250 lbs (114kg)	771 lbs (350 kg)	34 x 49 x 46 in (863 x 1244 x 1168 mm)
JEM EF (PIU)	981 lbs (445 kg) @ standard payload locations 5391 lbs (2445 kg) @ heavy payload locations	121 lbs (55 kg)	1102 lbs (500 kg) 5512 lbs (2500 kg)	31.5 x 39.4 x 72.8 in (800 x 1000 x 1850 mm)

ExPA: External Payload Adapter
CEPA: Columbus External Payload Adapter
PIU: Payload Interface Unit

Flight Support Equipment Weight includes ExPA, CEPA, PIU, FRGF, electrical connector, handrails

Express Logistics Carriers Overview



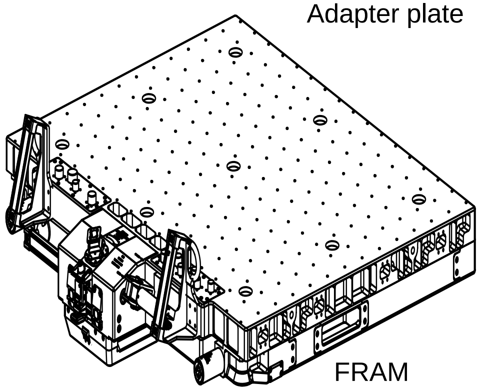
Payload Locations Circled

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

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

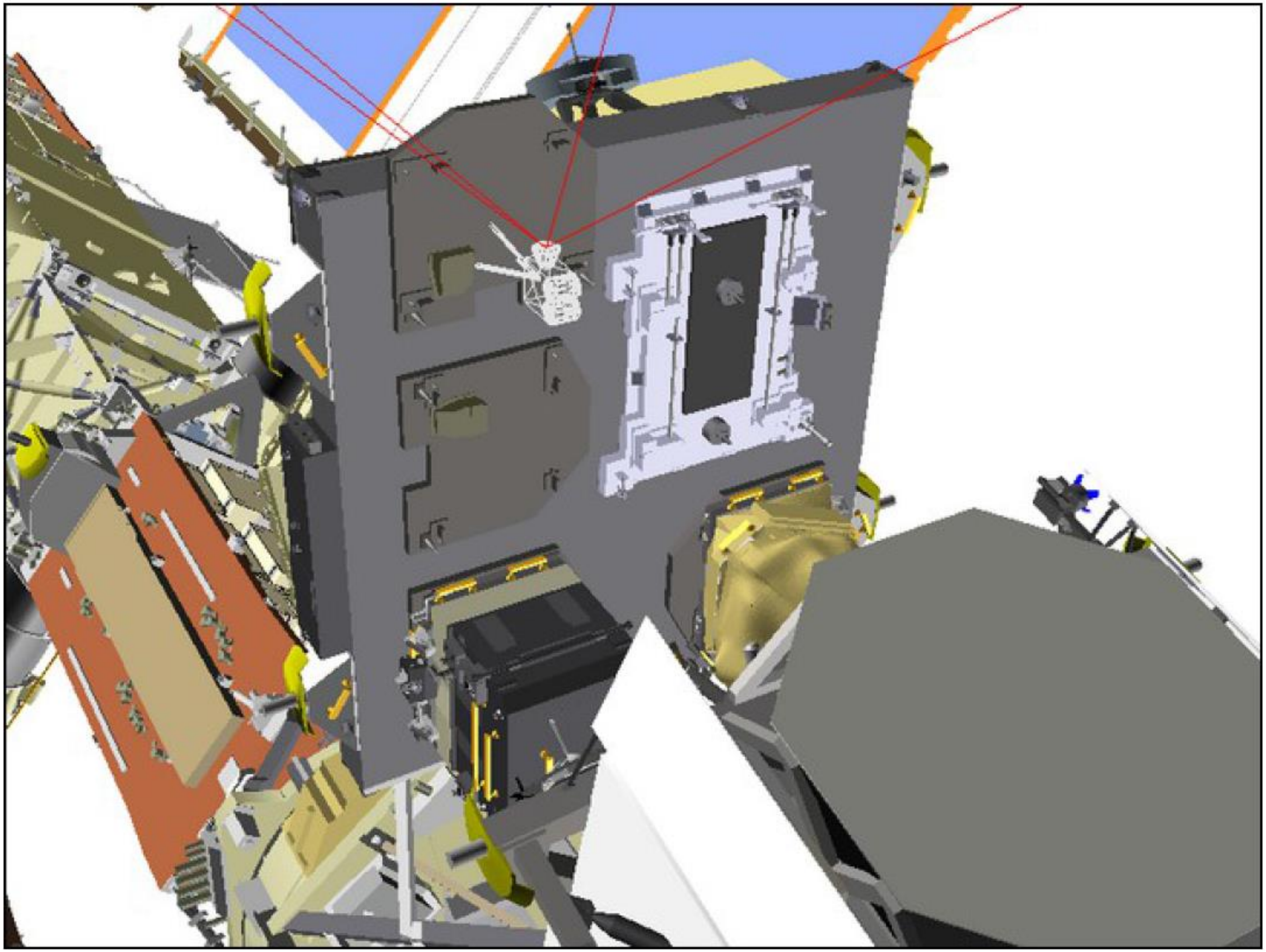
Express Pallet Adapter (ExPA) Assembly (GFE)

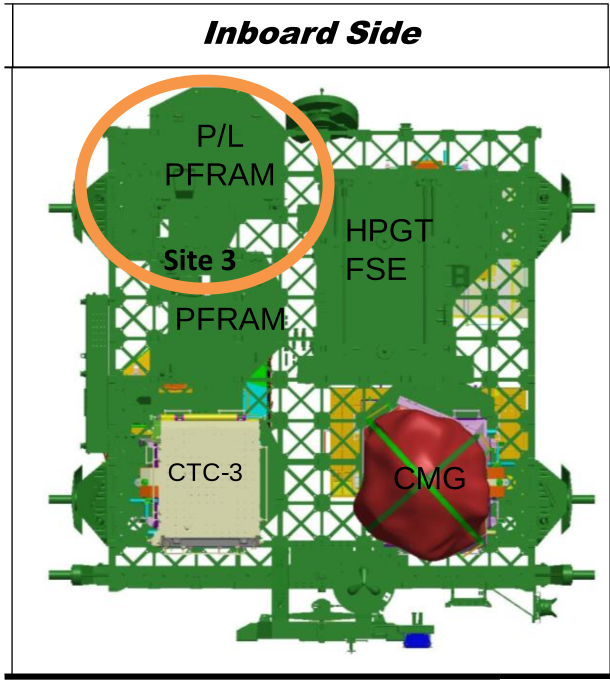
Express Pallet Adapter (ExPA) Assembly



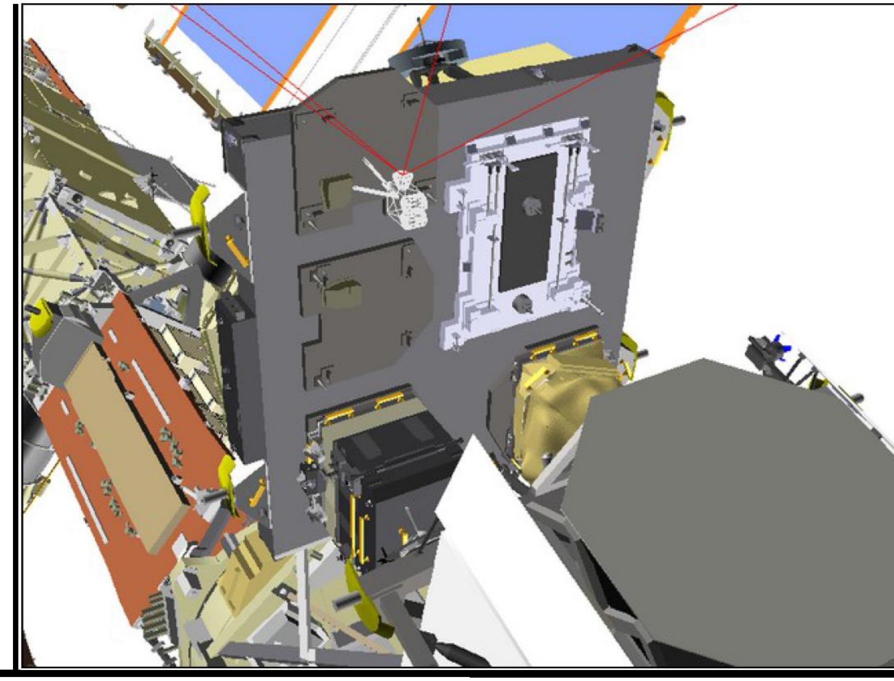
ExPA overall Mass	255 lb
ExPA overall dimension	46.05” x 47” x 13.06” (H)
ExPA payload carrying capability	34” x 46” x 49” (H) and 500 lb”
Payload electrical interface	Power(120VDC & 28VDC): Four NATC connectors Data (1553, Ethernet): Six NATC connectors
Payload thermal interface	Active heating, passive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

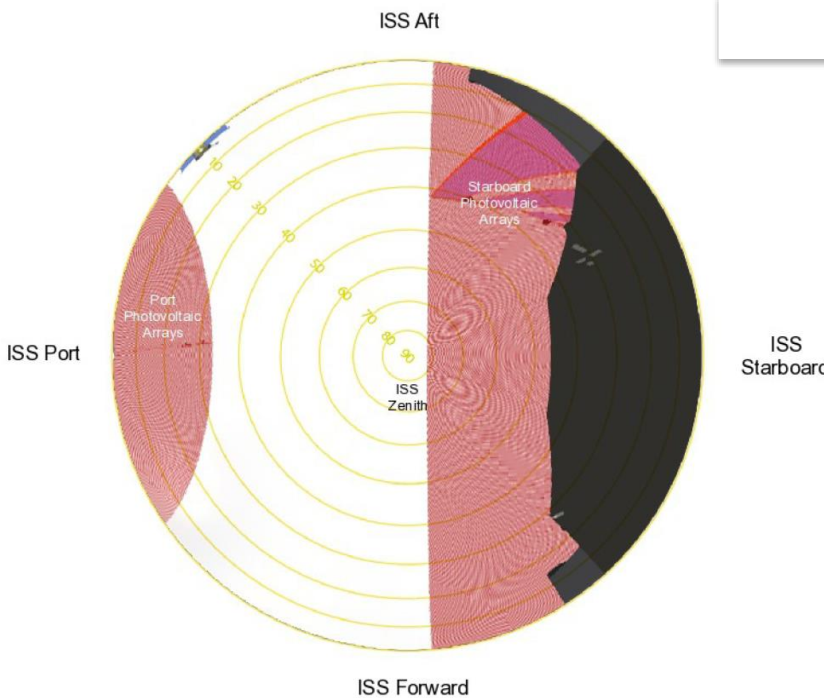
Placement of "Eye" Point for Sensor Viewing for Field of View Analysis

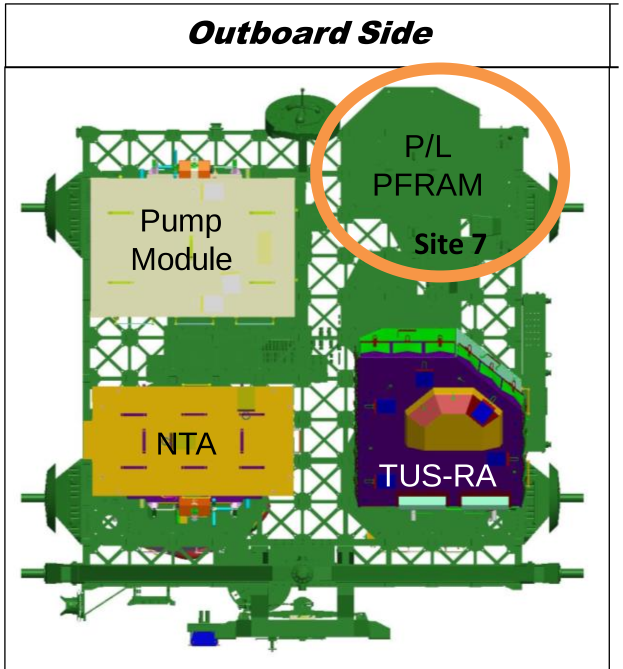




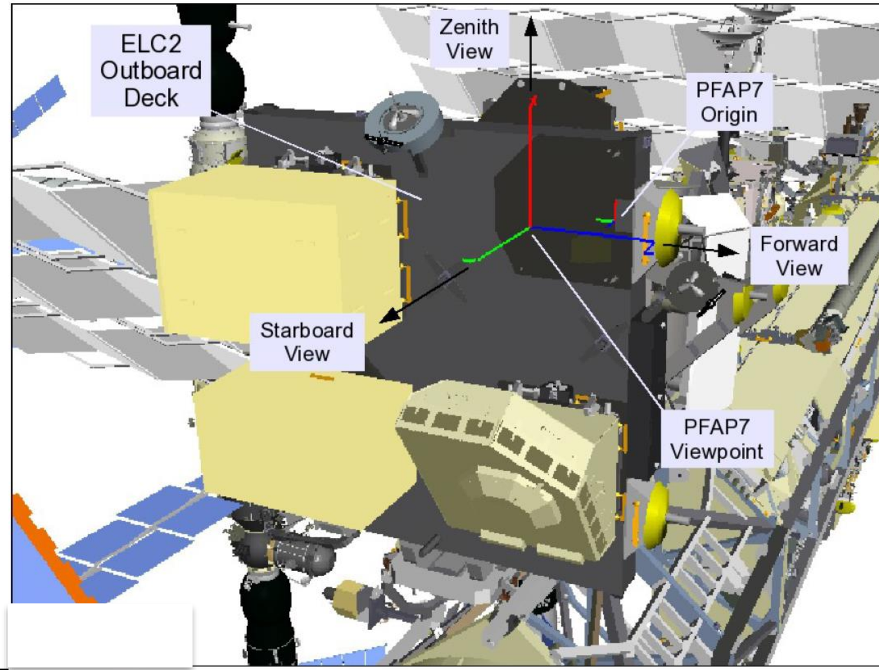
ELC-2 (Ram)/Site 3
Starboard upper
Zenith site

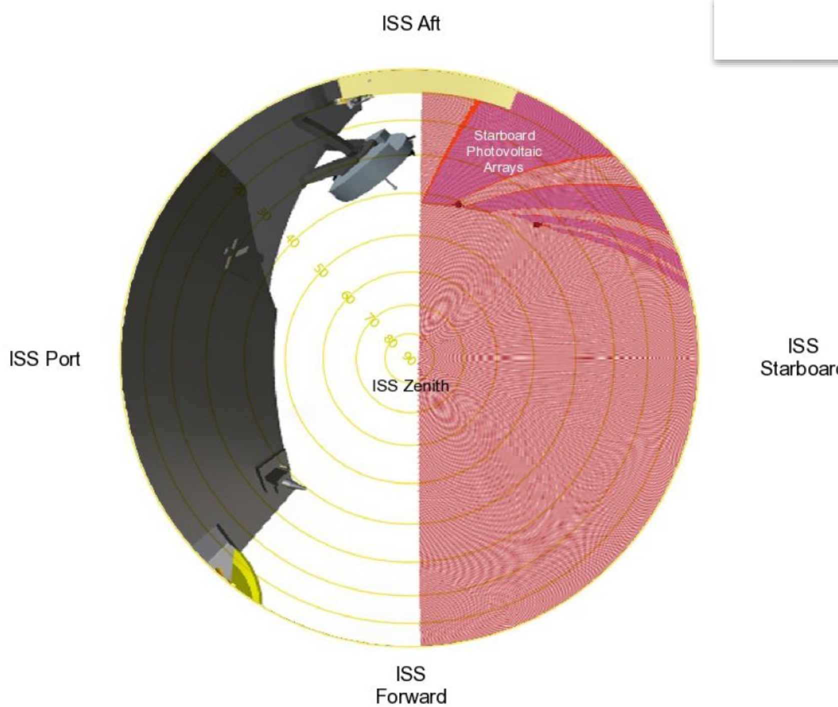


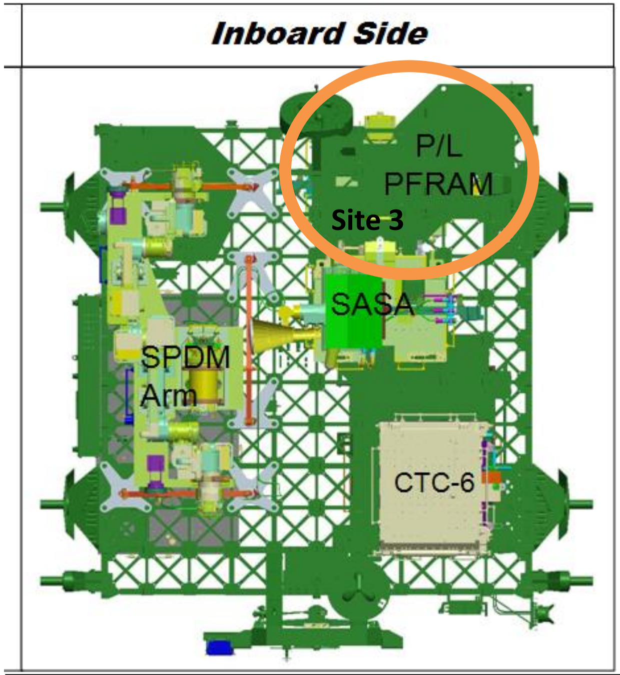




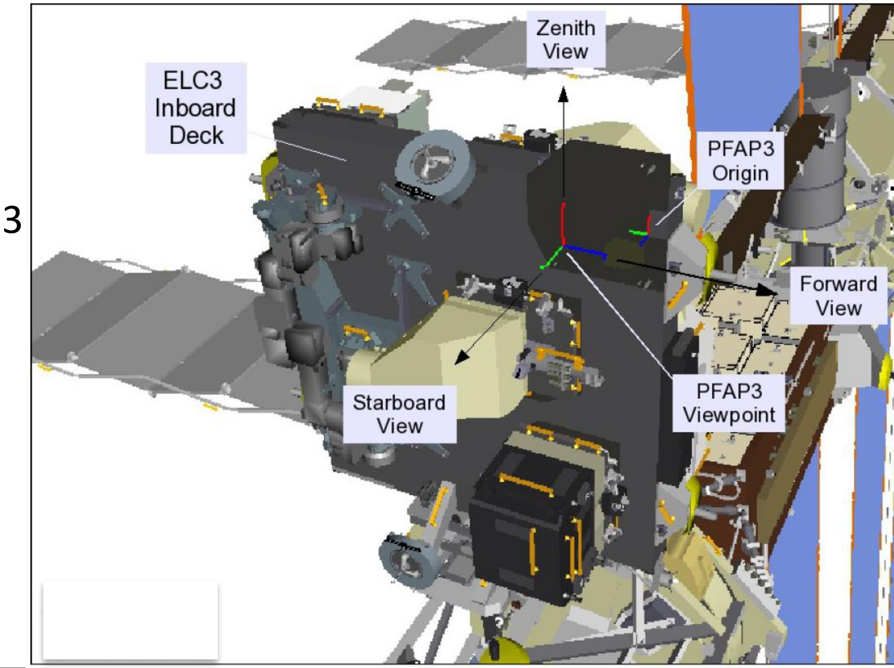
ELC-2 (Ram)/Site 7
Starboard upper
Zenith site

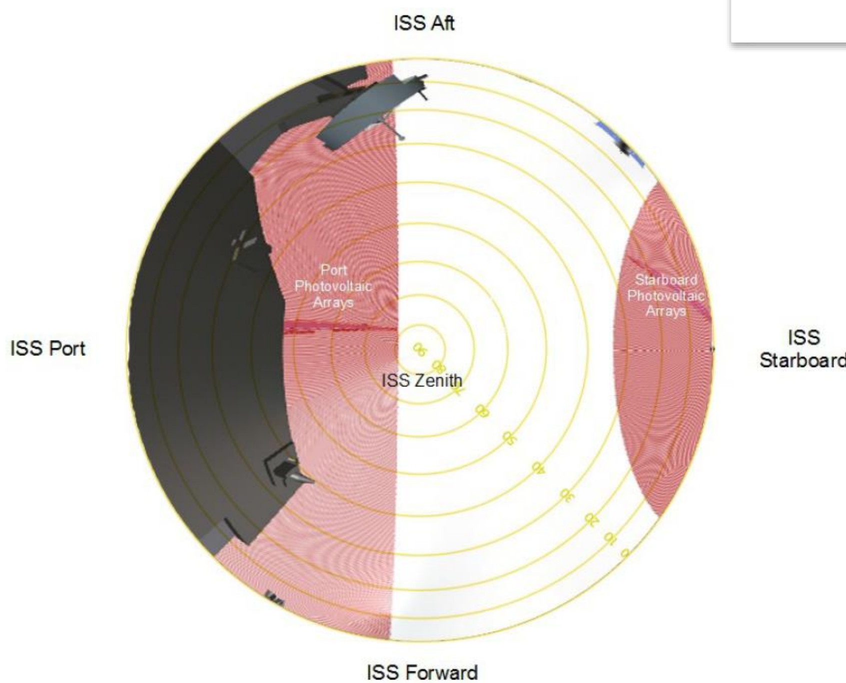


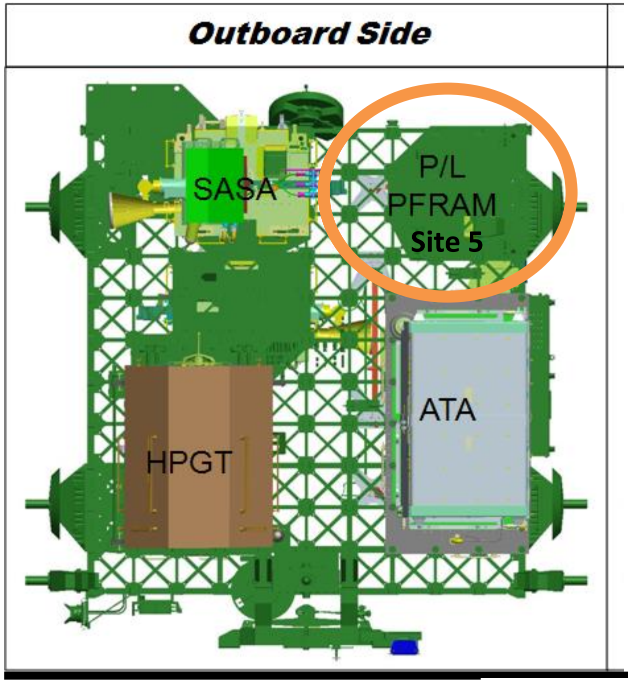




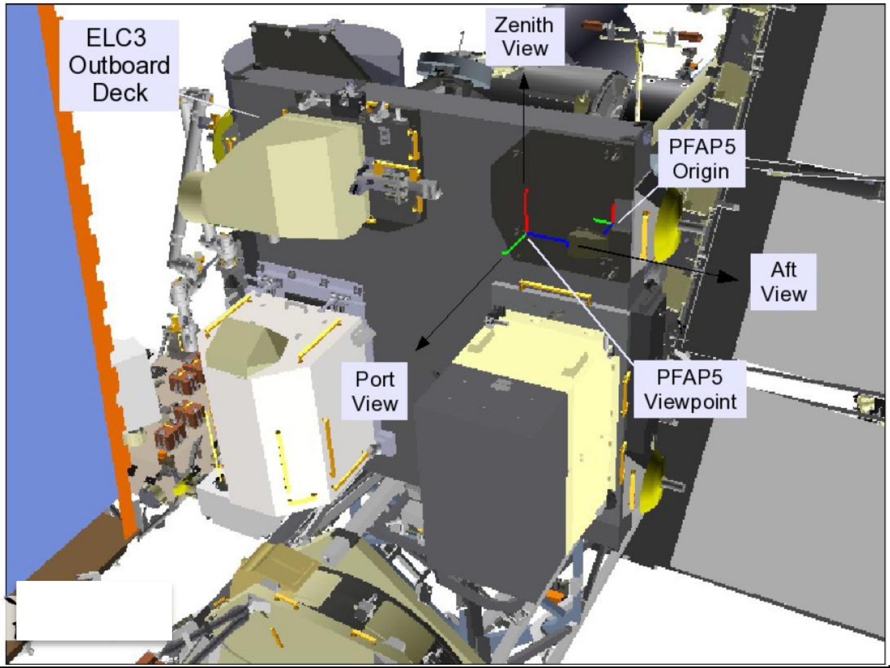
ELC-3 (Ram)/Site 3
Port upper
Zenith site

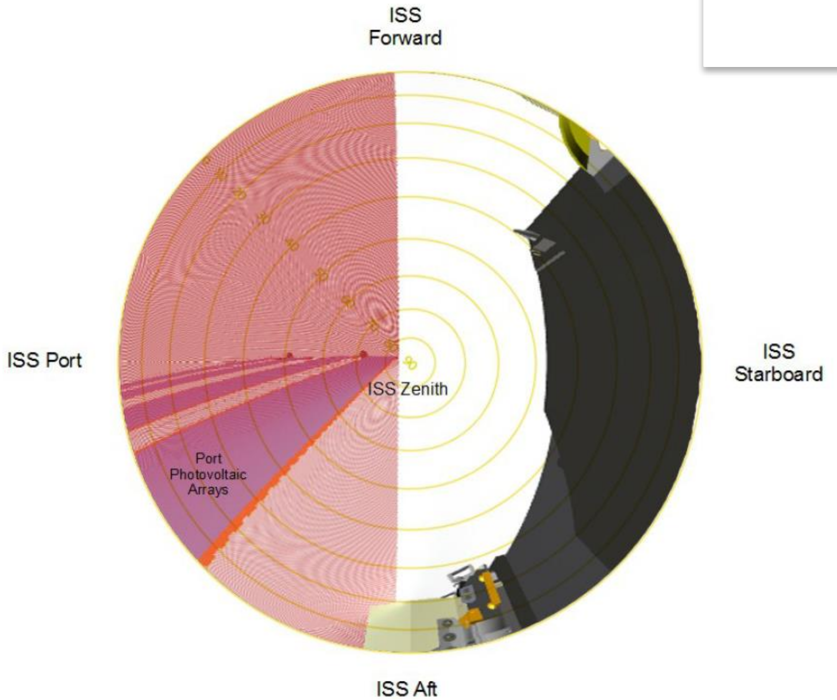






ELC-3 (Wake)/Site 5
Port upper
Zenith site



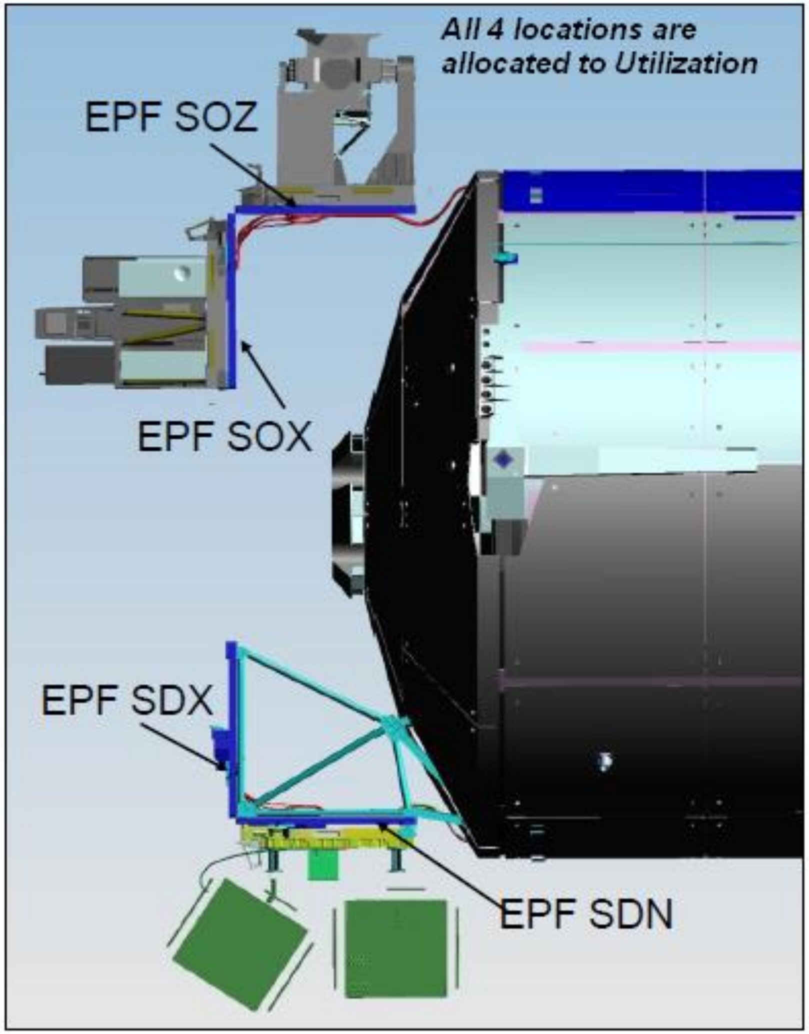


Columbus External Research Accommodations

Columbus External Resources

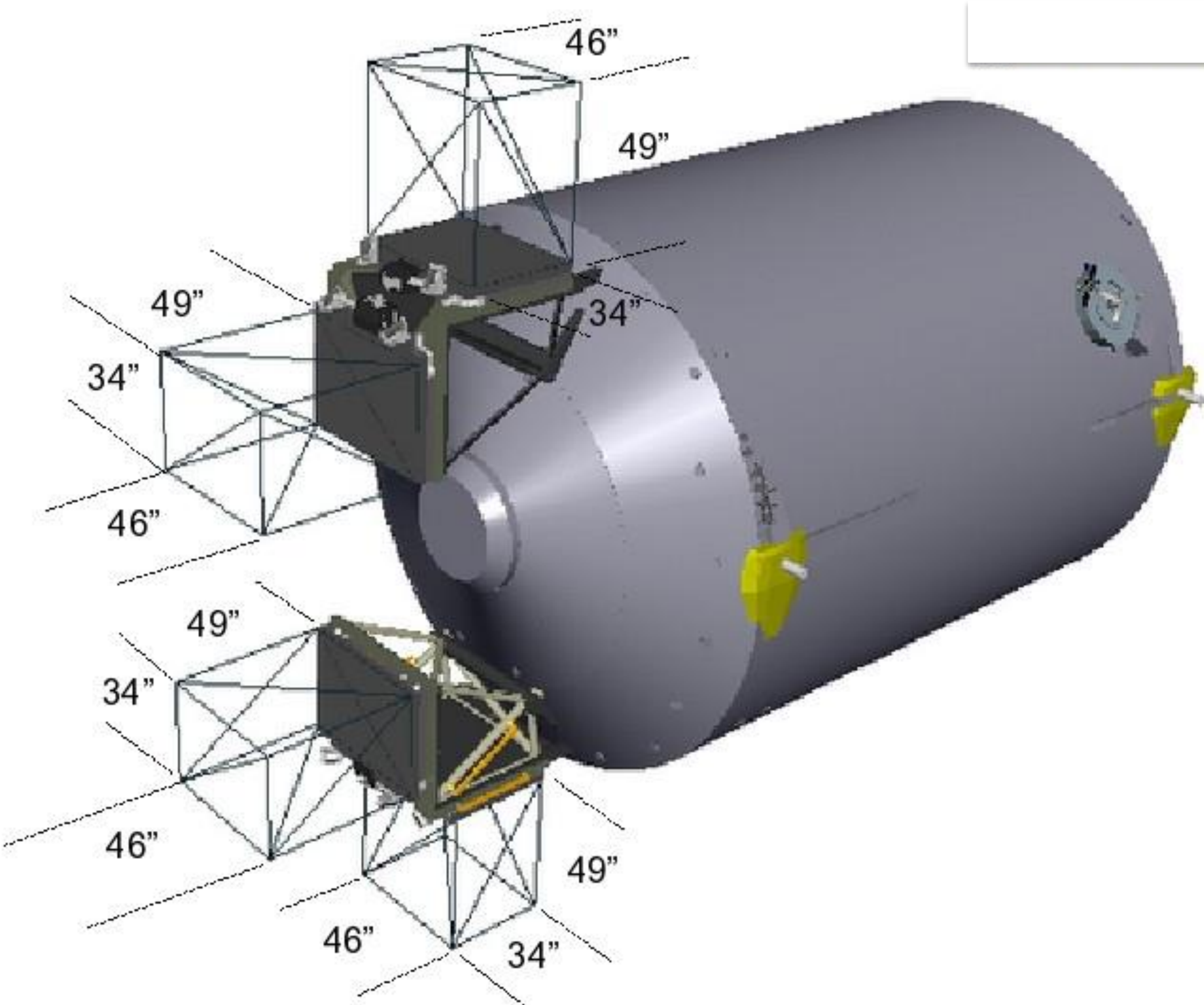
Mass capacity	230 kg (500 lb)
Volume	1 m^3
Power	2.5 kW total to carrier (shared)
Thermal	Passive
Low-rate data	1 Mbps (MIL-STD-1553)
Medium-rate data	2 Mbps (shared)
Sites available to NASA	2 sites

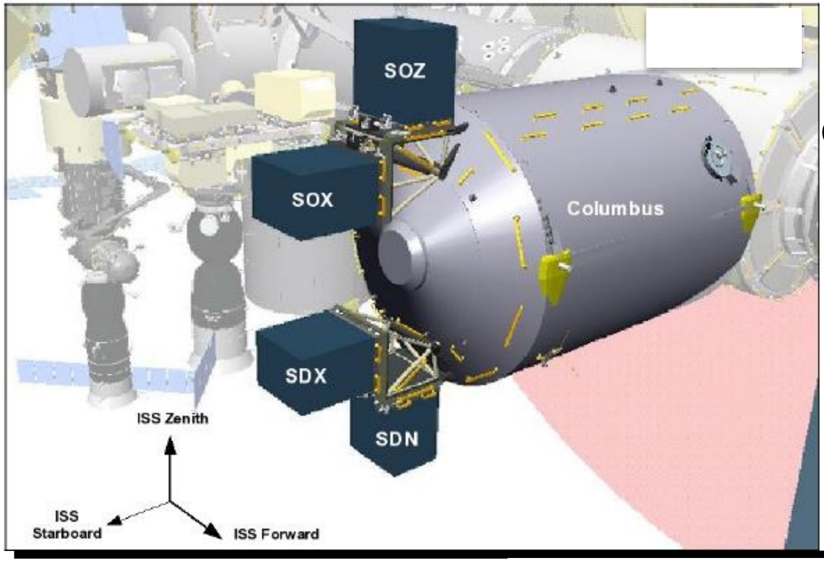
Columbus EF Overview



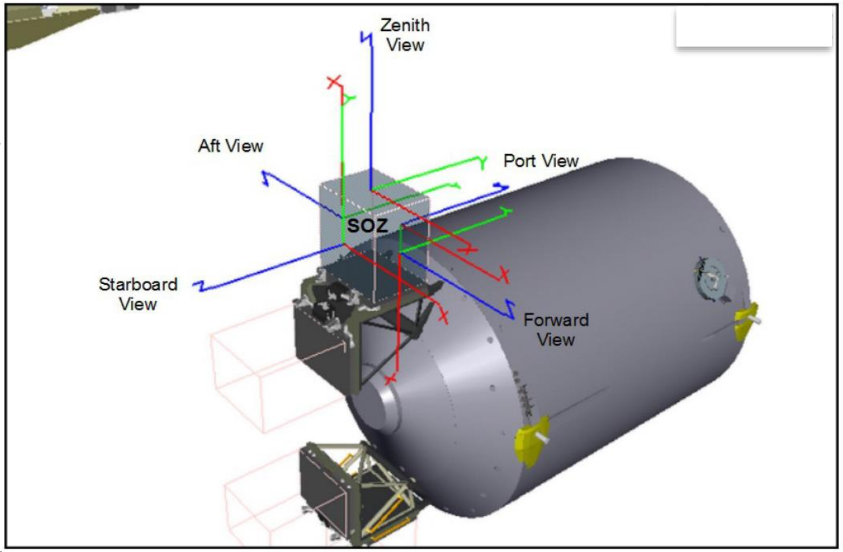
Location	Viewing	Payload Size	Power	Data
SOZ	Zenith	226 kg + CEPA	1.25 kW at 120 VDC 2.5 kW max (**Shared**)	Ethernet, 1553
SOX	Ram			
SDX	Ram			
SDN	Nadir			

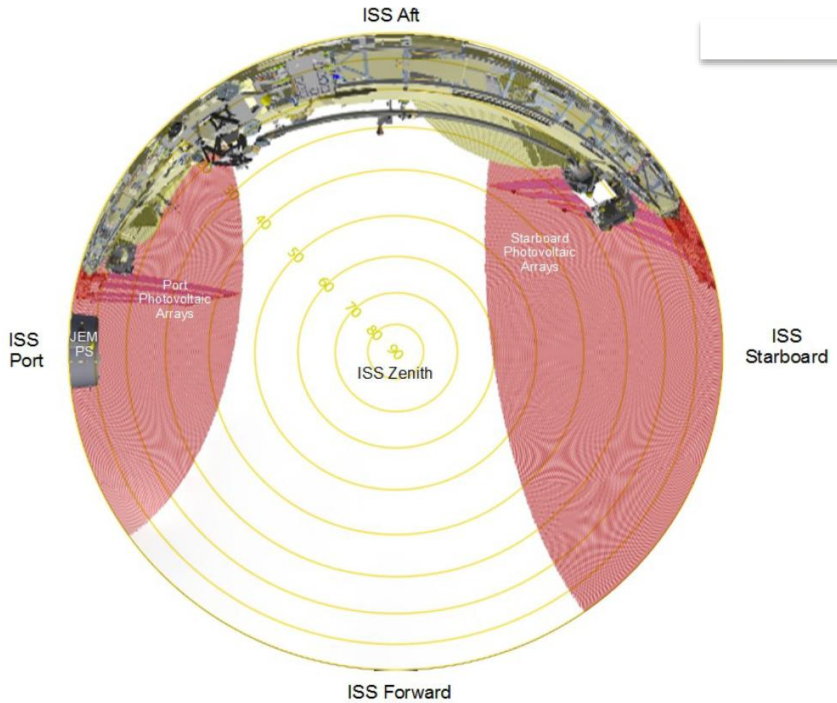
Columbus External Payload Envelope Dimensions

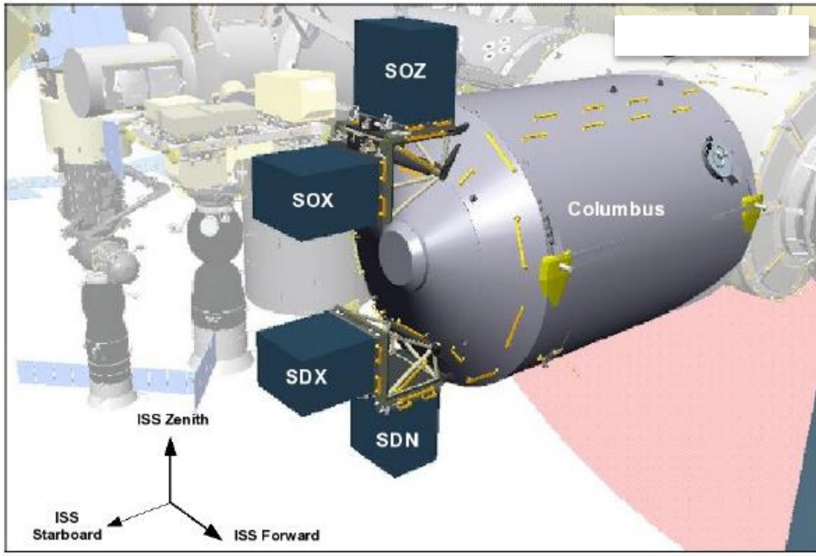




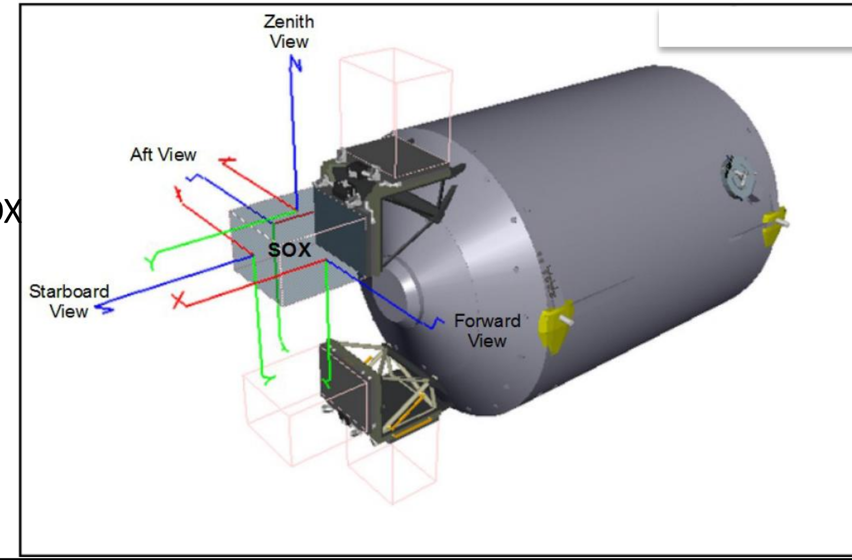
Columbus/S0Z
Overhead
Zenith site

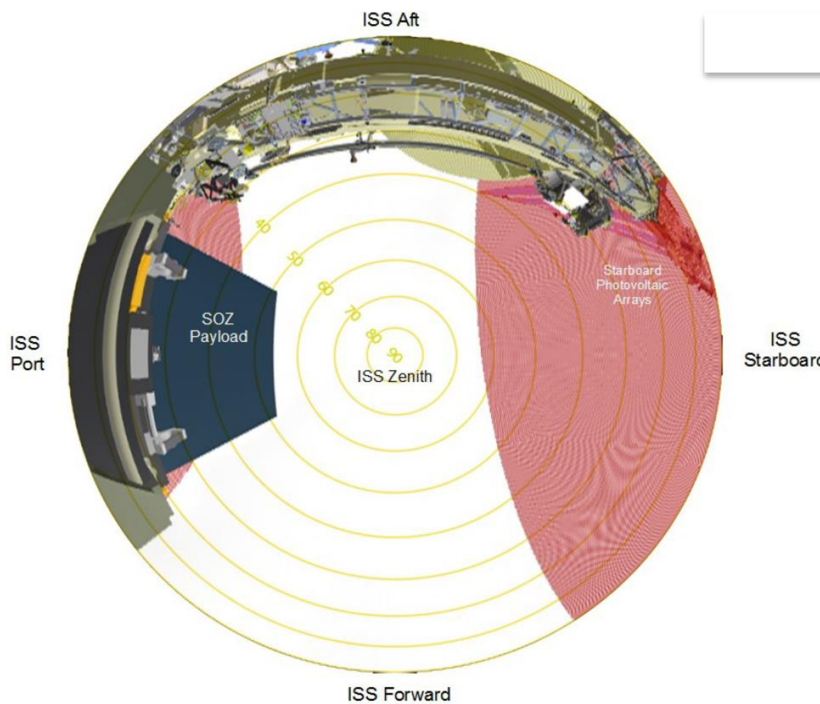




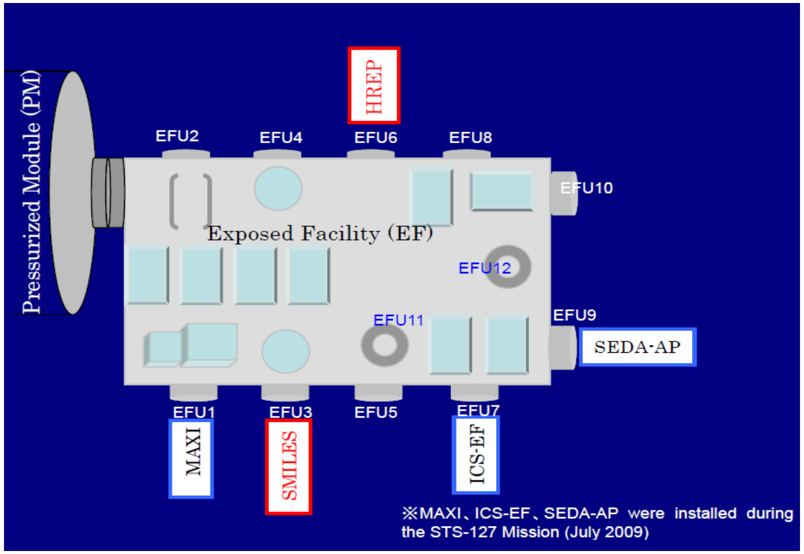


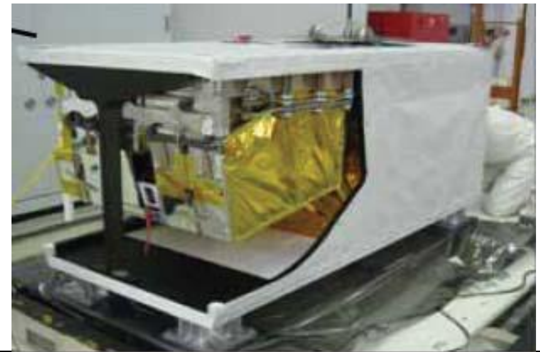
Columbus/SOX
Overhead
Zenith site





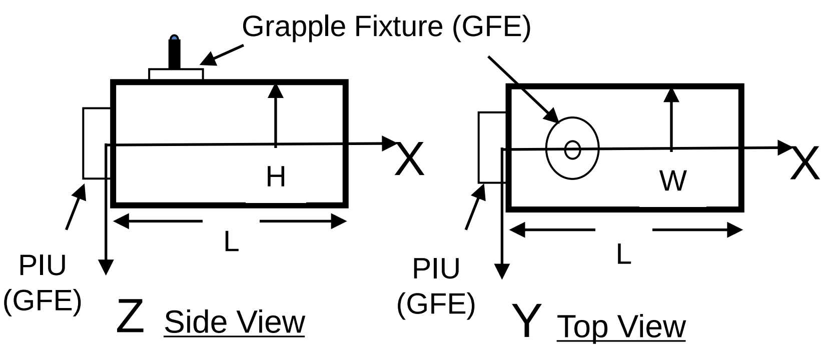
JEM EF External Research Accommodations





NASA/DOD
HREP payload

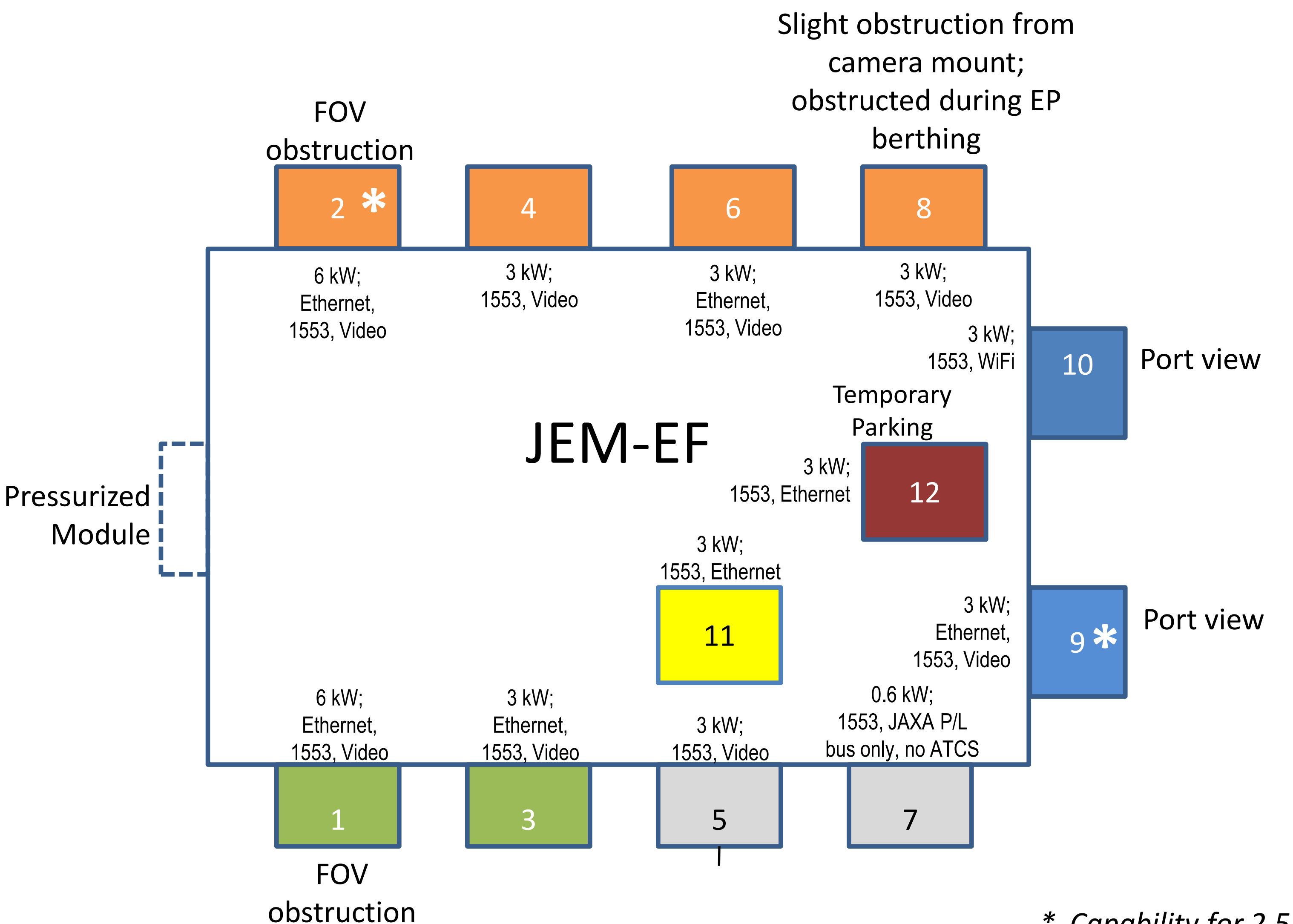
Mass capacity	550 kg (1,150 lb) at standard site 2,250 kg (5,550 lb) at large site
Volume	1.5 m^3
Power	3-6 kW, 113 – 126 VDC (**Shared resource**)
Thermal	3-6 kW cooling (**Shared resource**)
Low-rate data	1 Mbps (MIL-STD-1553, two way)
Medium-rate data	1EEE-802.3(10BASE-T, two way) *****
High-rate data	43 Mbps (shared, one way downlink)
Sites available to NASA	5 sites



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

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

JEM EF EFU Location Overview



Capability for 2.5 MT payload

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

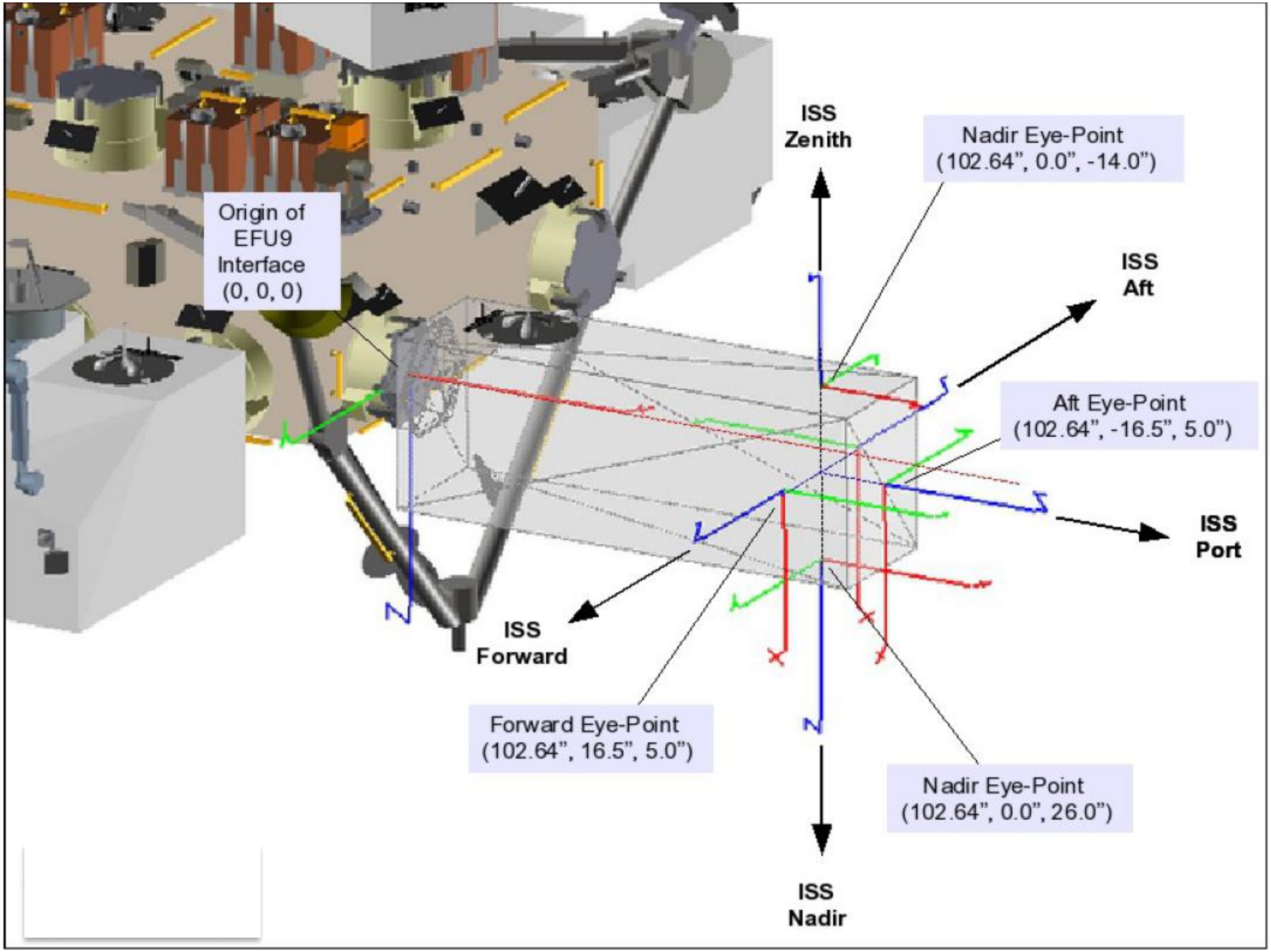
- Due to a design flaw uncovered recently in the ELC 28 dc power interface, which limits the Experiment Control Module (ECM) in the EXPRESS Carrier Avionics (ExPCA) to operate 40 degrees Celsius when two instruments are operating simultaneously on that ELC, the ISS Program recommends that all future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

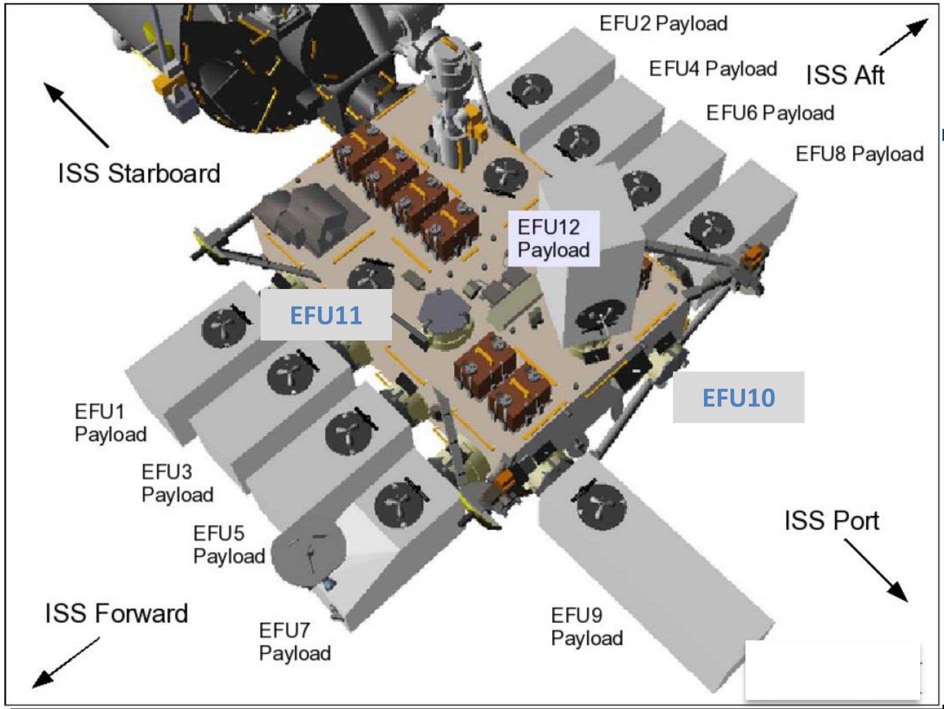
- Payload Developers (PDs), however, still have the option to design their instruments to interface with the 28 Vdc power feed at the risk of that payload being operations constraint (timeline constraint) whenever the 40 degrees Celsius limit is reached, which will trigger a power shed situation to balance 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.

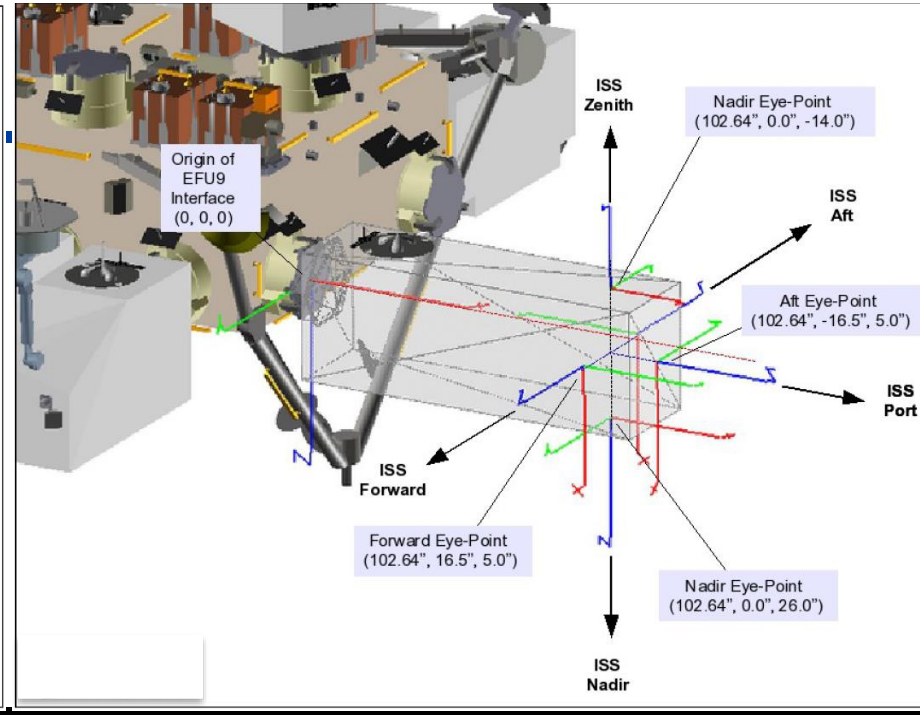
JEM-EF Detailed Accommodations by Site

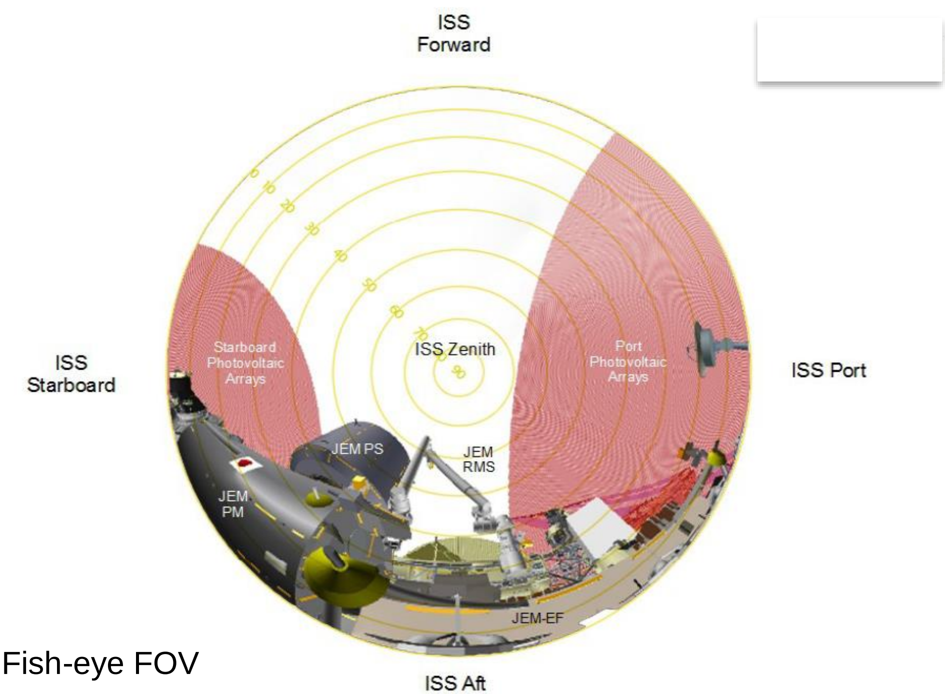
Location	Viewing	Payload Size	Description / Notes	Data
1	Ram, Nadir, Zenith	500 kg	Ram field of View (FOV) obstruction by JEM module	Ethernet, 1553, Video
3	Ram, Nadir, Zenith	500 kg	Clear view	Ethernet, 1553, Video
5	Ram, Nadir, Zenith	500 kg	Clear view	1553, Video
7	Ram, Nadir, Zenith	500 kg	Clear view	1553, JAXA P/L Bus
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	Port View	WiFi
11	Zenith only	500 kg	Good Zenith viewing	Ethernet
12	Zenith only	500 kg	Temporary stowage location	Ethernet

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

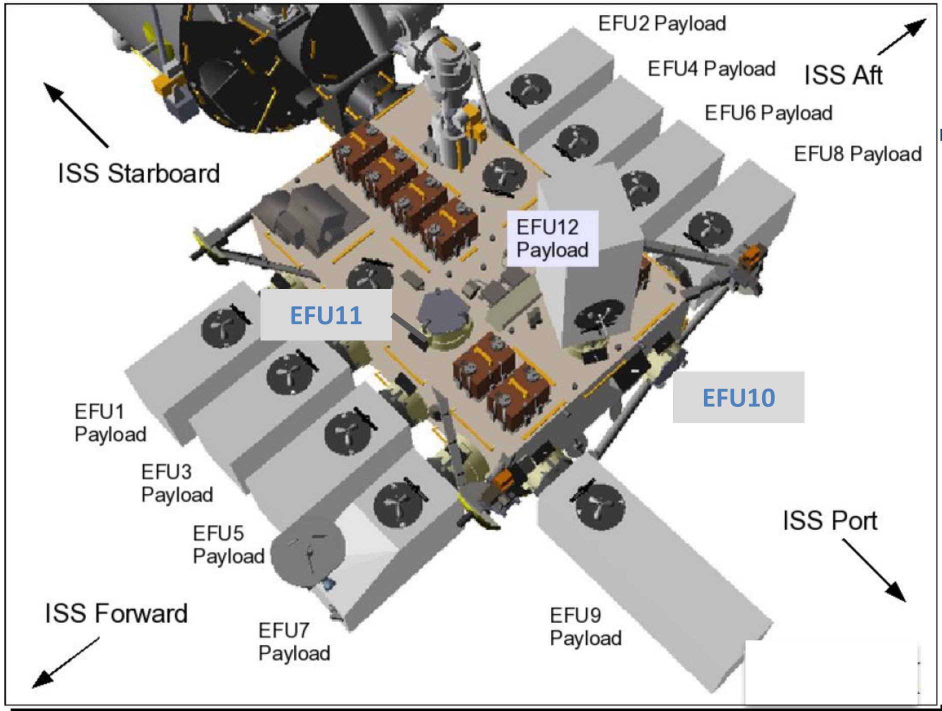


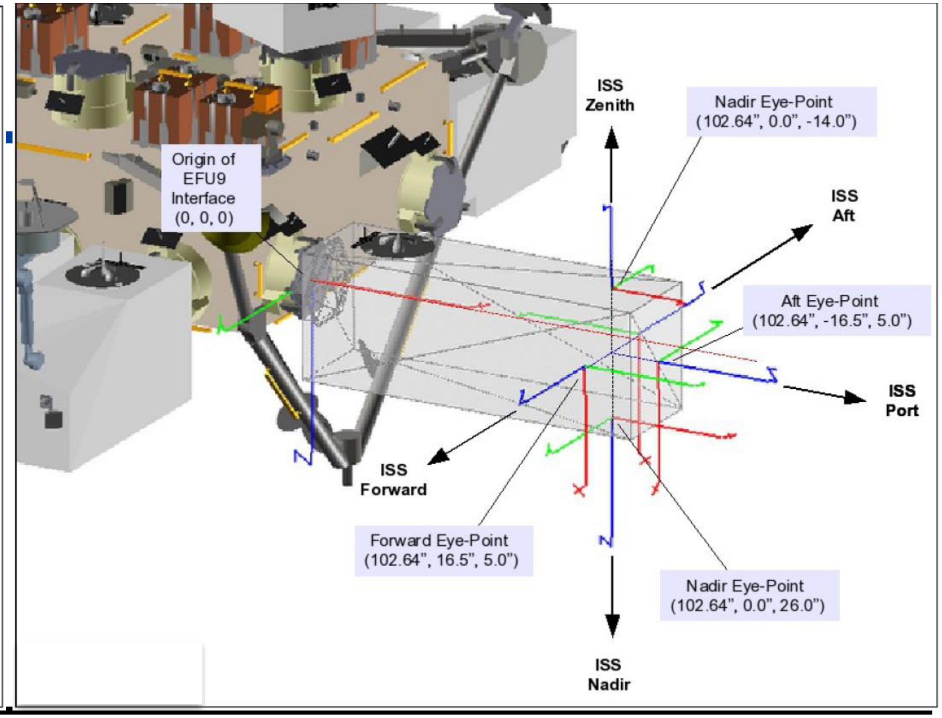


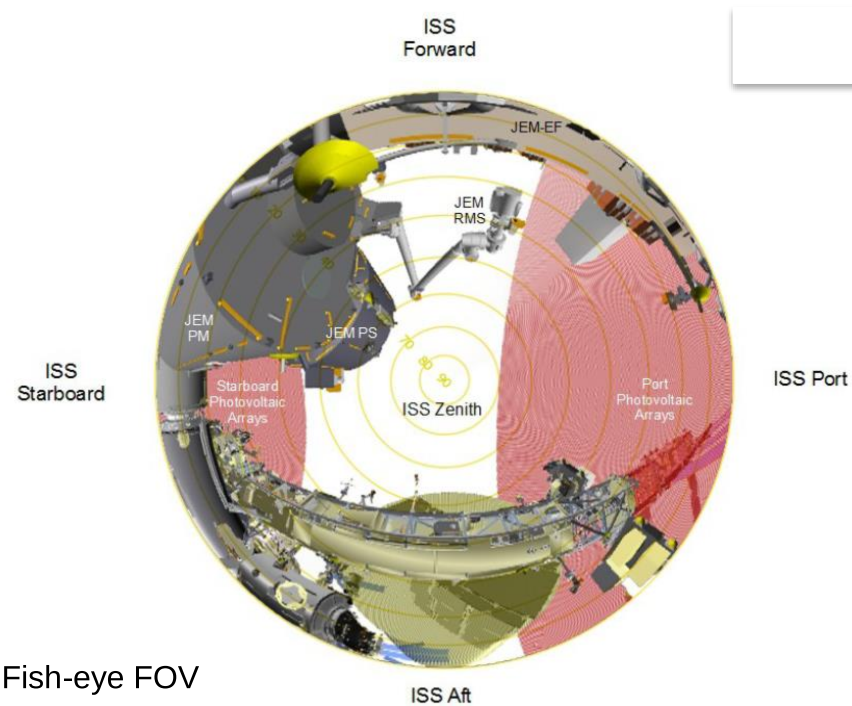




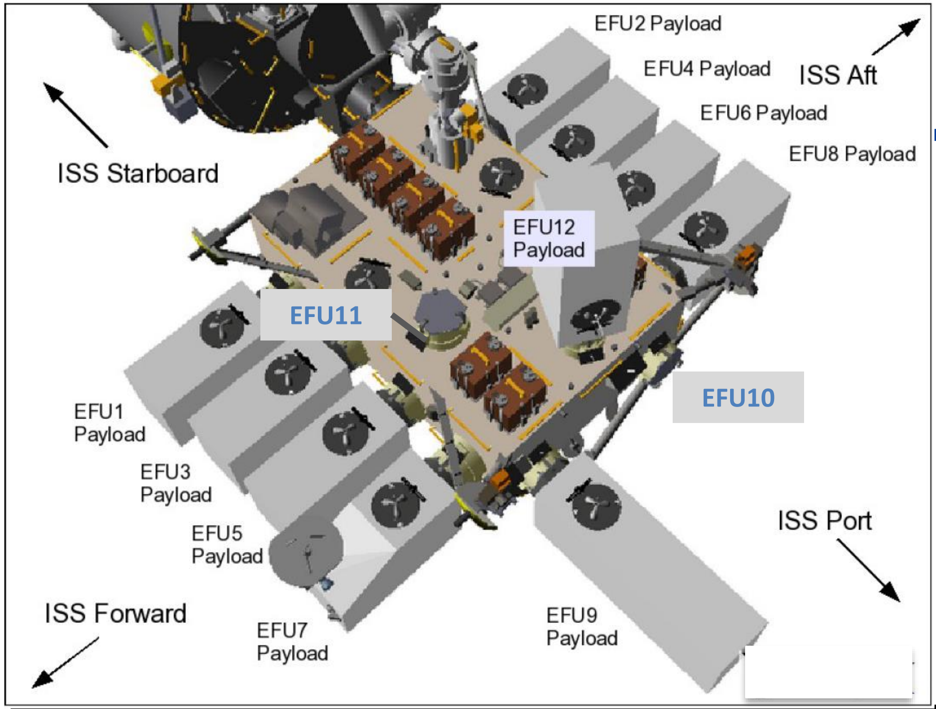
JEM EFU 1 Payload Zenith Face Fish-eye FOV

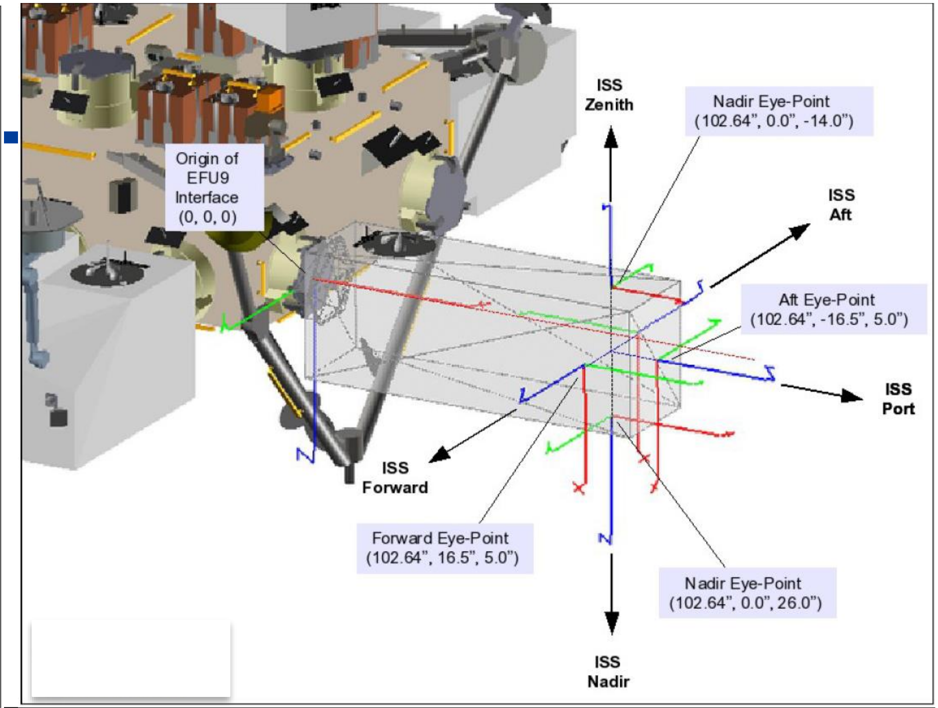


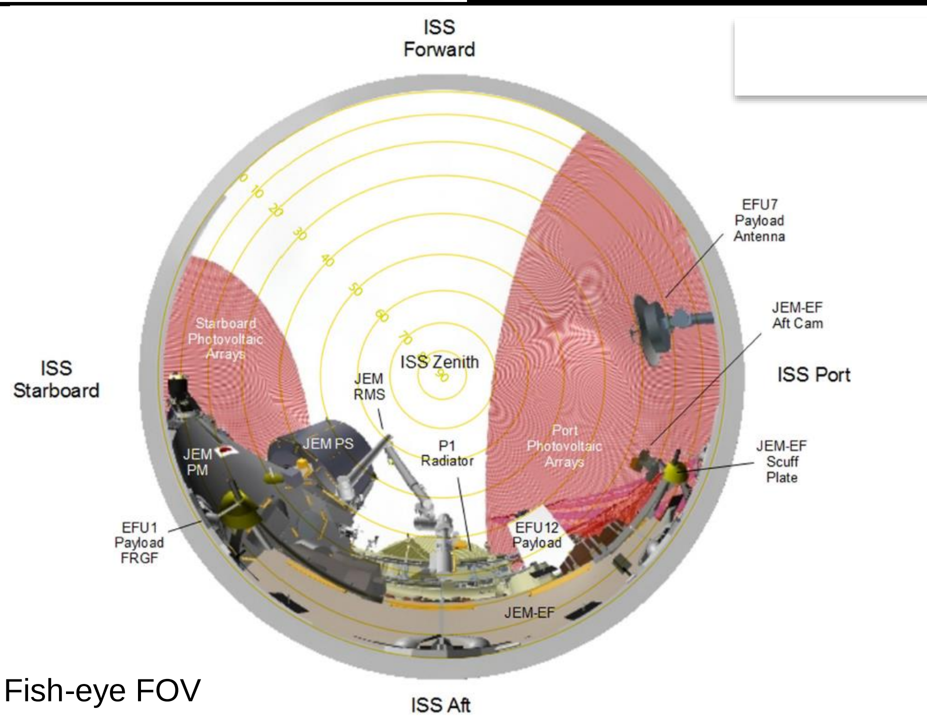




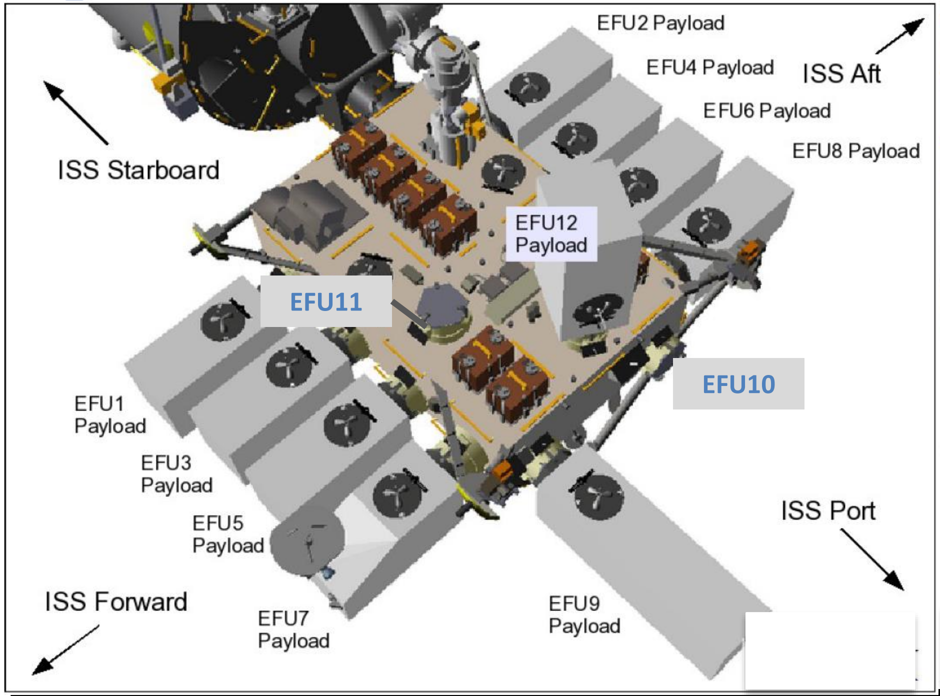
JEM EFU 2 Payload Zenith Face Fish-eye FOV

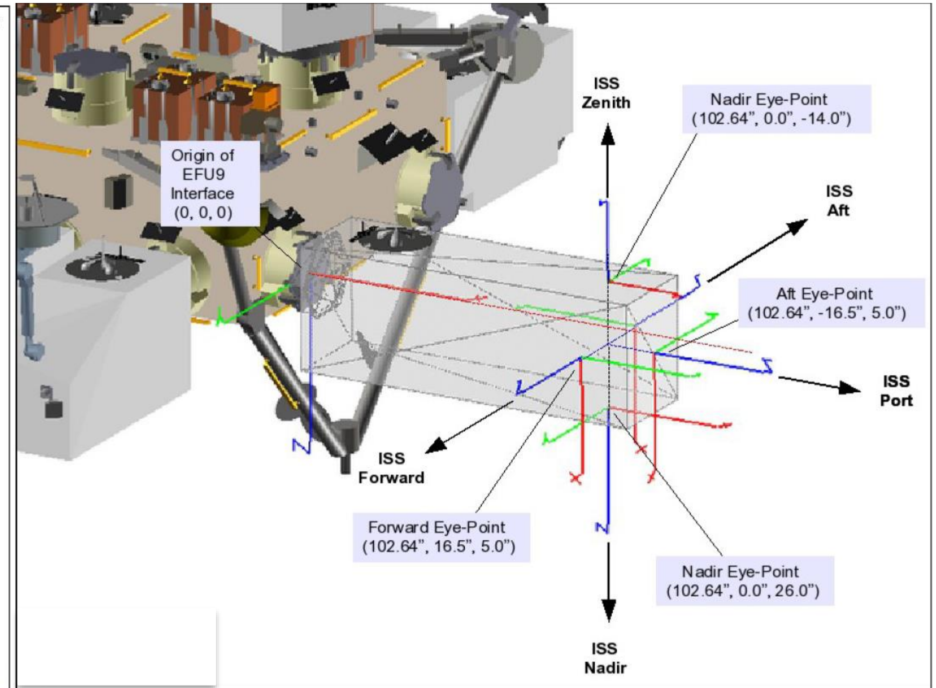


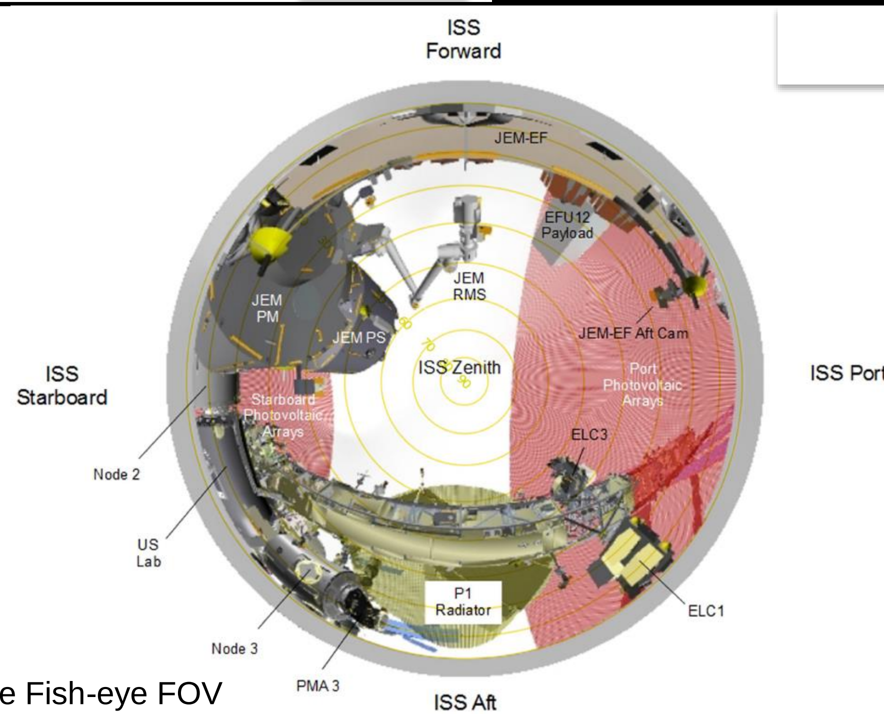




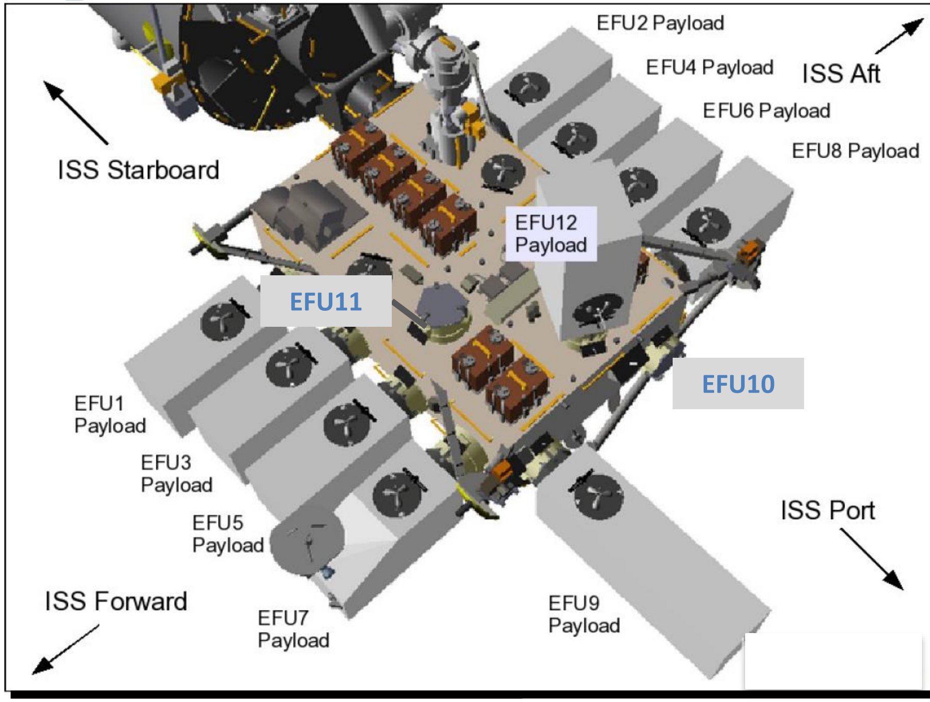
JEM EFU 3 Payload Zenith Face Fish-eye FOV

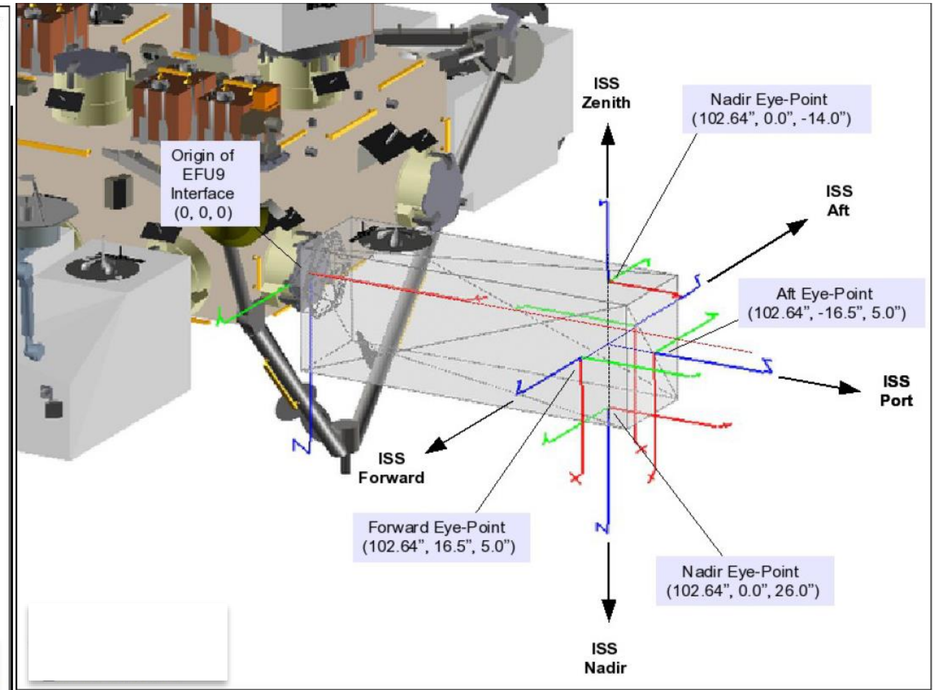


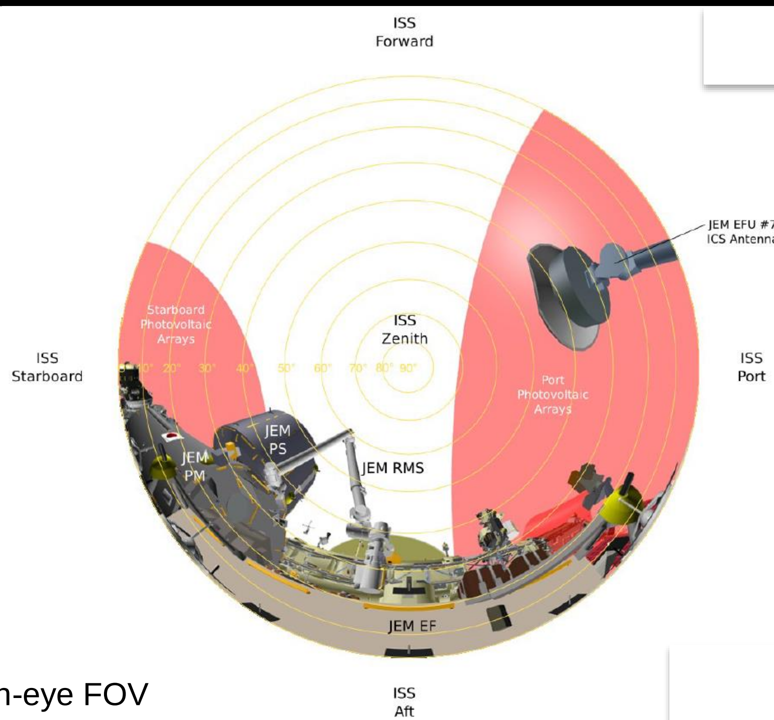




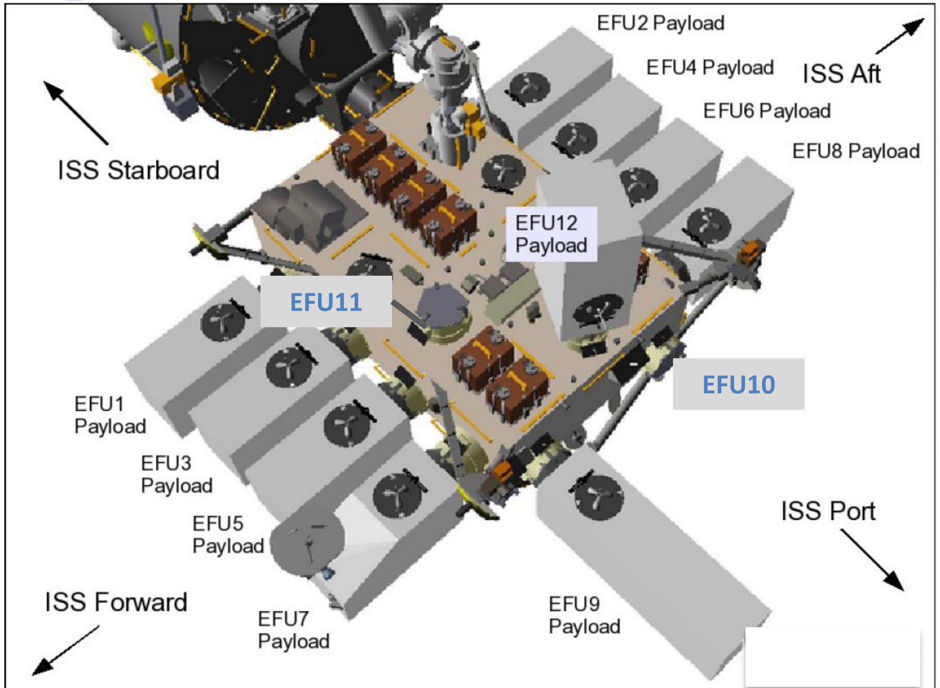
JEM EFU 4 Payload Zenith Face Fish-eye FOV

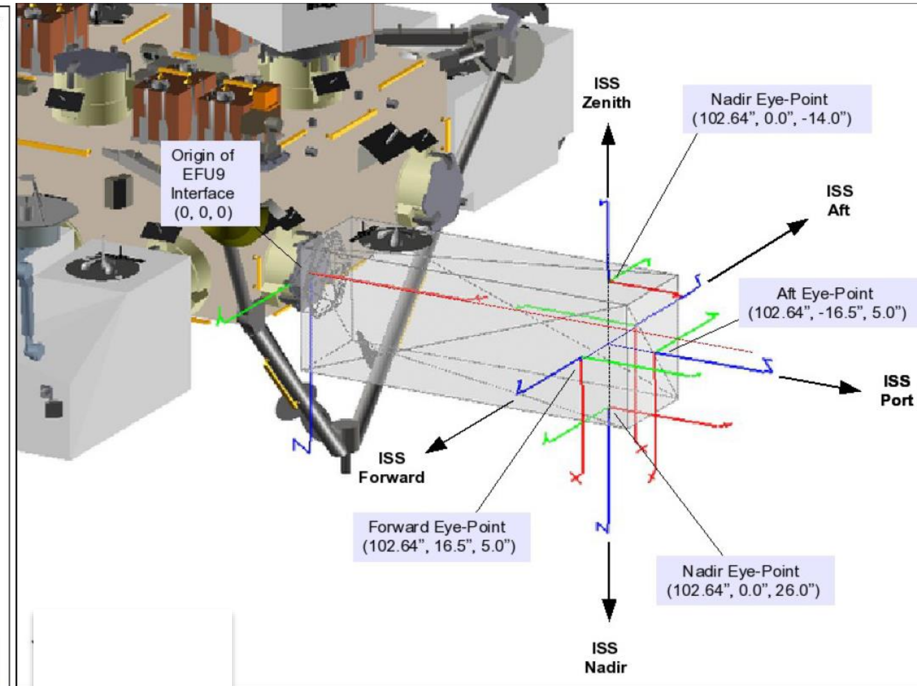


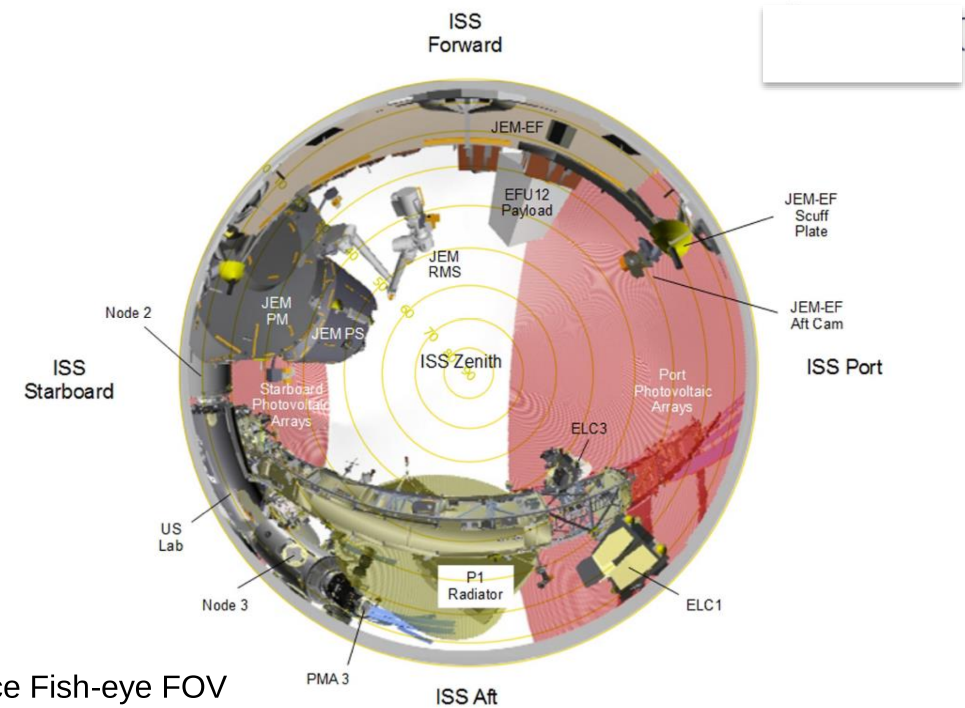




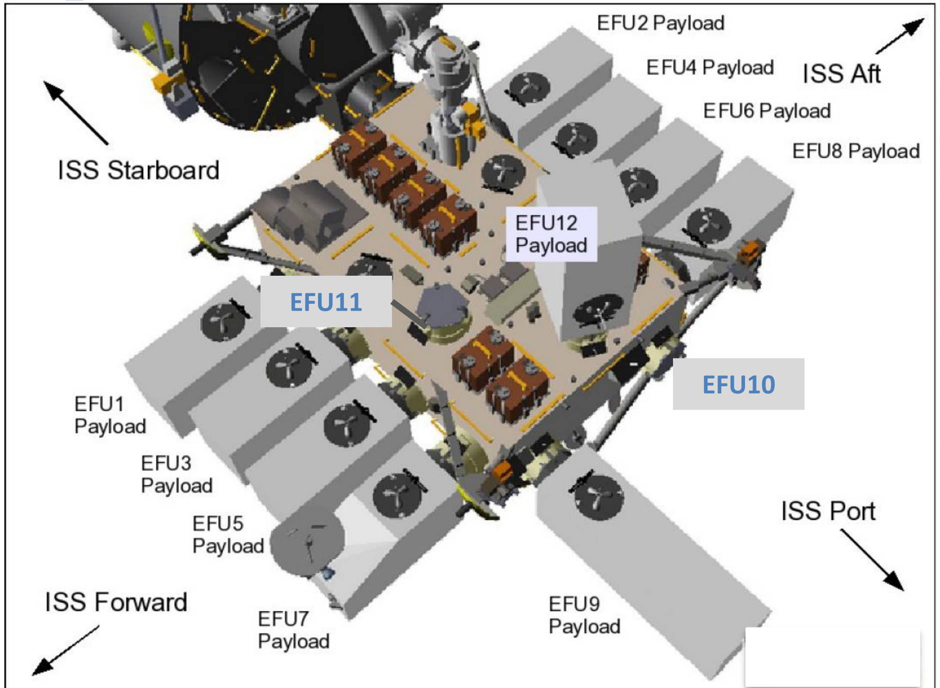
JEM EFU 5 Payload Zenith Face Fish-eye FOV

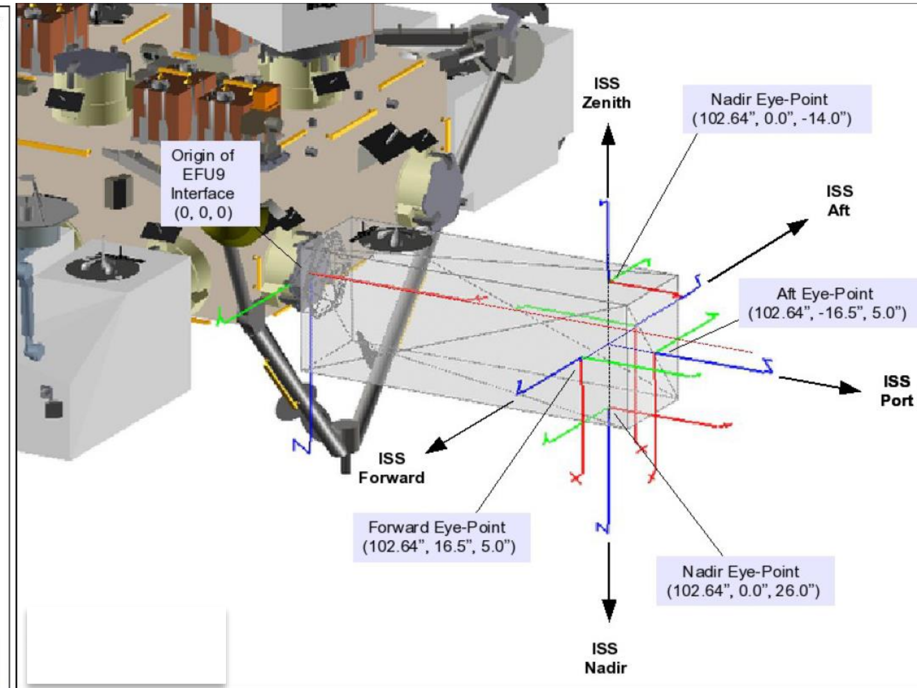


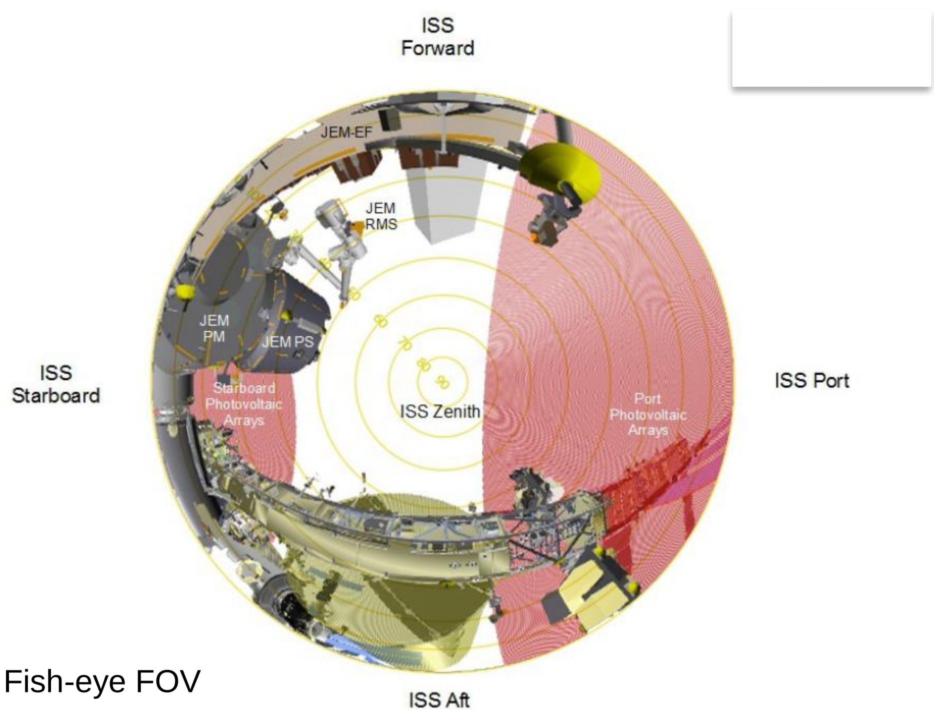




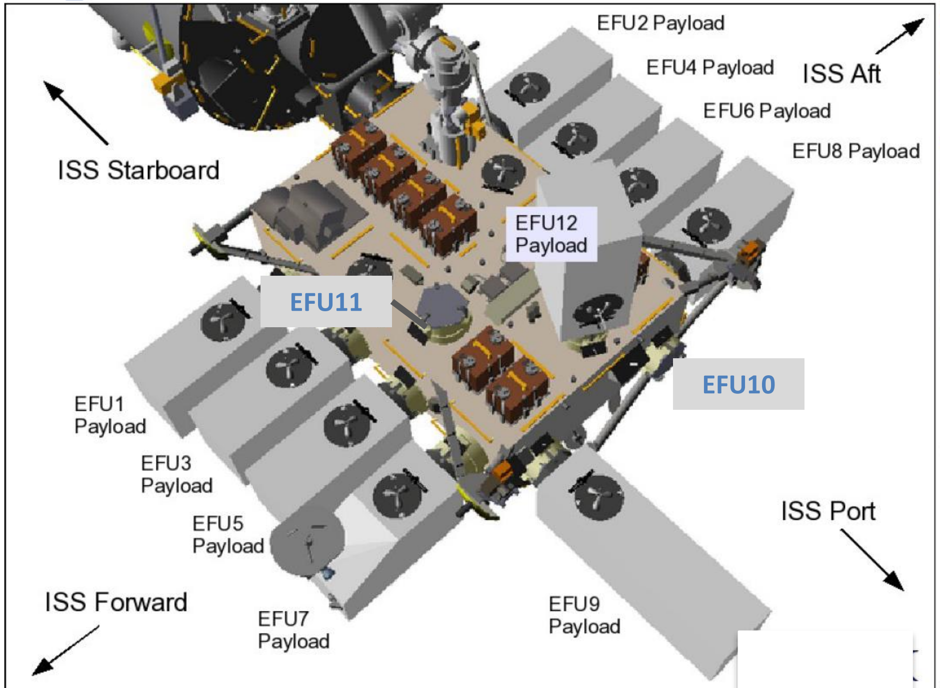
JEM EFU 6 Payload Zenith Face Fish-eye FOV

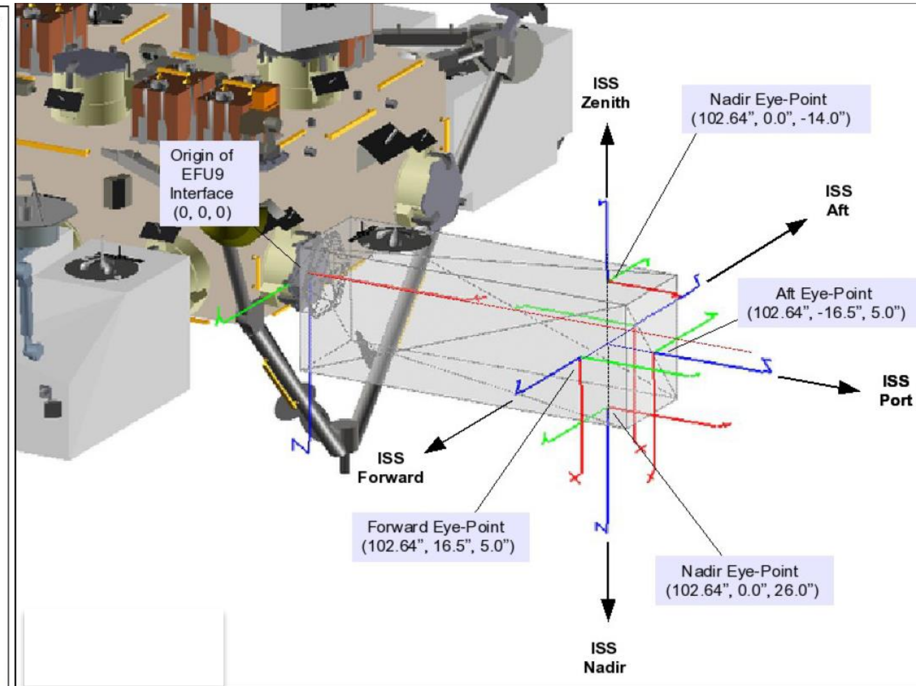


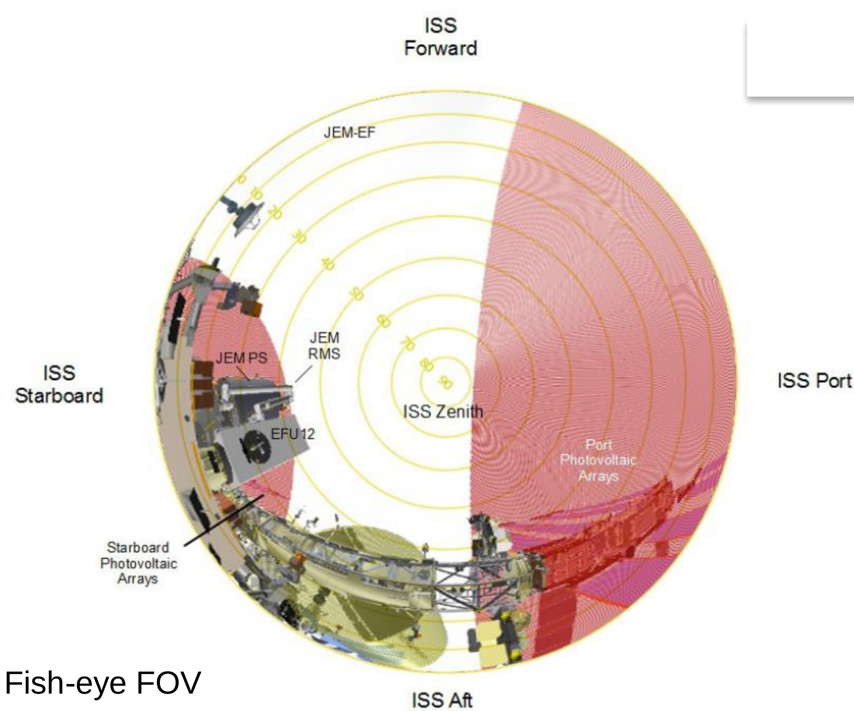




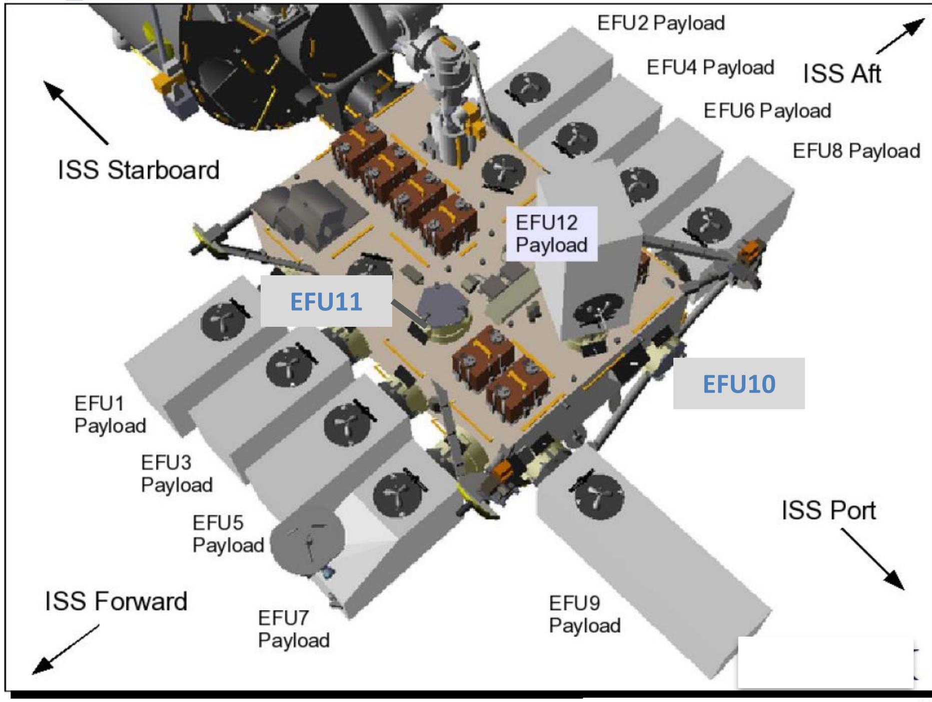
JEM EFU 8 Payload Zenith Face Fish-eye FOV

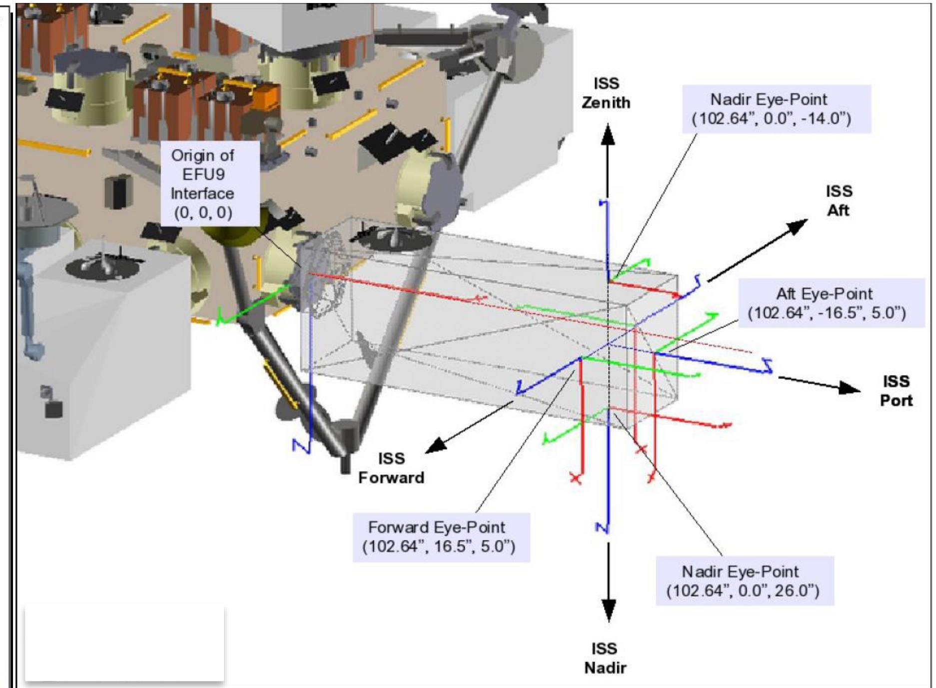


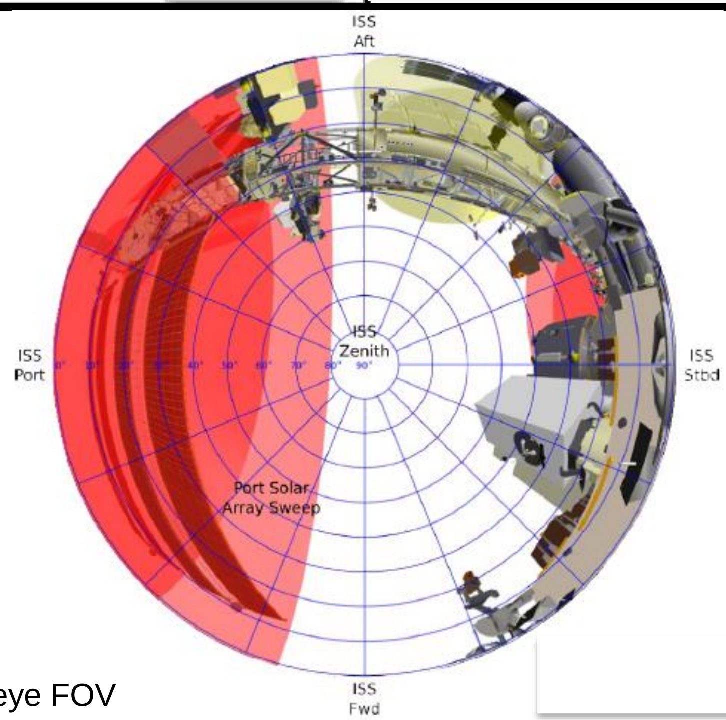




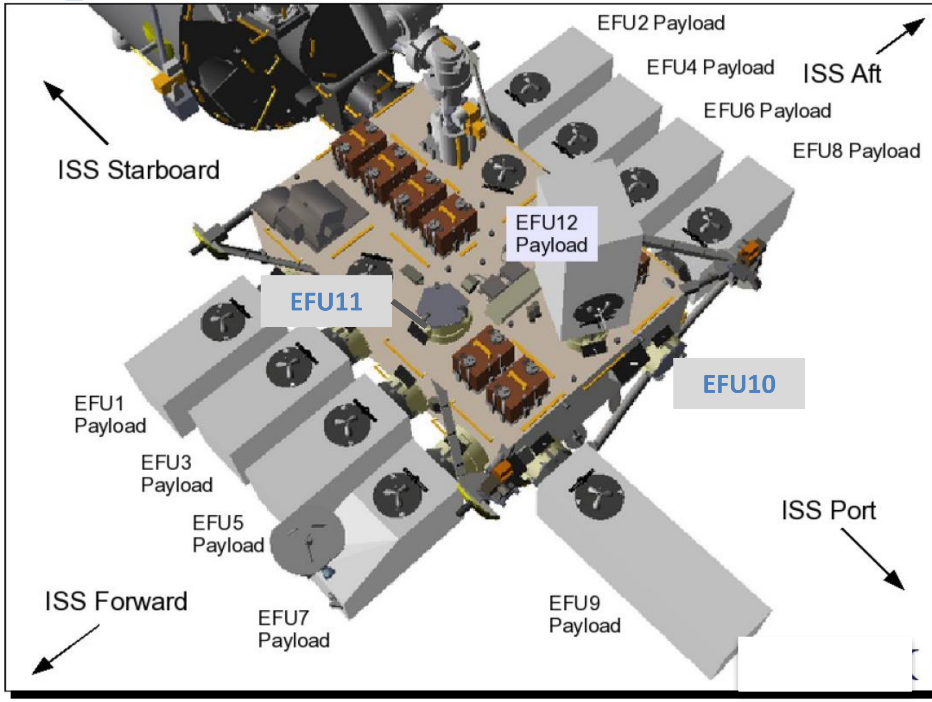
JEM EFU 9 Payload Zenith Face Fish-eye FOV

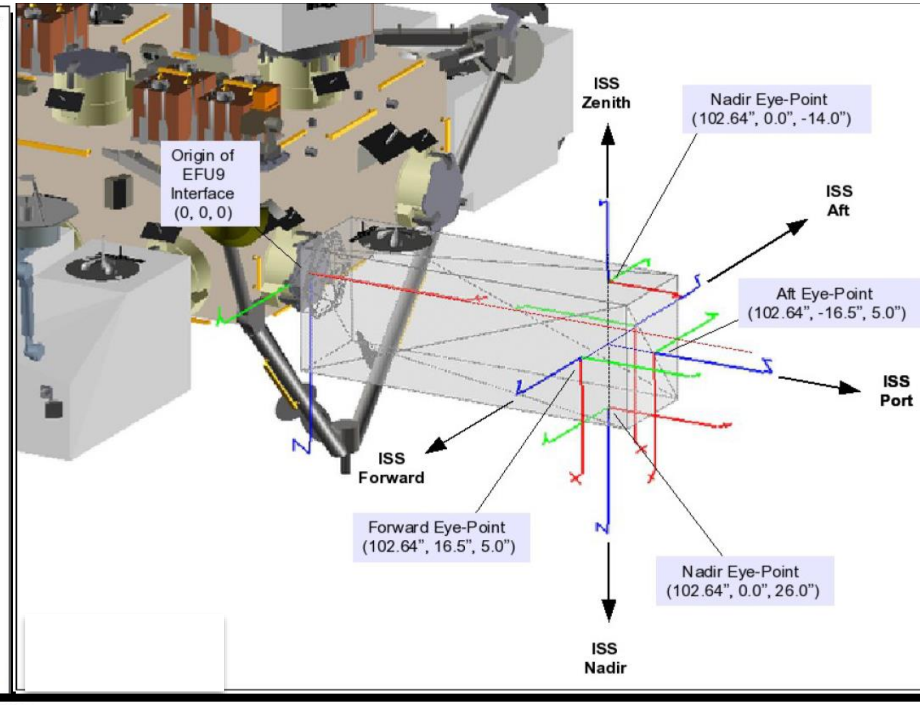


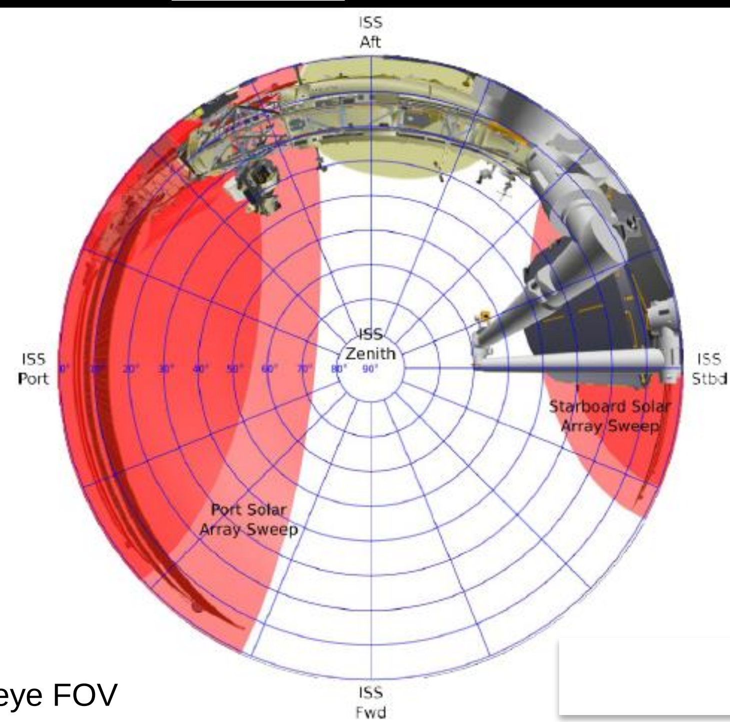




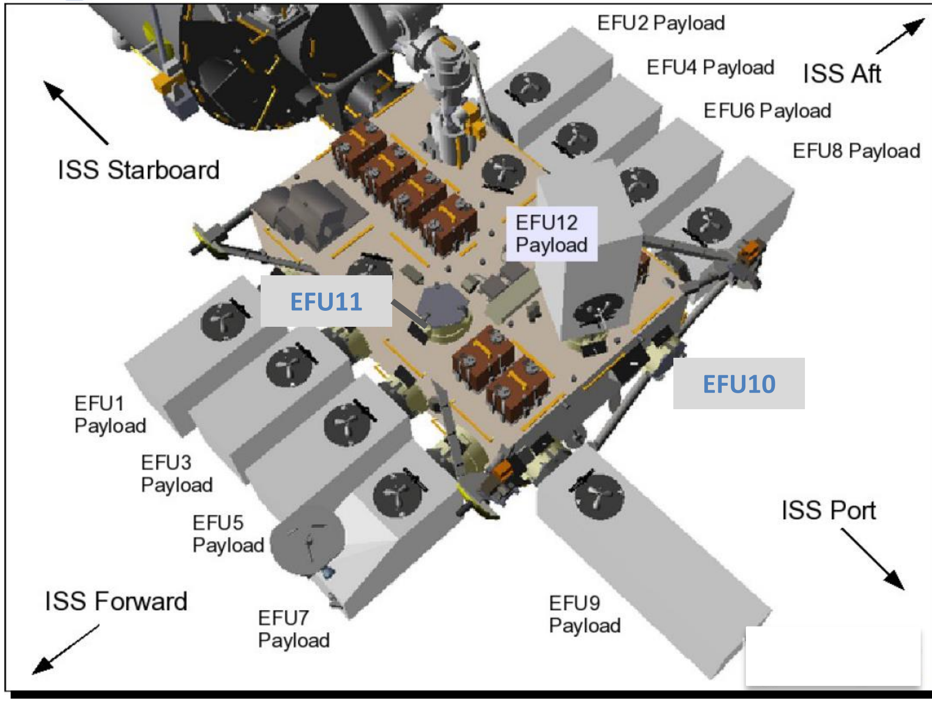
JEM EFU 10 Payload Zenith Face Fish-eye FOV

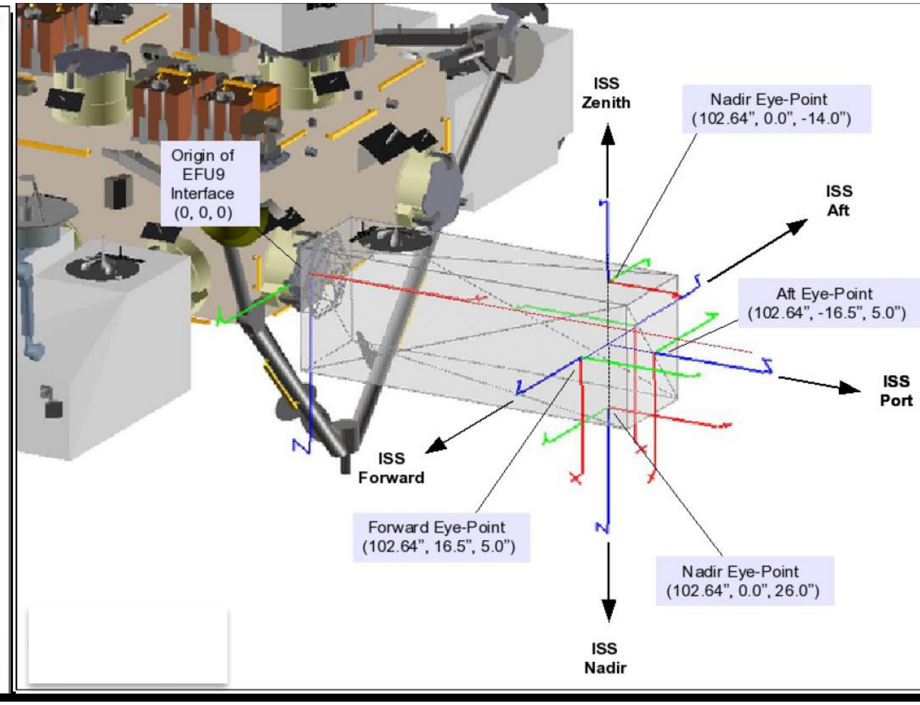


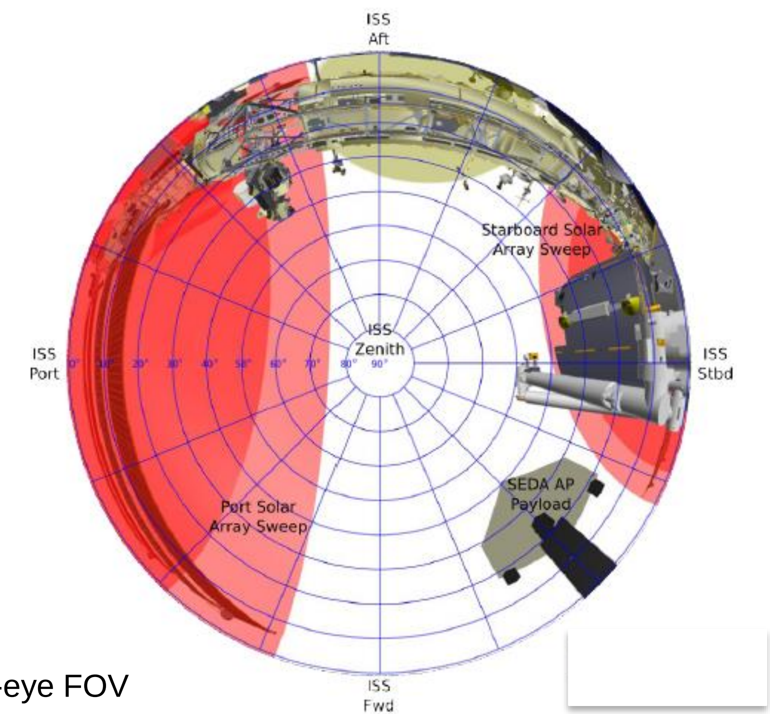




JEM EFU 11 Payload Zenith Face Fish-eye FOV







JEM EFU 12 Payload Zenith Face Fish-eye FOV