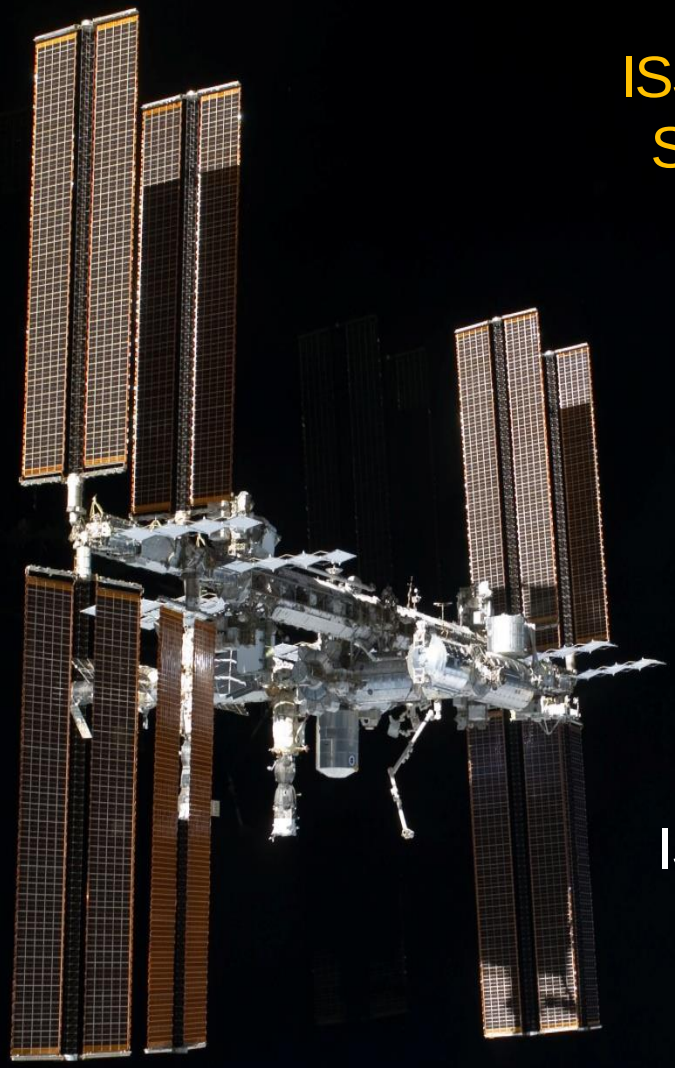


ISS Research Capability for a Wide Spectrum of Science Disciplines, Including Heliophysics

Kenol Jules
ISS Research Integration Office,
NASA Johnson Space Center,
Houston

NASA 2016 Heliophysics Small Explorer (SMEX) and Missions of Opportunity (MO) Pre-proposal Conference,

August 15, 2016

International Space Station

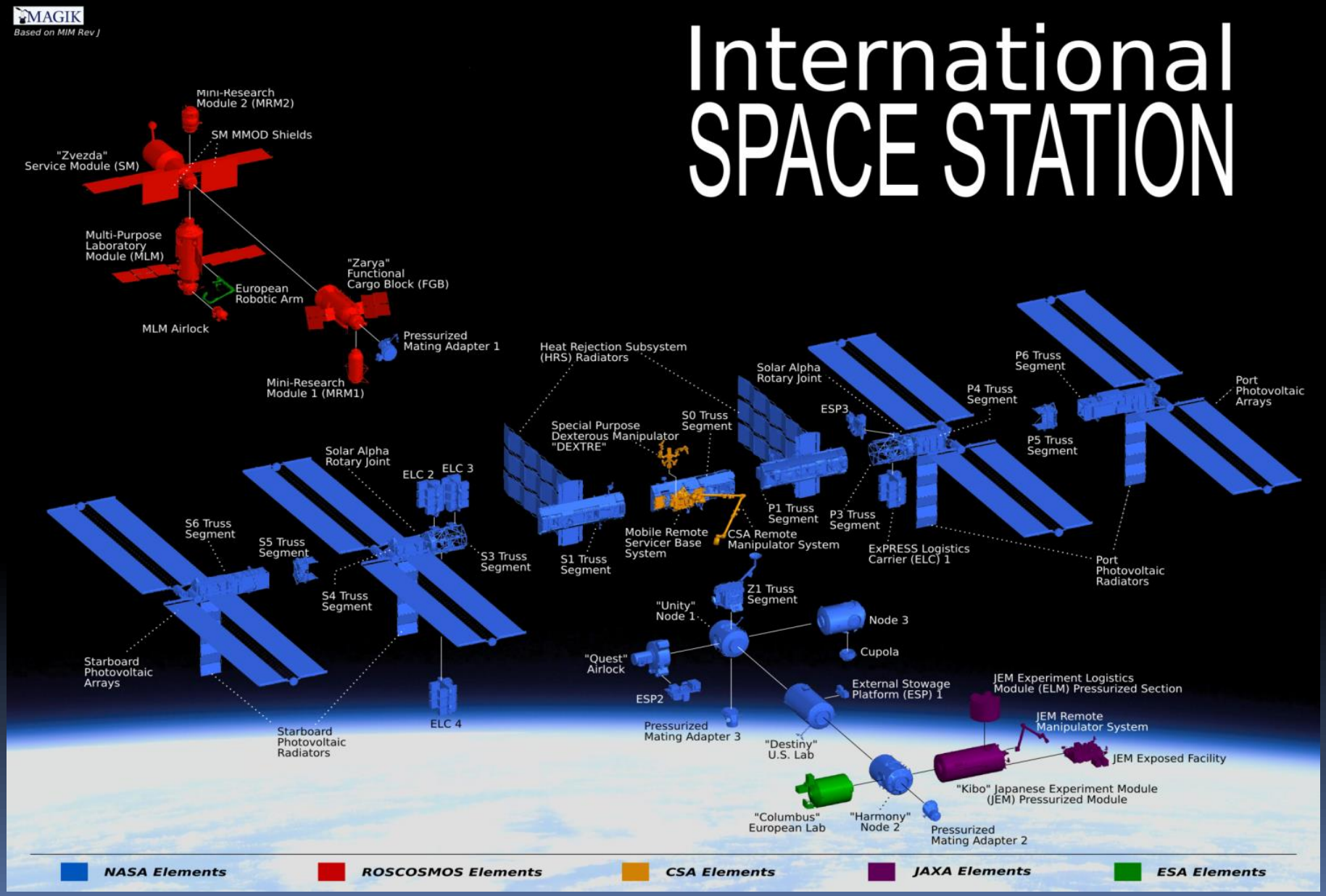
Created by a partnership of 5 space agencies

10 years and over 100 missions to assemble

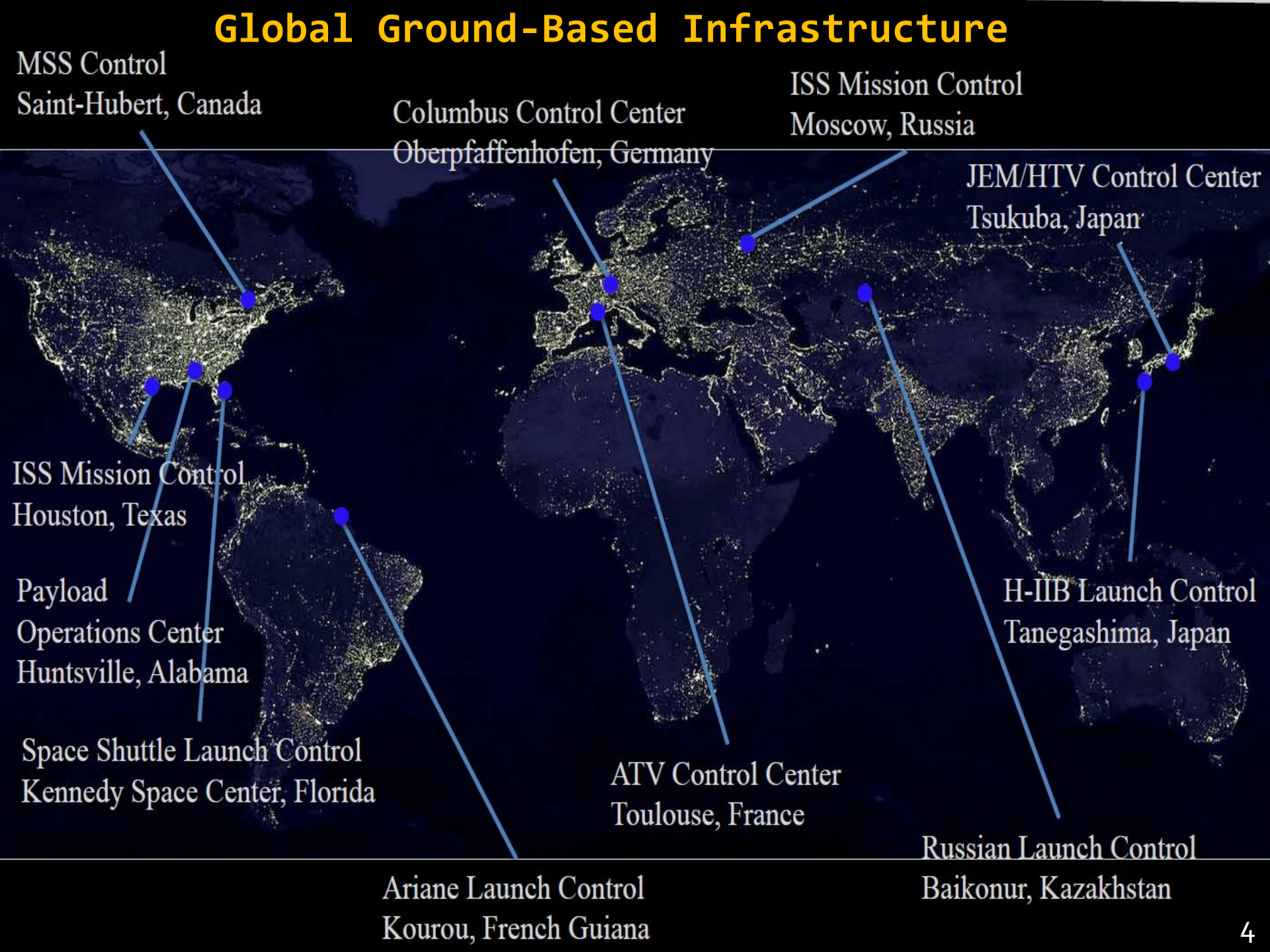
A laboratory for **Microgravity** and space research at a scale that has not been achieved before and that no one agency or country could sustain

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

International Space Station Key Features

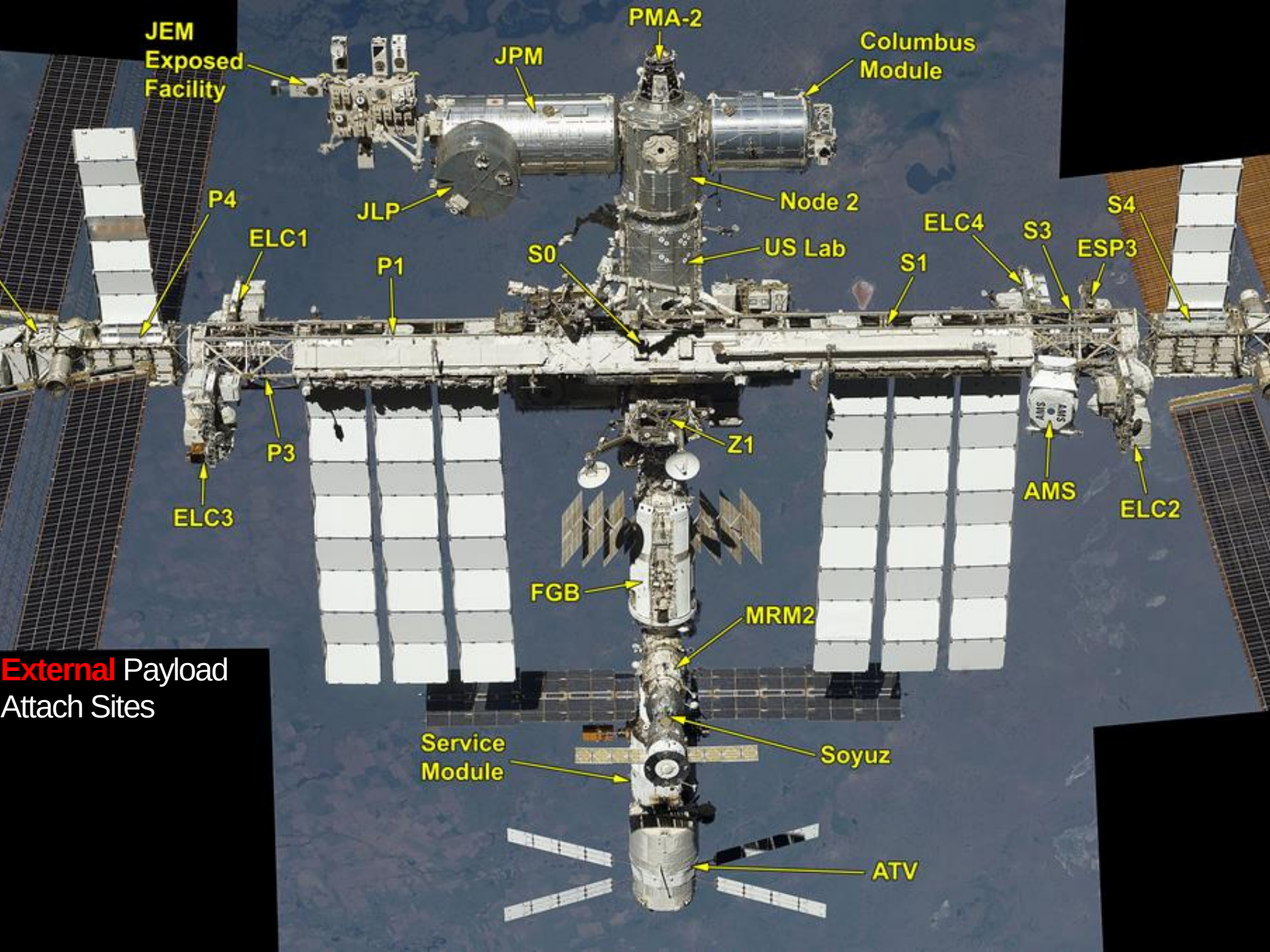
- Sustainable microgravity platform for long term studies
- Permanent Crew presence
- Access to vacuum of space
- External and internal research
- Automated, human, and robotic operated research
- Exposure to the thermosphere
- Earth observations at high altitude and velocity
- Habitable environmentally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

ISS Payload Philosophy

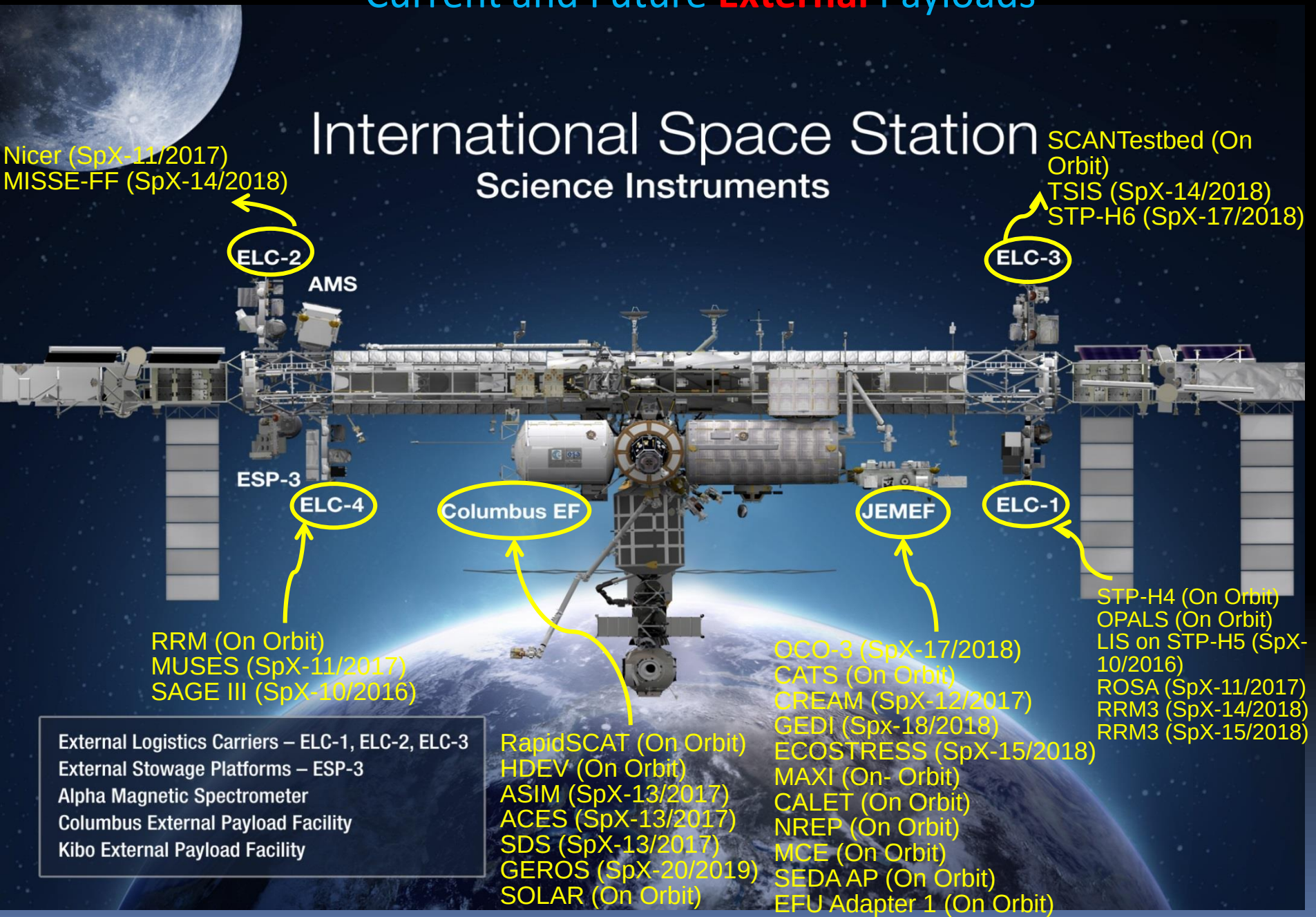
Our goal is to fly and operate a payload as soon as it is ready

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 like as possible


JEM
Exposed
Facility
JPM
PMA-2
Columbus
Module
Node 2
JLP
P4
ELC1
P1
S0
US Lab
S1
ELC4
S3
ESP3
S4
P3
Z1
AMS
ELC2
ELC3
FGB
MRM2
Service
Module
Soyuz
ATV
External Payload
Attach Sites

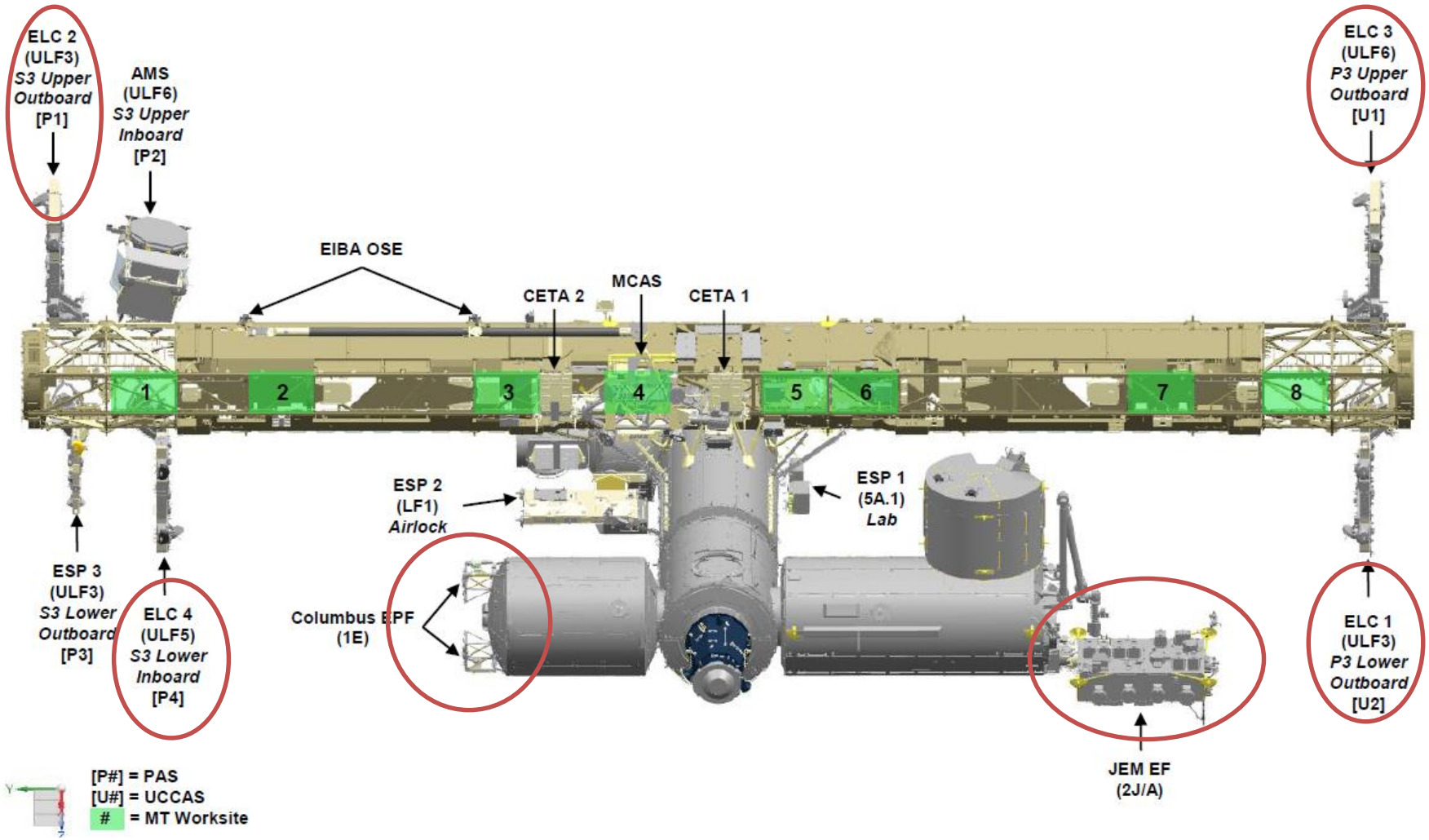
Current and Future **External** Payloads



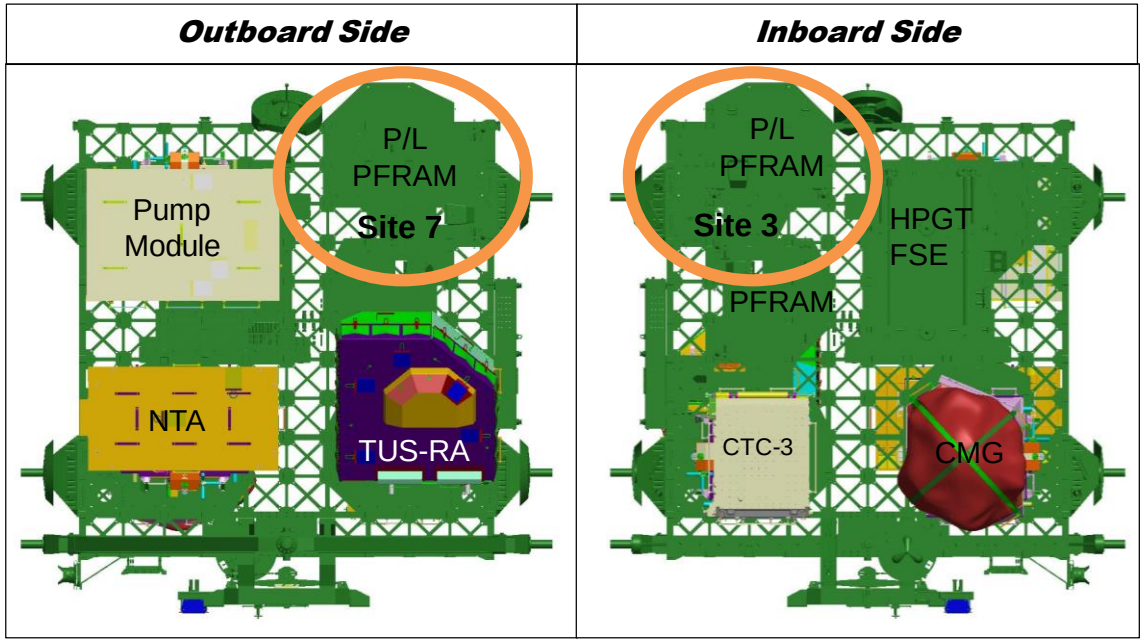
External Sites

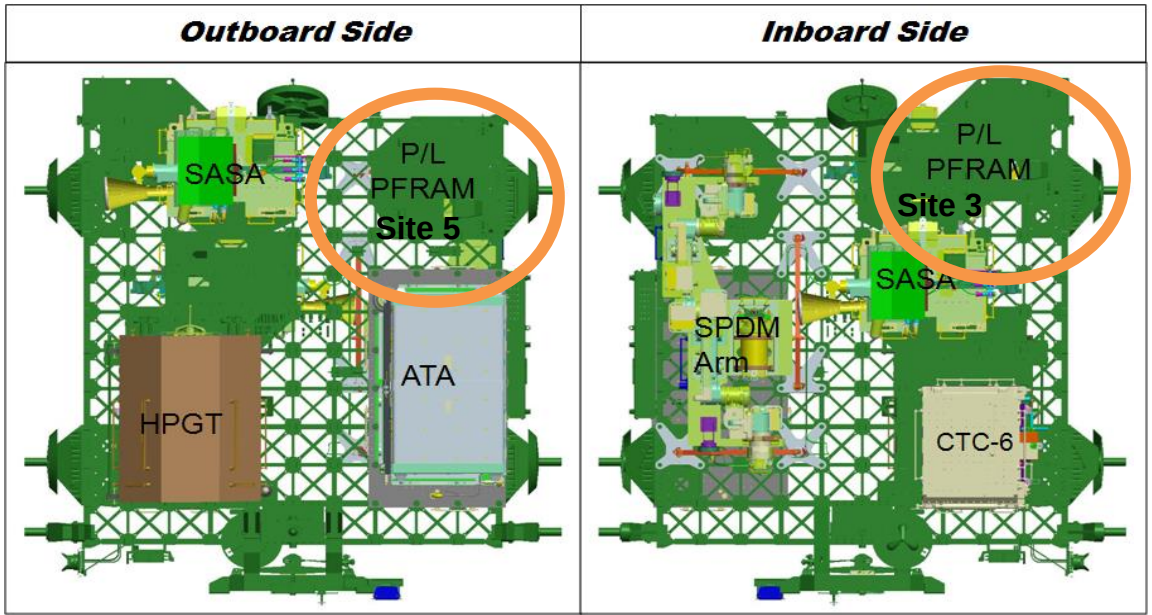
The Japan Aerospace Exploration Agency (JAXA) has demonstrated small satellite deployment from the Japanese Experiment Module "Kibo" of the International Space Station (ISS) in order to enhance the capability of Kibo's utilization and to offer more launch opportunities to small satellites.

ISS Attached Sites



Express Logistics Carriers Overview





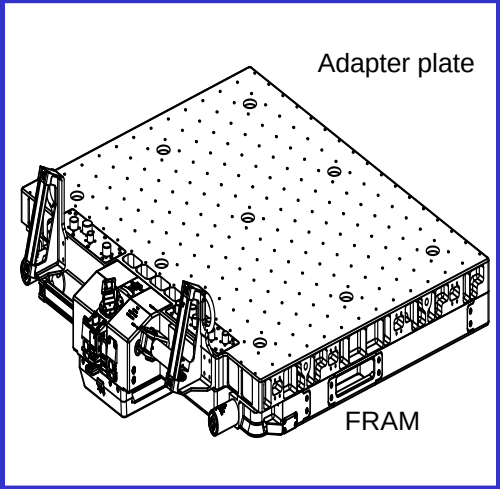
Payload Locations Circled

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

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

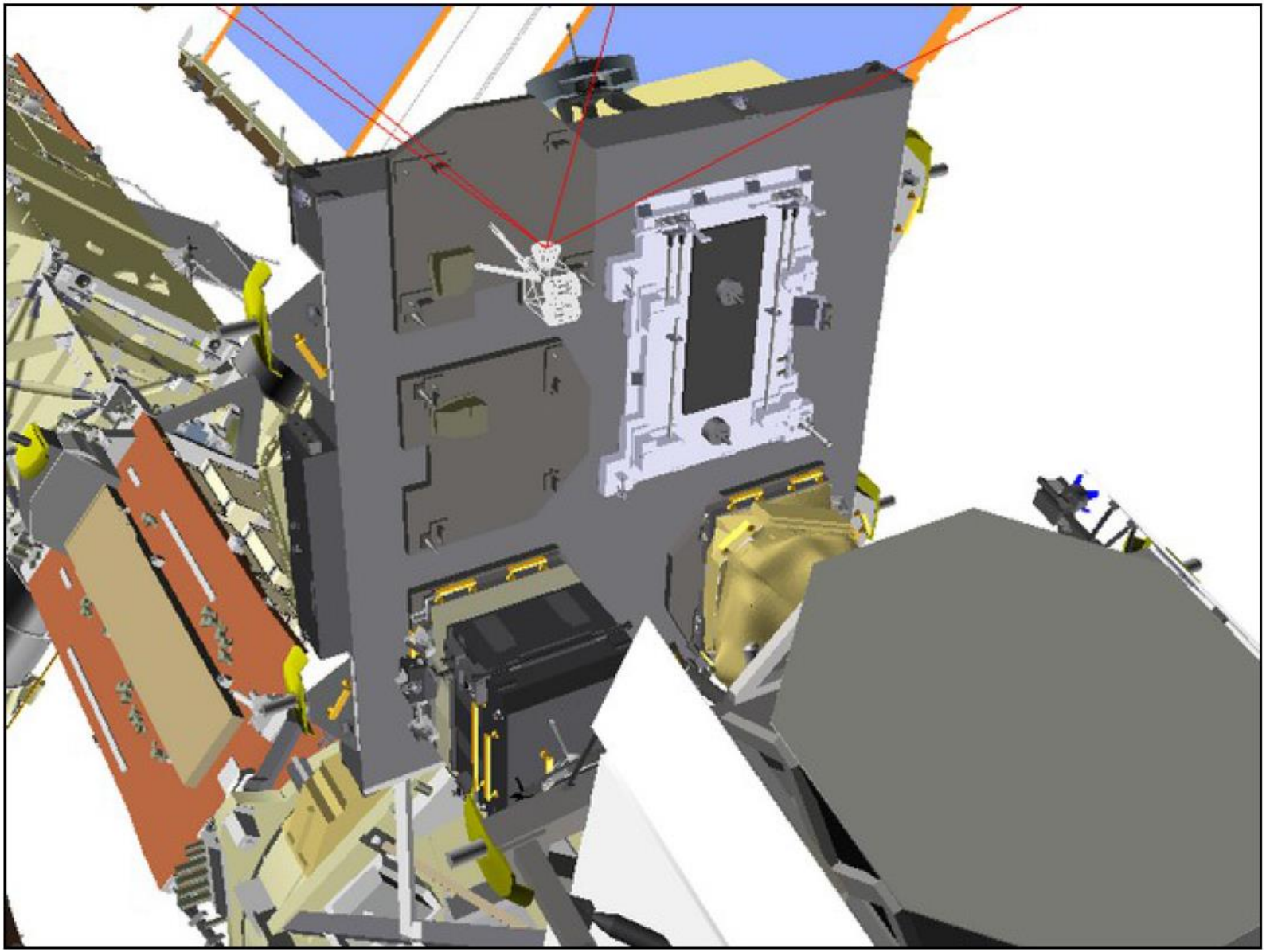
Express Pallet Adapter (ExPA) Assembly (GFE)

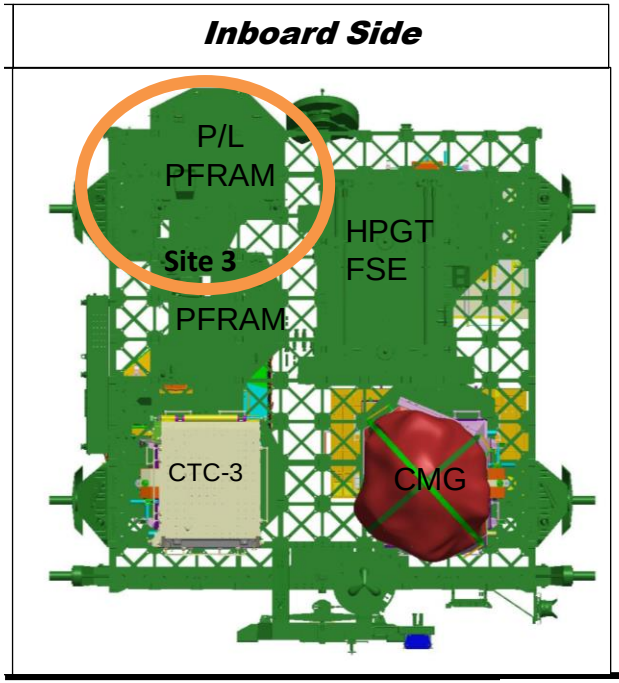
Express Pallet Adapter (ExPA) Assembly



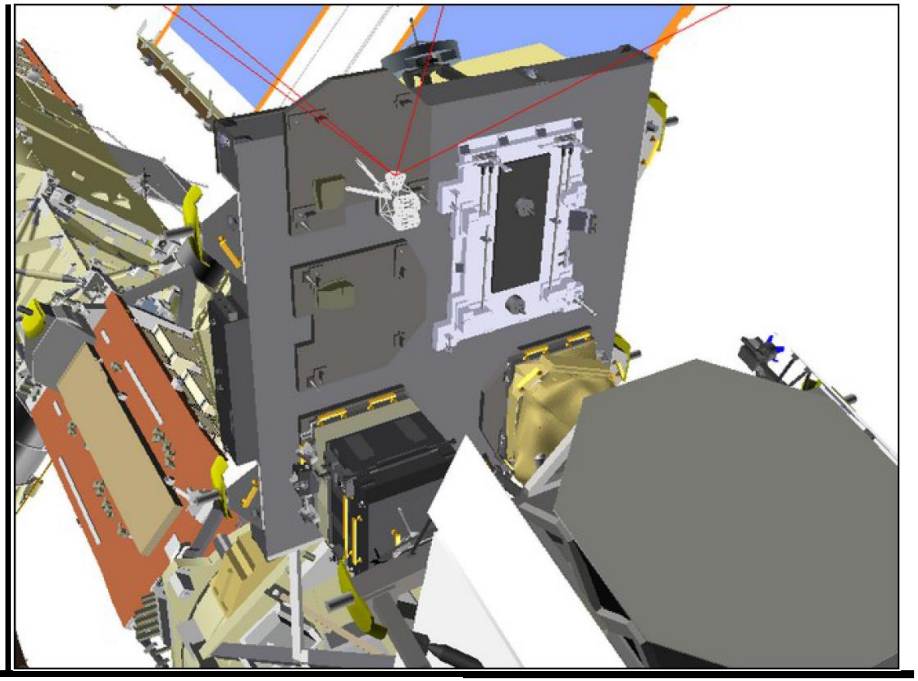
ExPA overall Mass	255 lb
ExPA overall dimension	46.05” x 47” x 13.06” (H)
ExPA payload carrying capability	34” x 46” x 49” (H) and 500 lb”
Payload electrical interface	Power(120VDC & 28VDC): Four NATC connectors Data (1553, Ethernet): Six NATC connectors
Payload thermal interface	Active heating, passive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

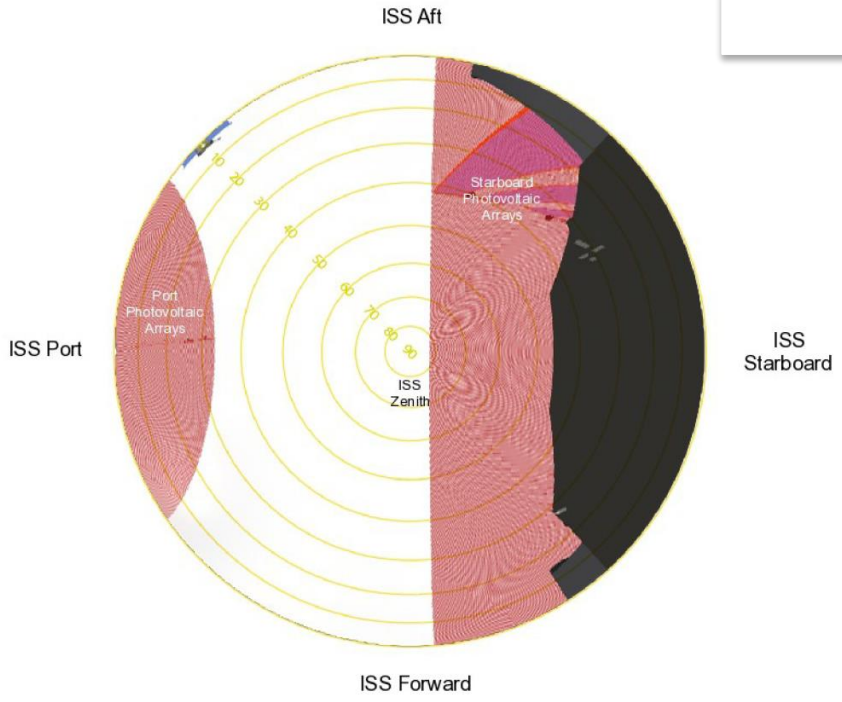
Placement of “Eye” Point for Sensor Viewing for Field of View Analysis

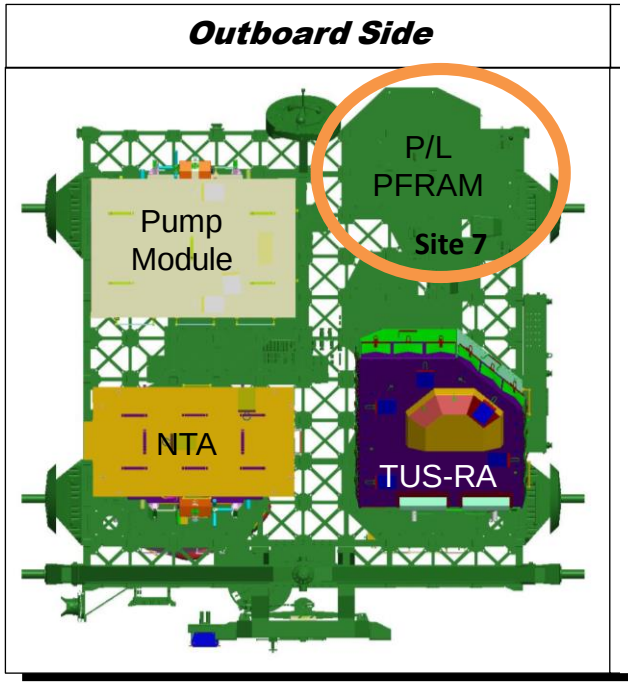




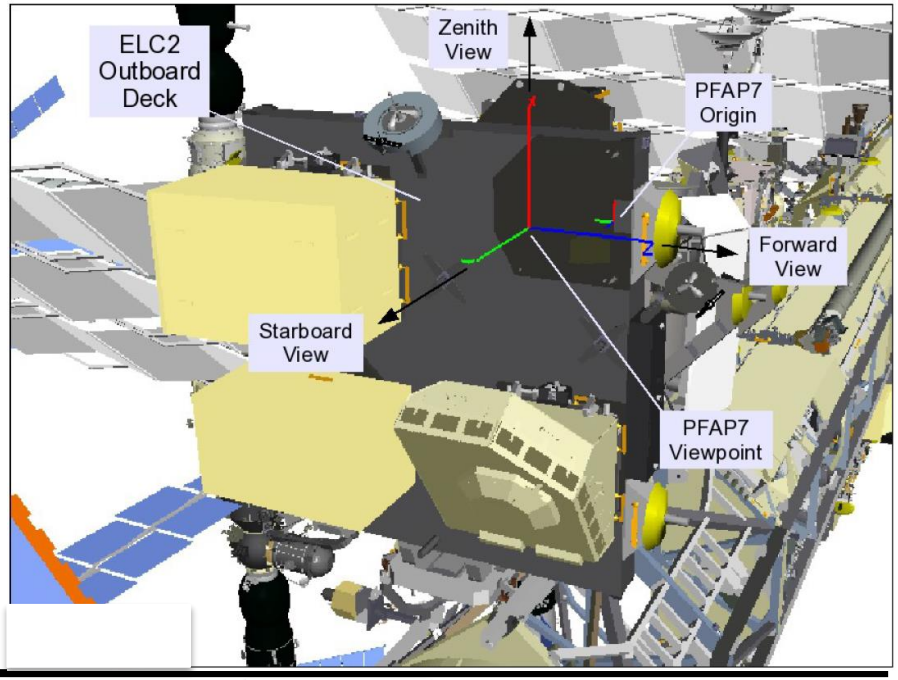
ELC-2 (Ram)/Site 3
Starboard upper
Zenith site

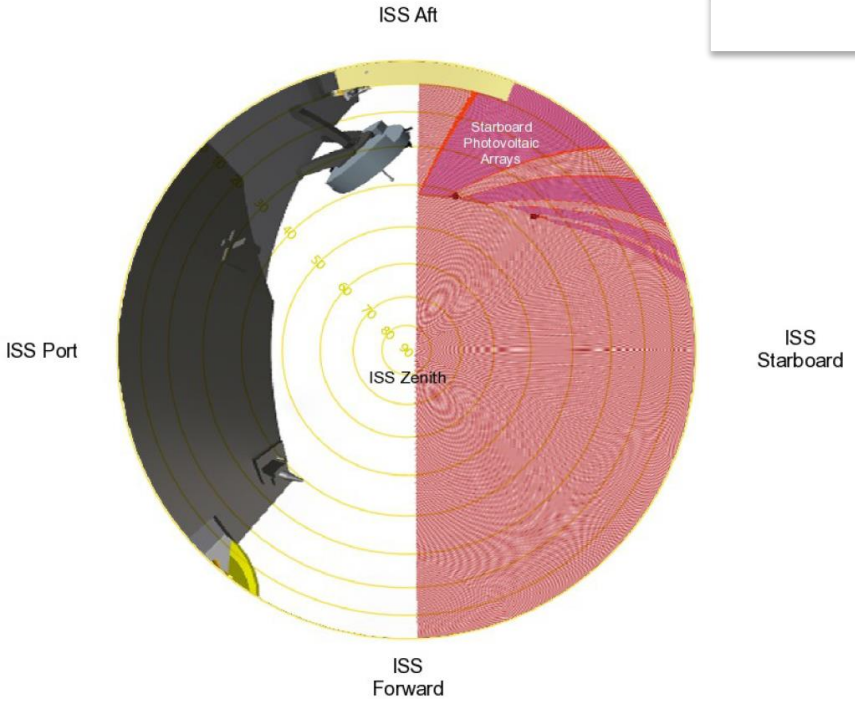


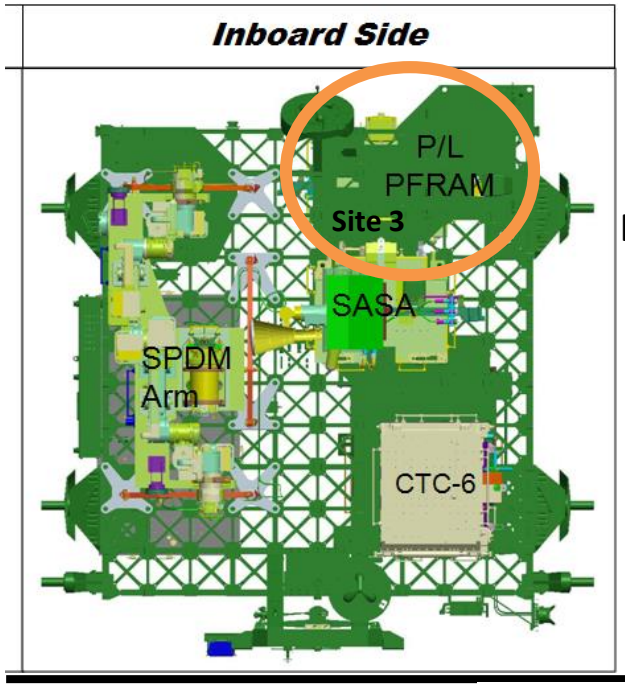




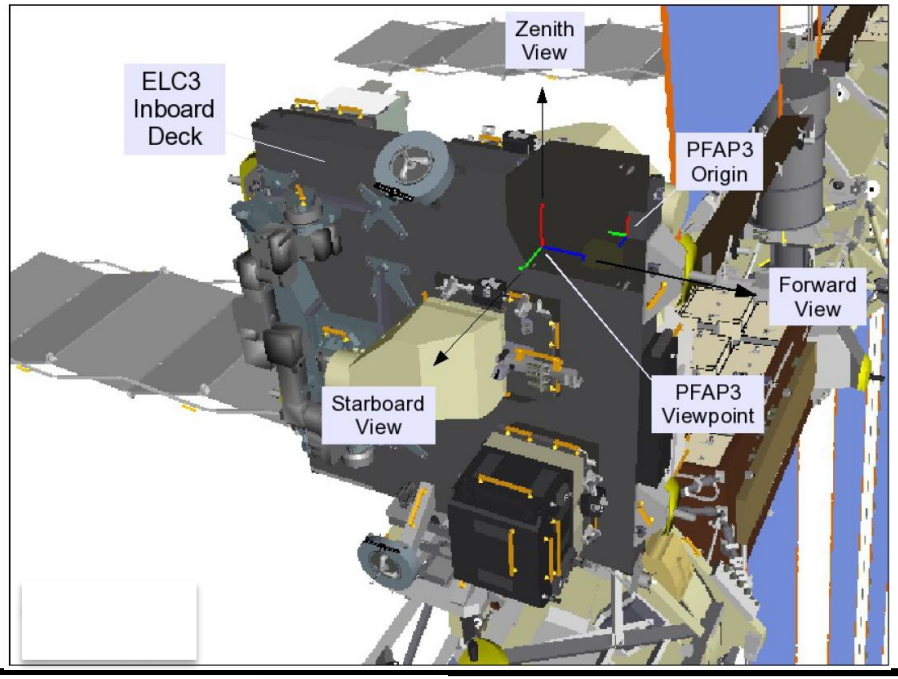
ELC-2 (Ram)/Site 7
Starboard upper
Zenith site

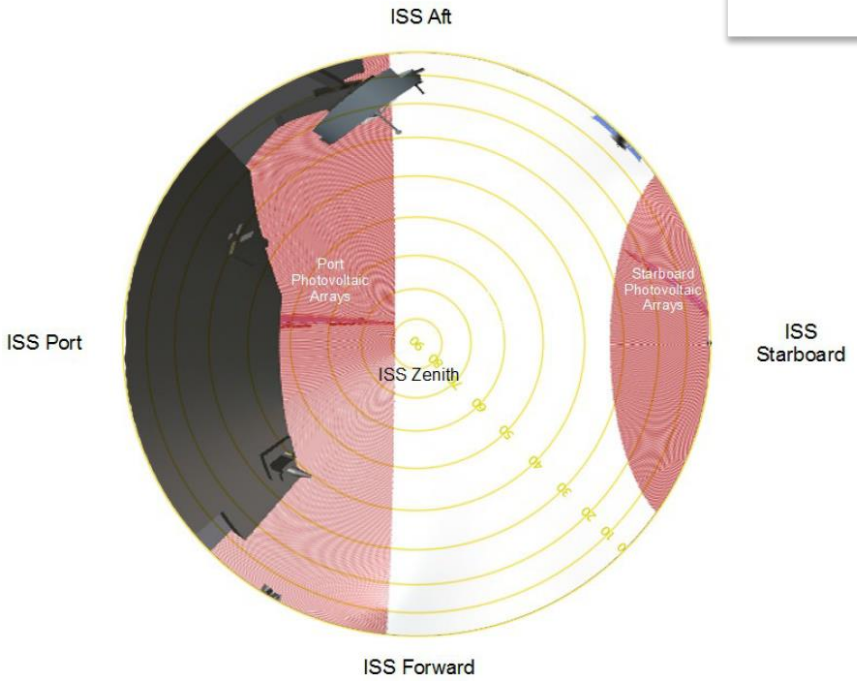


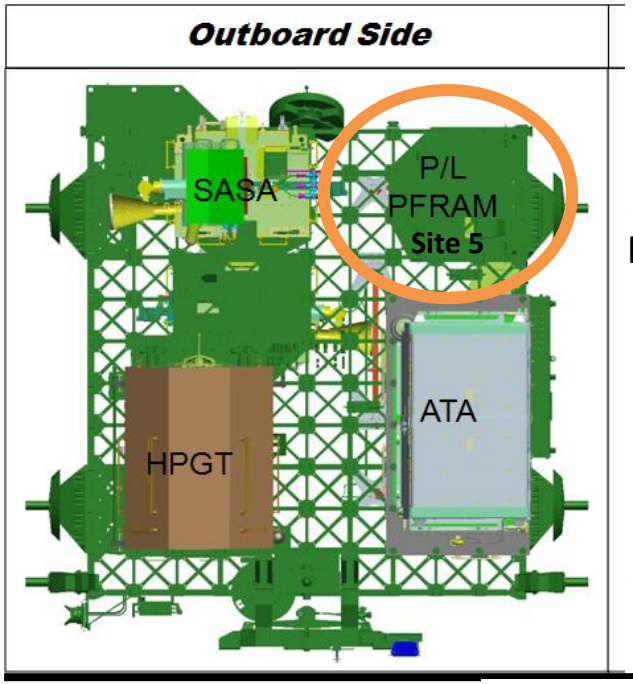




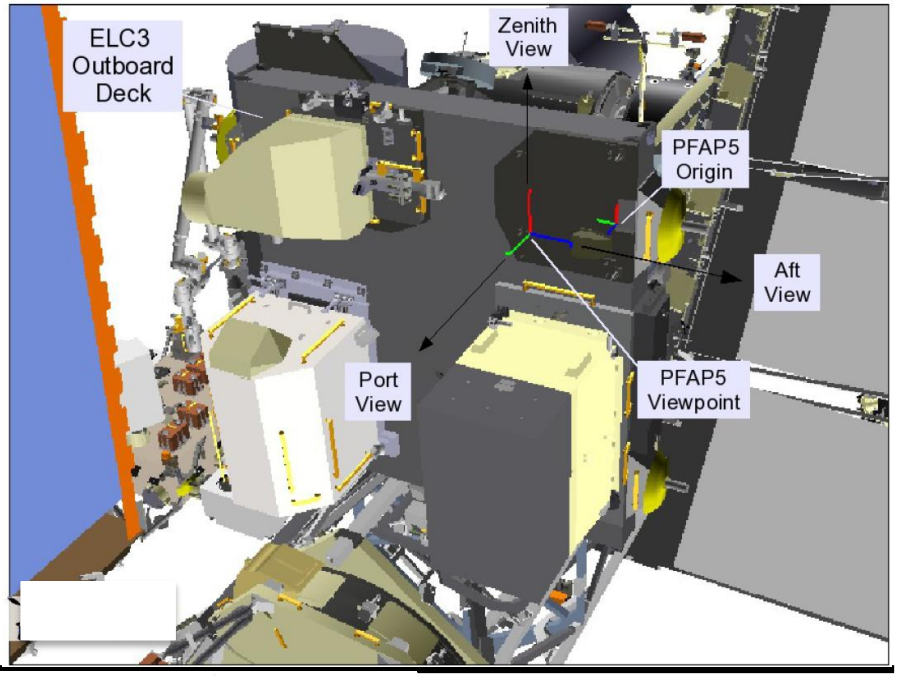
ELC-3 (Ram)/Site 3
Port upper
Zenith site

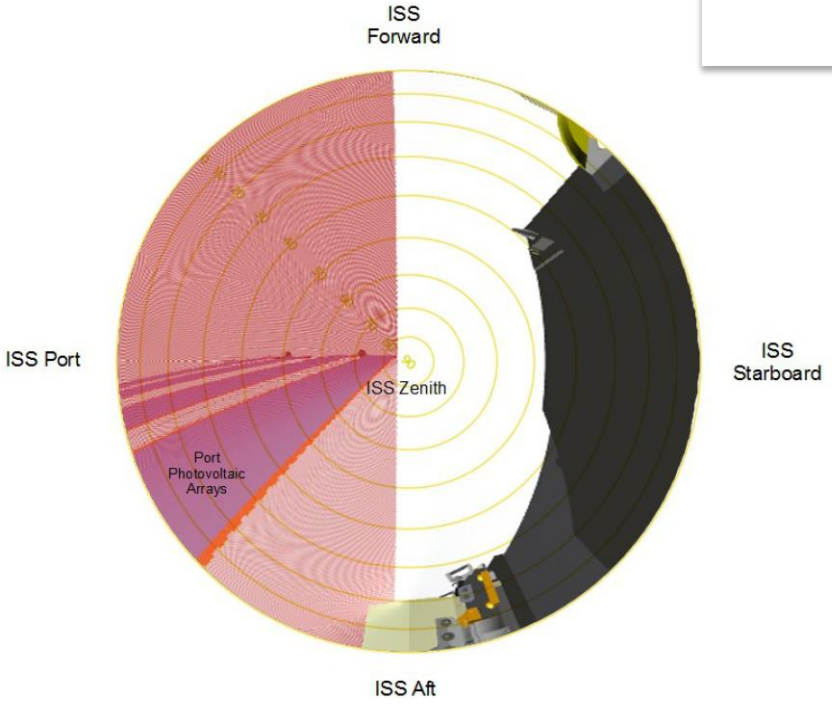






ELC-3 (Wake)/Site 5
Port upper
Zenith site



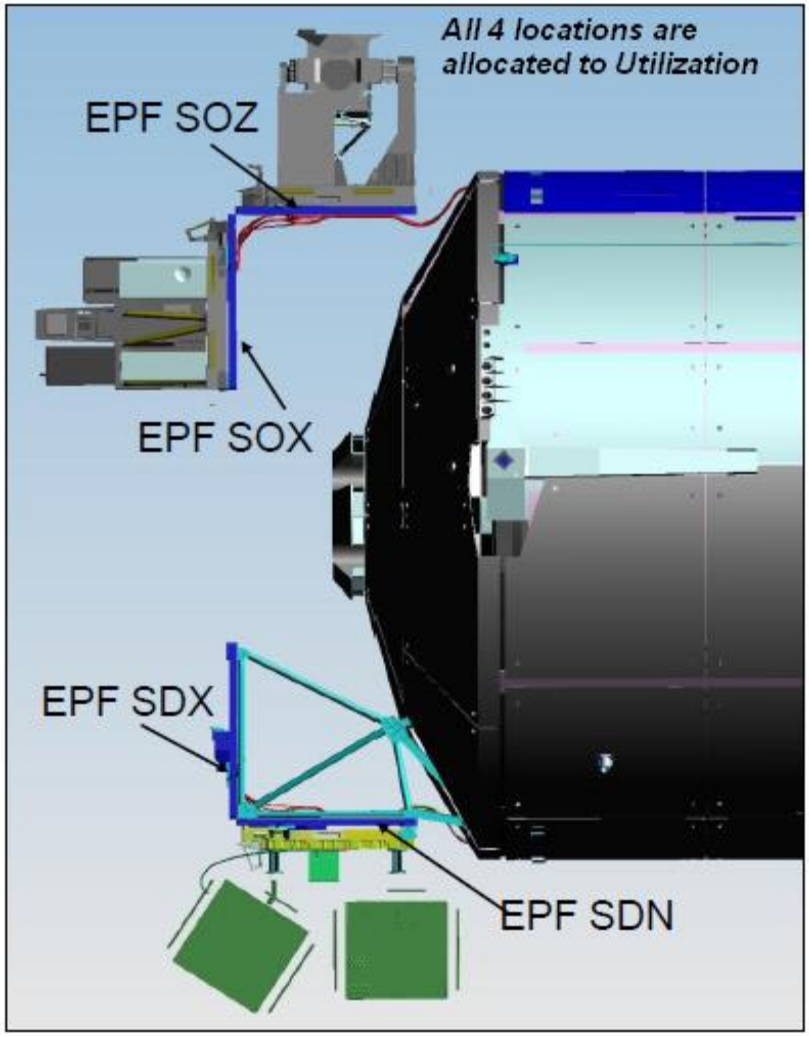


Columbus External Research Accommodations

Columbus External Resources

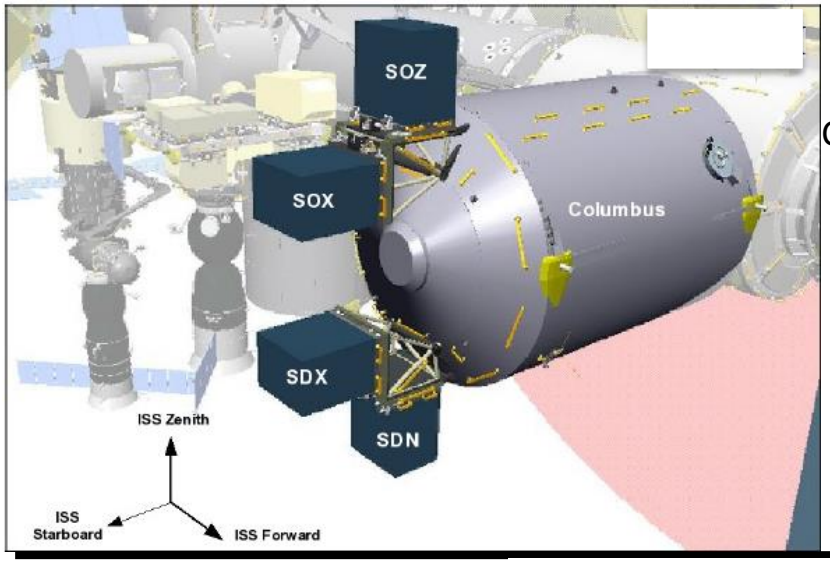
Mass capacity	230 kg (500 lb)
Volume	1 m^3
Power	2.5 kW total to carrier **(shared)**
Thermal	Passive
Low-rate data	1 Mbps (MIL-STD-1553)
Medium-rate data	2 Mbps (shared)
Sites available to NASA	2 sites

Columbus EF Overview

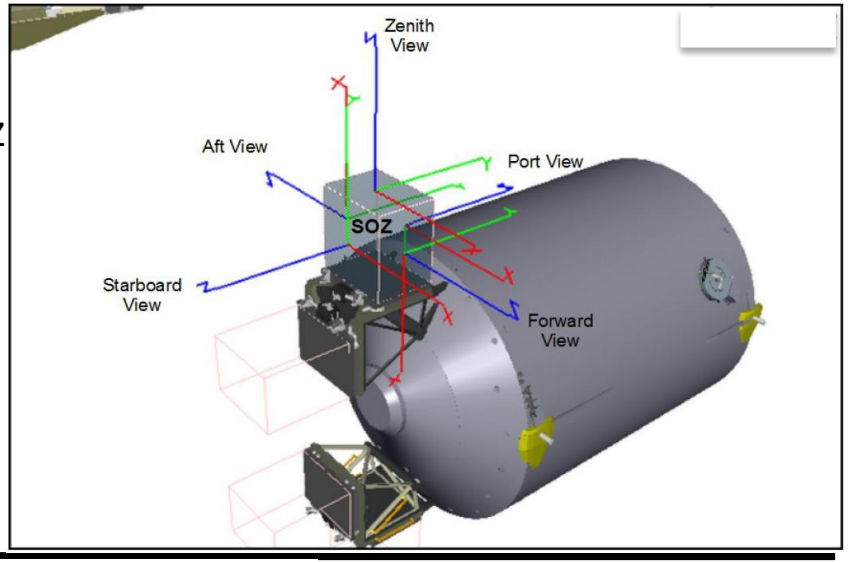


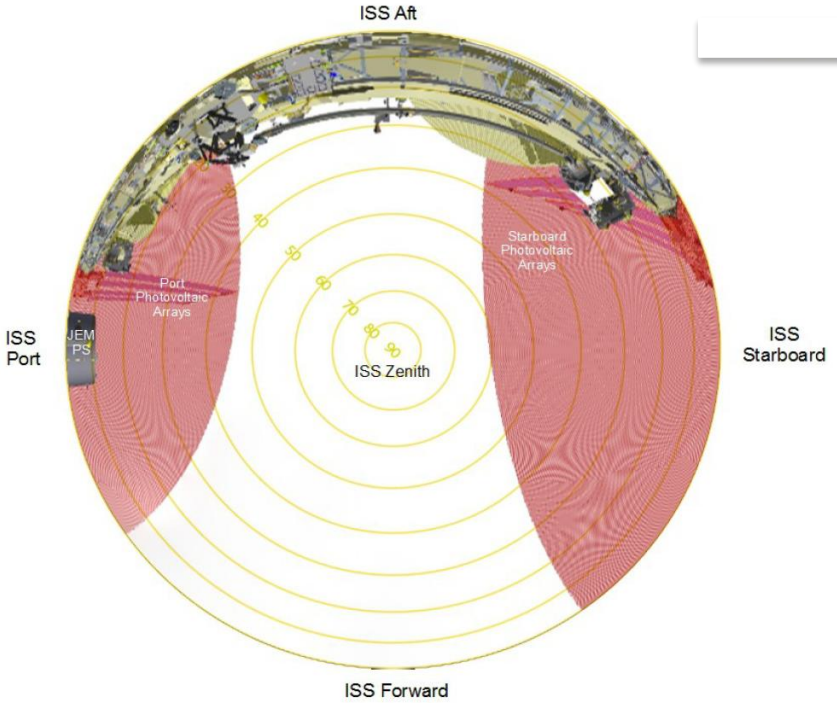
Location	Viewing	Payload Size	Power	Data
SOZ	Zenith	226 kg + CEPA	1.25 kW at 120 VDC 2.5 kW max (**Shared**)	Ethernet, 1553
SOX	Ram			
SDX	Ram			
SDN	Nadir			

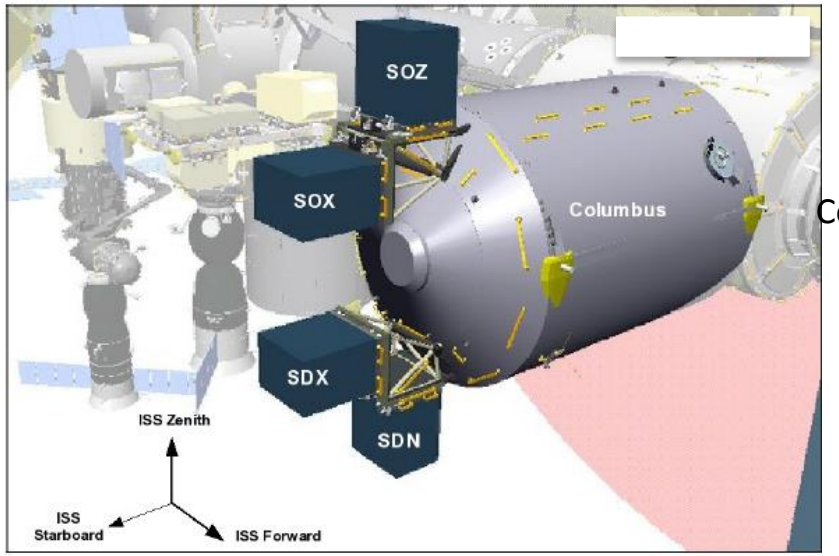
Columbus External Payload Facility



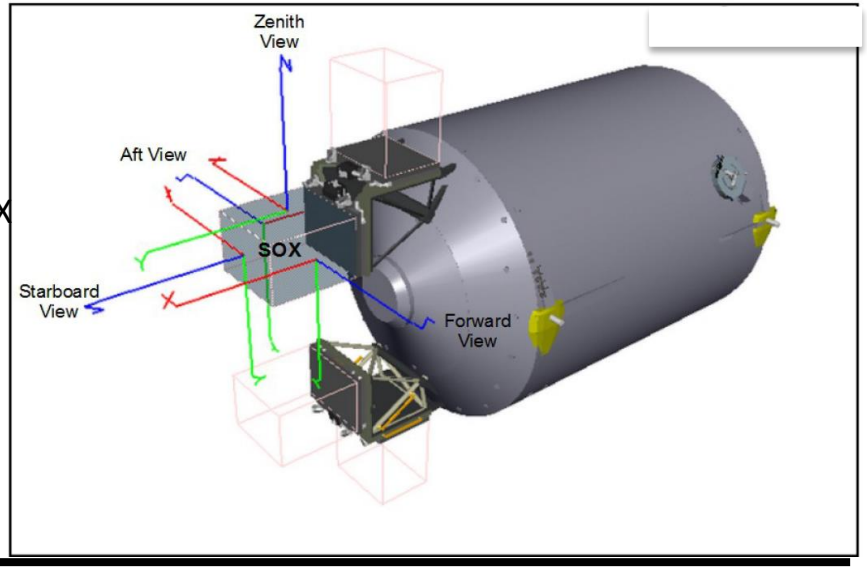
Columbus/S0Z Overhead Zenith site

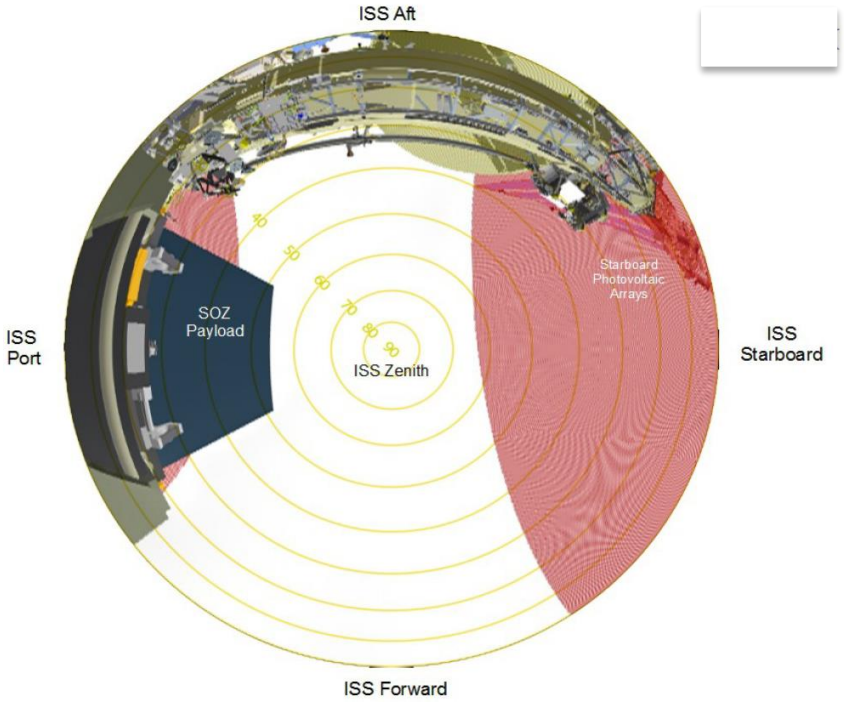




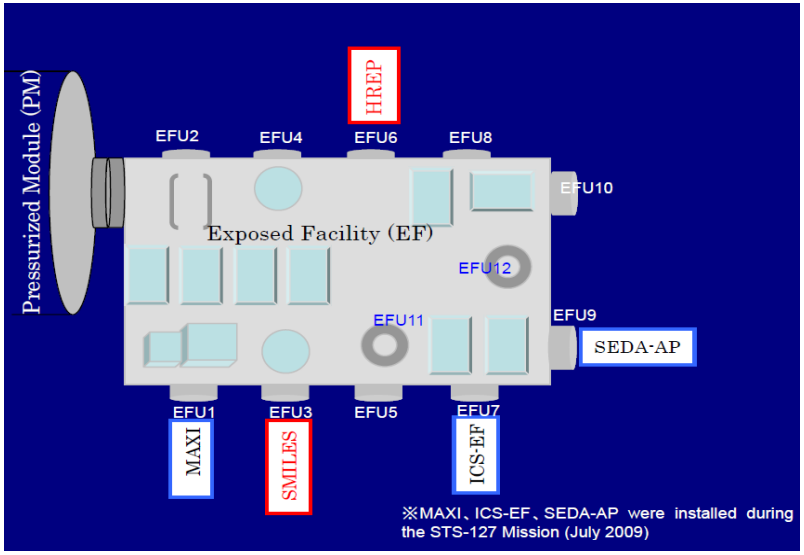


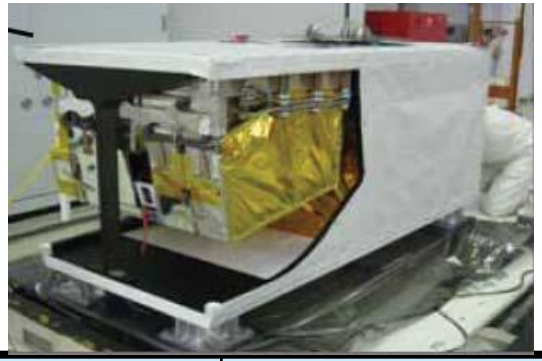
Columbus/SOX
Overhead
Zenith site



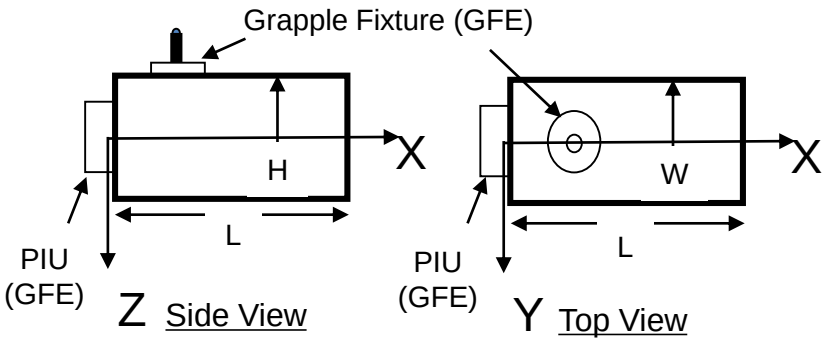


JEM EF External Research Accommodations





NASA/DOD HREP payload

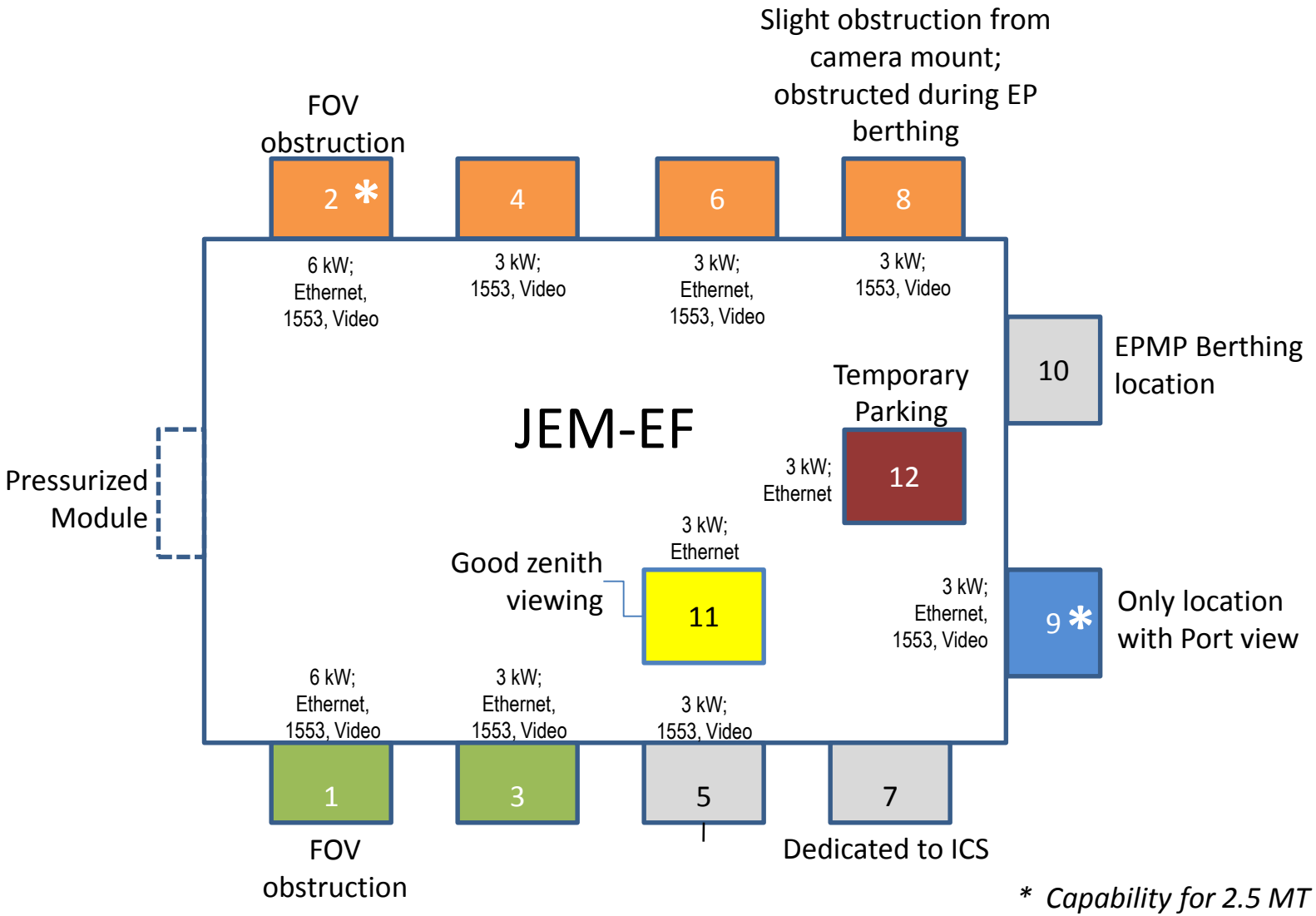


Axis	mm	ft	inch
W	800	2	7.50
H	1000	3	3.37
L	1850	6	0.83

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	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

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 2018-2022 timeframe to allow all of them 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

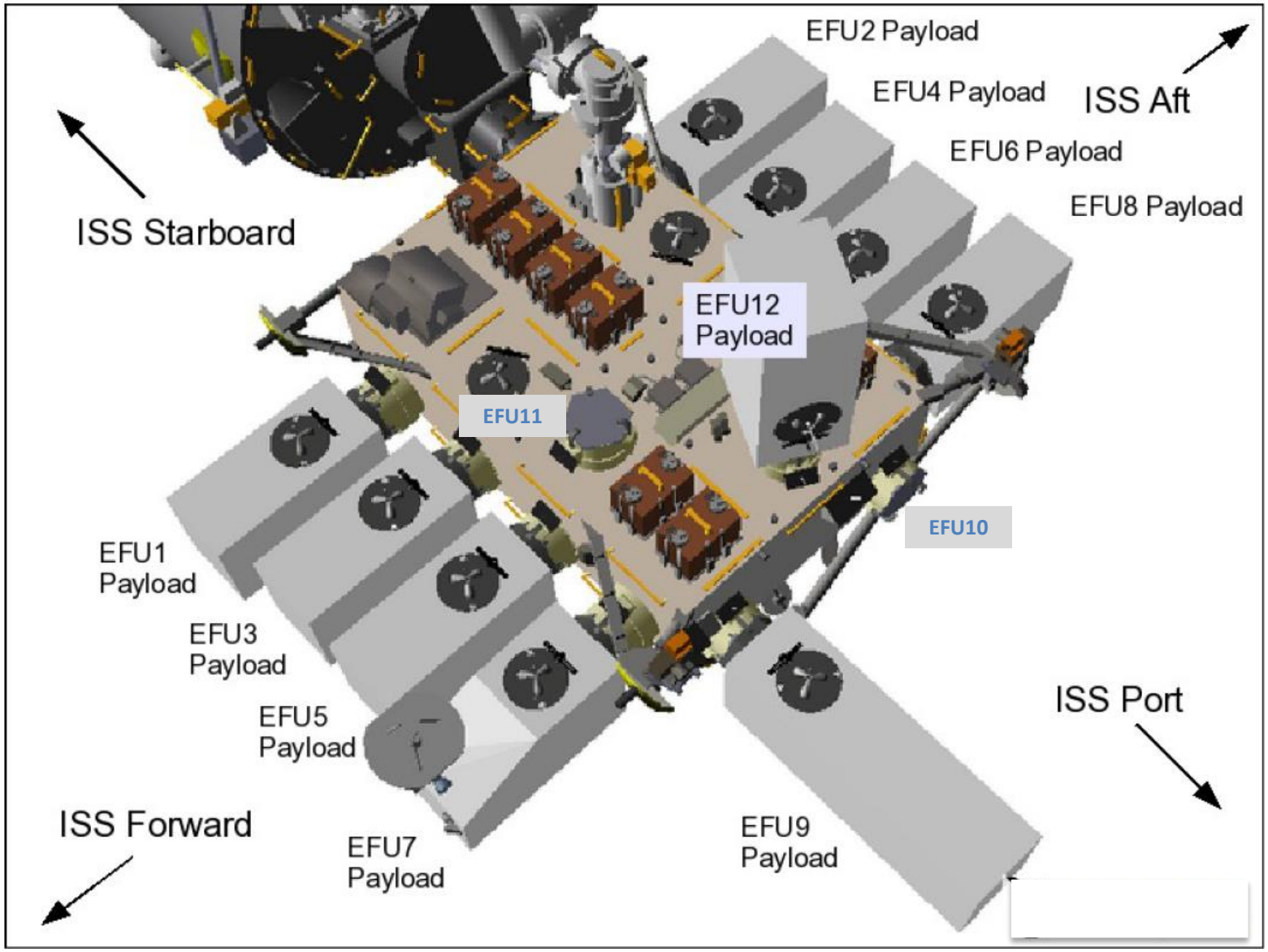
- *JEM-EF system can support the following during the 2018-2020 timeframe:
  - Maximum fluid flow per payload: **151 kg/hr**
  - Maximum Power draw per payload: **500 W**
  - Maximum accumulator volume: **2L**

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

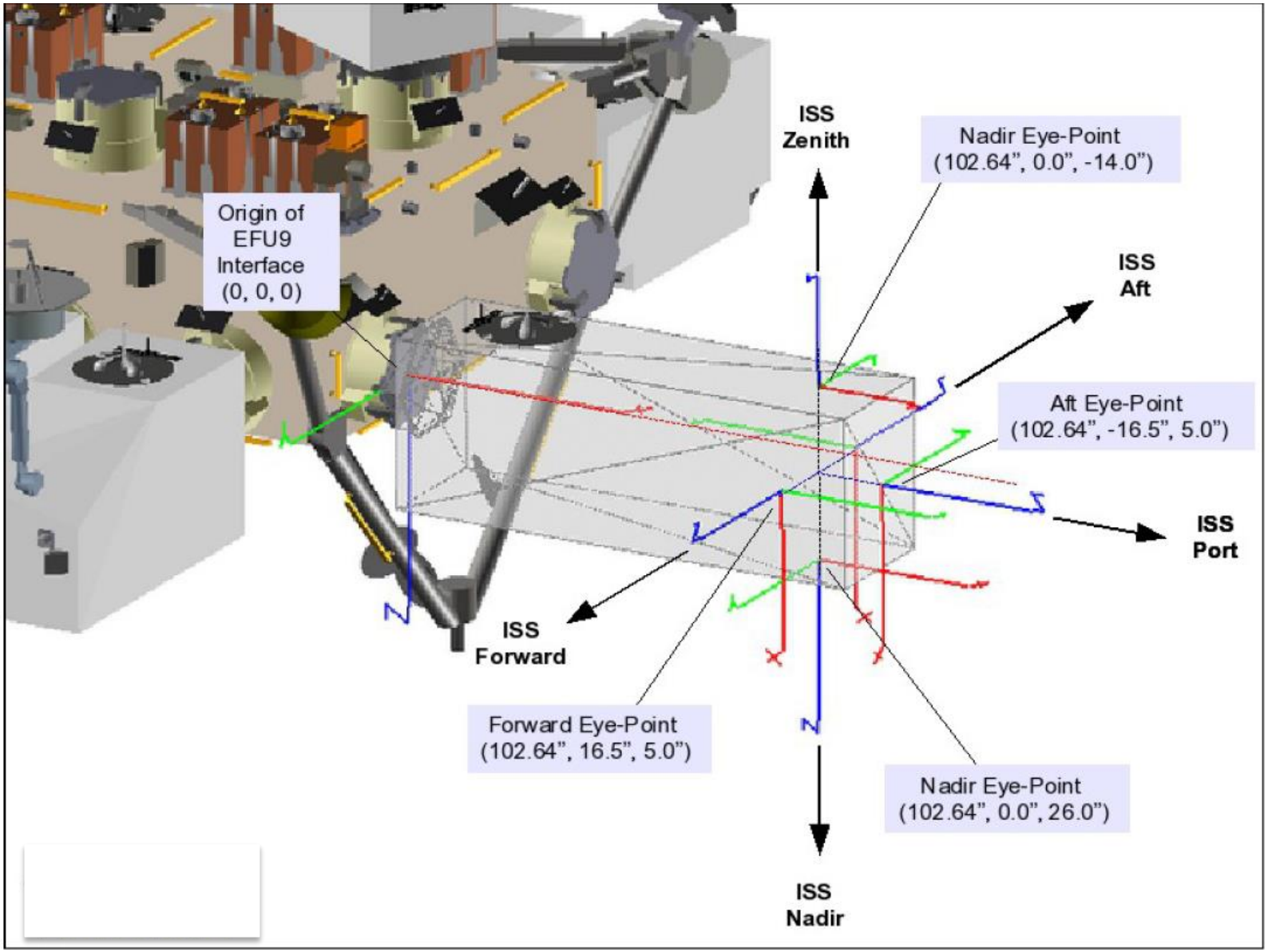
JEM-EF Detailed Accommodations by Site

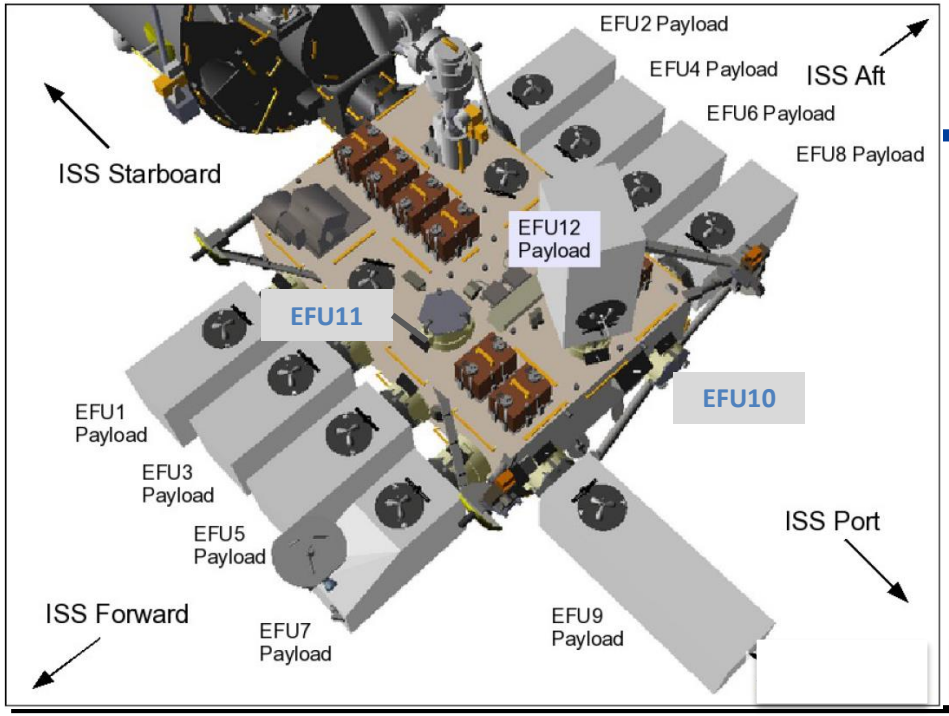
Location	Viewing	Payload Size	Description / Notes	Data
1	Ram, Nadir, Zenith	500 kg	Ram field of View (FOV) obstruction by JEM module	Ethernet, 1553, Video
3	Ram, Nadir, Zenith	500 kg	Clear view	Ethernet, 1553, Video
5	Ram, Nadir, Zenith	500 kg	ICS System back-up site (negotiable?)	1553, Video
7	Ram, 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

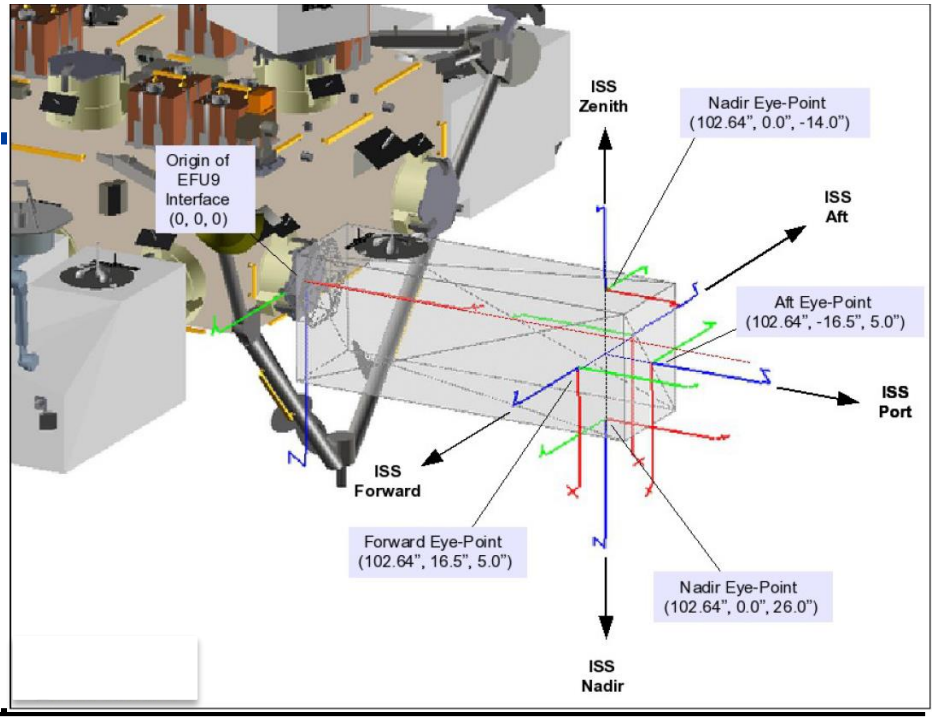
JEM-EF External Sites Locations

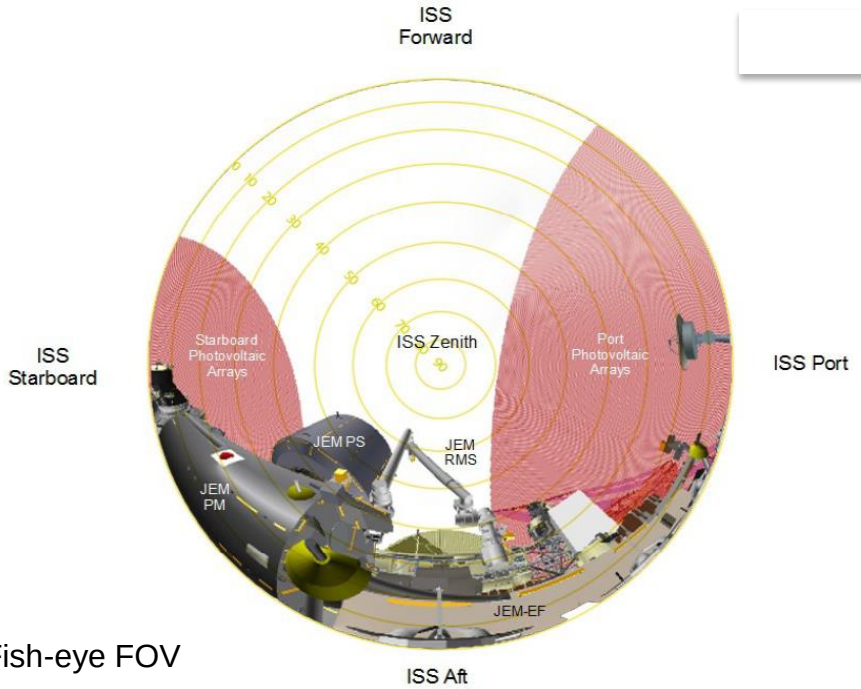


Placement of Eye-Point for Sensor Located on Zenith Face of Generic EFU Payload Facing ISS-Nadir

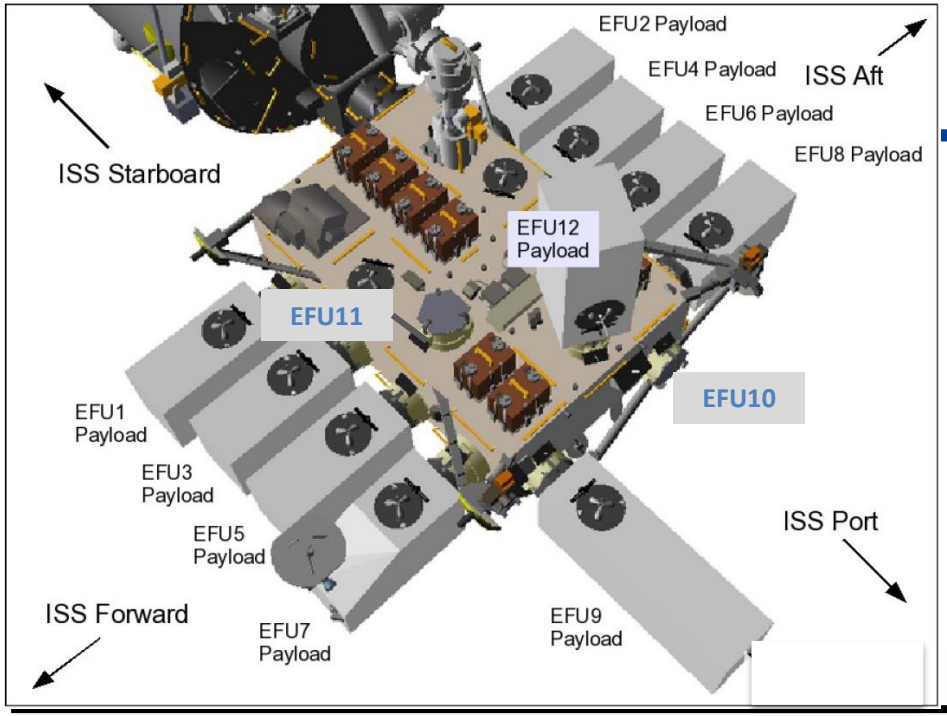


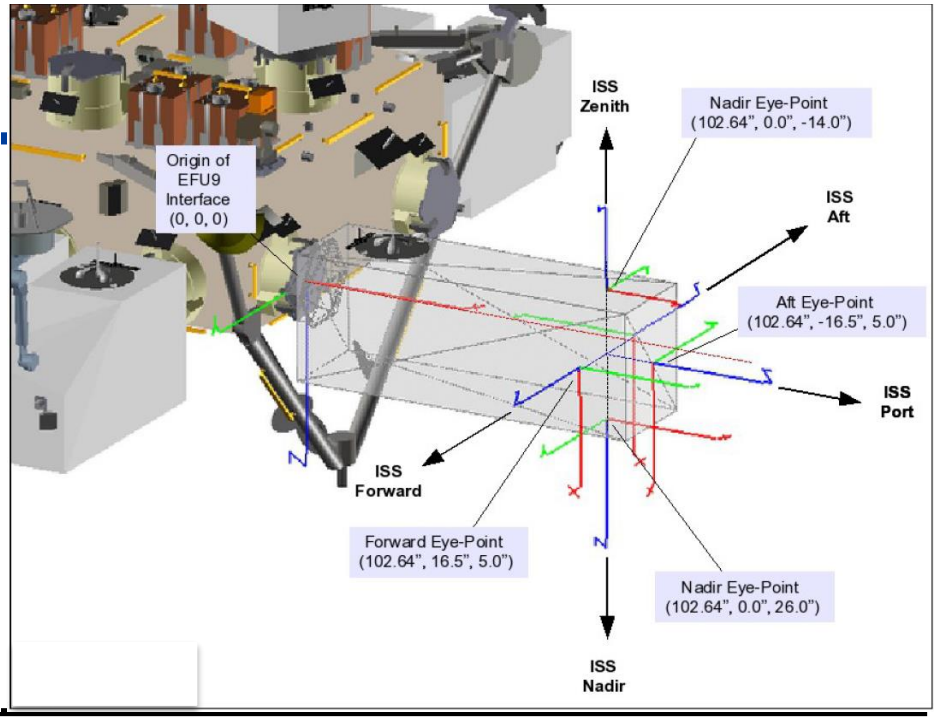


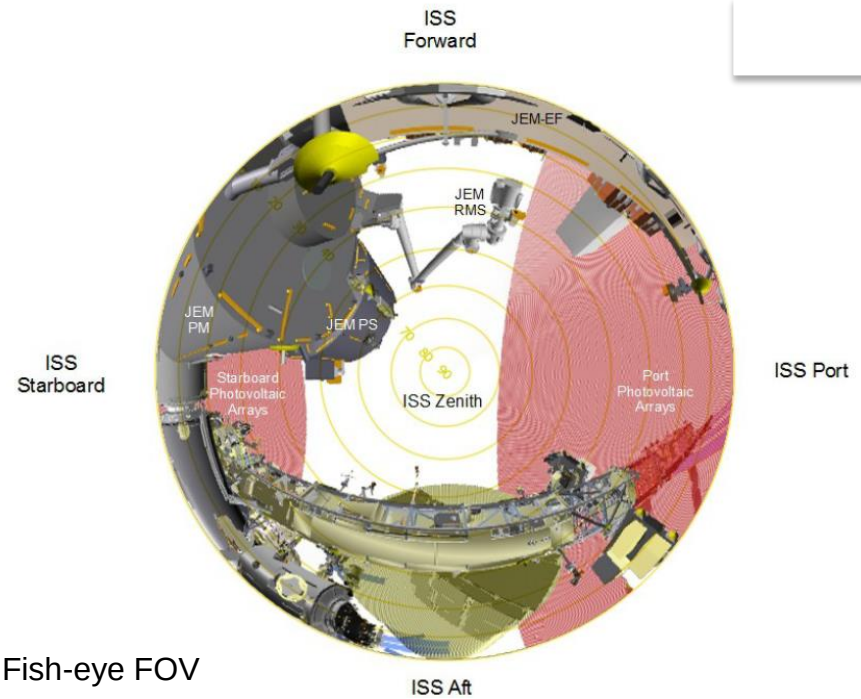




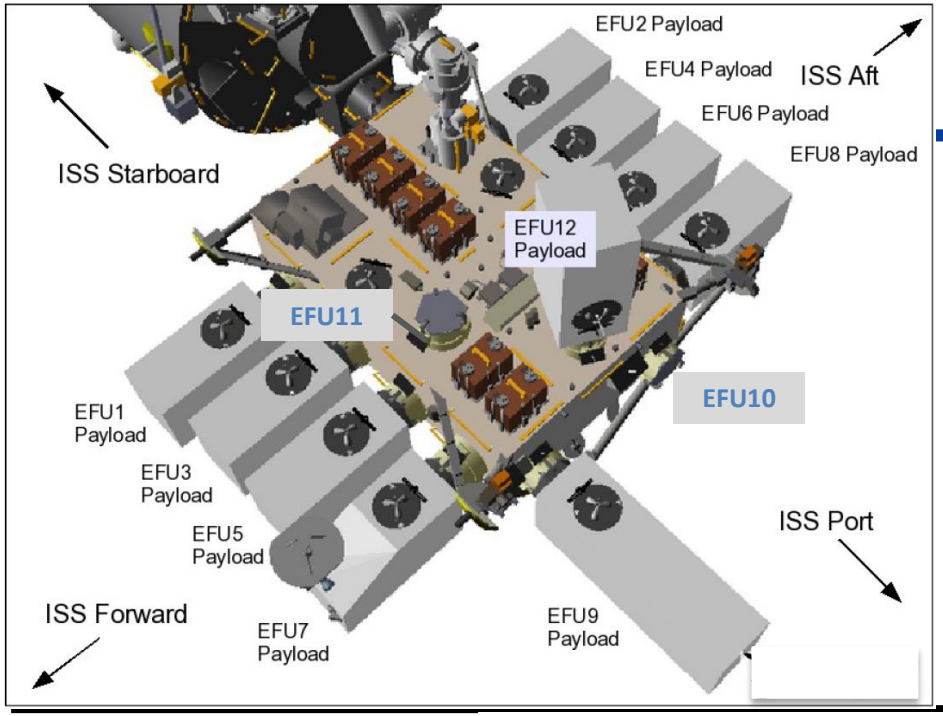
JEM EFU 1 Payload Zenith Face Fish-eye FOV

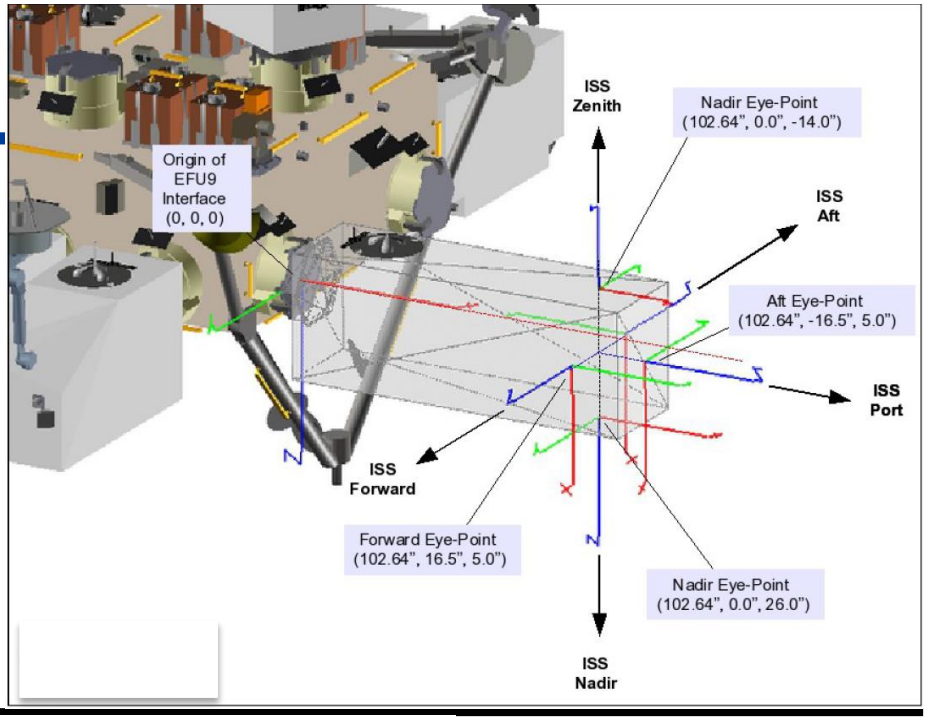


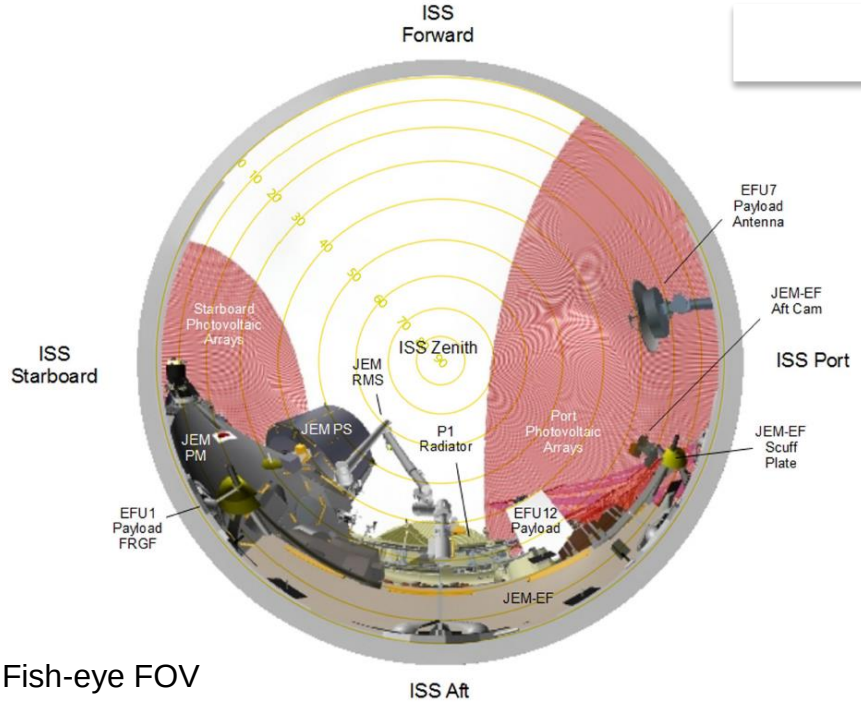




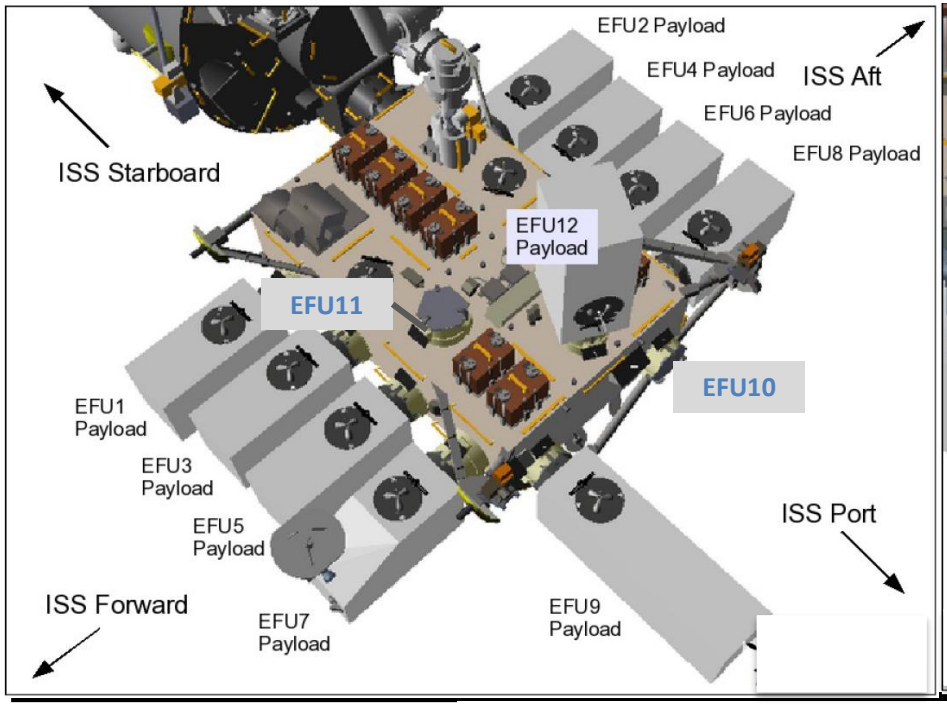
JEM EFU 2 Payload Zenith Face Fish-eye FOV

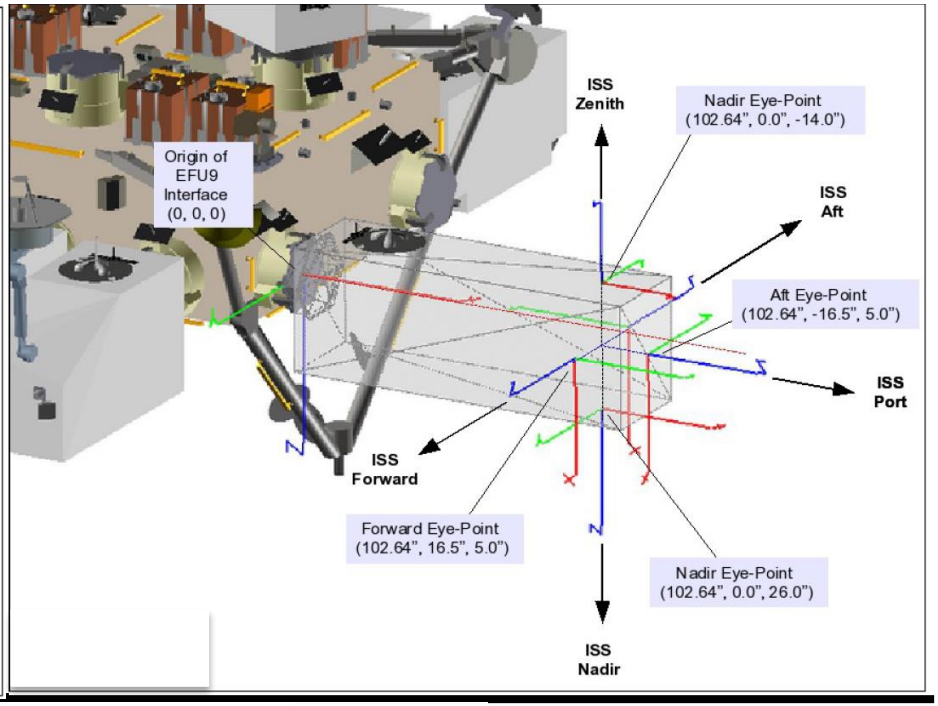


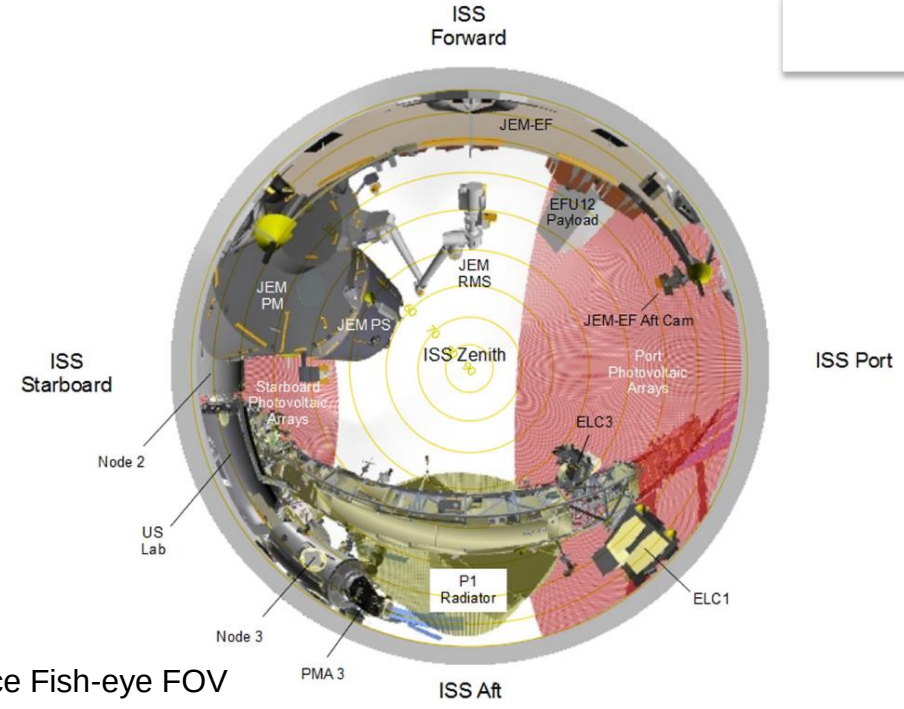




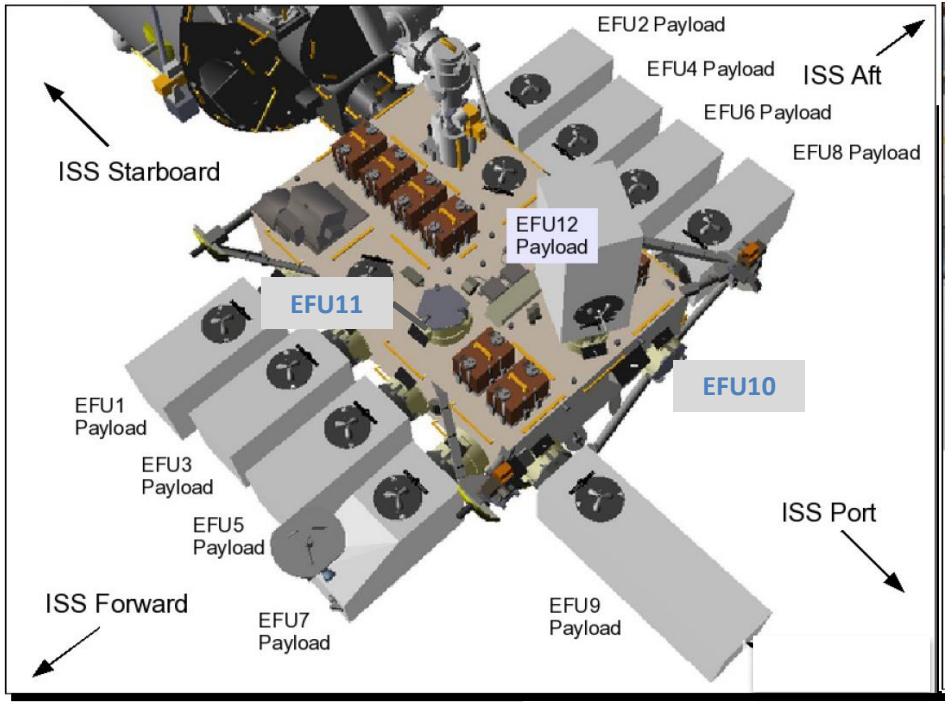
JEM EFU 3 Payload Zenith Face Fish-eye FOV

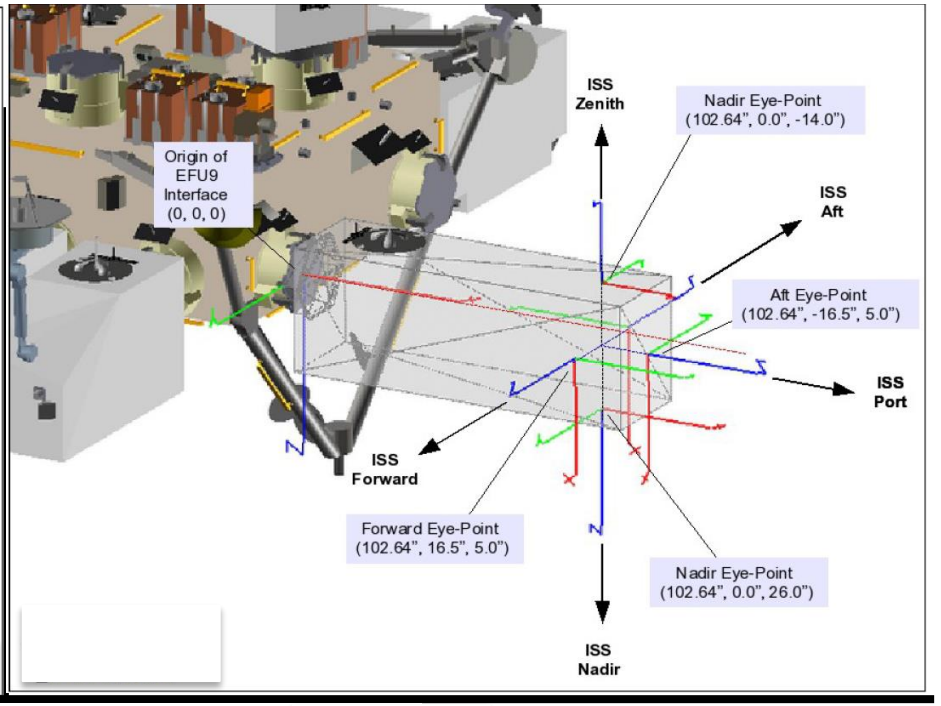


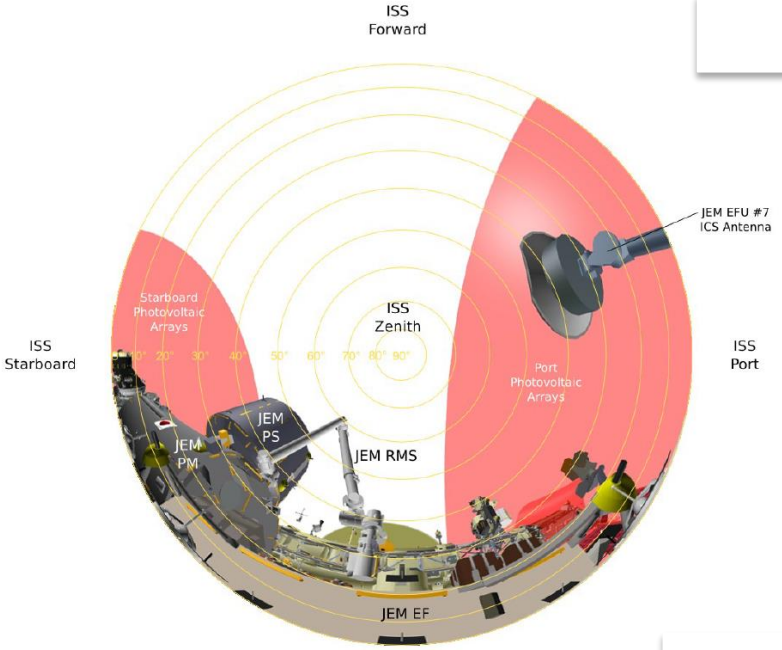




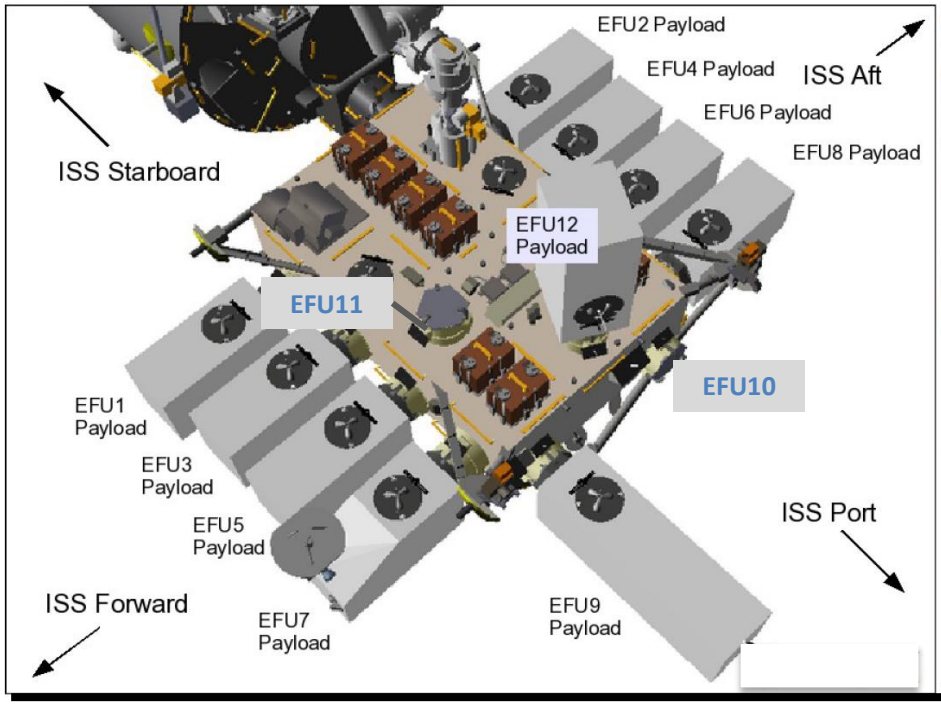
JEM EFU 4 Payload Zenith Face Fish-eye FOV

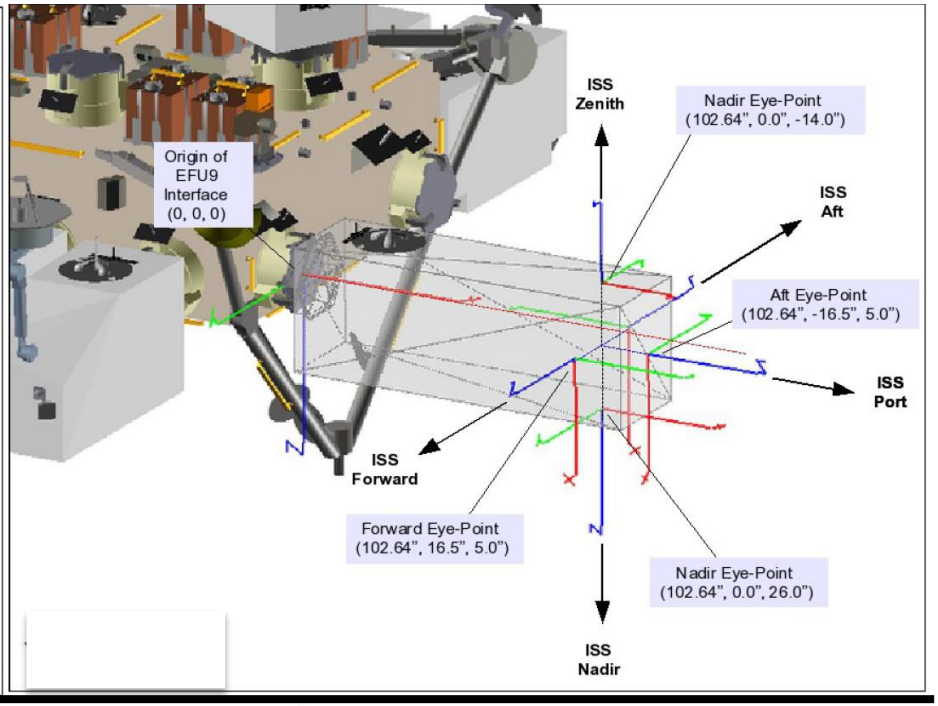


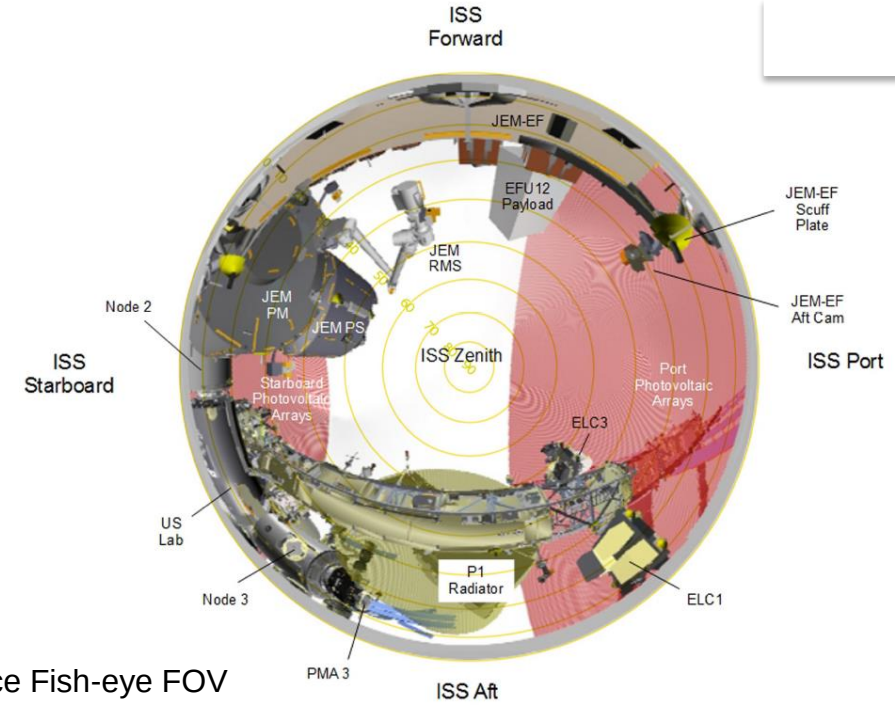




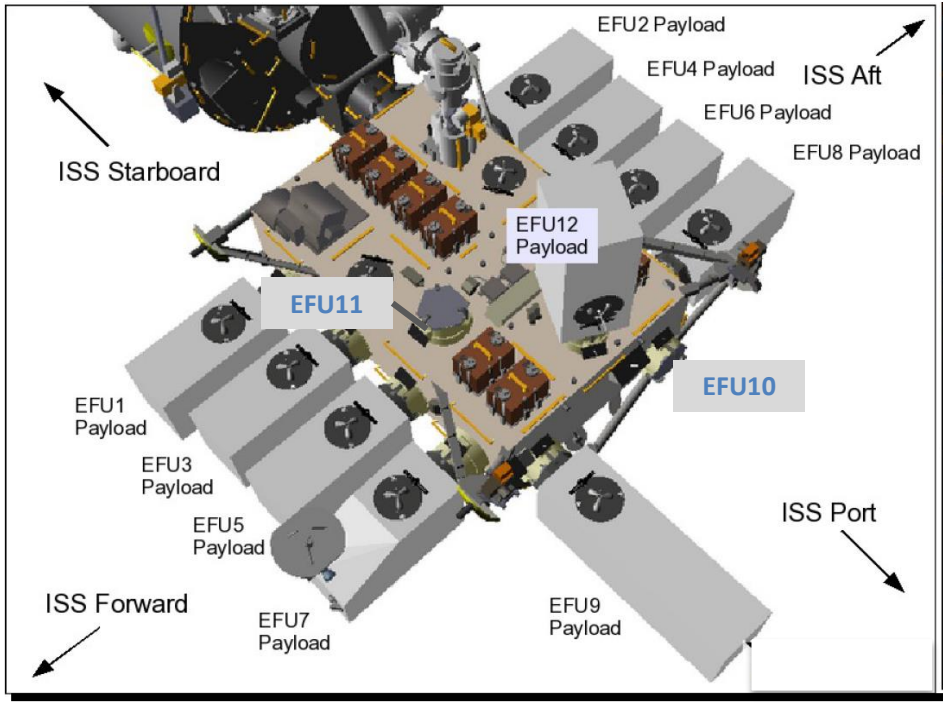
JEM EFU 5 Payload Zenith Face Fish-eye FOV

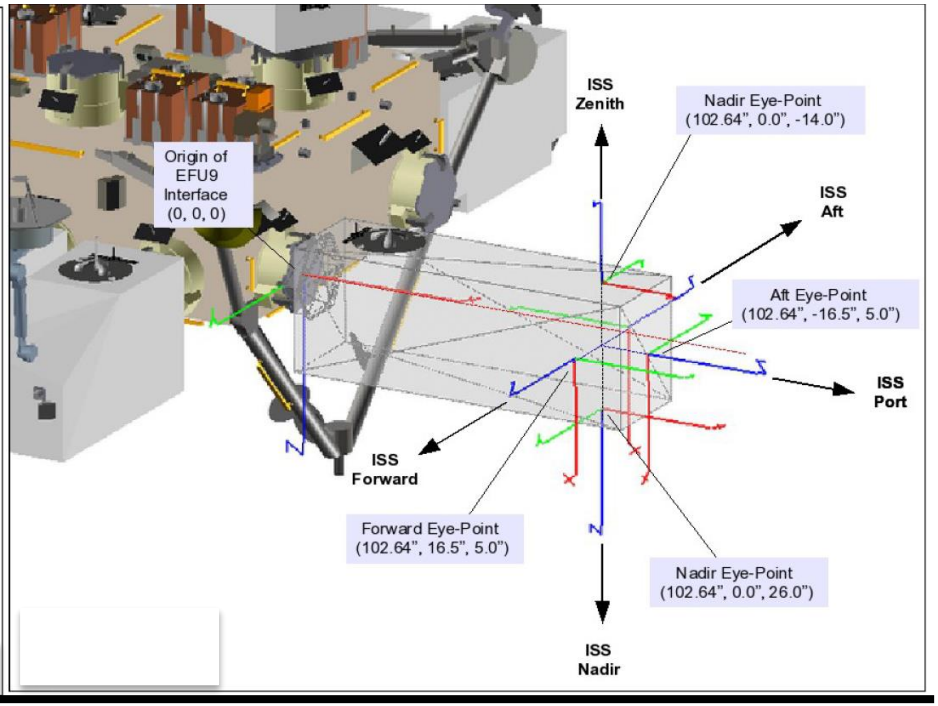


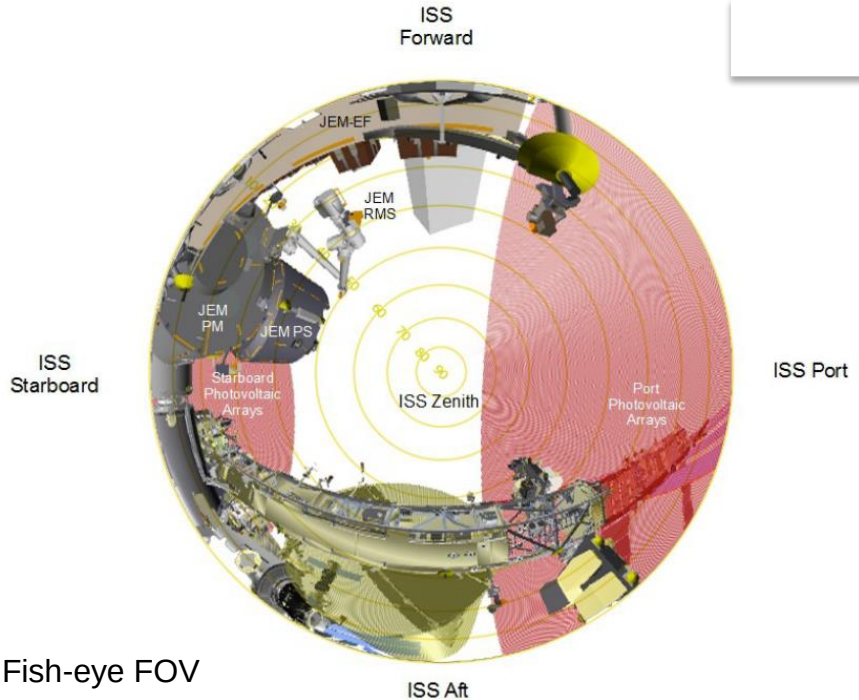




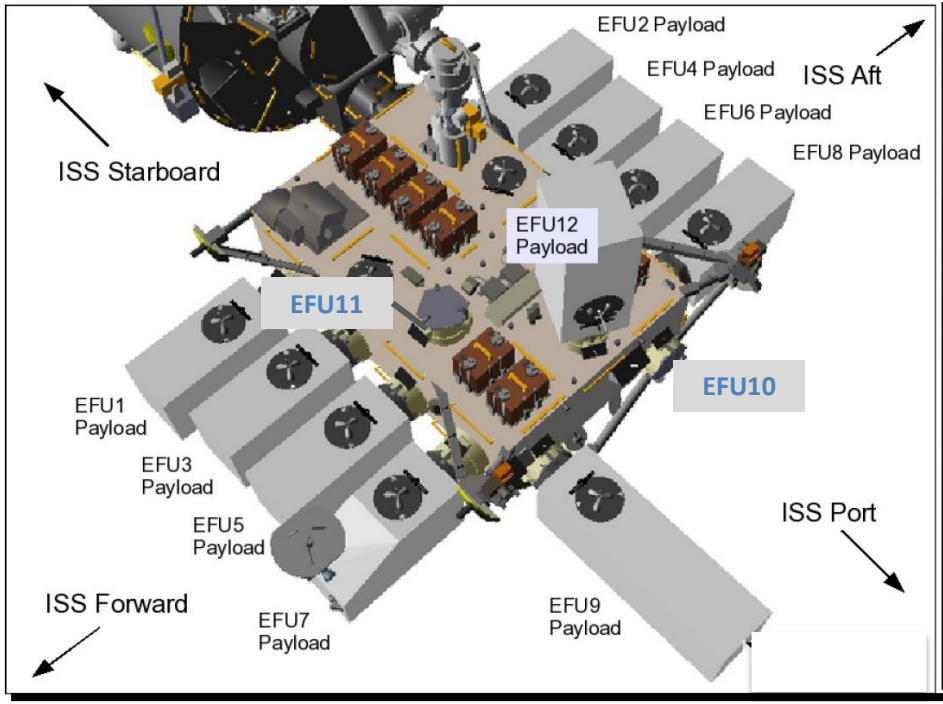
JEM EFU 6 Payload Zenith Face Fish-eye FOV

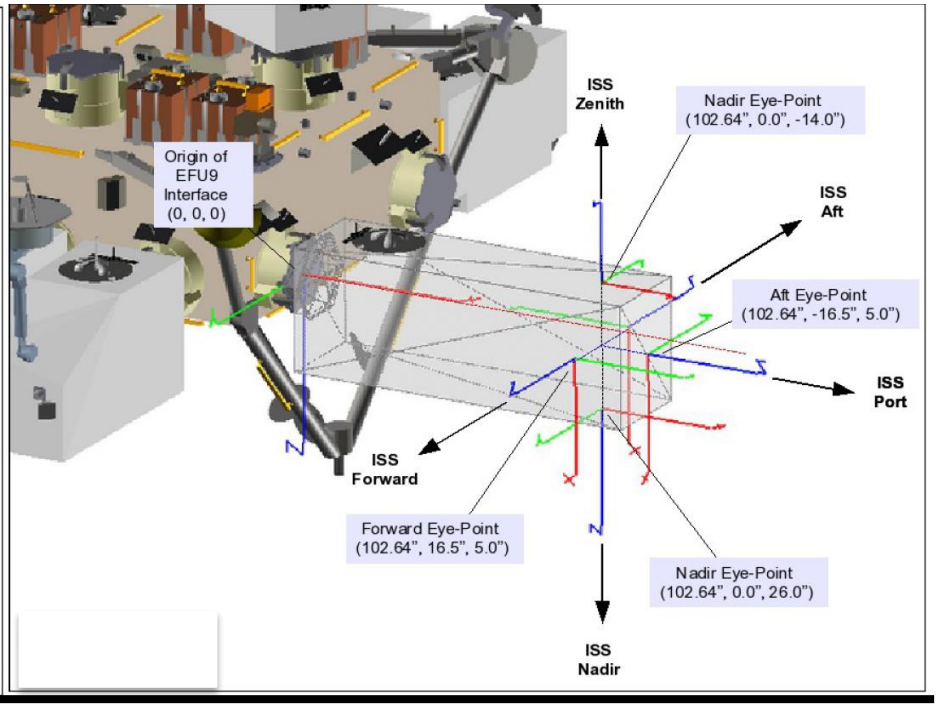


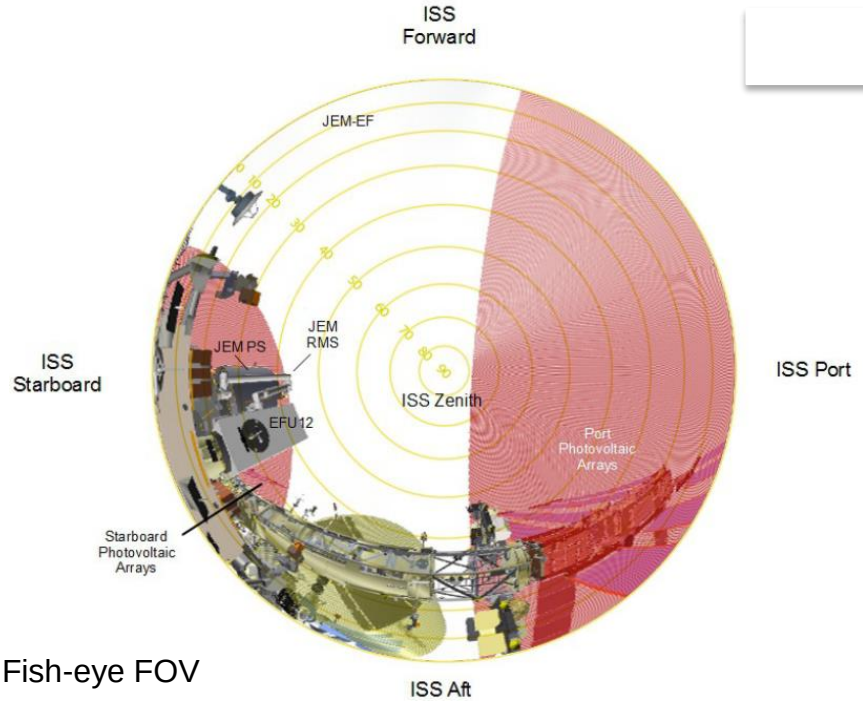




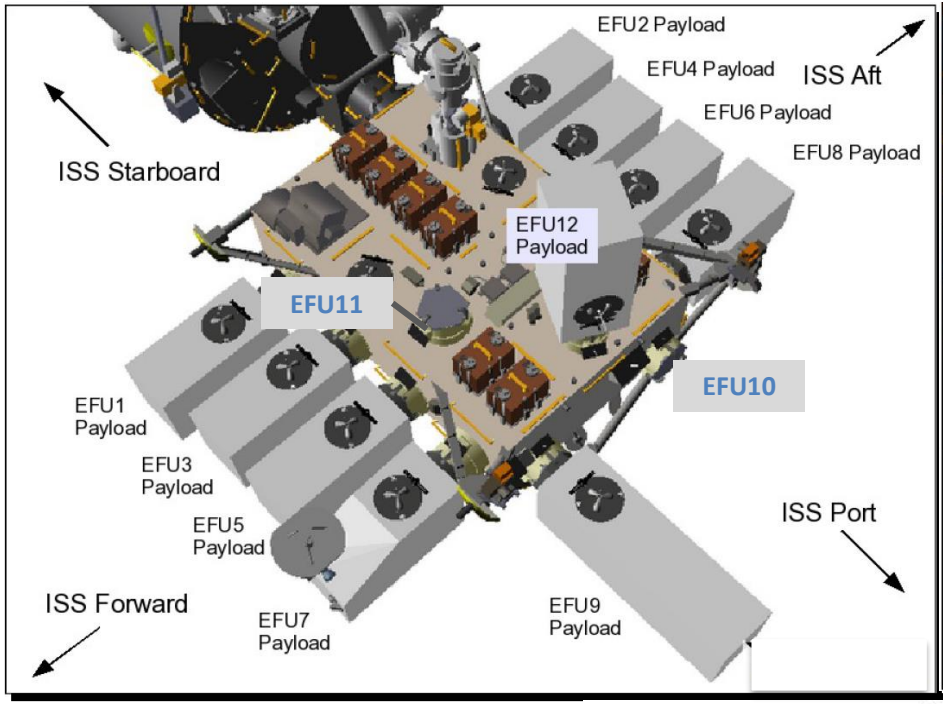
JEM EFU 8 Payload Zenith Face Fish-eye FOV

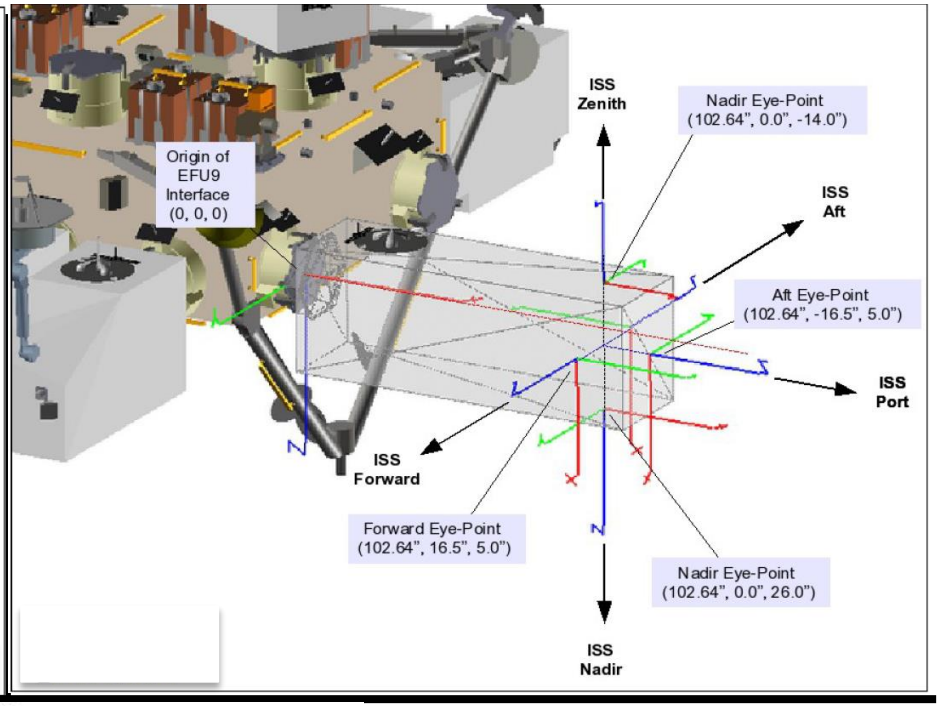


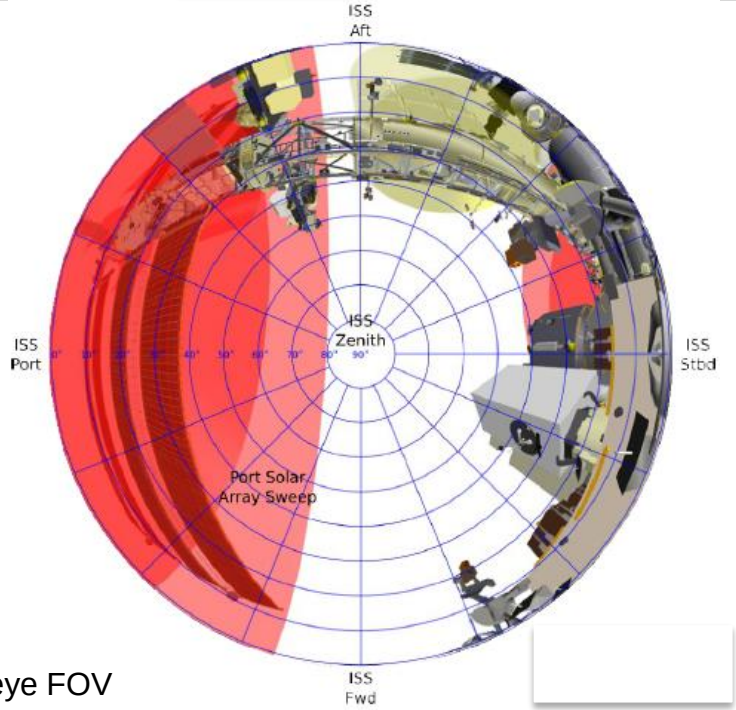




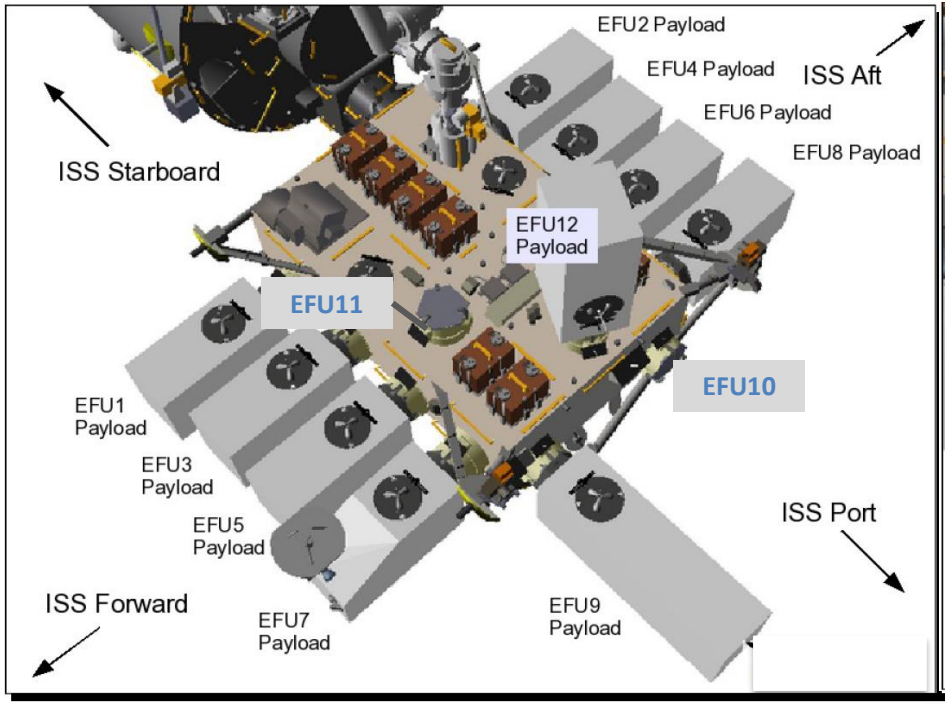
JEM EFU 9 Payload Zenith Face Fish-eye FOV

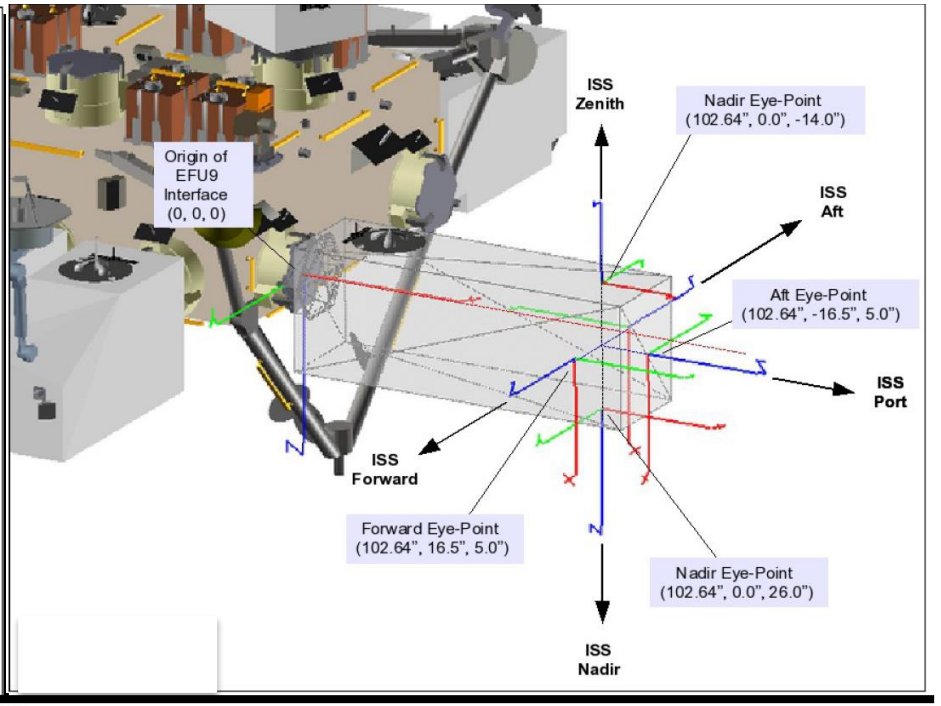


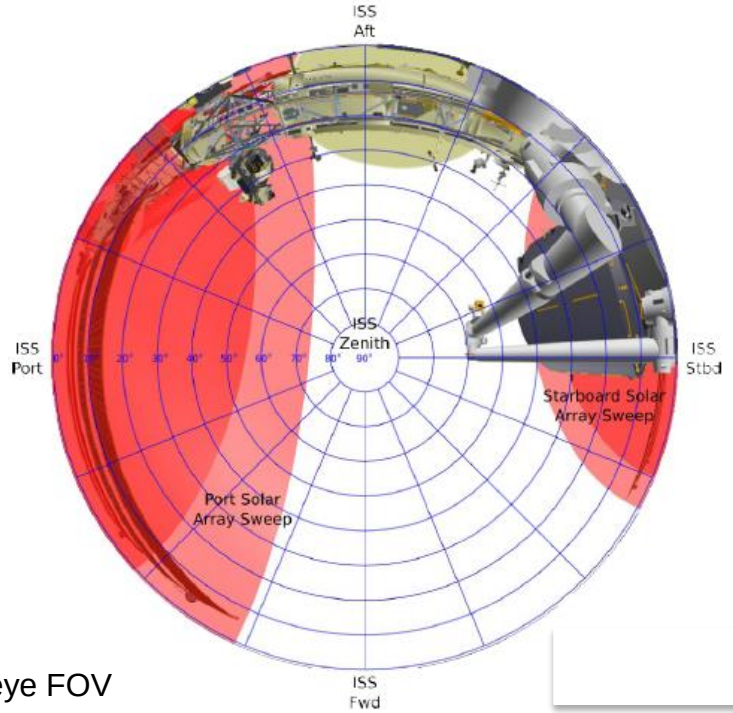




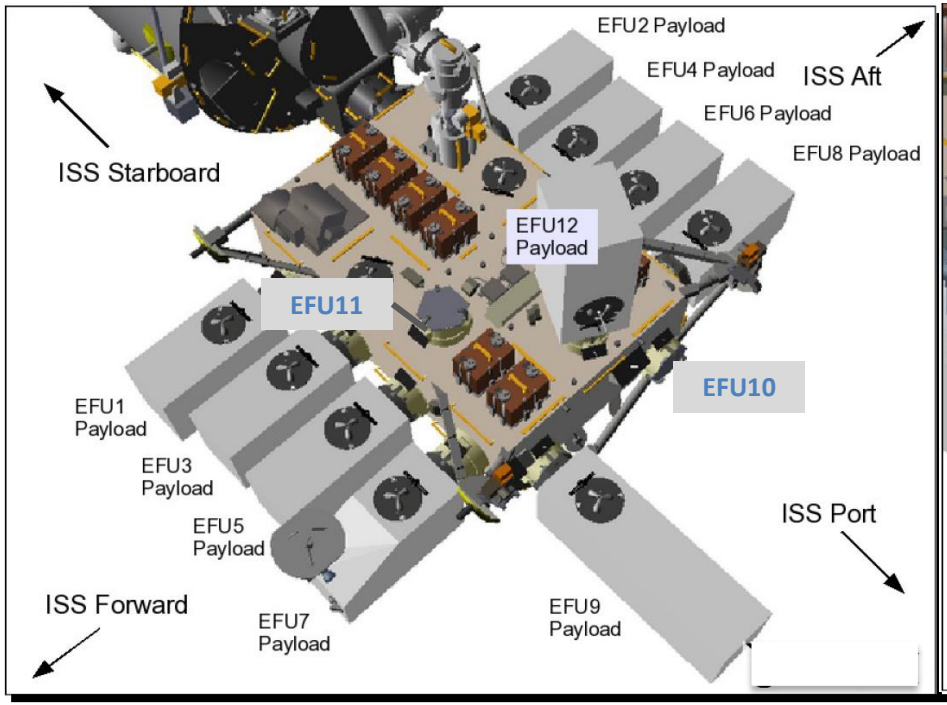
JEM EFU 10 Payload Zenith Face Fish-eye FOV

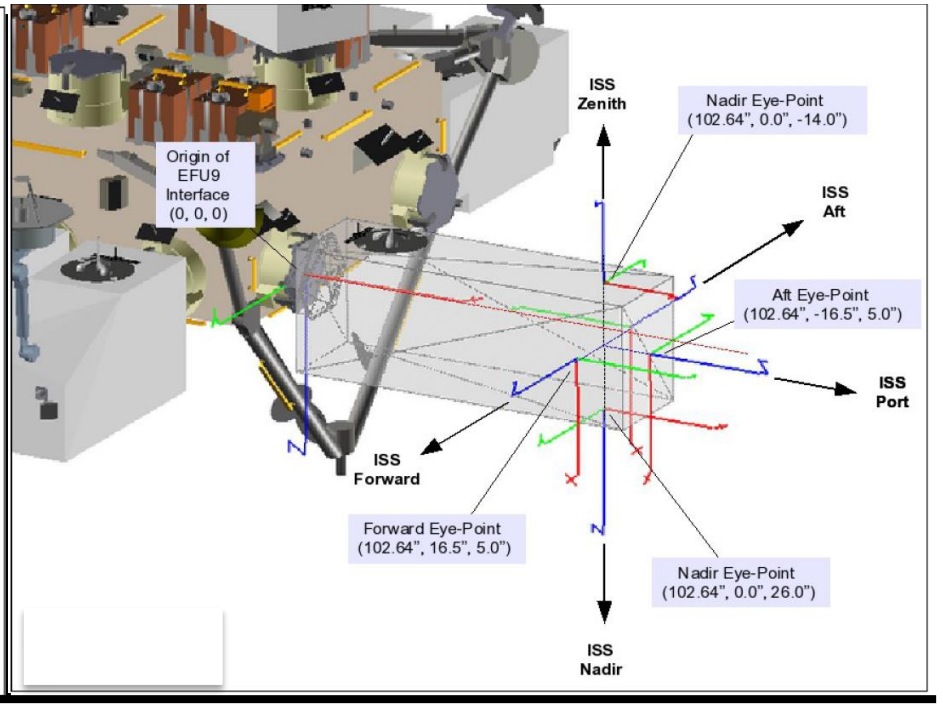


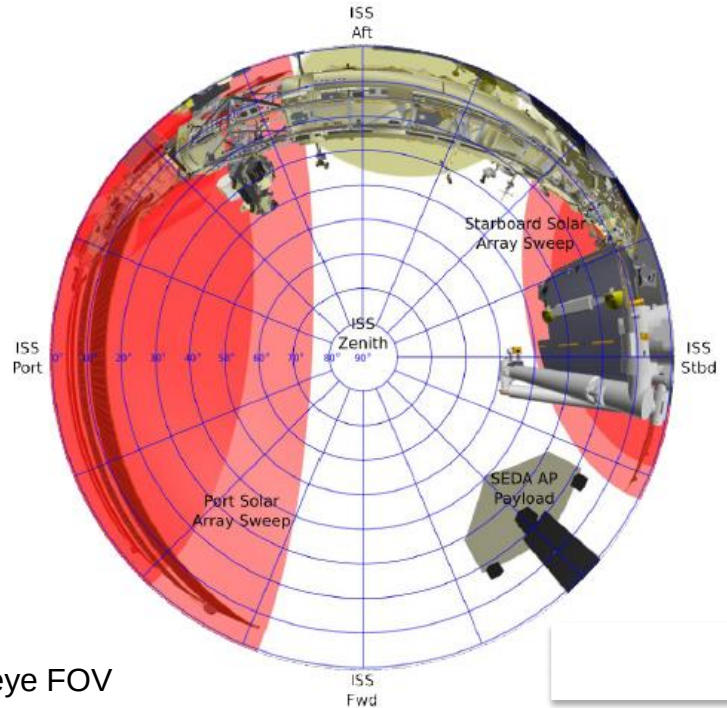




JEM EFU 11 Payload Zenith Face Fish-eye FOV







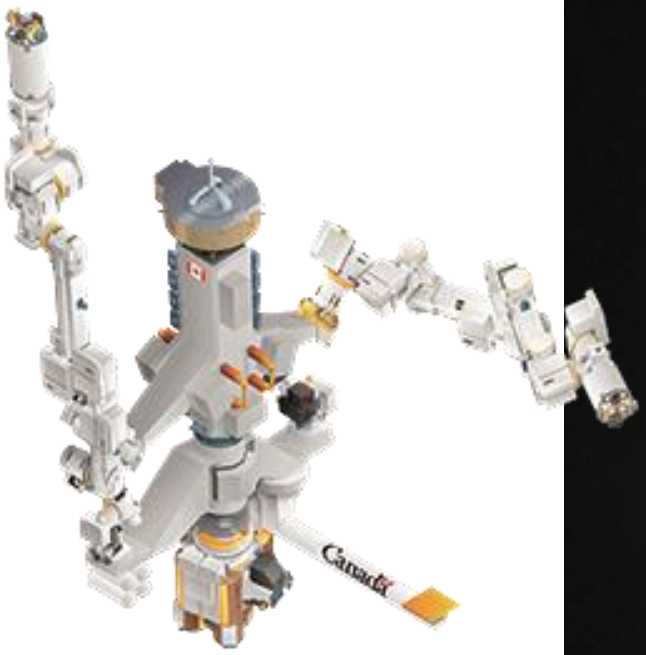
JEM EFU 12 Payload Zenith Face Fish-eye FOV

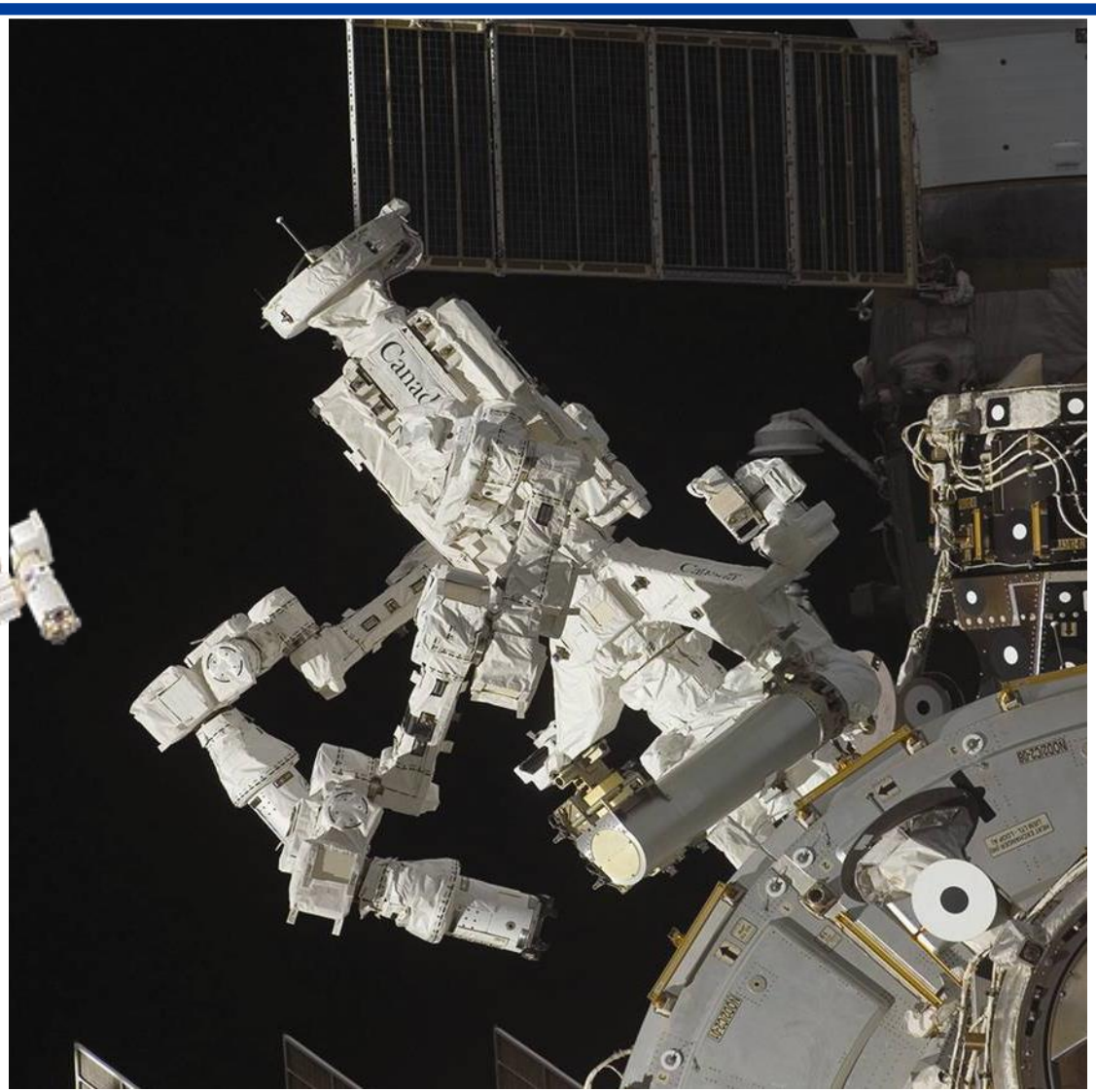
Payload Allowable Up-Mass & Volume Summary Table

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

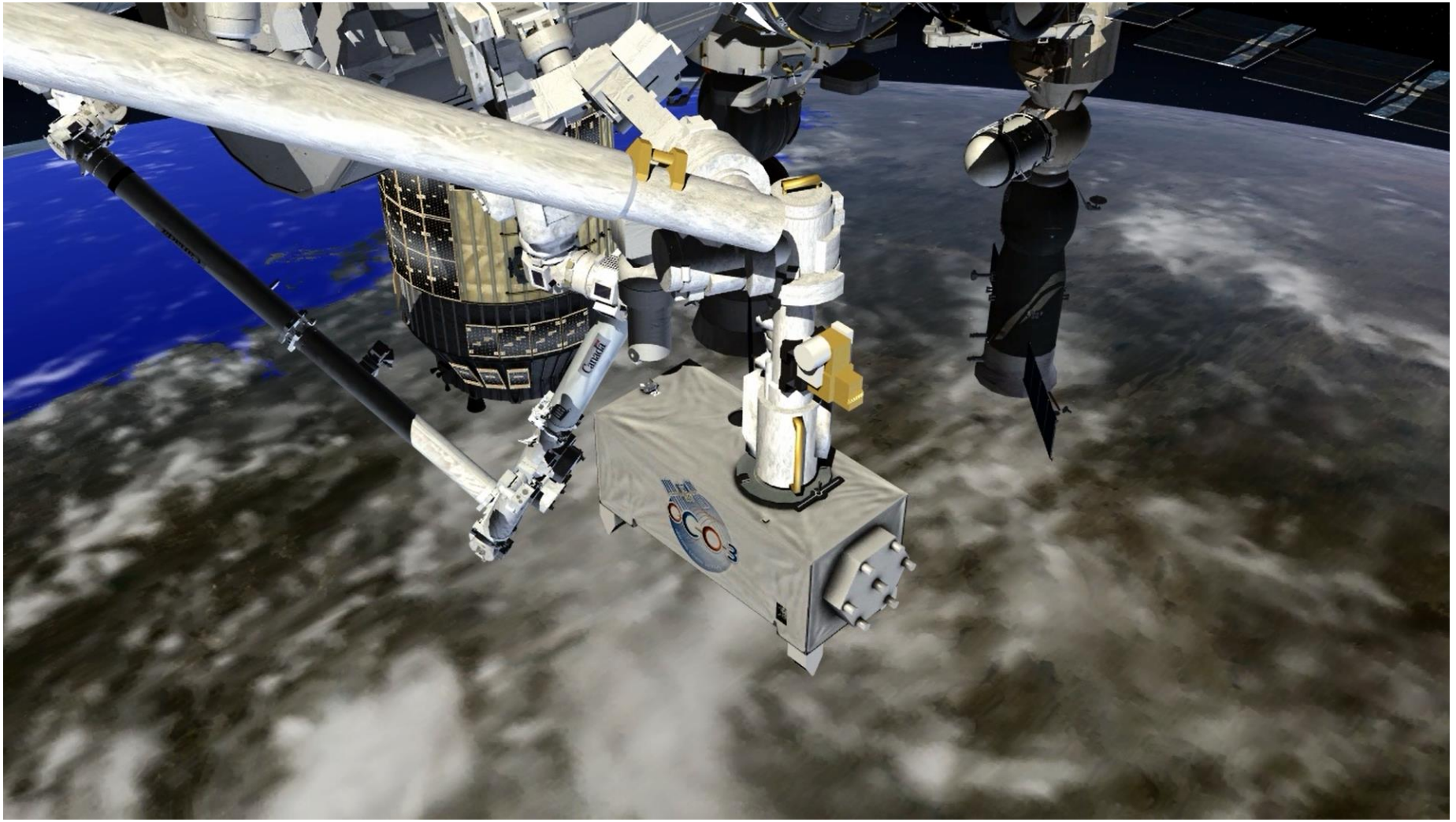
Dexterous End Effector



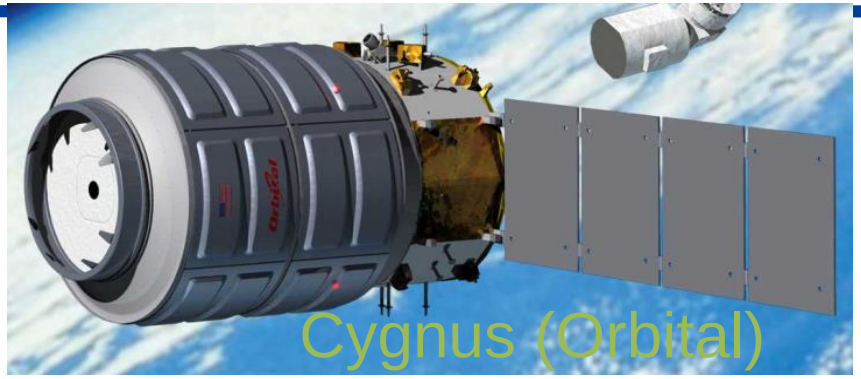


SSRMS attachment which the ground team or on-orbit crew can use robotically to install, remove and replace payloads and failed components

Robotic Installation of Instrument to ISS



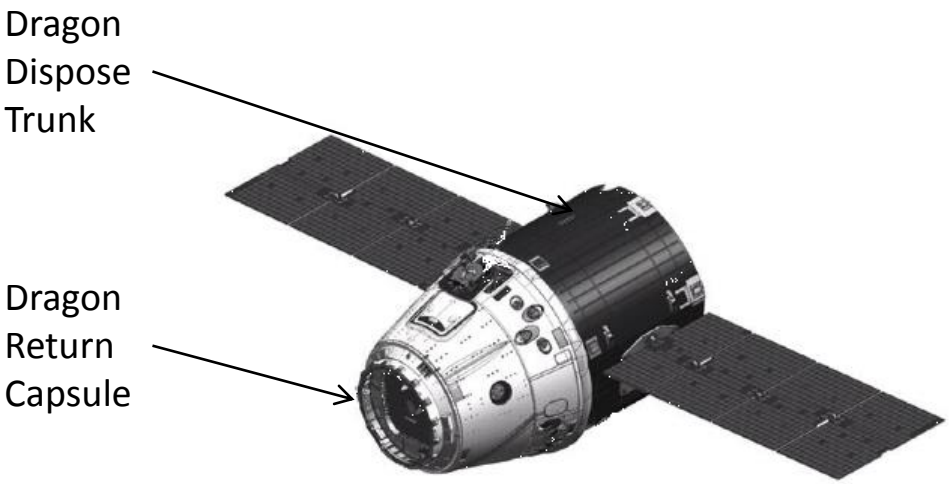
ISS Visiting Vehicles Post-Shuttle



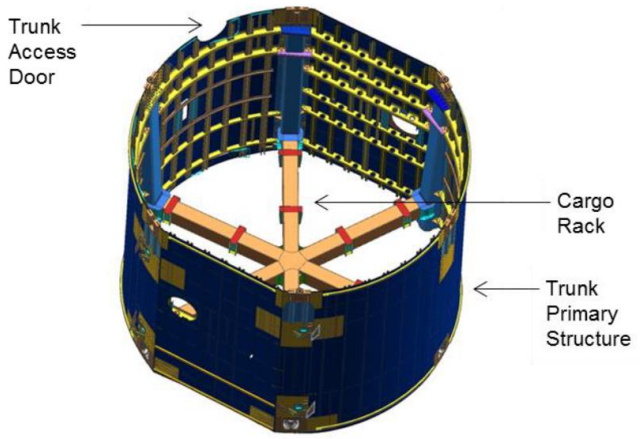
Progress/Soyuz (Energia)

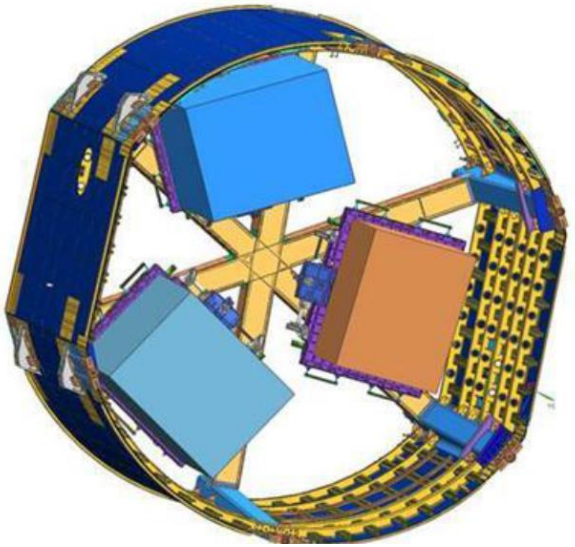
HTV (JAXA)

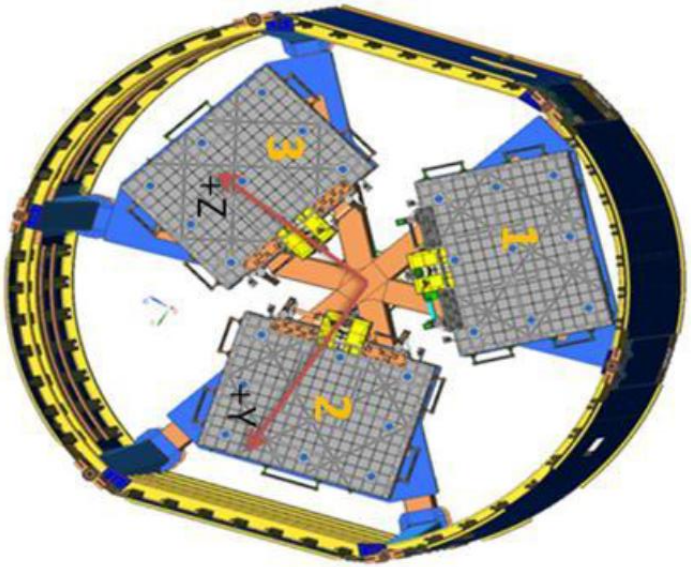
- **Space X Dragon Launch Vehicle**
  - The Commercial Resupply Contract (CRS) is a vehicle to provide up-mass to ISS using commercial services Space X “Falcon 9” rocket and Dragon spacecraft
  - Trunk behind Dragon for unpressurized cargo (no return capability – disposal only)
  - Dragon Trunk Capacity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

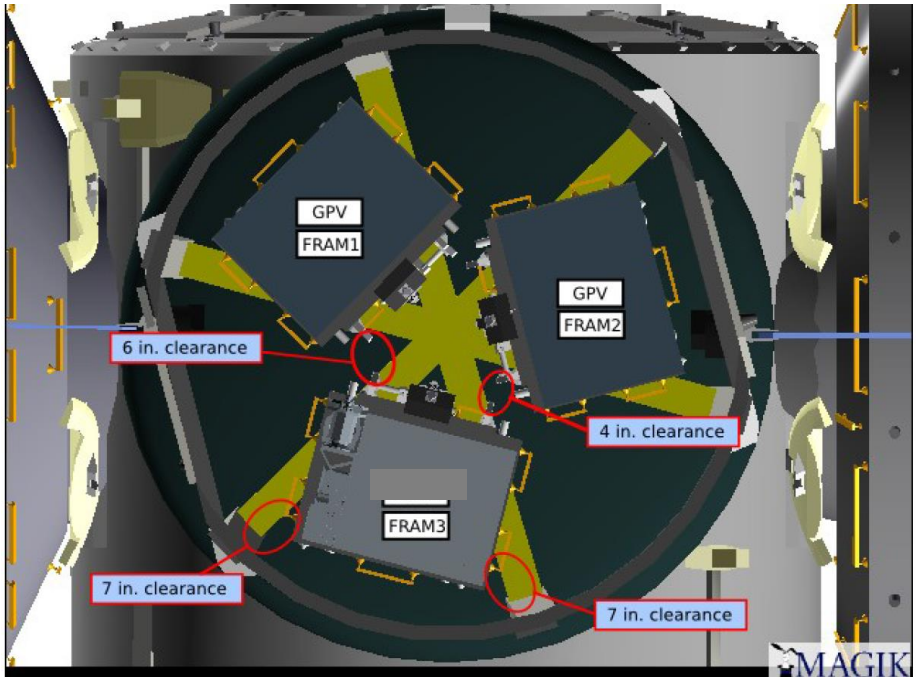


SpaceX Dragon External Payload Trunk FRAM Lay-out

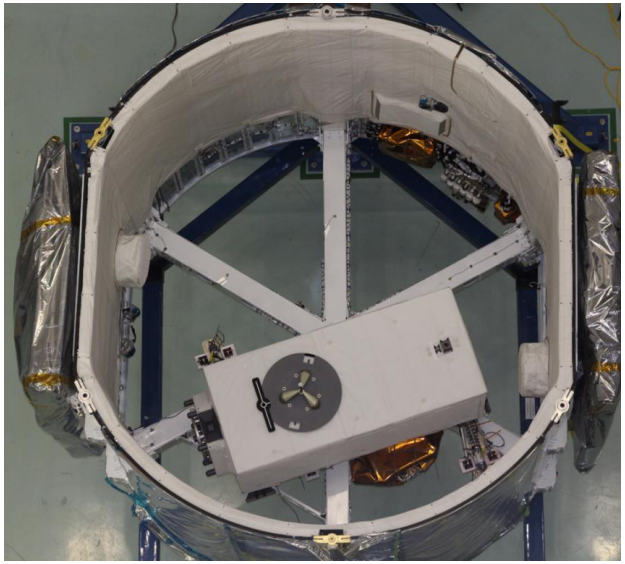


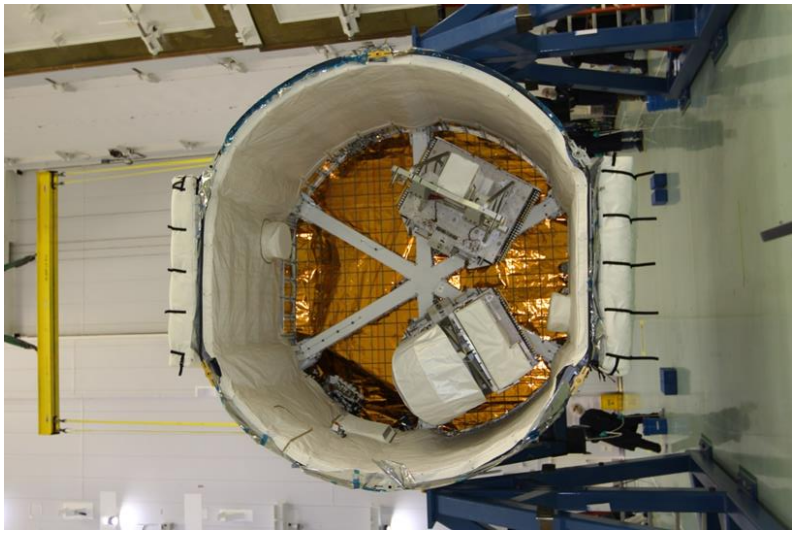


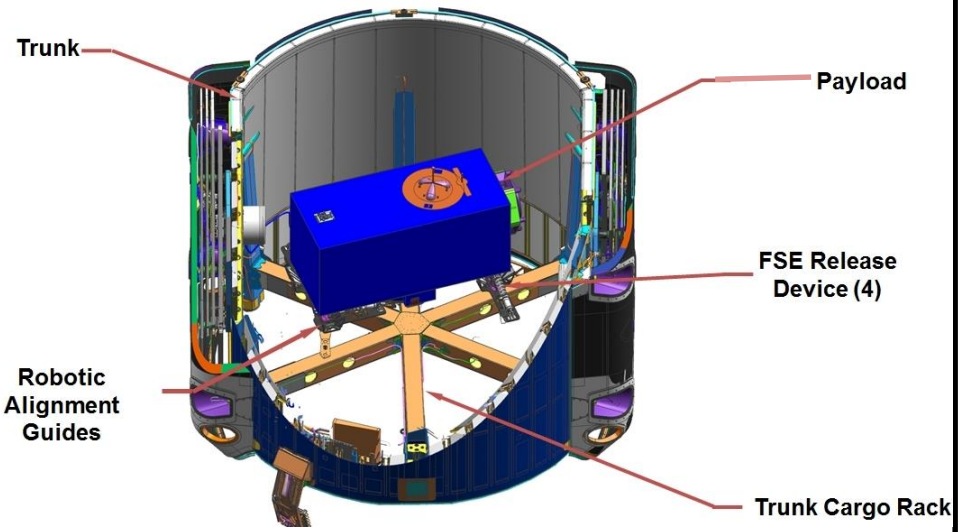


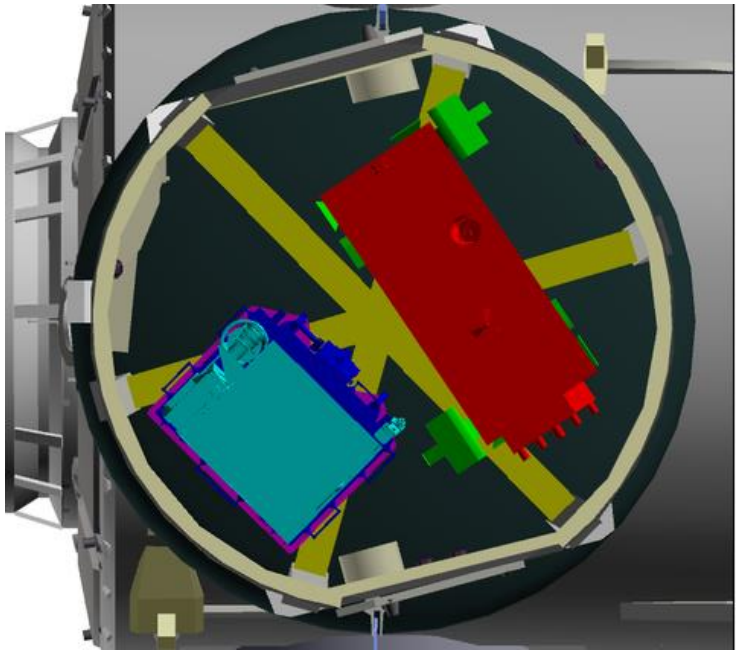


SpaceX Dragon External Payload Trunk JEM-EF Lay-out



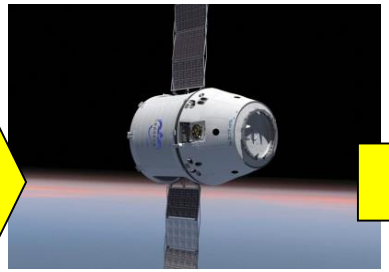




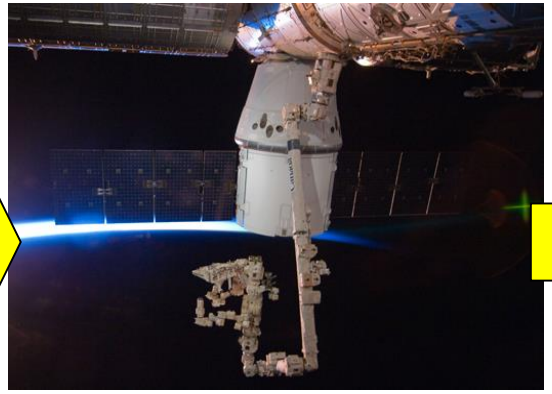


Launch and Installation

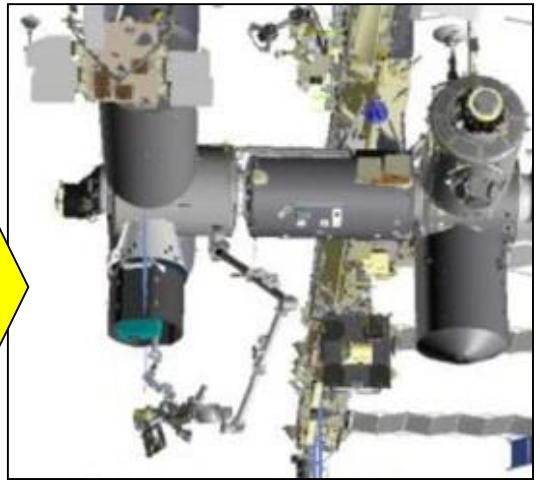
Dragon Launch



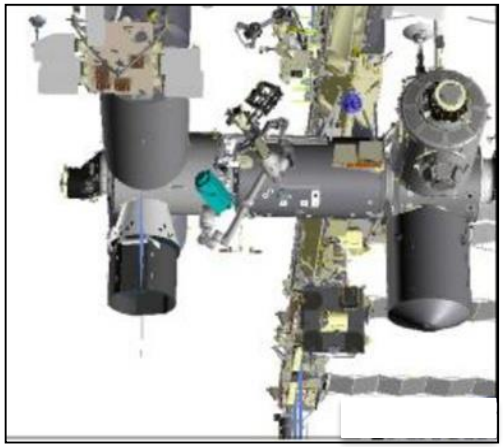
Dragon travels in lower rendezvous orbit for 2-3 days



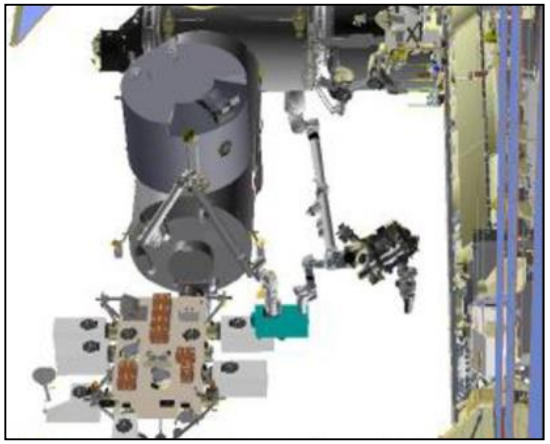
Dragon rendezvous with ISS; captured and berthed at Node 2



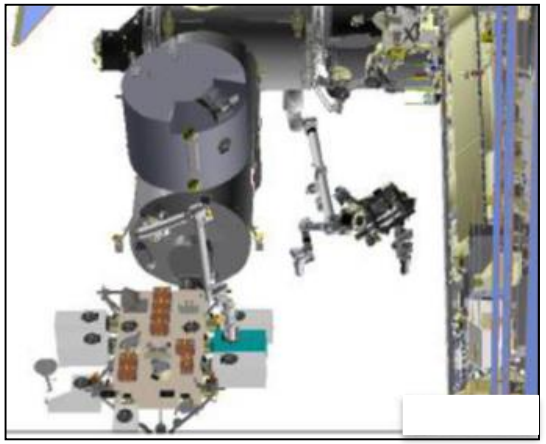
Instrument is removed from Dragon trunk by the SSRMS



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

Astrophysics 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

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:

Kenol Jules
NASA Johnson Space Center
Email: Kenol.jules-1@nasa.gov
Tel.: 281-244-5516

ISS External Sites Availability Forecast till 2024

Working Copy: Multi-Increment Payload Resupply and Outfitting Model (MiPROM), as of 30 June 2016

Derived from the 2015 Consolidated Operations and Utilization Plan (COUP), approved by the SOP/UOP on 25 Feb 2016

NOTE: This is a strategic plan and subject to change.

Date Printed: 5-Jun-16

PAYLOAD READINESS DATE (last update 30 June 2016)					Increment-Year	2016		2017		2018		2019		2020		2021		2022		2023		2024	
						2016-1	2016-2	2017-1	2017-2	2018-1	2018-2	2019-1	2019-2	2020-1	2020-2	2021-1	2021-2	2022-1	2022-2	2023-1	2023-2	2024-1	2024-2
					Period Start (Calendar Date)	Oct-15	Apr-16	Oct-16	Apr-17	Oct-17	Apr-18	Oct-18	Apr-19	Oct-19	Apr-20	Oct-20	Apr-21	Oct-21	Apr-22	Oct-22	Apr-23	Oct-23	Apr-24
Carrier	Location	Site Number		Max Size[a]	Data	Notes	45/46	47/48	49/50	51/52	53/54	55/56	57/58	59/60	61/62	63/64	65/66	67/68	69/70	71/72	73/74	75/76	77/78	79/80
ELC 1	P3 Lower	3	Outboard / Ram / Nadir	227 kg	Ethernet, 1553	ExPA2	(STP-H4) ↓		ROSA ↑ (NASA) ---------- OPALS ↓ ---------- STP-H5 ↑ (NASA)	ROSA ↓	RRM3 ↑ (NASA)	RRM3	RRM3	RRM3	RRM3									
		8	Inboard / Wake /Nadir	227 kg	Ethernet, 1553	ExPA1	(OPALS)	(OPALS)			STP-H5	STP-H5	STP-H5											
ELC4	S3 Lower Inboard	2	Inboard / Wake / Nadir	227 kg	Ethernet, 1553	ExPA1	(MUSES) (NASA)	(MUSES)	MUSES ↑	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES	MUSES
		3	Inboard / Ram / Nadir	227 kg	Ethernet, 1553	ExPA2	RRM	RRM	RRM [9] ↓ ---------- (SAGE NVP) [6] ↑ (NASA) ---------- (SAGE [illegible] [9] ↑	SAGE III	SAGE III	SAGE III	SAGE III	SAGE III	SAGE III	SAGE III	SAGE III	SAGE III	SAGE III	(SAGE III) [11]	(SAGE III)	(SAGE III)	(SAGE III)	(SAGE III)	(SAGE III)
ELC2	S3 Upper Outboard	3	Inboard / Ram / Zenith	227 kg	Ethernet, 1553	ExPA2	MISSE 8	MISSE 8	MISSE 8 [12] ↓	MISSE-FF ↑ (NASA)	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF	MISSE-FF
		7	Outboard / Ram / Zenith	227 kg	Ethernet, 1553	ExPA1			NICER ↑ (NASA)	NICER	NICER	NICER	NICER	[NICER] [11]	(NICER)	(NICER)	(NICER)	(NICER)						
ELC3	P3 Upper	3	Inboard / Ram / Zenith	227 kg	Ethernet, 1553	ExPA1	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed ↓ ---------- STP-H6 [7] ↑ (NASA)	STP-H6	STP-H6	STP-H6	(STP-H6)							
		5	Outboard / Wake / Zenith	227 kg	Ethernet, 1553	ExPA2				TSIS ↑ (NASA)	TSIS	TSIS	TSIS	TSIS	TSIS	TSIS	TSIS	TSIS	TSIS						
Columbus	EPF SOZ		Overhead / Zenith	256 kg[w]	Ethernet, 1553		SOLAR	SOLAR	SOLAR	SOLAR	SOLAR	SOLAR	SOLAR	SOLAR	SOLAR	SOLAR								
	EPF SOX		Overhead / Ram	256 kg	Ethernet, 1553		[SDS]	[SDS]	[SDS]	[SDS]	SDS ↑	SDS	SDS	GEROS (ESA)	GEROS	GEROS								
	EPF SDX		Deck / Ram	256 kg	Ethernet, 1553		(RapidScat)	(RapidScat)	(RapidScat)	(RapidScat) ↓ (Adapt. Bracket) ↓ ---------- ASIM ↑ (NASA launch; ESA ops)	ASIM	ASIM	ASIM	ASIM	ASIM	ASIM								
	EPF SDN		Deck / Nadir	256 kg	Ethernet, 1553		HDEV	HDEV	HDEV	HDEV	HDEV	HDEV ↓ ---------- ACES ↑ (NASA launch; ESA ops)	ACES	ACES	ACES	ACES								
JEM-EF	1		Ram/ Nadir/ Zenith	500 kg	Ethernet, 1553, Video, Hi-Rate	Field of View (FOV) obstruction by JEM module	MAXI	MAXI	MAXI	MAXI	MAXI	MAXI	MAXI [2] ---------- HISUI	HISUI	HISUI	HISUI	HISUI	HISUI	HISUI	HISUI	(HISUI)	(HISUI)	(HISUI)	(HISUI)
	3		Ram/ Nadir/ Zenith	500 kg	Ethernet, 1553, Video, Hi-Rate	Clear view	CATS	CATS	CATS	CATS	CATS	CATS	CATS ↓ ---------- OCO-3 ↑	OCO-3	OCO-3	OCO-3	OCO-3	OCO-3						
	5		Ram/ Nadir/ Zenith	500 kg	Ethernet, 1553, Video, Hi-Rate	Clear view	ISEEP1 [5] (EFU Adapter 1) (GOA)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)	ISEEP1 (EFU Adapter 1)
	7[z]		Ram/ Nadir/ Zenith	500 kg	-	ICS-dedicated	ICS (System)								Next ICS (System)									
	9[3]		Port/ Nadir/ Zenith	2.5 MT	Ethernet, 1553, Video, Hi-Rate	Best volumetrically for large payloads (up to 2.5 MT)	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET	CALET
	2		Wake/ Nadir/ Zenith	2.5 MT	Ethernet, 1553, Video, Hi-Rate	Can hold large payloads, but has an FOV obstruction by JEM module			[CREAM] (NASA)	CREAM ↑	CREAM	CREAM	CREAM	[CREAM] [11]	[CREAM]	[CREAM]	[CREAM]	[CREAM]	[CREAM]	[CREAM]	[CREAM]	[CREAM]	[CREAM]	[CREAM]
	4		Wake/ Nadir/ Zenith	500 kg	1553, Video, Hi-Rate	Clear view	[NREP]	NREP ↑	NREP	NREP	NREP	NREP	NREP	NREP	NREP	NREP	NREP	NREP	NREP	NREP	NREP	NREP	NREP	NREP
	6		Wake/ Nadir/ Zenith	500 kg	Ethernet, 1553, Video, Hi-Rate	Clear view	HREP	HREP	[HREP]	[HREP]	[HREP]	[HREP]	GEDI Lidar ↑ (NASA)	GEDI Lidar	[GEDI Lidar]	TBD J-4								
	8		Wake/ Nadir/ Zenith	500 kg	1553, Video, Hi-Rate	Obstruction during EP berthing, slight obstruction from camera mount						ISEEPEFU Adapter 2 [5] (GOA) [TBR] [14]	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)	ISEEP2 (EFU Adapter 2)
	10		Wake/ Nadir/ Zenith	500 kg	-	EPMP berthing site						ECOSTRESS ↑ (NASA) [TBR] [14]	ECOSTRESS	ECOSTRESS	(ECOSTRESS)									
	11		Zenith	500 kg	Ethernet, 1553	Good Zenith viewing	SEDA-AP	SEDA-AP	SEDA-AP	SEDA-AP	SEDA-AP	SEDA-AP	SEDA-AP ↓ [TBD] [3]	[SEDA-AP]	[SEDA-AP]	NASA-TBD-NL								
	12[4]		Zenith	500 kg	Ethernet, 1553	Temporary stowage location																		

To Be Determined