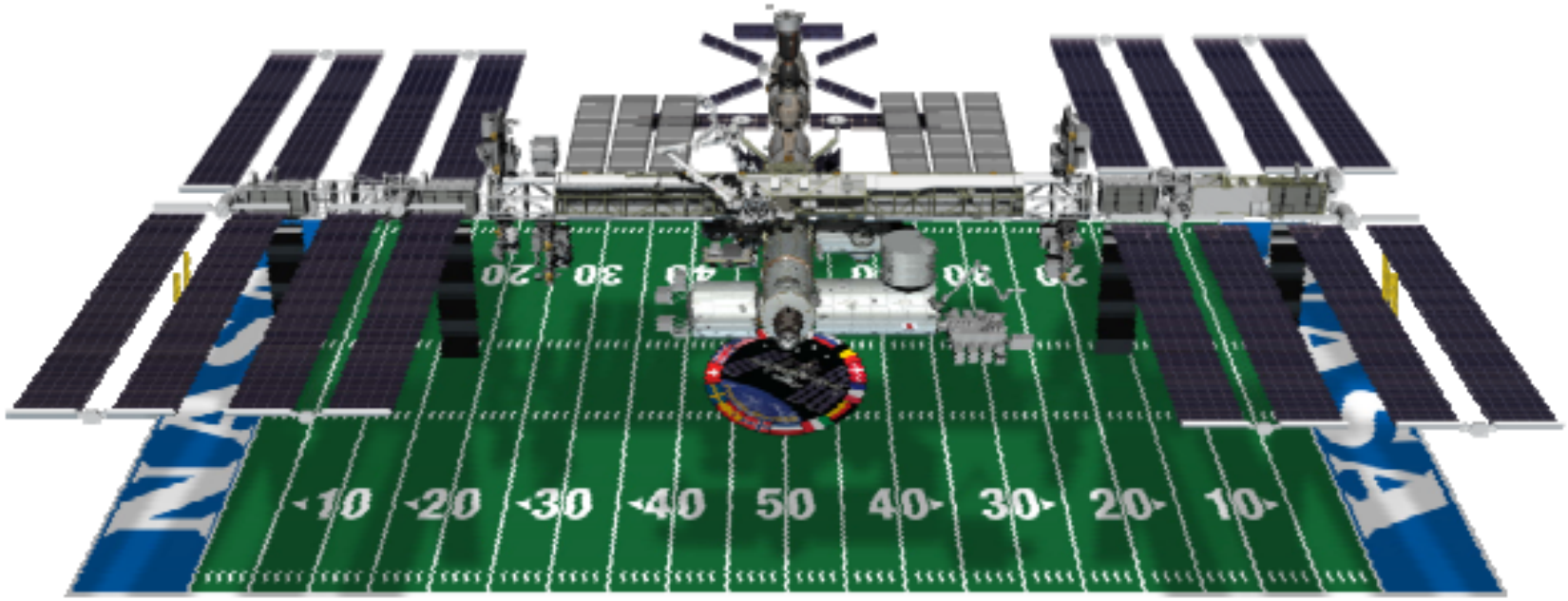
International Space Station External Payload Accommodations

NASA Explorers Workshop
13 July, 2010

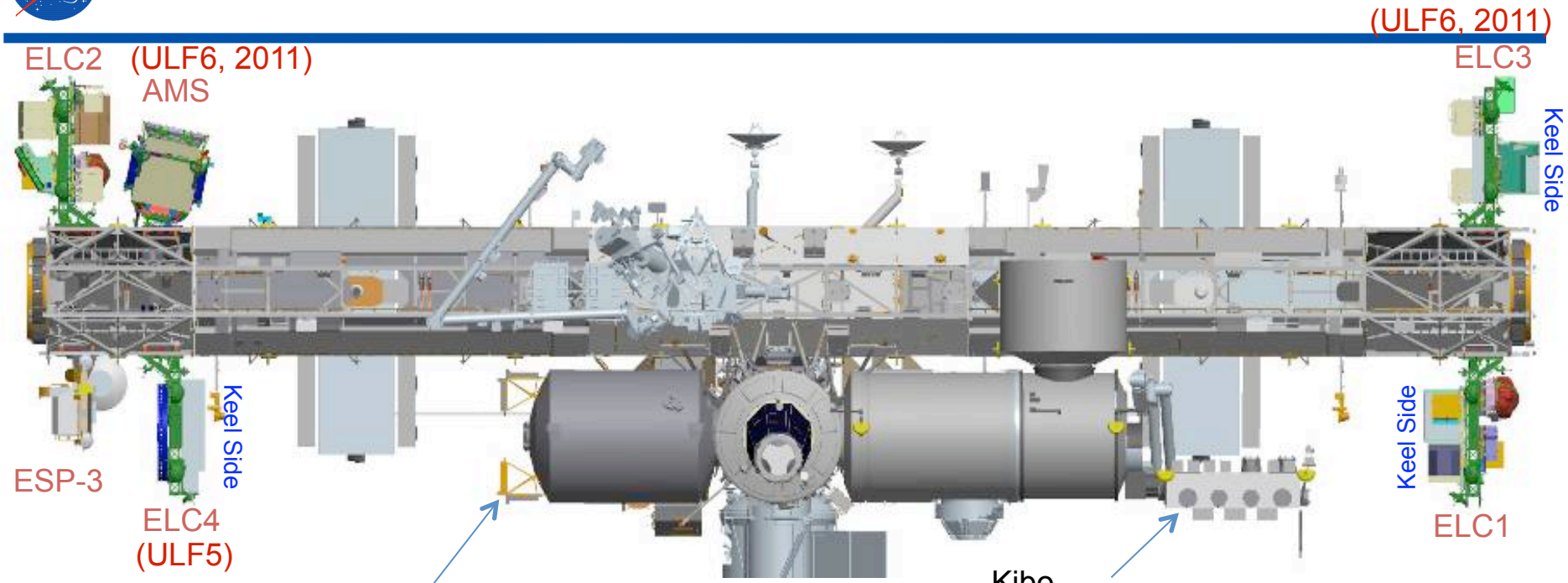
Ron Ticker
NASA Headquarters/SOMD

International Space Station Facts



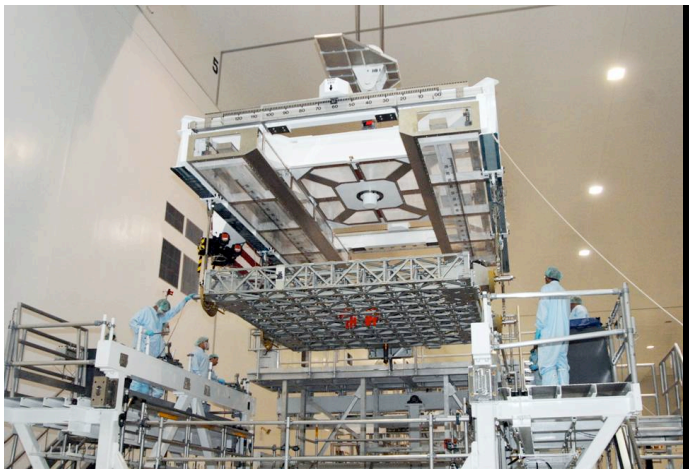
Spacecraft Mass: 799,046 lb (362,441 kg)
Velocity: 17,500 mph (28,200 kph)
Altitude: 220 miles above Earth
Power: 80 kW continuous
Science Capability: Laboratories from four international space agencies – US, Europe, Japan, and Russia

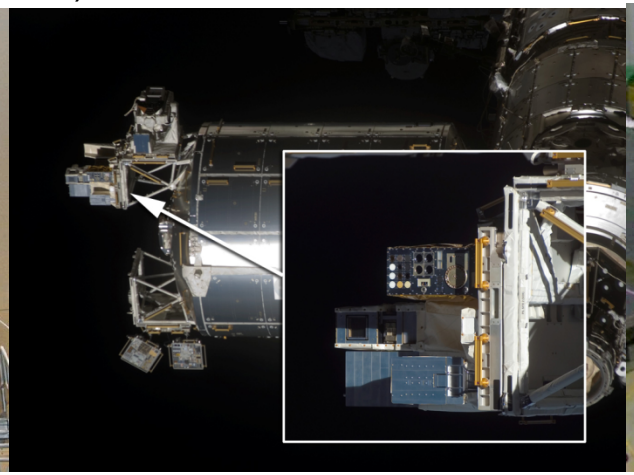
International Space Station (ISS) External Research Facilities

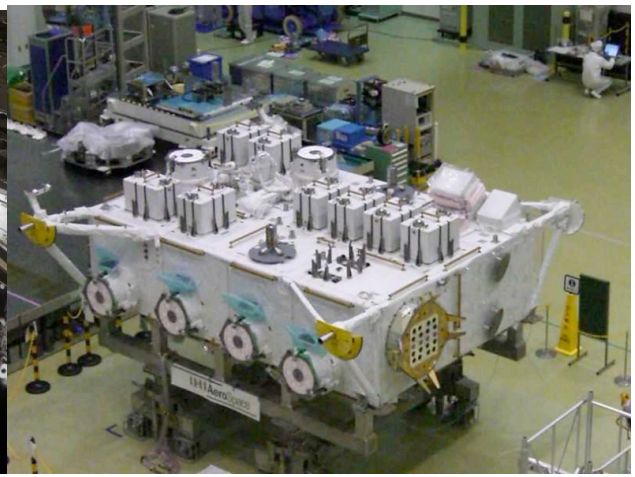


Columbus
External Payload Facility
(2 sites NASA, 4 sites total)

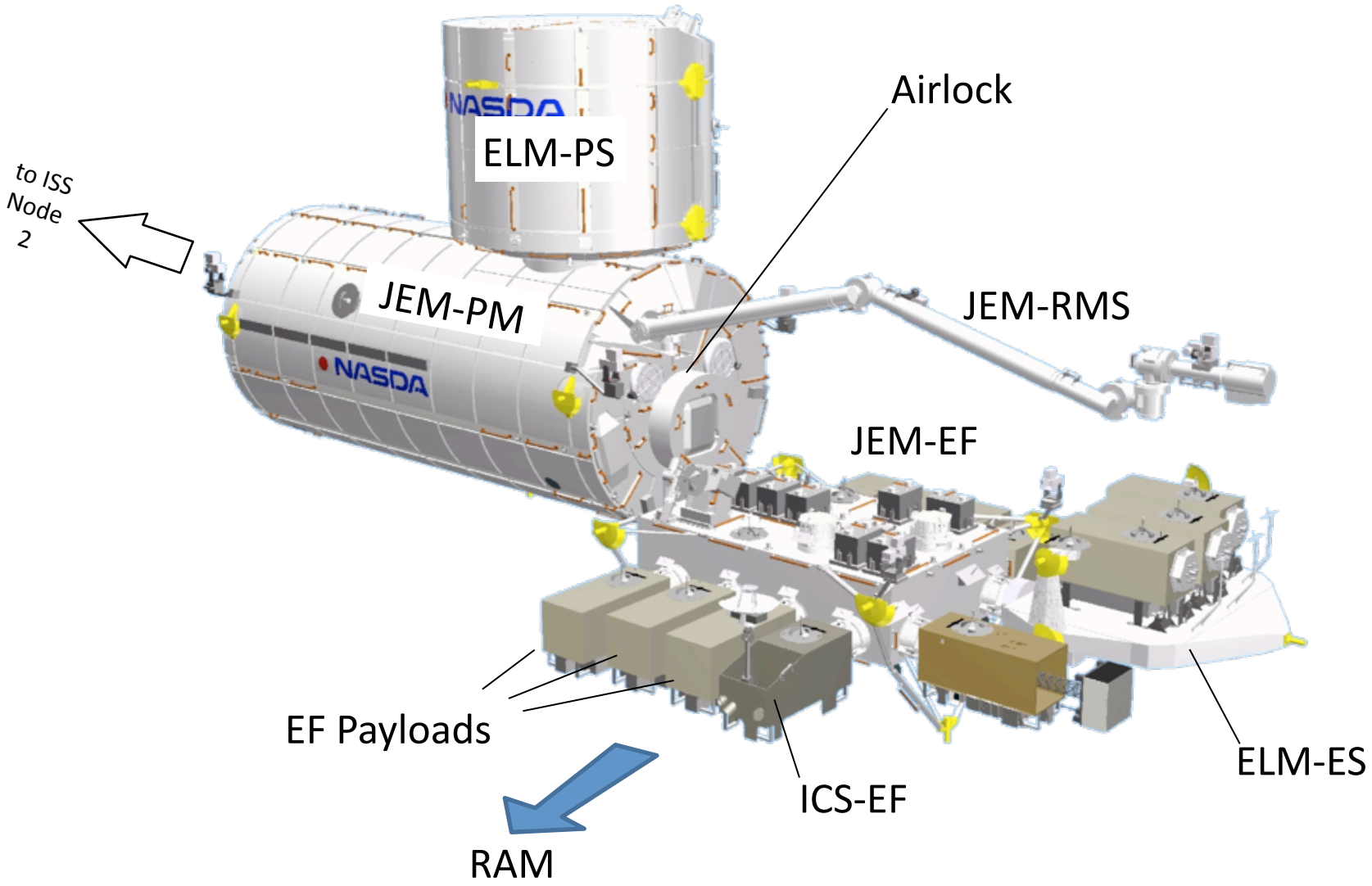
Kibo
External Facility
5 sites NASA, 10 sites total



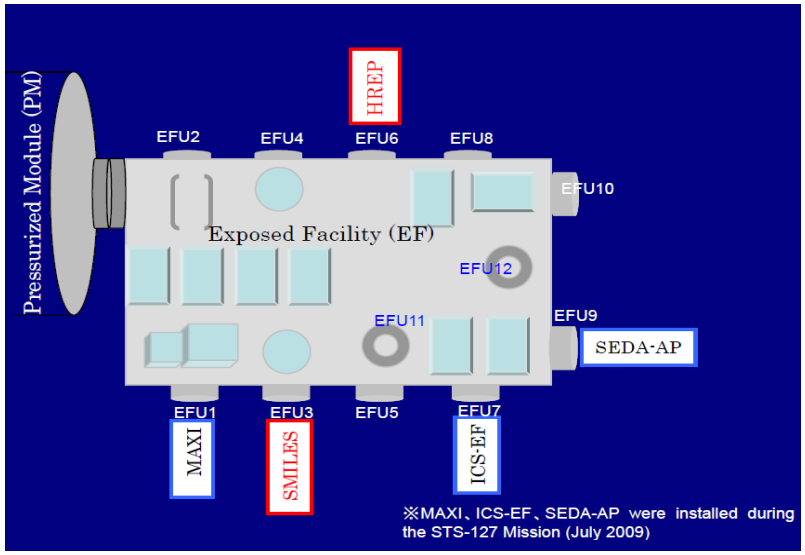


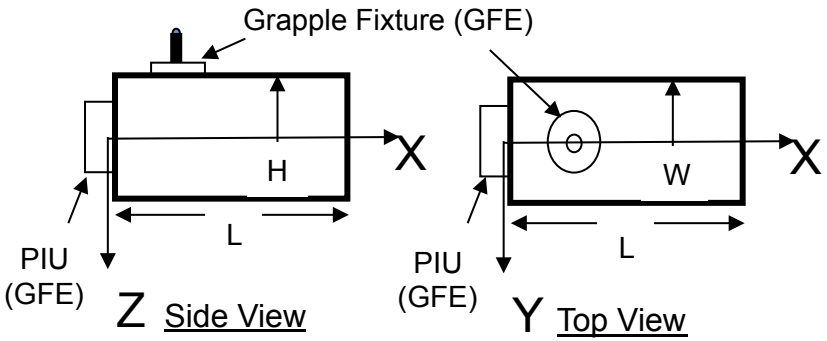


Japanese Experiment Module Exposed Facility (JEM EF) Overview

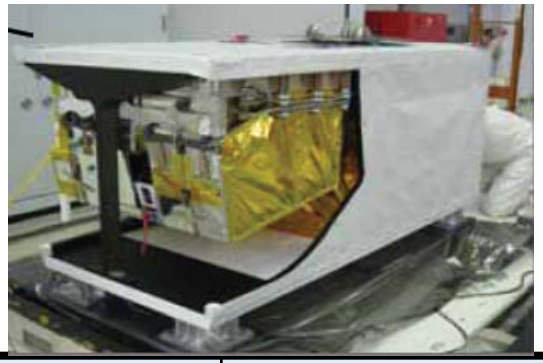


JEM EF External Research Accommodations





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

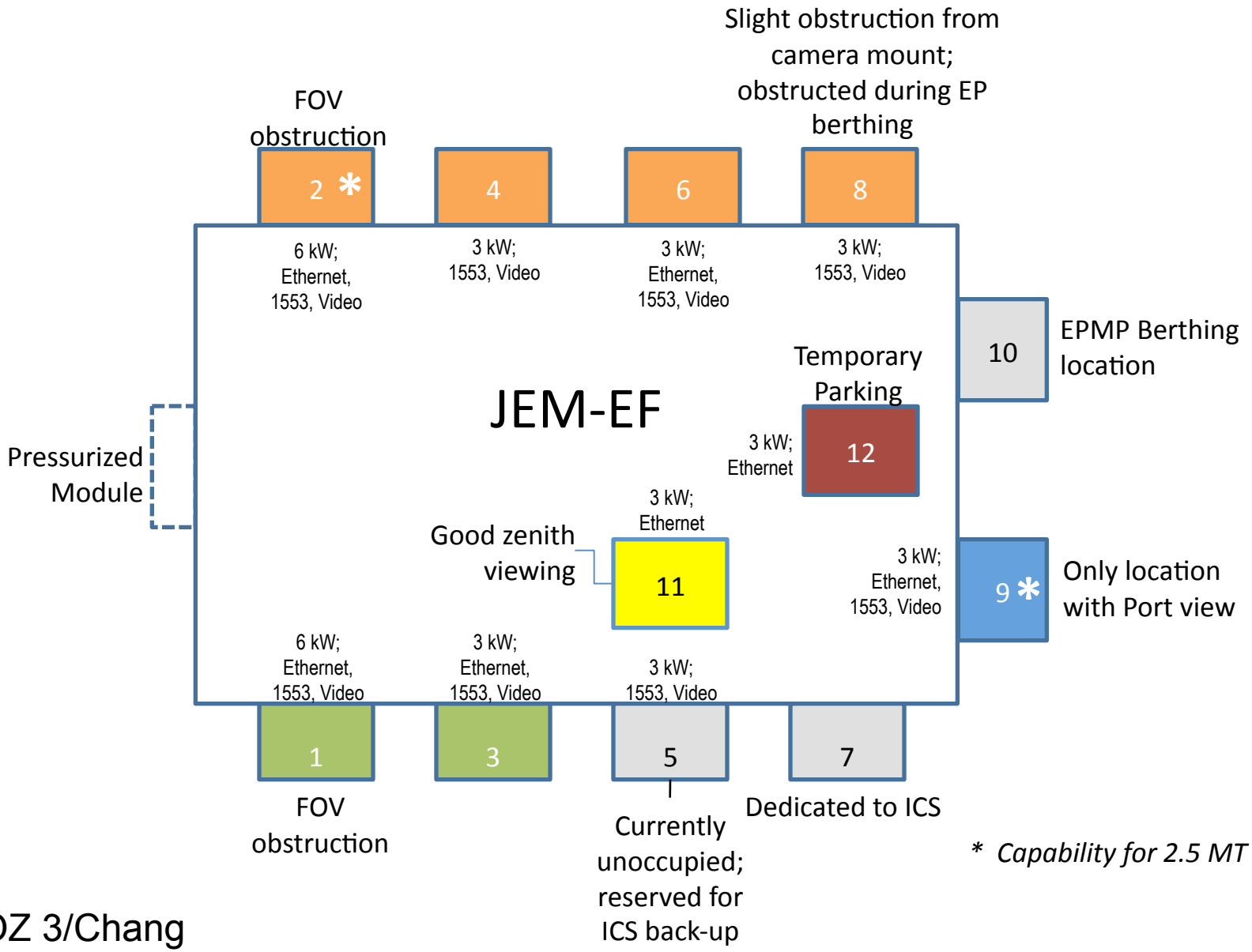


NASA/DOD HREP payload

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
Thermal	3-6 kW cooling
Low-rate data	1 Mbps (MIL-STD-1553, two way)
Medium-rate data	1EEE-802.3(10BASE-T, two way) *
High-rate data	43 Mbps (shared, one way downlink)
Sites available to NASA	5 sites

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

JEM EF EFU Location Overview

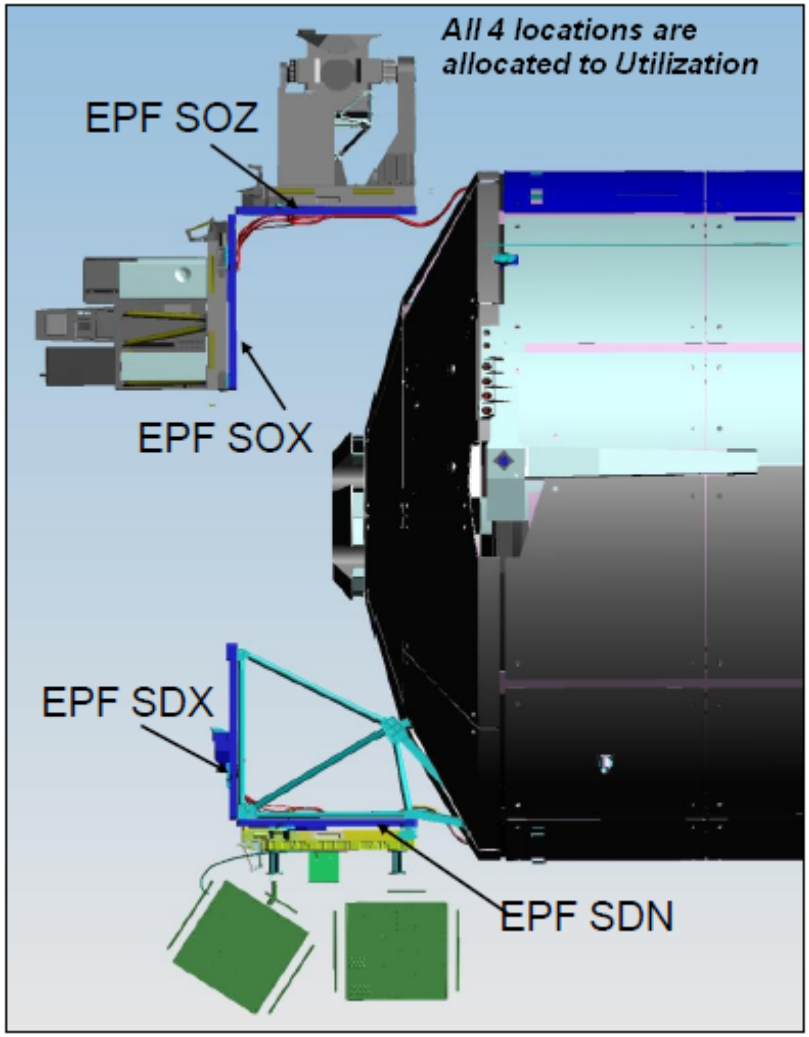


* *Capability for 2.5 MT payload*

JEM-EF Detailed Accommodations by Site

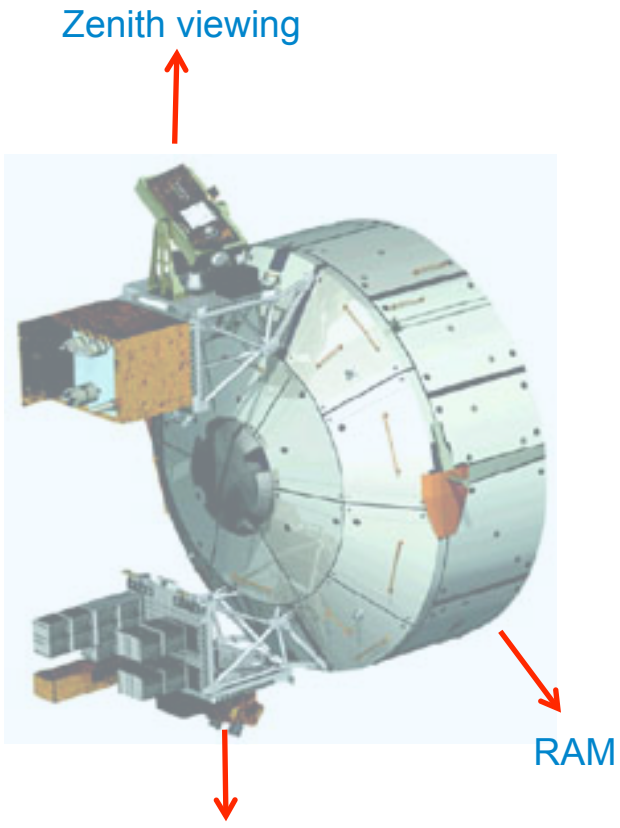
Location	Viewing	Payload Size	Description / Notes	Power	Data
1	Ram, Nadir, Zenith	500 kg	Ram field of View (FOV) obstruction by JEM module	6 kW	Ethernet, 1553, Video
3	Ram, Nadir, Zenith	500 kg	Clear view	3 kW	Ethernet, 1553, Video
5	Ram, Nadir, Zenith	500 kg	ICS System back-up site (negotiable?)	3 kW	Ethernet, 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	3 kW	Ethernet, 1553, Video
2	Wake, Nadir, Zenith	2.5 MT	Can hold large payloads, but has an FOV obstruction by JEM module	6 kW	Ethernet, 1553, Video
4	Wake, Nadir, Zenith	500 kg	Clear view	3 kW	1553, Video
6	Wake, Nadir, Zenith	500 kg	Clear view	3 kW	Ethernet, 1553, Video
8	Wake, Nadir, Zenith	500 kg	Obstruction during EP berthing, slight obstruction from camera mount	3 kW	1553, Video
10	Wake, Nadir, Zenith	500 kg	EPMP berthing site	-	-
11	Zenith only	500 kg	Good Zenith viewing	3 kW	Ethernet
12	Zenith only	500 kg	Temporary stowage location	3 kW	Ethernet

Columbus EF Overview



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

Columbus EF External Research Accommodations



Mass capacity	550 kg (1,150 lb) at standard site 2,250 kg (5,550 lb) at large site
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, two way)
Medium-rate data	2 Mbps (shared, two way) *
Sites available to NASA	2 sites

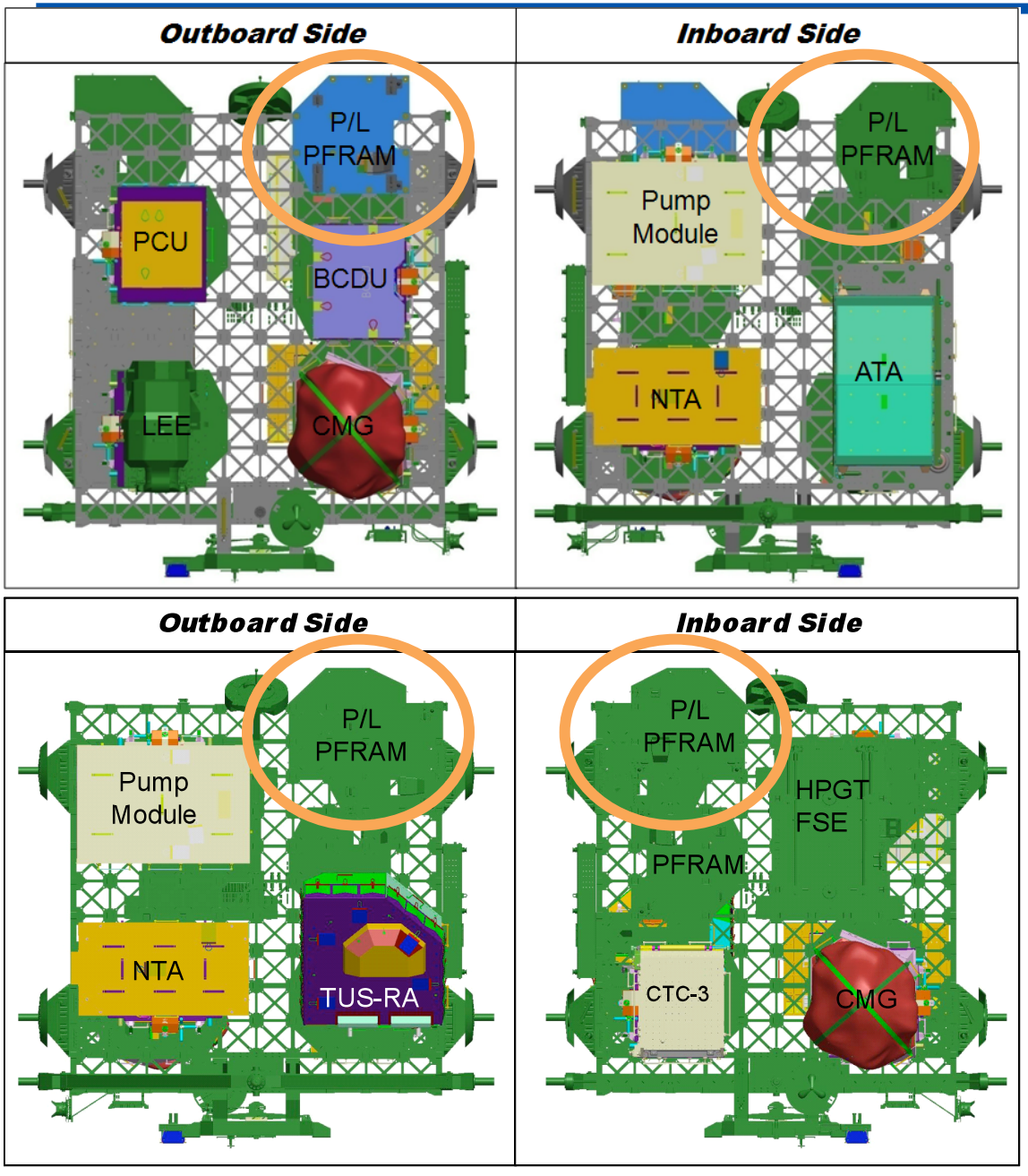
*** Ethernet bus is tested to 100BASE-T capacity. Upgrade to 100BASE-T is being worked by NASA ODAR project**

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

Express Logistics Carriers Overview

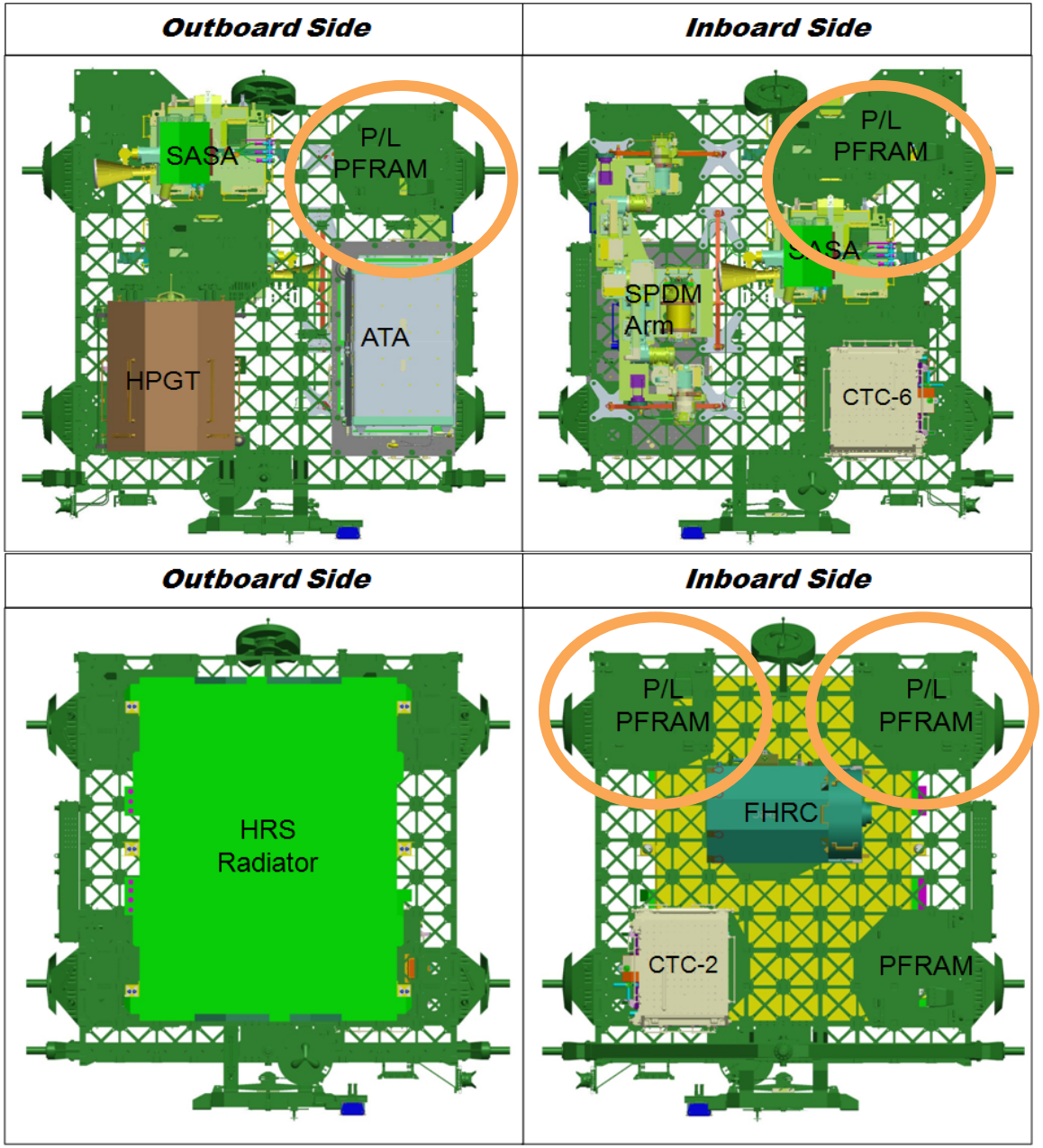


Payload Locations Circled

ELC-1
Port lower
2 Nadir payload sites

ELC-2
Starboard upper
2 Zenith payload sites

Express Logistics Carriers Overview



Payload Locations Circled

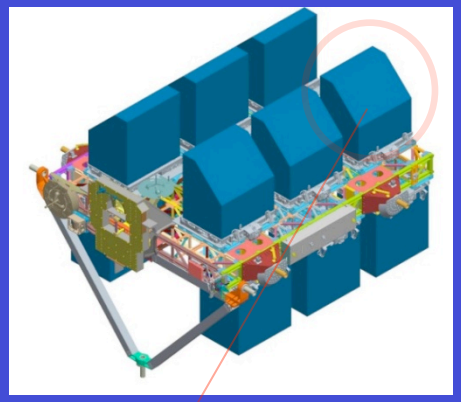
ELC-3
Port upper
2 Zenith payload sites

ELC-4
Starboard lower
2 Nadir payload sites

External Research Accommodations

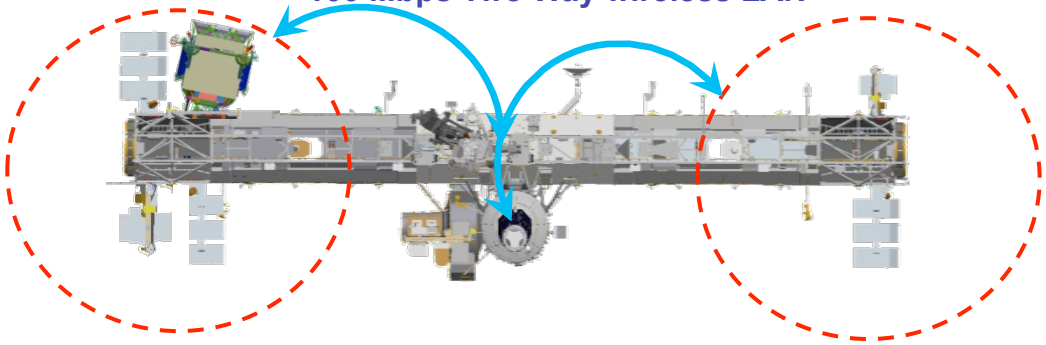
Express Logistic Carrier

ELC Single Adapter Resources (2 NASA payload sites per ELC)	
Mass capacity	227 kg (500 lb)
Volume	1 m^3
Power	750 W, 113 – 126 VDC; 500 W at 28 VDC/adapter
Thermal	Active heating, passive cooling
Low-rate data	*1 Mbps (MIL-STD-1553)
Medium-rate data	*6 Mbps (shared) - Return link (payload to ISS) only
Sites available per ELC	2 sites
Total ELC sites available	8 sites



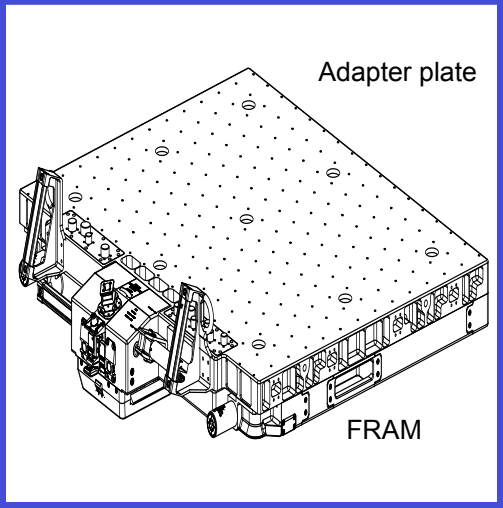
Research Payload ExPA
(see next chart)

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



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

External Manifesting and ISS Locations (draft through 2015 shown)
ELCs, Columbus-EF

FLIGHTS		Calendar Year	Launched / On Orbit	2011 - Tactical		2012			2013			2014		2015				
		Month		JAN	JUN	JAN	JUL	AUG	MAY	JUL	OCT	FEB	NOV	MAR	JUN	JUL	SEP	TBD
		Flight		HTV2	HTV3	Sx3	HTV4	Sx4	Sx6	HTV5	Sx7	Sx8	Sx10	Sx11	HTV7	Sx12	Orb8	TBD
Carrier	Location	Site Number	Viewing															
ELC 1	P3 Lower	3	*Nadir*										SAGE III/ Hexapod	SAGE III/ Hexapod				
		8	*Nadir*				OPALS	OPALS	OPALS	OPALS	OPALS	OPALS	OPALS	OPALS/EuTEF-2				
ELC 4	S3 Lower	1	*Nadir*			DPP	DPP	DPP	DPP	DPP	DPP	DPP	TBD-E4-1	TBD-E4-1				
		4	*Nadir*			R2D2	R2D2	R2D2	R2D2	R2D2	R2D2	R2D2	TBD-E4-4	TBD-E4-4				
ELC 2	S3 Upper	3	*Zenith*	MISSE 8[3,4]	MISSE 8[3]	MISSE 8[3]	MISSE 8[3]	MISSE 8[3]	PRELSE	PRELSE II[3]	PRELSE II[3]	PRELSE II[3]	PRELSE II[3]	PRELSE II[3]				
		7	*Zenith*					TBD-E2-7	TBD-E2-7	TBD-E2-7	TBD-E2-7	TBD-E2-7	TBD-E2-7					
ELC 3	P3 Upper	1	*Zenith*		SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed	SCAN Testbed / SCAN Testbed-2[5]				
		5	*Zenith*	STP-H3[4]	STP-H3	STP-H3		STP-H4	STP-H4	STP-H4	STP-H4	STP-H4	STP-H4	STP-H4				
Columbus	EPF SOZ		*Zenith*	SOLAR[4]	SOLAR	SOLAR	SOLAR	SOLAR	SOLAR	SOLAR	SOLAR[2]	TBD ESA-1[2,6]	TBD ESA-1 / TBD ESA-2[2, 6]	TBD ESA-1 / TBD ESA-2[2, 6]				
	EPF SOX		*Ram*					TBD-C-OX	TBD-C-OX	TBD-C-OX	TBD-C-OX	TBD-C-OX	TBD-C-OX	TBD-C-OX				
	EPF SDX		*Ram*								ASIM	ASIM	ASIM	ASIM				
	EPF SDN		*Nadir*								ACES	ACES	ACES	ACES				

All TBDs except TBD-ESA-1 and TBD-ESA-2 (highlighted in gold) represent NASA opportunities that have not yet been named (minimum of 1 Columbus opportunity and 3 ELC opportunities)

External Manifesting and ISS Locations (draft through 2015 shown)
JEM-EF

FLIGHTS		Calendar Year	Launched / On Orbit	2011 - Tactical		2012			2013			2014		2015				
		Month		JAN	JUN	JAN	JUL	AUG	MAY	JUL	OCT	FEB	NOV	MAR	JUN	JUL	SEP	TBD
		Flight		HTV2	HTV3	Sx3	HTV4	Sx4	Sx6	HTV5	Sx7	Sx8	Sx10	Sx11	HTV7	Sx12	Orb8	TBD
Carrier	Location	Site Number	Viewing															
JEM-EF	1		*Ram*	MAXI[4]	MAXI	MAXI	MAXI	MAXI	MAXI	MAXI	MAXI	MAXI	MAXI	MAXI				
	3		*Ram*	SMILES[4]	SMILES	SMILES	SMILES	SMILES	SMILES	SMILES				Attached Facility				
	5		*Ram*	*Systems Back-Up (ICS-EF)*														
	7		*Ram*	*Systems (ICS-EF)*														
	9[7]		*Ram*	SEDA-AP[4]	SEDA-AP	SEDA-AP	SEDA-AP	SEDA-AP	SEDA-AP	SEDA-AP / CALET[8]	CALET[8]	CALET[8]	CALET[8]	CALET[8]				
	2		*Wake*				TBD-J-2	TBD-J-2	TBD-J-2	TBD-J-2	TBD-J-2	TBD-J-2	TBD-J-2	TBD-J-2				
	4		*Wake*							TBD-J-4	TBD-J-4	TBD-J-4	TBD-J-4	TBD-J-4				
	6		*Wake*	HREP[4]	HREP	HREP	HREP		TBD-J-6	TBD-J-6	TBD-J-6	TBD-J-6	TBD-J-6	TBD-J-6				
	8		*Wake*		MCE	MCE	MCE	MCE	MCE	MCE	MCE	MCE						
	10		*Wake*	*Systems (ELM-ES/HTV)*														
	11		*Zenith*															
	12		*Zenith*	*Temp / Staging [10]*														
S3 Upper Inboard			*Zenith*	AMS[4]	AMS	AMS	AMS	AMS	AMS	AMS	AMS	AMS	AMS	AMS				

- All TBDs (highlighted in gold) represent NASA opportunities that have not yet been named (minimum of 3 sites with flight opportunities)
- Location/site numbers are color-coded to match the illustration on page 5

ISS Contamination Environment Description For Truss Attached Payload

- The International Space Station provides an exceptionally clean environment to external payloads and science assets
- External contamination control requirements limit contaminant deposition to 130Å/year on external payloads and ISS sensitive surfaces
  - Specified levels are lower than any previous space station (Mir, Skylab, Salyut) by several orders of magnitude
- Measurements of contaminant deposition on ISS returned hardware have demonstrated that requirements are met at ISS payload sites

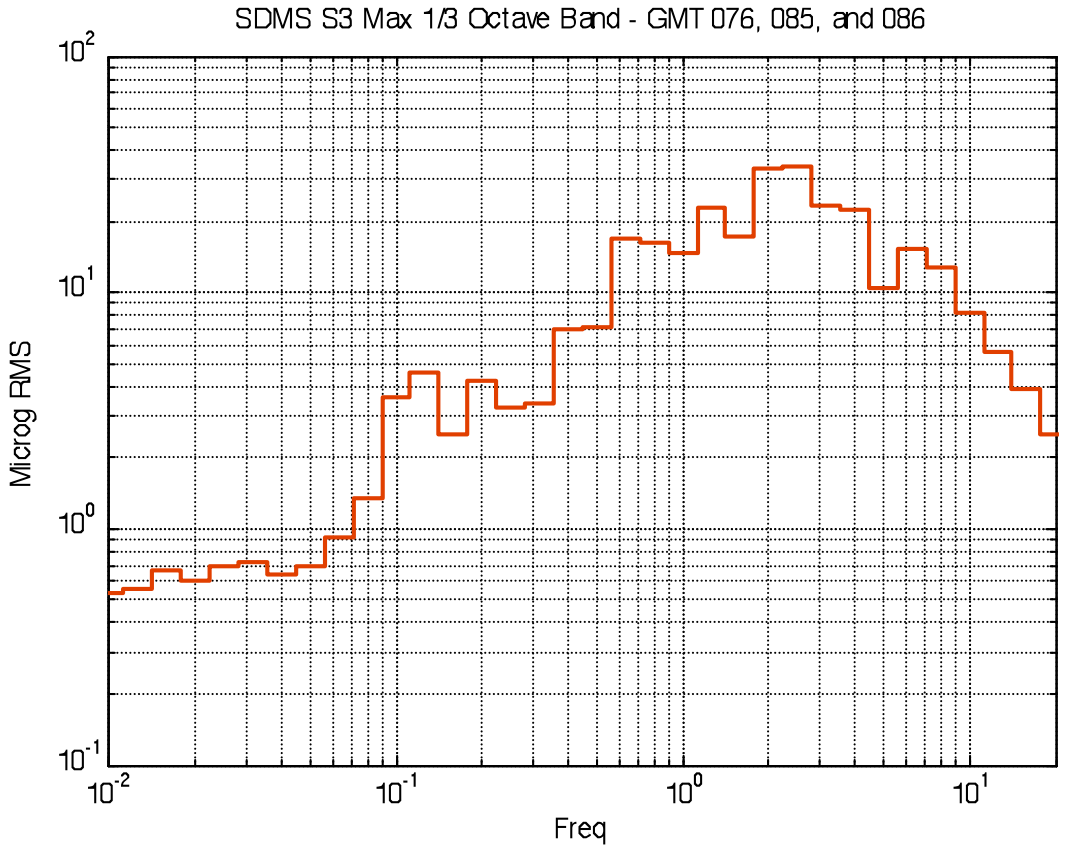
Experiment	Side	Requirement (130Å/year)	Measured
MISSE 2	ram	520 Å (4 years)	50 Å
	wake	520 Å (4 years)	500 Å
Node 1 nadir window cover	nadir	390 Å (3 years)	50 Å

Data provided by Boeing, June 2010

ISS Quiescent Mode Truss Vibratory Environment For External Payload Pointing Instrument

Data measured on ISS S3 truss

- ISS quiescent mode = No thruster firings, dockings, EVA, or robotics operations
- Typical response, not worst case
- Maximum per octave band
  - SDMS S3B1N on-orbit accelerometer data.
  - Snapshot of 3 10-minute data takes
  - All data taken on March 16, 26, and 27, Stbd SARJ Rotating, exercise, 3 crew.



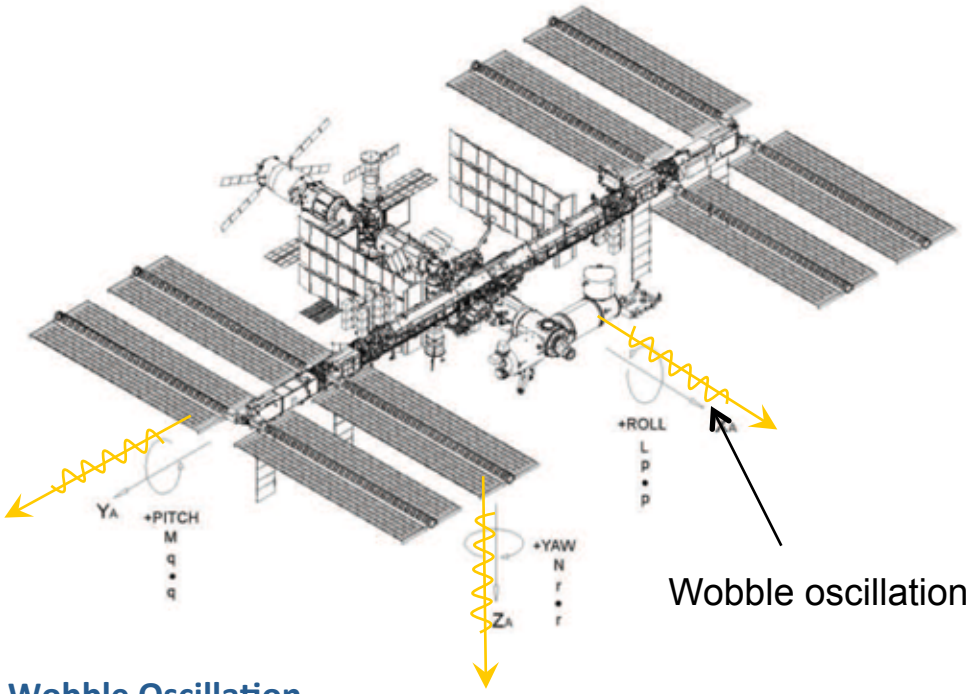
ULF-4 analysis concluded peak ELC rotations on the order of 0.03 degrees (quiescent mode)

Data provided by Boeing, June 2010

ISS Attitude Torque Equilibrium Attitude (TEA) & Wobble Oscillation Description

For Stage configurations (i.e.; no Orbiter or Orbiter sized vehicle docked on the ISS) in the foreseeable future, the predicted TEA ranges are:

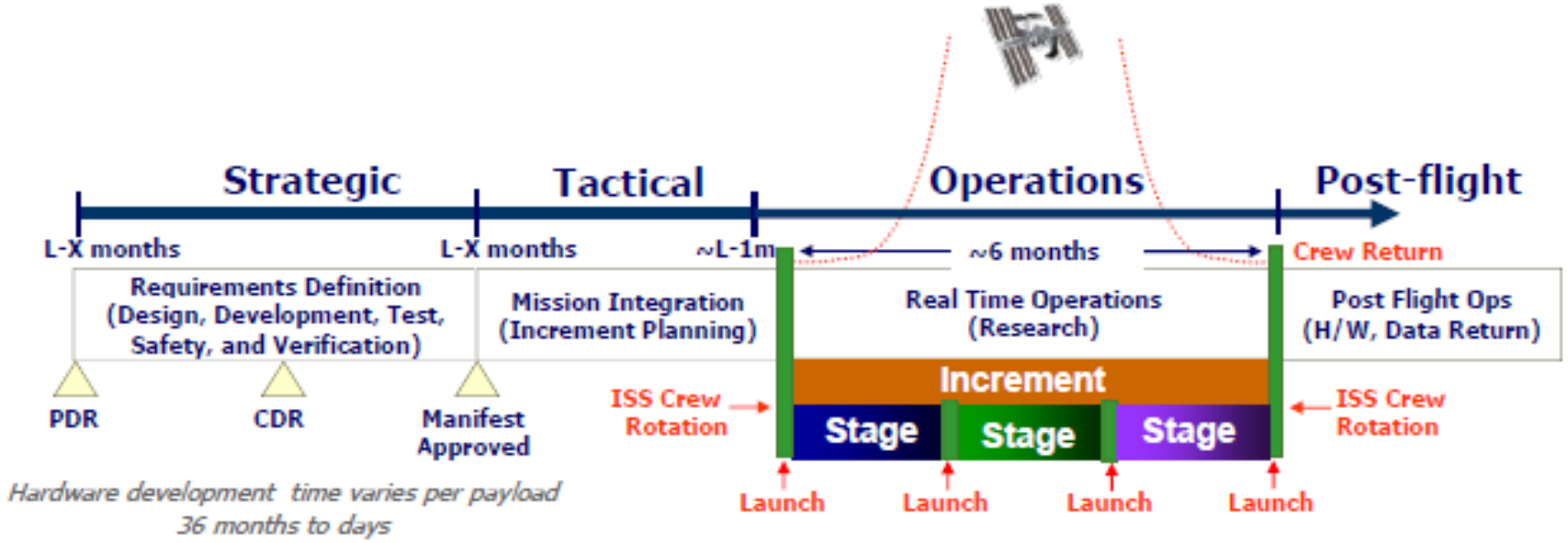
Roll: -1.0 ~ +3.0 deg
Pitch: -7.0 ~ +2.0 deg
Yaw: -15 ~ +15 deg.



Momentum Manager Controller Peak to Peak Attitude Wobble Oscillation

Performance Descriptions	Peak to Peak Attitude Oscillations Per Orbit			Peak Attitude Variation from Steady-State Orbit-Average Attitude		
	Roll (X) (deg)	Pitch (Y) (deg)	Yaw (Z) (deg)	Roll (X) (deg)	Pitch (Y) (deg)	Yaw (Z) (deg)
Non-Micro-Gravity (Assembly Stages) Non-Propulsive (Momentum Manager) Attitude Control Performance Requirement	10.0	10.0	10.0	+/- 5	+/- 5	+/- 5
Micro-Gravity (Assembly Complete) Non-Propulsive (Momentum Manager) Attitude Control Performance Requirement	7.0	7.0	7.0	+/- 3.5	+/- 3.5	+/- 3.5
Typical Steady-State Performance of **Minimum** *CMG momentum oscillation* Momentum Manager Controller	1.6	1.6	2.0	+/- 0.8	+/- 0.8	+/- 1
Typical Steady-State Performance of **Minimum** *Attitude oscillation* Momentum Manager Controller	1.6	0.4	0.2	+/- 0.8	+/- 0.2	+/- 0.1
Typical Steady-State Performance of **Minimum** *CMG momentum & Attitude oscillation* **Blended** Momentum Manager Controller	1.6	0.7	1.2	+/- 0.8	+/- 0.35	+/- 0.6

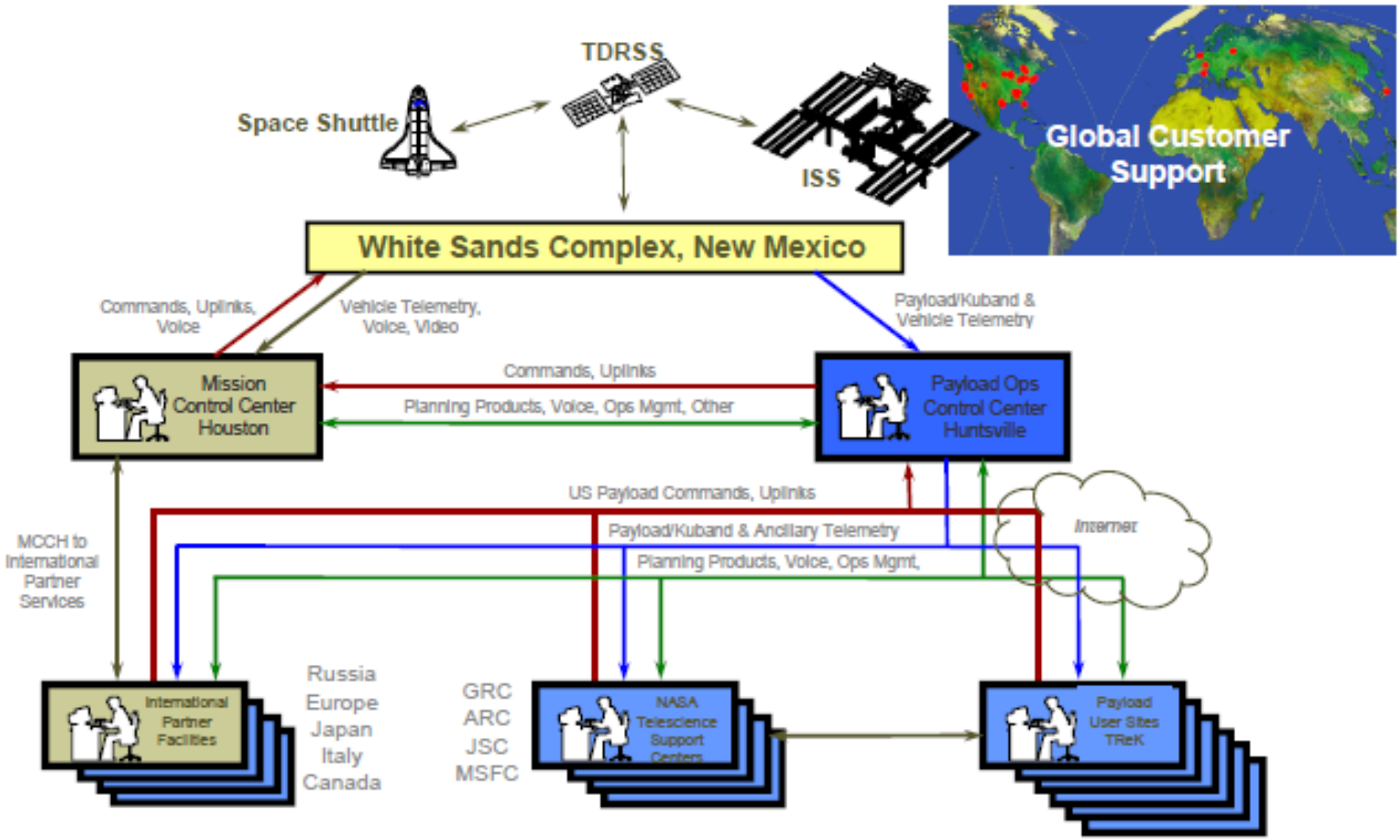
ISS Payload Integration Process



ISS provides:

- Launch to ISS
- Installation on ISS at identified site
- On-orbit utilities and operations support, including crew or robotics time (if needed)
- Data handling and delivery
- End-of-life removal and disposal

Payload Operations Integration Center Interfaces



49 Telescience Resource Kit (TReK) Clients

References

- ISS Program Scientist Toolbox - http://iss-science.jsc.nasa.gov/index.cfm
- ISS National Laboratory Office - http://www.nasa.gov/mission_pages/station/science/nlab/index.html
- Advanced Avionics Development Office - http://iss-www.jsc.nasa.gov/nwo/avionics/aado/home/web/
- Attached Payload Interface Requirements Document, SSP 57003
- Common Interface Requirements Document, SSP 50835
- ATV-2 Cargo Summary (24 Sep 2009)
- HTV Cargo Accommodation Handbook, JFX-99102
- Requirements for International Partner Cargo Transported On Russian Progress and Soyuz Vehicles, П32928-103
- SpaceX Introduction For Payloads (OZ3, Jan 2010)
- Cygnus Fact Sheet (Orbital, 2009)

For technical questions associated with International Space Station Payloads:

Ms. Marybeth Edeen
Explorer ISS Payload POC
Space Station Payload Office
Mail Stop OZ
NASA Johnson Space Center
Houston, TX 77058
Tel: 281-483-9122
Email: marybeth.a.edeen@nasa.gov

Acronyms

ACES	Atomic Clock Ensemble in Space
AMS	Alpha Magnetic Spectrometer
ASI	Italian Space Agency
ASIM	Atmospheric Space Interactions Monitor
ATA	Ammonia Tank Assembly
BCDU	Battery Charge Discharge Unit
CALET	Calorimetric Electron Telescope
C&DH	Command and Data Handling
CEF	Columbus Exposed Facility
CEPA	Columbus External Payload Adapter
CMG	Control Moment(um) Gyro(scope)
COL-EPF	Columbus Exposed Payload Facility
CSA	Canadian Space Agency
CTC	Cargo Transport Container
DPP	Dextre Pointing Package
ELC	External Logistics Carrier
ELM-ES	Experiment Logistics Module-Exposed Section
ELM-PS	Experiment Logistics Module – Pressurized Section
EF	Exposed Facility
EFU	Exposed Facility Unit
EPF	Exposed Payload Facility
EPMP	Exposed Pallet – Multi-Purpose
ESA	European Space Agency
EuTEF	European Technology Exposure Facility
EVA	Extravehicular Activity
EVR	Extravehicular Robotics
ExPA	EXPRESS Pallet Adapter

Acronyms *(Continued)*

FHRC	Flex Hose Rotary Coupler
FOV	Field of View
FSE	Flight Support Equipment
HPGT	High Pressure Gas Tank
HREP	Hyperspectral Imager for the Coastal Ocean (HICO)/Remote Atmospheric and Ionospheric Detection System (RAIDS) Experiment Payload
HRS	Heat Rejection Subsystem
HTV	H-II Transfer Vehicle (Japanese resupply vehicle)
ICS-EF	Inter-Satellite Communication System – Exposed Facility
ISS	International Space Station
JAXA	Japan Aerospace Exploration Agency
JEM	Japanese Experiment Module
JEM-EF	Japanese Experimental Module-Exposed Facility
JEM-PM	Japanese Experimental Module-Pressurized Module
Kg	kilogram
LAN	Local Area Network
LEE	Latching End EffectorMAXI Monitor All-sky X-ray Image
MCE	Multi-mission Consolidated Equipment
MIM	Multi-Increment Manifest
MiPROM	Multi-Increment Payload Resupply and Outfitting Manifest
MISSE	Materials International Space Station Experiment
NASA	National Aeronautics and Space Administration
NTA	Nitrogen Tank Assembly
ODAR	Obsolescence Driven Avionics Re-Design
OPALS	Optical Planetary Access Link for Space Station
PCU	Plasma Contactor Unit
PFRAM	Passive Flight Releasable Attach Mechanism

Acronyms *(Continued)*

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