International Space Station Research Integration and Capabilities

Committee on Biological and Physical Sciences in Space
Rod Jones Research Integration Office
October 2014

International Space Station

Created by a partnership of 5 space agencies

10 years and over 100 missions to assemble

A laboratory for Microgravity
Biological, Material and Technology Research

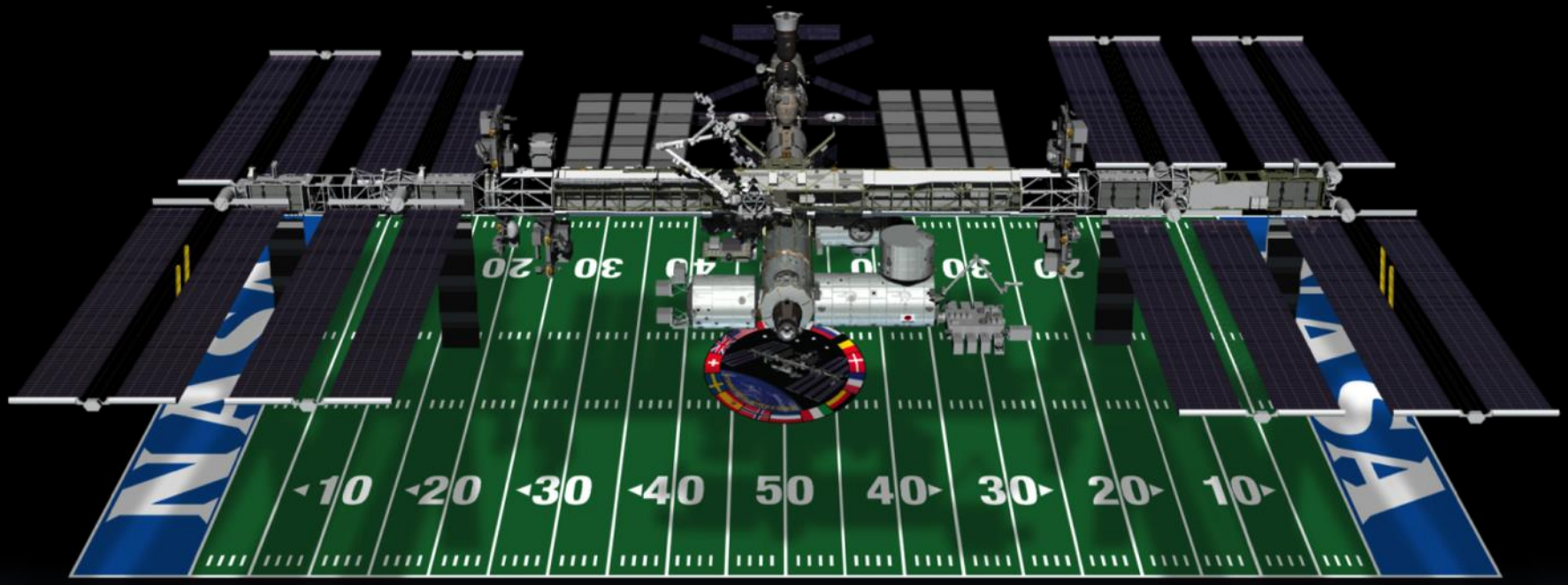
A Low Earth Orbiting Platform for
Heliophysics, Astrophysics and Earth science

At a scale that has not been achieved before and that no one agency or country could sustain

International Space Station Key Features

- Sustainable microgravity platform for long term studies
- External and internal research sites
- Habitable controlled environment
- Exposure to the thermosphere
- Earth observations at a unique altitude and inclination
- Automated, human, tele-operated and robotic operated research
- Payload to orbit and return capability
- Nearly continuous data and communication link to anywhere in the world
- Modularity and maintainability built into the design ensures mission life, allows life extension, vehicle evolution and technology upgrades

International Space Station Facts



Spacecraft Mass: +800,000 lb (+362,874 kg)
Velocity: 17,500 mph (28,200 kph)
Altitude: 220 miles above Earth
Power: 80 kW continuous

On Orbit Payload Resources and Upgrades

Power	30kw average
Air to Ground Data	~37.5 Mbps of video (3 lines of video at 12.5 Mbps e
	~8 Mbps of MRDL data (Science return)
	~5 Mbps for payload still imag
	~20 Mbps utilized for payload data recorded over LOS
Internal Payload Racks	13 NASA Lab
	11 ESA Lab
	10 JAXA Lab
External Sites	8 NASA Truss ELC Platform Sites
	10 JAXA Platform Sites
	4 ESA Platform Sites
Crew time	35 hrs per week (average)

Up graded see next chart

2 additional Express Racks and another glove box

Proposing additional External sites

Updated ISS Data Infrastructure

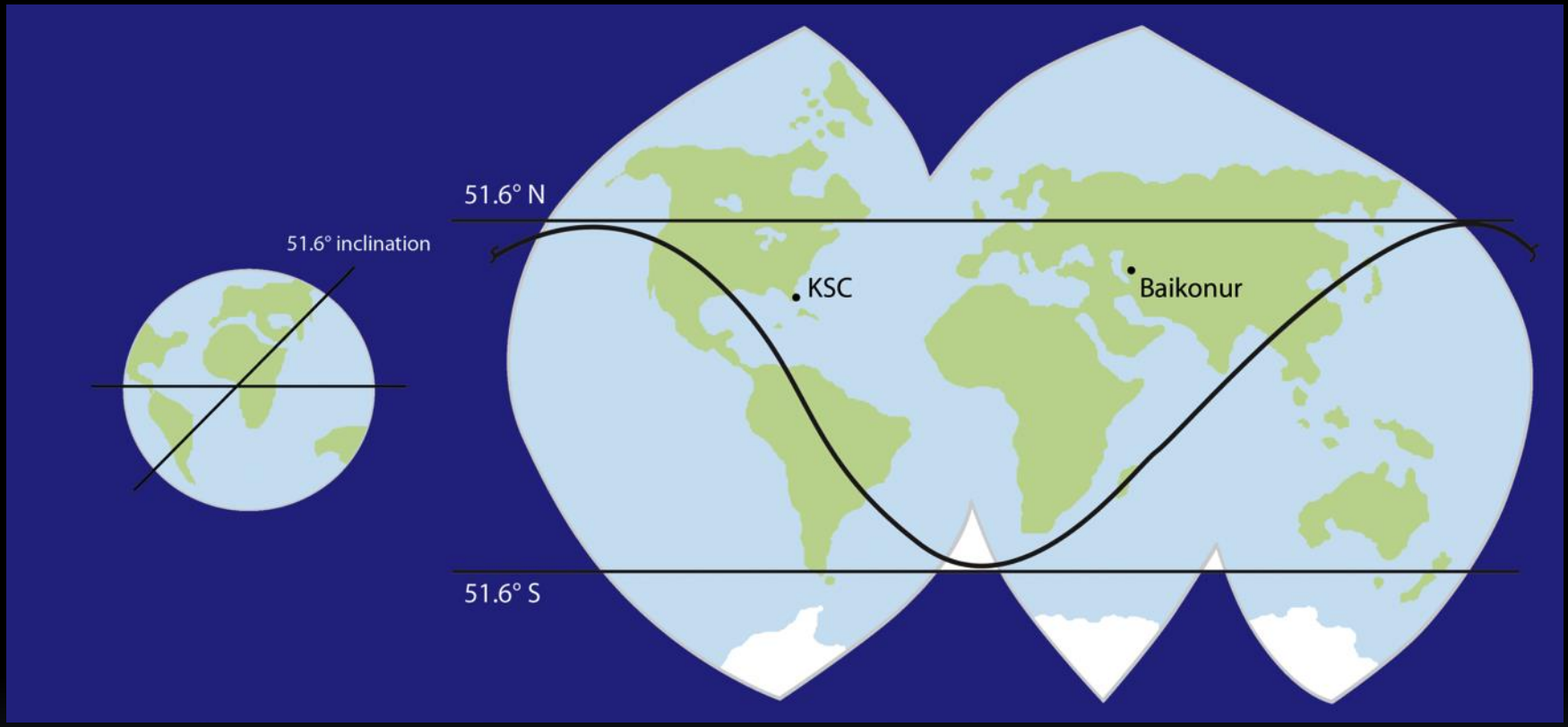
Enhanced Processor and Integrated Communications (EPIC) Project	Phase A will upgrade the three Command and Control (C&C) MDMs and the two Guidance, Navigation, & Control (GN&C) MDMs.
	Phase B will upgrade the two Payload MDMs, and add Ethernet support for the C&C and Payload MDMs.
Air to Ground High Rate Communications System (HRCS) Project	Increase data rates internally and on the RF link (300 Mbps downlink, 7/25 Mbps uplink)
	Combine audio and video on orbit
	Provide two way, high quality audio
	Open the door to internet protocol communications
	Open the forward link to multiple users
	Allow for the capability of transmitting & recording HDTV
On Orbit External Wireless High Rate	100 Mbps 2-way Ethernet capability
	1 Mbps 1553 capability
	Up to 2 antennas (+2 more in work) attached to EVA handrails on US Lab

Internal Research Accommodations

Architecture based on Modular racks

Modularity = maintainable, reconfigurable, interchangeable between ESA, JAXA, NASA

ISS as a Platform for Earth Science

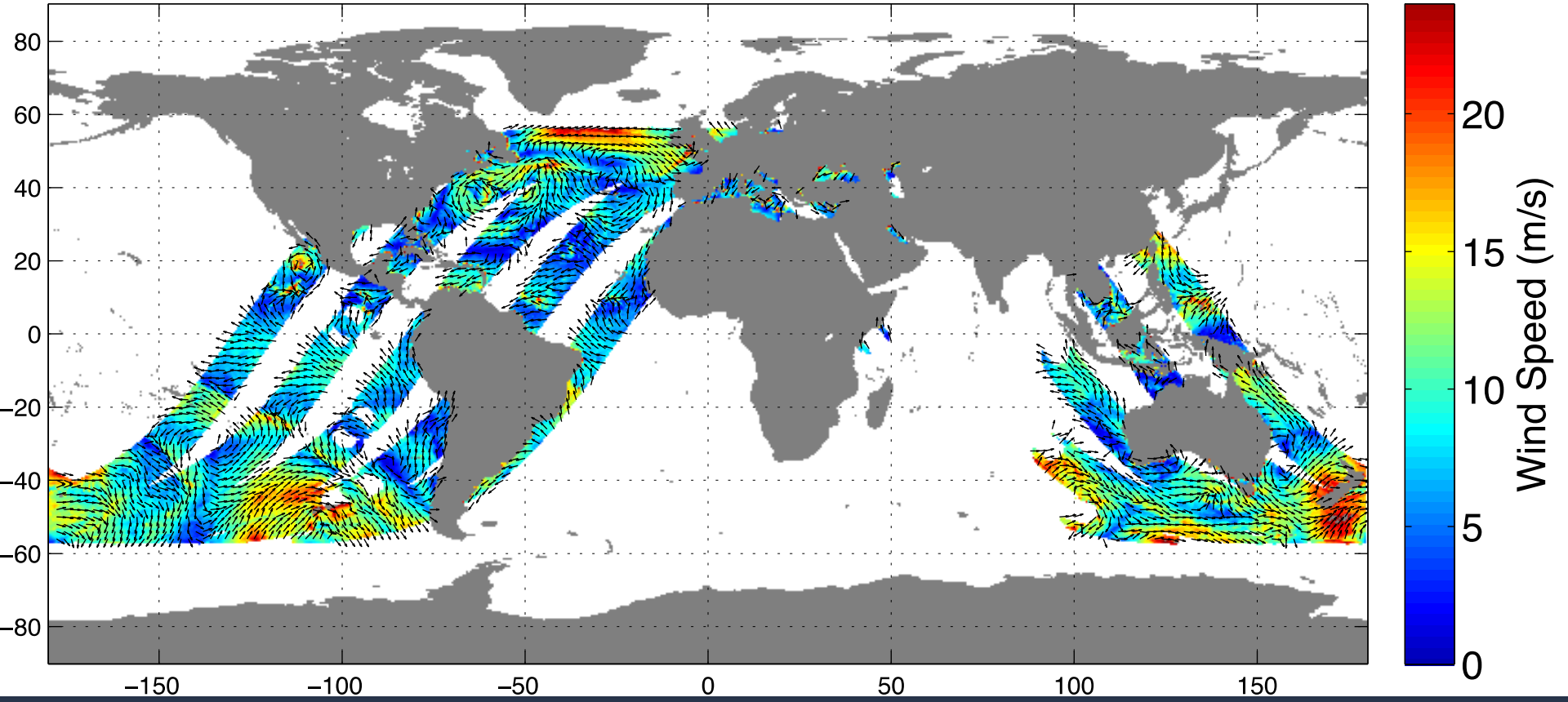


All geographic locations between 51.6 North and South latitude can be observed NADIR pointing

Provides coverage of 85% of the Earth's surface and 95% of the world's populated landmass every 1-3 days

Processing lighting (changes with subsequent passes)

ISS as a Platform for Earth Science



ISS SMD Rapid Scat measurements of sea winds in its first 5 operational orbits

Cargo Launch Capability

Proton *Progress*	**Ariane 5** *ATV*	**HII** *HTV*	**Falcon 9** *Dragon*	**Taurus II** *Cygnus*

ROSCOSMOS

esa

JAXA

SpaceX

Orbital

An International fleet of space vehicles that delivers propellant, supplies and replenishes science experiments

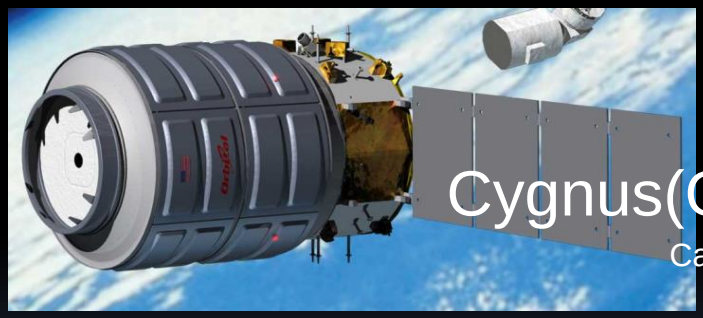
ISS Cargo Vehicles

ATV (ESA)

Cargo Capacity
5,500 kg

Progress

Cargo Capacity
2,250 kg



Cygnus(Orbital)

Cargo Capacity
2,000 kg

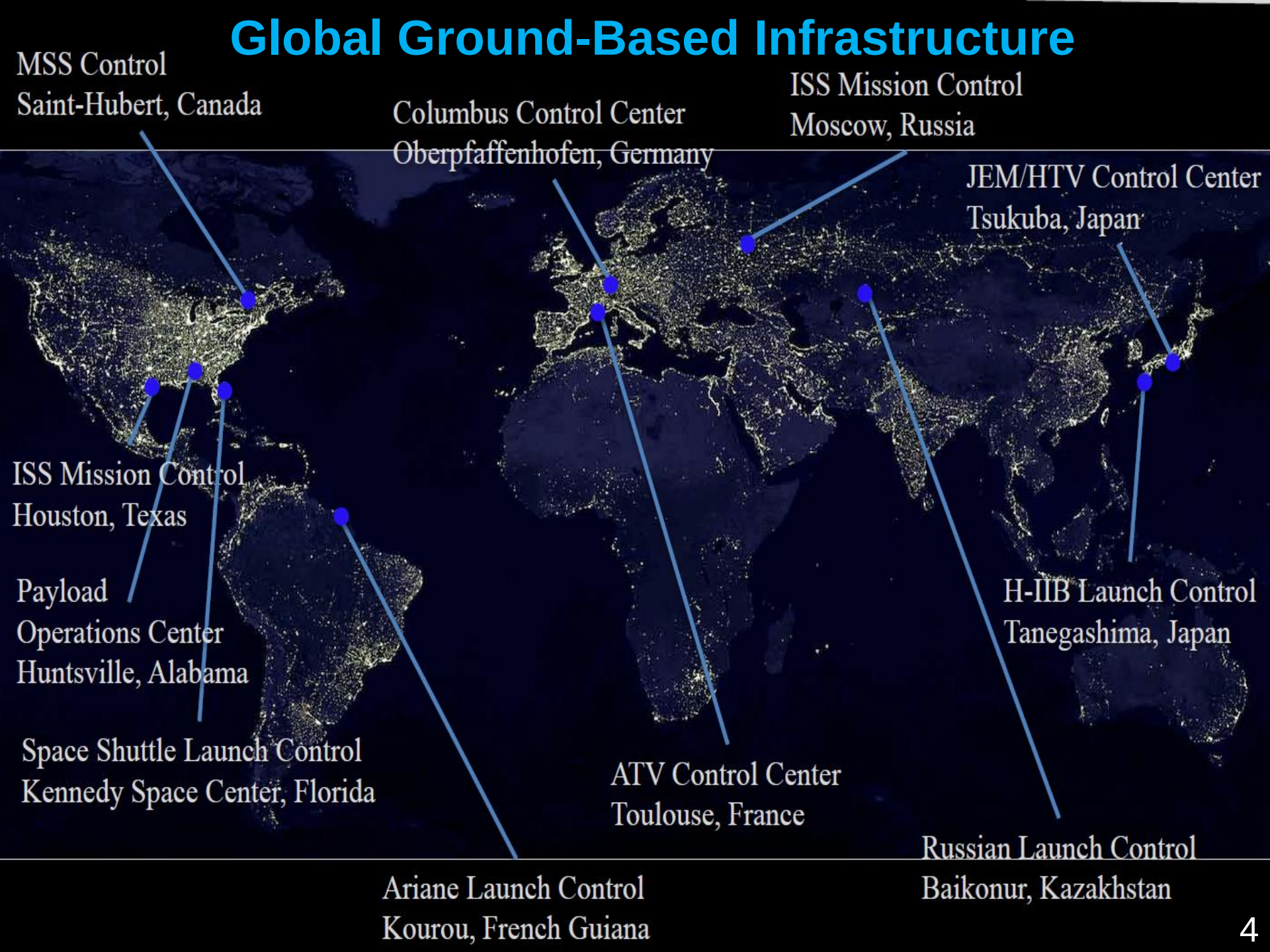
Dragon (SpaceX)

Cargo Capacity
3,100 kg ascent

HTV (JAXA)

Cargo Capacity
5,500 kg

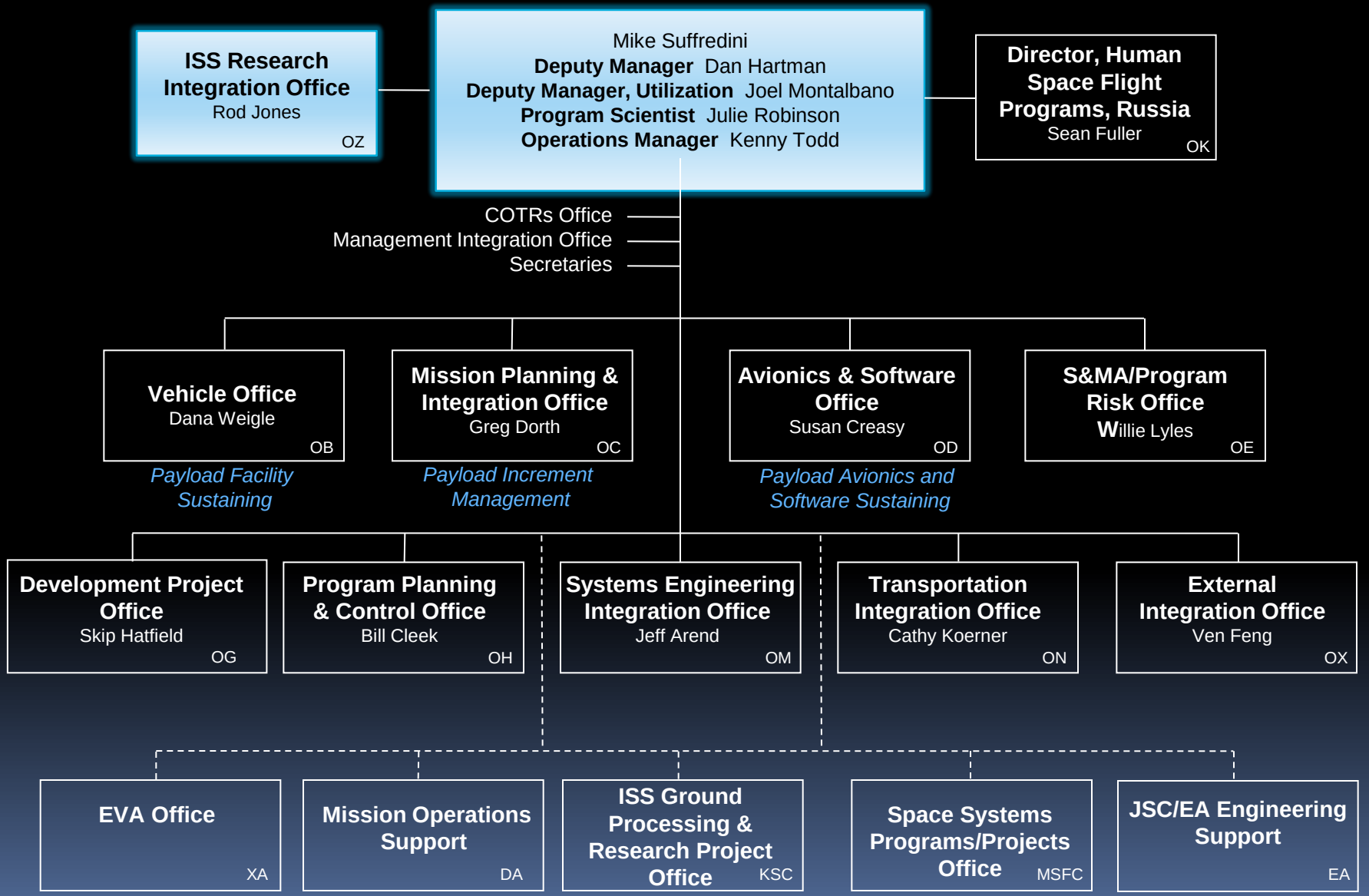
Global Ground-Based Infrastructure



Research Sponsors and Allocations on ISS

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

International Space Station Program



ISS Research Integration Office Functions

Conduct strategic planning with science partners

Facilitate collaboration between researchers and facilities

Plan tactical missions

Produce training and operational products

Train the crew

Enable and Operate the research on-orbit

Allocate and Track customer resources

Continuously measure ISS productivity through metrics

Conduct customer satisfaction surveys each planning mission

Track and communicate science results

Strategic Research Resource Planning

NASA and its' International Partners conduct a strategic review each year that:

- Documents the previous years actual resource use
- Summarizes the current year and next years resource demand based on manifest and tactical data
- Looks forward strategically two additional years collecting projected resource demands and comparing them against the in that time frame capabilities

Observations, finding and recommendations are documented from this review and used by the program to guide the effective future allocation of resources, validate the projected flight rate and identify any resources shortfalls in time to take corrective action

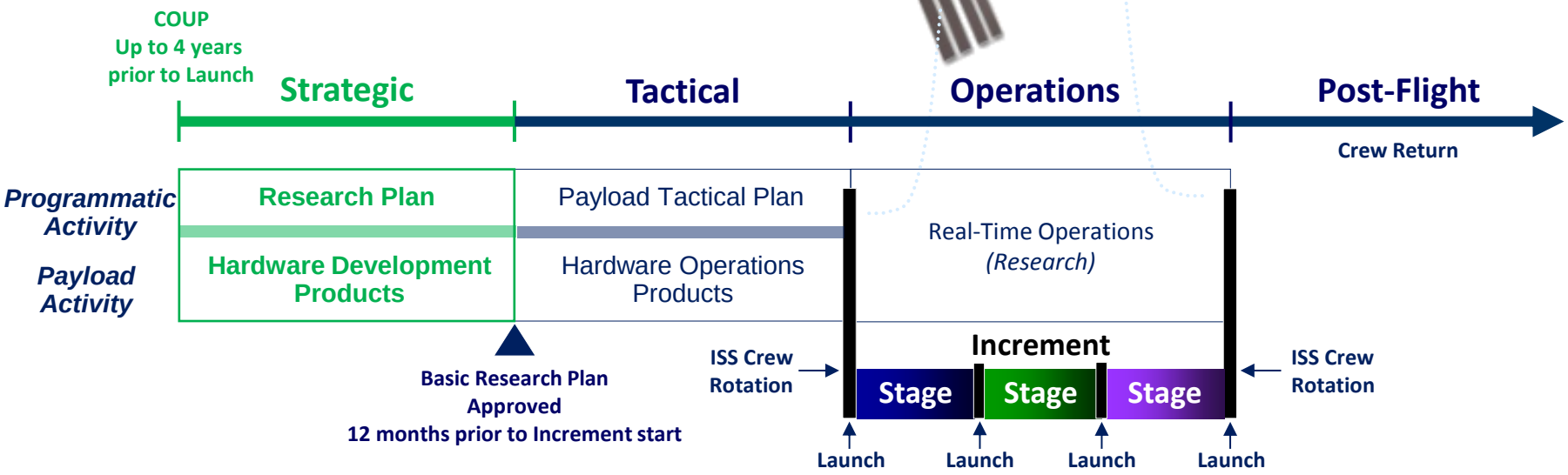
Tactical Research Planning

Increment specific Research Planning begins 18 months prior to the mission

The first Research Plan is base lined 12 months prior to the mission and refined up to the start of the increment where it transitions to the real time planning and execute phase

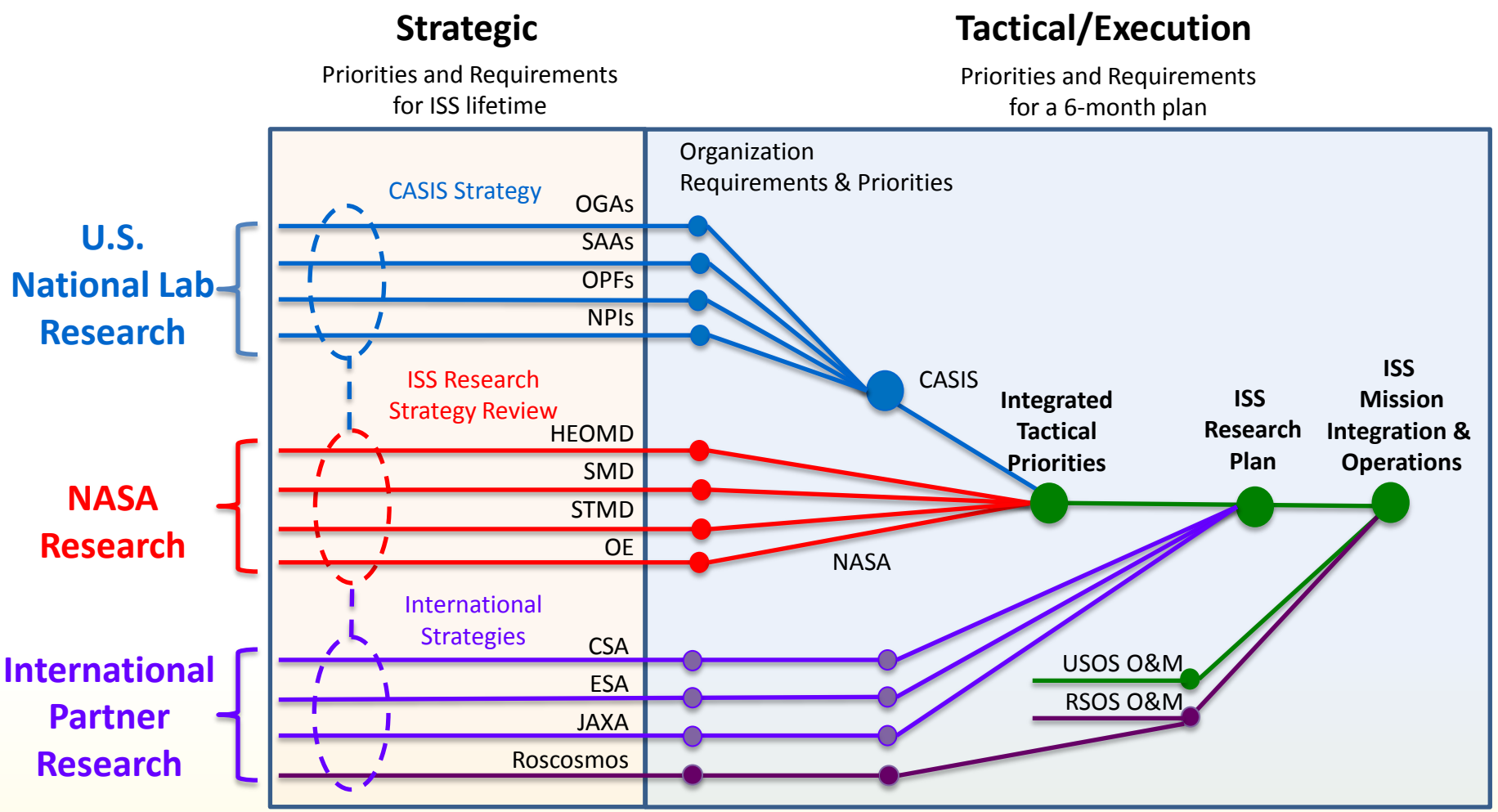
Depending on its complexity a Payload can be entered into the plan any where along the process

Planning and Operational Phase's



Depending on its complexity a Payload can be entered into the plan any where along the planning process

ISS Requirements Integration & Prioritization



CASIS – Center for the Advancement of Science in Space
CSA – Canadian Space Agency
ESA – European Space Agency
HEOMD – Human Exploration and Operations Mission Directorate (NASA)
IMMT – ISS Mission Management Team
JAXA – Japan Aerospace Exploration Agency
NPI – Non Profit Institutions (U.S.)
O&M – Operations and Maintenance

OE -- Office of Education (NASA)
OGA – Other Government Agency (U.S.)
OPF -- Other Private Firm (U.S.)
RSOS – Russian Segment Operating System
SAA -- Space Act Agreement (NASA)
SMD – Science Mission Directorate (NASA)
STMD – Space Technology Mission Directorate (NASA)
USOS – U.S. Segment Operating System

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

Examples:

- Increased air to ground communication channels allows the crew to talk directly to the scientists during operations to review research objectives, discuss observations and findings and collaborate on new ideas
- Improved data rates and on board diagnostic equipment allows researchers to get their results without waiting for the hardware and samples to be returned shortening the research cycle

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

Examples:

- Implemented a software environment to allow the use of common lab software on-orbit
- Certified 110v AC power source with commercial power connectors
- Continue expand our remote operation system that allows you to operate your payload anywhere the internet is available
- Deploying a payload test set that allows our customer to conduct their end to end testing and verification at their facility
- Delay Tolerant Network = send and forget

Full Utilization

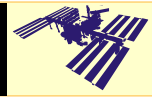
- Multiple Resource are tracked and planned to optimize the use of ISS
  - Up-mass and Sample return
  - Crew time
  - Power and Thermal
  - Internal and External payload site occupancy
  - Data downlink
- Factors affecting these resources
  - Changing operational plans
  - Scheduling and choreographing science operations
  - Hardware failures and contingency maintenance
  - Payload anomalies
  - Science discoveries
- At a minimum Full utilization can be defined as all internal and external sites are occupied and the crew has more than enough to do.
- More realistically Full Utilization is when all resources are in balance given the systems capability at any given moment
- We continuously monitor and adjust Strategic, Tactical and Real time plans to ensure Full Utilization

To get the most out of ISS, we continue to expand each resource when it becomes limiting

ISS Research Accommodations Status

12 Sept 2014 (Data through 31 Aug 2014) [POC: Rod Jones/OZ]

Status: GREEN → based upon steady progress in executing and achieving ISS research objectives *(Last month →)*



PARTNERSHIP – Current and Future

NASA & NATIONAL LABORATORY – Current and Future

Research Resources: ISS resources are often described as upmass (mass of material brought to the ISS), downmass (mass of material returned from ISS) and crewtime (amount of time crew dedicates to an activity). During the ISS assembly, the majority of the resources were needed to construct the ISS. However, significant upmass and crewtime were set aside to deliver and then outfit and configure large research facilities as part of ISS laboratory outfitting. No future large facilities are planned; therefore, the profile of future research resources will likely not resemble that of the past reported below. These figures are provided for reference value only and will not be predictive.

Note: Planning data are the most current cited at end of recording month	ISS Expeditions 37/38 Sep 2013 – Apr 2014	ISS Expeditions 39/40 Apr 2014 – Sep 2014	ISS Expeditions 37-40 Sep 2013 – Sep 2014	ISS Expeditions 41/42 Sep 2014 – Apr 2015	ISS Expeditions 43/44 Apr 2015 – Sep 2015
Upmass – Planned [Total (USOS, RS)]	1138.0 kg (791.2, 346.8)	2459.9 kg (2459.9, 0.0)	3597.2 kg (3250.4, 346.8)	6320.7 kg (5956.2, 364.5)	*tbd* (4879.3 kg, *tbd*)
Downmass – Planned [Total (USOS, RS)]	38.9 kg (19.9, 19.0)	702.5 kg (666.9, 35.6)	741.4 kg (686.8, 54.6)	2153.9 kg (2124.2, 35.1)	*tbd* (1236.7 kg, *tbd*)
Crewtime - Planned [Total (USOS, RS)]	1336.7 hrs (884.2, 452.5)	1581.5 hrs (963.7, 617.8)	2918.2 hrs (1847.9, 1070.3)	1622.4 hrs (895.4, 727.0)	*tbd* (1117.8 hrs, *tbd*)
Crewtime - Actuals [Total (USOS, RS)]	2049.7 hrs (1097.1, 952.6)	1649.5 hrs (968.8, 680.7)	3699.3 hrs (2066.0, 1633.3)	*tbd hrs* (*tbd*, *tbd*)	*tbd hrs* (*tbd*, *tbd*)

Note: NASA = NASA sponsored and NL = National Lab sponsored.	ISS Expeditions 37/38 Sep 2013 – Apr 2014	ISS Expeditions 39/40 Apr 2014 – Sep 2014	ISS Expeditions 37-40 Sep 2013 – Sep 2014	ISS Expeditions 41/42 Sep 2014 – Apr 2015	ISS Expeditions 43/44 Apr 2015 – Sep 2015
Upmass – Planned [Total (NASA, NL)]	790.8 kg (456.1, 334.7)	1103.2 kg (714.1, 389.1)	1894.0 kg (1170.2, 723.8)	4921.3 kg (3720.9, 1200.4)	4098.3 kg (2487.1, 1611.1)
Downmass – Planned [Total (NASA, NL)]	10.3 kg (2.4, 7.9)	638.2 kg (440.4, 197.8)	651.9 kg 439.5, 212.5)	1765.0 kg (1046.6, 718.3)	tbd (450.0 kg, *tbd*)
Crewtime - Planned [Total (NASA, NL)]	696.8 hrs (601.8, 95.0)	746.8 hrs (650.6, 96.2)	1443.6 hrs (1252.4, 191.2)	691.8 hrs (416.2, 275.6)	881.2 hrs (573.7, 307.5)
Crewtime - Actuals [Total (NASA, NL)]	898.6 hrs (859.8, 38.8)	772.6 hrs (755.3, 17.3)	1671.2 hrs (1615.2, 295.0)	*tbd hrs* (*tbd, tbd*)	*tbd hrs* (*tbd, tbd*)

Number of Current and Future Investigations on the International Space Station

The investigations statistics represented below reflect research operated for Expeditions 37/38; and operated, planned, scheduled, or operated for Expeditions 39/40; and planned or scheduled for Expeditions 41/42 and 43/44.

	ISS Expeditions 37/38 Sep 2013 – Apr 2014 (operated)*	ISS Expeditions 39/40 Apr 2014 – Sep 2014 (operated, planned or scheduled)†	ISS Expeditions 37-40 Sep 2013 – Sep 2014 (operated, planned or scheduled)	ISS Expeditions 41/42 Sep 2014 – Apr 2015 (planned or scheduled)†	ISS Expeditions 43/44 Apr 2015 – Sep 2015 (planned or scheduled)
Total Investigations	281	315	371	256	231
New Investigations	52	75	127	109	74
Number of Investigators with Research on the ISS	640	382**	*tbd*	432**	*tbd*
Countries with ISS Investigations	45	29**	*tbd*	28**	*tbd*

** Prelim numbers, subject to change pending upcoming review.*

*** Pending finalization of Expeditions 0 – 38 statistics.*

† Roscosmos numbers pending

Note: NASA = NASA-sponsored and NL = National Lab-sponsored.	ISS Expeditions 37/38 Sep 2013 – Apr 2014 (operated)	ISS Expeditions 39/40 Apr 2014 – Sep 2014 (operated, planned or scheduled)	ISS Expeditions 37-40 Sep 2013– Sep 2014 (operated, planned or scheduled)	ISS Expeditions 41/42 Sep 2014 – Apr 2015 (planned or scheduled)	ISS Expeditions 43/44 Apr 2015 – Sep 2015 (planned or scheduled)
Total Investigations (NASA+National Lab)	135	159	185	189	159
National Lab Investigations	45	58	74	63	44
New Investigations (NASA+National Lab)	33	50	83	84	50
New National Lab Investigations	22	29	51	39	24
Number of Investigators with Research on the ISS	294*	204*	*tbd*	*tbd*	*tbd*

Did You Know?

Since March 2001 to date:

- **13 years, 6 months** of continuously crewed research operations
- **29** research racks on board
- **11** external payloads attached, including HDEV and OPALS that arrived with SpaceX-3 and not counting AMS. Total includes NASA and IPs.
- **Number of Investigations Expedition 0-38: 1651.** *Note: Expeditions 0-38 statistics have been approved by the Program Science Forum and Space Station Control Board.; currently pending approval by the Multilateral Coordination Board .*
- More than **700** scientific results publications (Expedition 0 - present)

*During August 2014, after **23.4** work weeks of operation in Expeditions 39 & 40:*

53 USOS investigations operated; **0** New investigations operated for the *first* time in August 2014.

Pre-Decisional - For Internal Use Only

Chart prepared by Roger Weiss (Barrios/MAPI), NASA/JSC, ISS-OP, roger.h.weiss@nasa.gov and Tracy Thumm (Barrios/MAPI), tracy.thumm-1@nasa.gov

ISS Research Accommodations Status

12 September 2014 (Data through 31 August 2014)

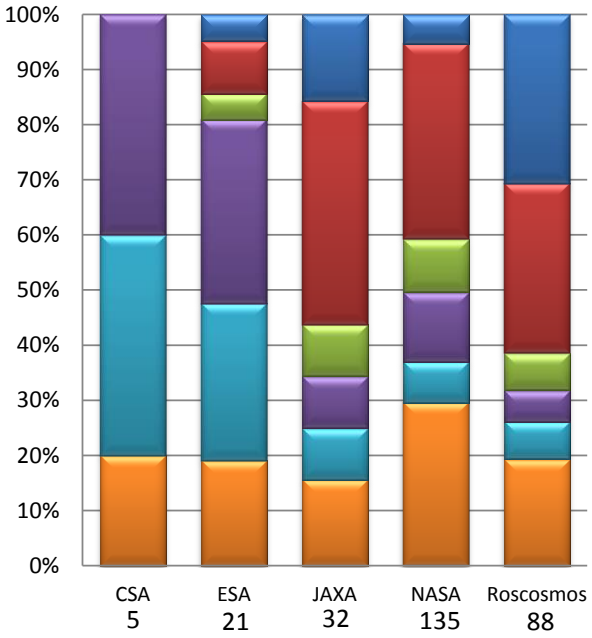
PARTNERSHIP
Current and Future
[POC: Rod Jones/OZ]

Research Disciplines of ISS USOS Investigations by Partner Agency: Expeditions 37/38, 39/40, 41/42, and 42/43

Sept 2013 – Sept 2015: These investigations statistics represented below reflect research operated for Expeditions 37/38; operated, planned, or scheduled for Expeditions 39/40; and planned or scheduled for Expeditions 41/42 and Expeditions 43/44 to date.

Biology & Biotechnology | *Educational & Cultural Activities* | *Physical Science* | *TBD*
Earth & Space Science | *Human Research* | *Technology Development & Demonstration*

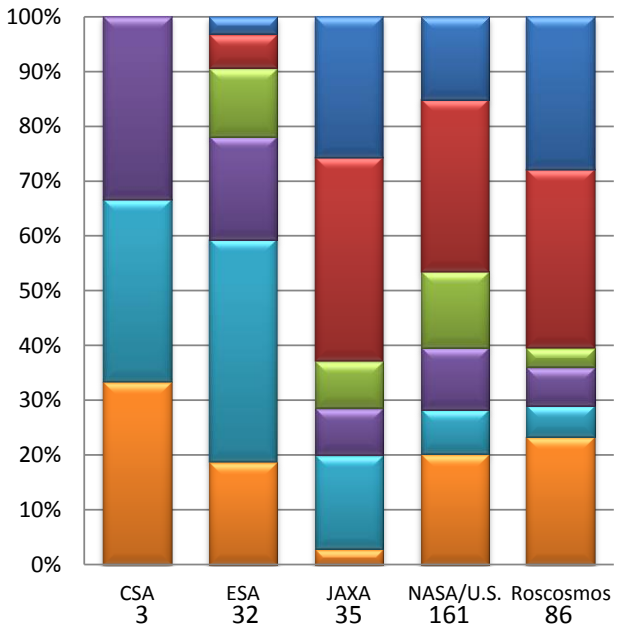
Expeditions 37/38
September 2013 – April 2014



Total Investigations = 281*
*New Investigations = 52**
Investigators with Research on ISS = 640*
Countries with ISS Investigations = 46*

** Prelim numbers, subject to change pending upcoming review.*

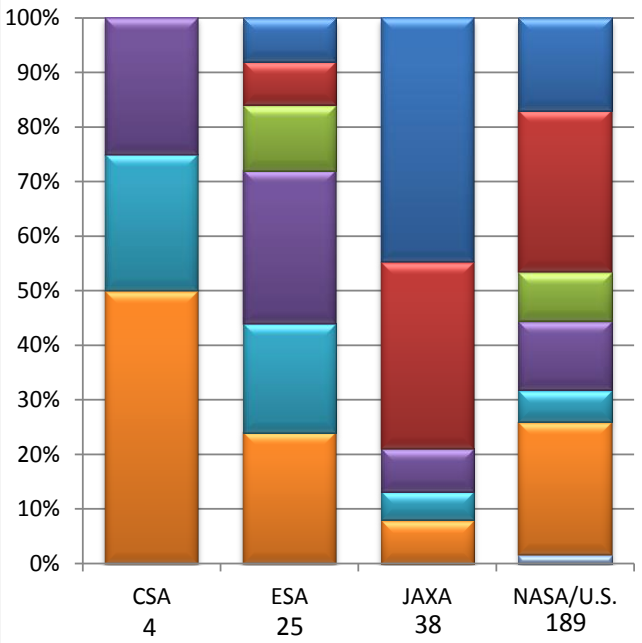
Expeditions 39/40
April 2014 – September 2014



Total Investigations = 315
New Investigations = 75
Investigators with Research on ISS = 382*
Countries with ISS Investigations = 29*

** Prelim numbers, subject to changed pending upcoming review.*

Expeditions 41/42
September 2014 – April 2015

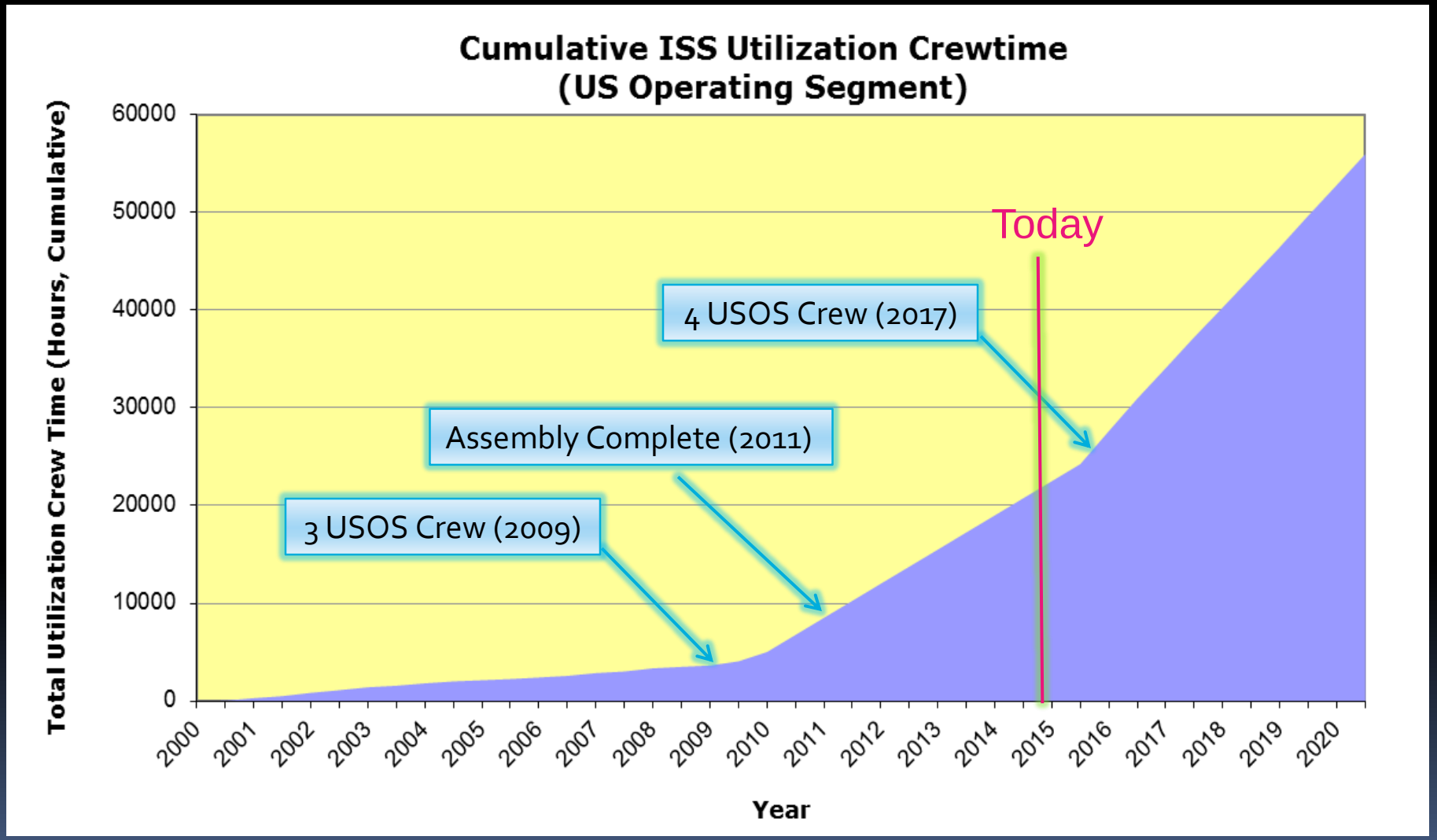


Total Investigations = 256*
New Investigations = 109
Investigators with Research on ISS = 432
Countries with ISS Investigations = *28*

**Roscosmos numbers pending*

Chart prepared by Tracy Thumm (Barrios/MAPI), tracy.thumm-1@nasa.gov and Roger Weiss (Barrios/MAPI), NASA/JSC, ISS-OP, roger.h.weiss@nasa.gov

Accumulative Crew Time Resource



USOS RESEARCH CREW TIME

12 September 2014 (Data through 31 August 2014)

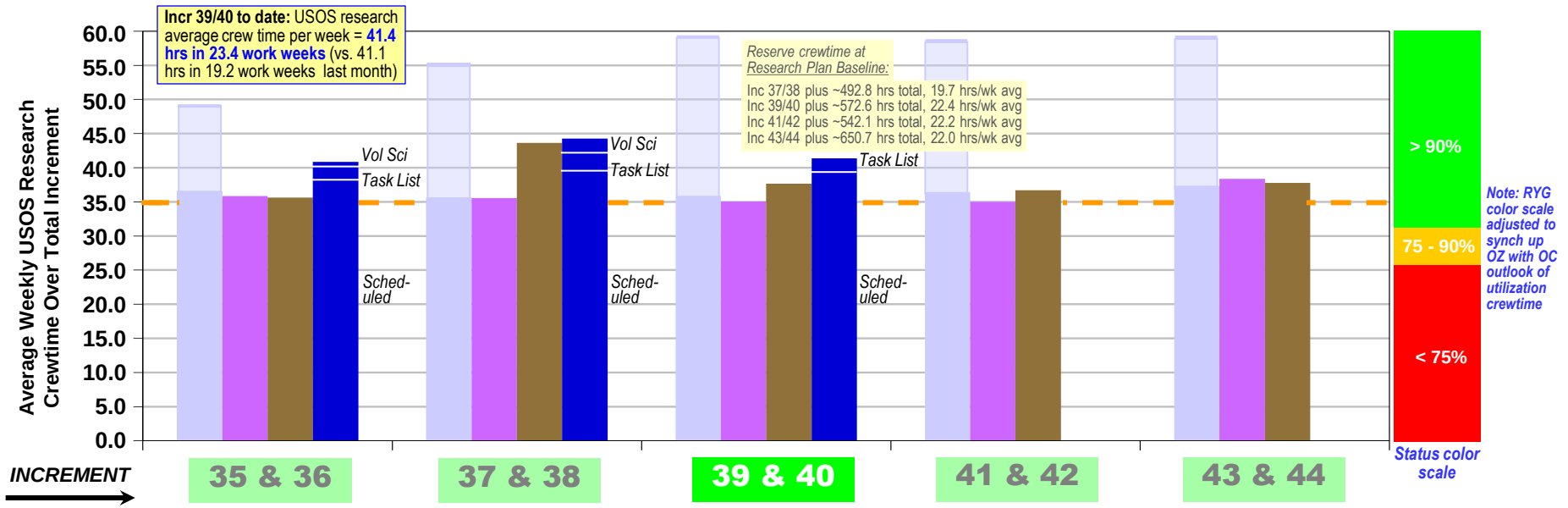
Average Weekly Utilization Actuals Compared to Minimum Requirements, Subscriptions, Allocations, and Scheduled

[POC: Rod Jones/OZ]

Legend

- Generic Groundrules, Requirements & Constraints *(GGR&C)* Minimum Requirement
- L-12 Month Increment Definition and Requirements Document Subscription (or Requirement) from baselined Research Plan
- L-12 Month Increment Definition and Requirements Document *(IDRD)* Allocation
- L-1 Month Pre-Flight On-Orbit Operations Summary *(OOS)* Scheduled (or most-current-to-launch IDRD allocation until final OOS released)
- Actuals Provided -- includes all Scheduled, Task-List, Voluntary Science, Commissioned, and utilization during joint docked operations *(IMC)*
- Plus *n#* Hours Per Week Average Reserve Crewtime *(from Annex 5 Payload Tactical Plan or Multilateral Research Control Board Approval)*

Status: GREEN ➡ **Based on continued research activity as avg weekly crewtime edged up, still above OOS scheduled hrs. Strong throughput expected in Sept as Exp 40 concludes, and utilization to keep in high gear into Exp 41. *(Last month ⬆)***



	Avg weekly	Total	Avg weekly	Total	Avg weekly	Total	Avg weekly	Total	Avg weekly	Total
GGR&C (Min Reqt)	35.0	875.0	35.0	875.0	35.0	875.0	35.0	875.0	35.0	875.0
L-12 IDRD Subscription	36.6	893.7	35.7	884.2	35.9[b]	918.7[b]	36.5[e]	889.5[e]	37.4[h]	1106.2[h]
L-12 IDRD Allocation	35.9	876.0	35.6	882.0	35.0[c]	896.3[c]	35.0[f]	854.0[f]	38.4[i]	1136.0[i]
L-1 OOS Sched *(or IDRD Alloc)*	5.6	869.5	43.6	1082.0	37.6[d]	963.7[d]	36.7[g]	895.4[g]	37.8[j]	1117.8[j]
Actuals (to date)	41.3	949.0	44.3	1097.7	**41.4[a]** *To Date*	**968.3[a]**	--	--	--	--

Int'l Partner Sub-Allocations and Actuals Breakdowns

IP	L-1 hrs	Percent	Final
NASA	684.3	78.0%	740.0
ESA	71.9	9.0%	85.2
JAXA	92.7	9.0%	85.0
CSA	17.3	3.2%	30.1

(includes 2.0 total hrs commissioning)

IP	L-1 hrs	Percent	Final
NASA	855.6	78.3%	859.8
ESA	87.3	8.6%	94.1
JAXA	116.4	10.3%	113.6
CSA	22.7	2.8%	30.3

IP	L-1 hrs	To Date	Percent
NASA	746.8	772.6	79.8%
ESA	92.1	87.2	9.0%
JAXA	106.0	86.8	9.0%
CSA	18.8	21.8	2.3%

(18.3 total hrs commissioning added to Req't)

[e]*Per Research Plan, baselined at MRICB/MMIOCB, 10/30/13.* [f]*Per draft Payload Authorization Letter, signed Nov 2013.* [g]*Per L-1 Final OOS revision, Sept 2014*

[h]*Per Research Plan, baselined at MRICB/MMIOCB, 6/4.14.* [i]*Per draft Payload Auth Letter, April 2014. PTP baselined June 2014.* [j]*Per PTP, Rev A in work, 9/2/14.*

[a]*Incr 39/40 actuals to date after **23.4 work weeks***

[b]*Per Research Plan, baselined at MRICB/MMIOCB, 4/17/13;*

[c]*L-12 allocation per Planning Authorization Letter, April 2013;*

[d]*Per Final Preflight OOS, February 2014*

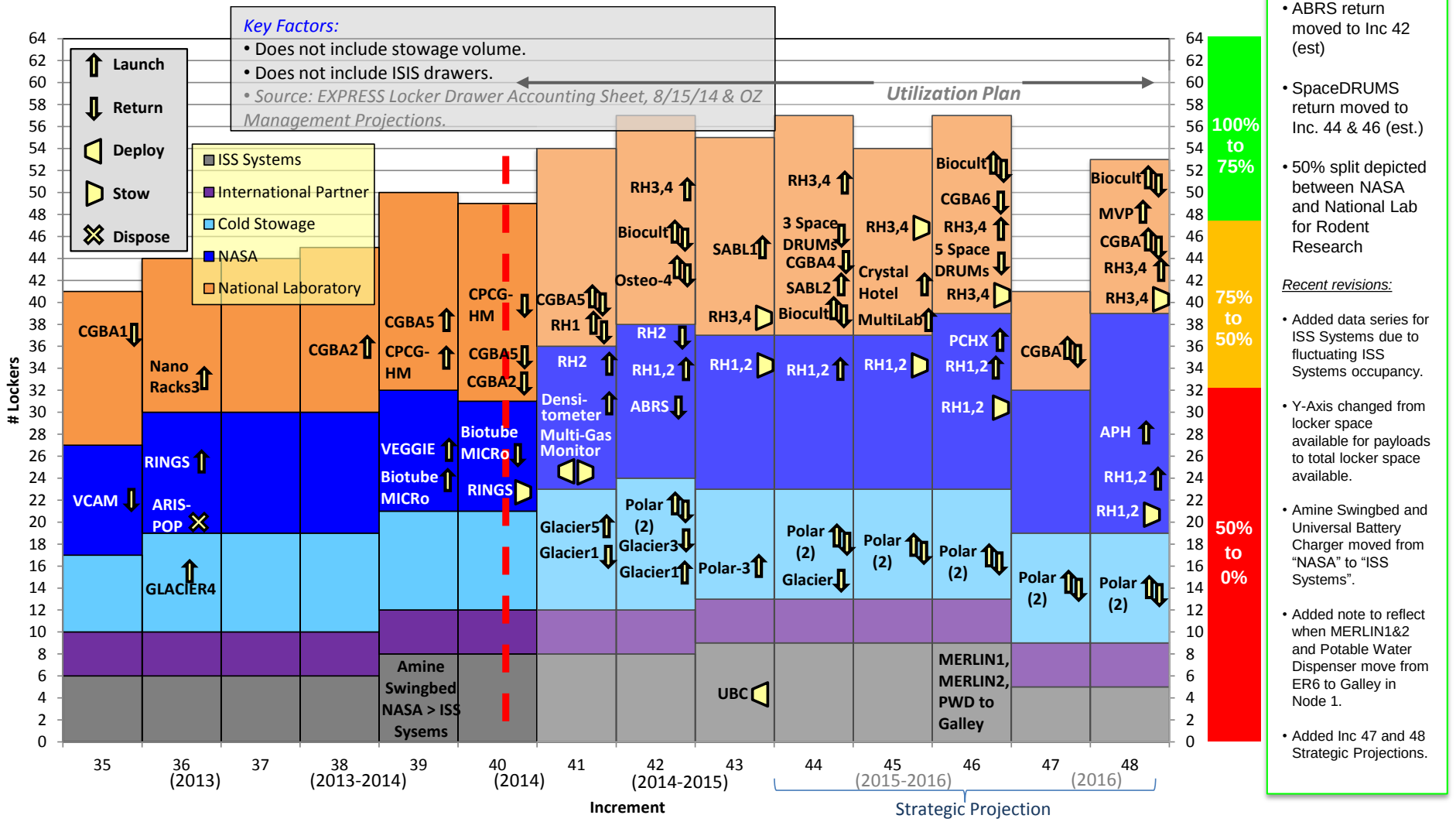
Chart prepared by Roger Weiss (Barrios/MAPI), NASA/JSC, ISS-OP, roger.h.weiss@nasa.gov

ISS OCCUPANCY -- EXPRESS RACKS

12 September 2014 (Data through 31 August 2014)

Number of EXPRESS Inserts in Available EXPRESS Accommodations

[POC: Rod Jones/OZ]



Update

- ABRS return moved to Inc 42 (est)
- SpaceDRUMS return moved to Inc. 44 & 46 (est.)
- 50% split depicted between NASA and National Lab for Rodent Research

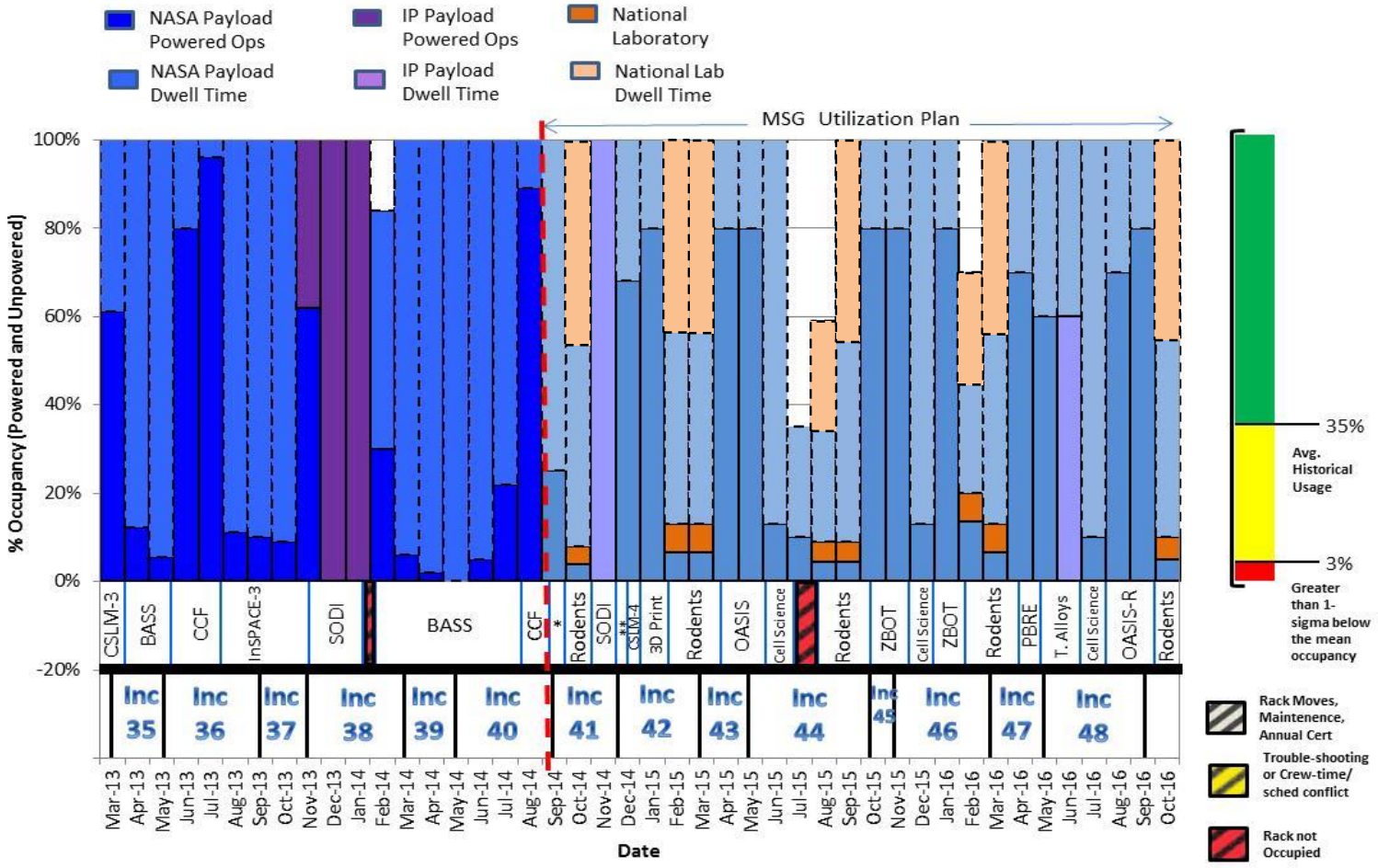
Recent revisions:

- Added data series for ISS Systems due to fluctuating ISS Systems occupancy.
- Y-Axis changed from locker space available for payloads to total locker space available.
- Amine Swingbed and Universal Battery Charger moved from "NASA" to "ISS Systems".
- Added note to reflect when MERLIN1&2 and Potable Water Dispenser move from ER6 to Galley in Node 1.
- Added Inc 47 and 48 Strategic Projections.

Chart prepared by Sean Thompson, NASA/MSFC, sean.thompson@nasa.gov and Roger Weiss (Barrios/MAPI), NASA/JSC, ISS-OP, roger.h.weiss@nasa.gov

ISS OCCUPANCY -- MSG RACK and POWERED OPS

12 September 2014 (Data through 31 August 2014) ***[POC: Rod Jones/OZ]***



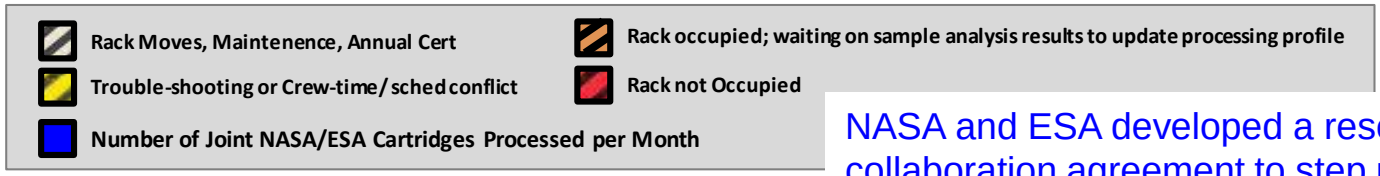
Update:

- MSG occupied by BASS until Aug 5 when it was replaced by CCF.
- BASS and CCF combined operated for 89% of available hours in August.
- BASS completed 128 sample runs, 103 baseline and 25 extra.
- * VUE hardware checkout and CSLM ECU will occur after CCF and before rodents installed.
- ** Micro 5 (~4 days) and Bioculture Systems (~4 days) will be run in MSG after SODI and prior to CSLM-4.
- Note: T. Alloys is short for Transparent Alloys, which was formerly listed as DIRSOL.
- 50% split depicted between NASA and National Lab for Rodent Research

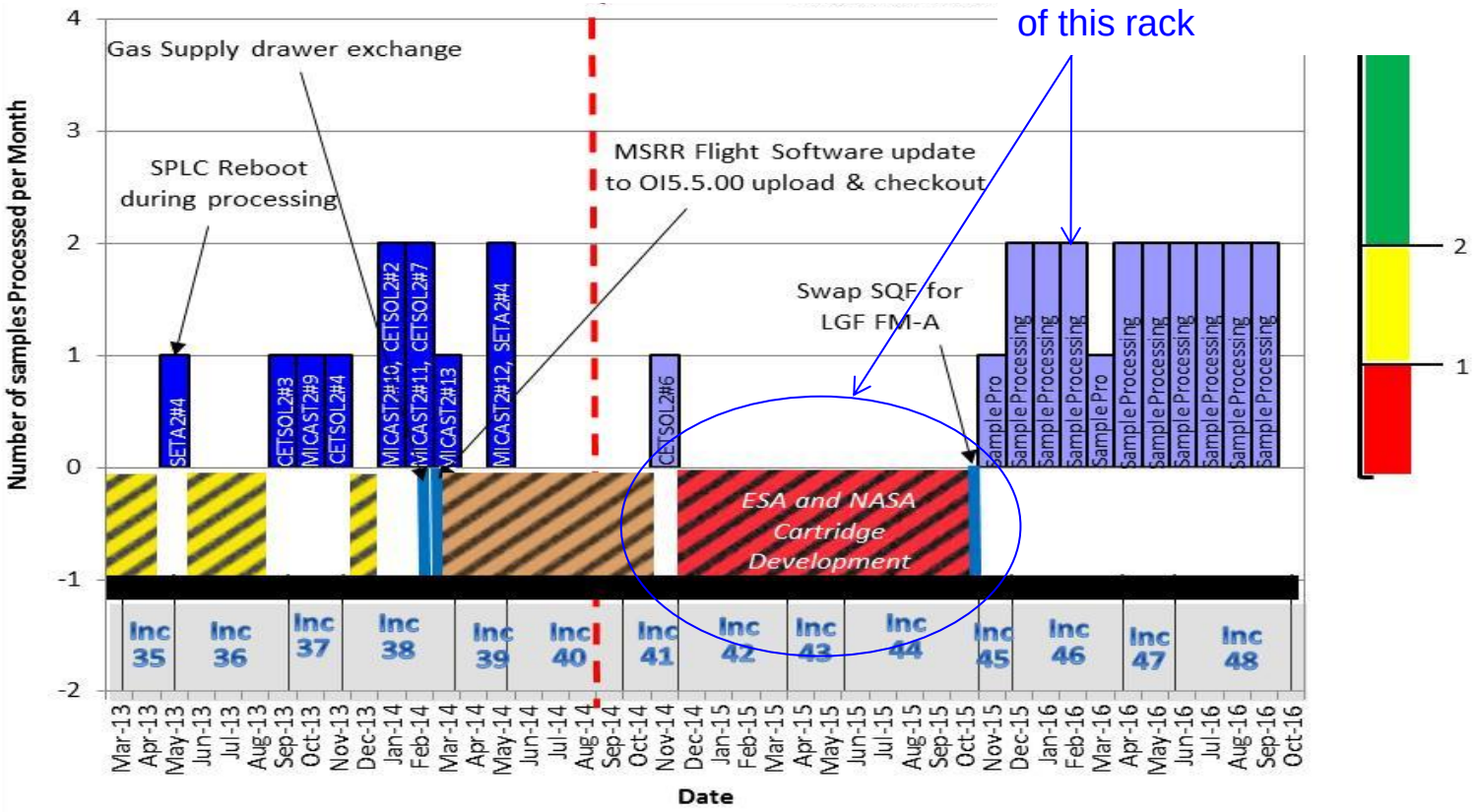
Chart prepared by Andrew Tygielski, TecMasters, NASA/MSFC, andrew.p.tygielski@nasa.gov and Roger Weiss (Barrios/MAPI), NASA/JSC-ISS-OP, roger.h.weiss@nasa.gov; and originated by Kirt Costello, NASA/JSC--OZ111, kirt.costello-1@nasa.gov

ISS OCCUPANCY – MSRR/MSL FACILITY and POWERED OPS

12 September 2014 (Data through 31 August 2014) ***[POC: Rod Jones/OZ]***



NASA and ESA developed a research collaboration agreement to step up utilization of this rack



- CETSOL2#6 processing planned for the early Nov 2014 timeframe. Analysis results from the CETSOL samples returned on SpX-3 will determine processing parameters.
- Plan to return 5 SCAs on SpX-4, this assumes CETSOL2#6 processing is completed prior to SpX-4 return.
- Gas Supply return flight is still being determined. It may return on SpX-4 as originally planned.

Note: The yellow/black hatch area in Inc 38 is a constraint against operations due to SOLAR operations, i.e., cannot vent when SOLAR is operating.

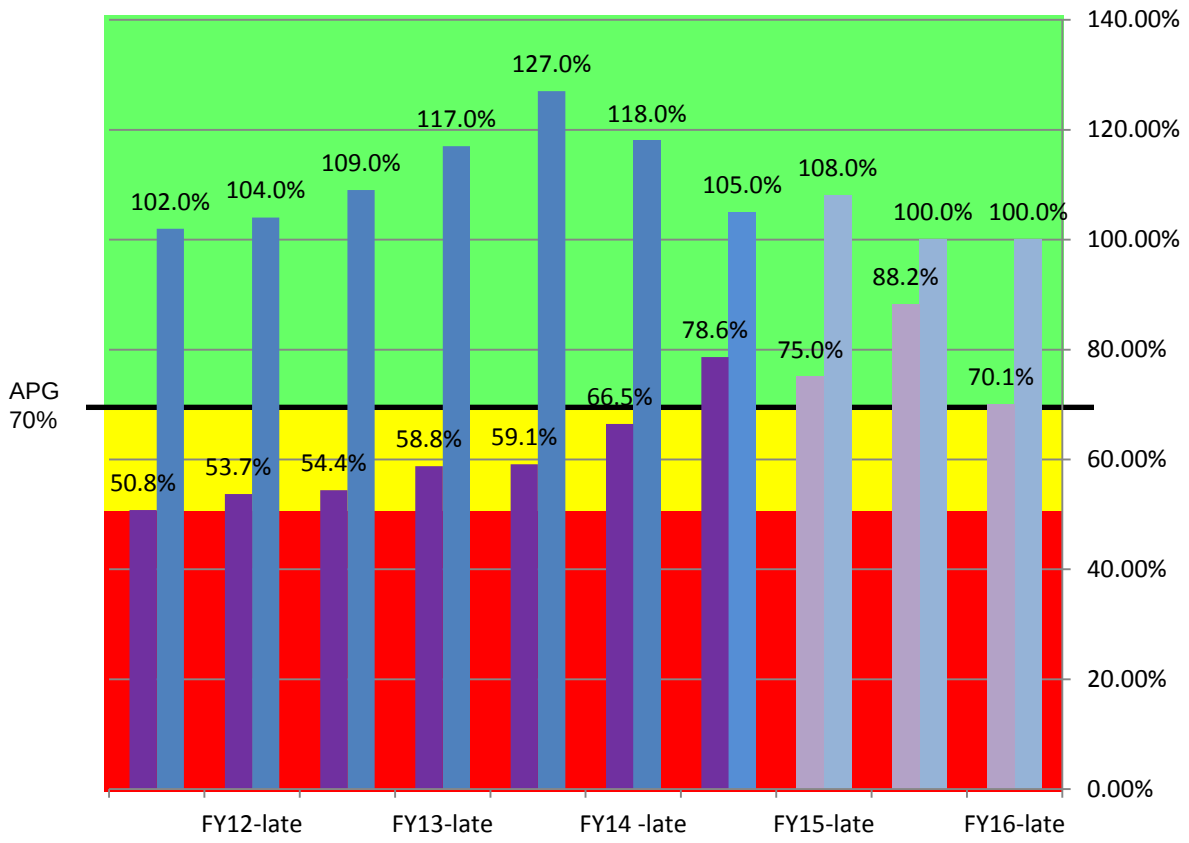
Chart prepared by Shawn Reagan, NASA/MSFC, sean.reagan@nasa.gov; Natalie Frazier, NASA/MSFC, natalie.c.frazier@nasa.gov and Roger Weiss (Barrios/MAPI), NASA/JSC-ISS-OP, roger.h.weiss@nasa.gov and originated by Kirt Costello, NASA/JSC--OZ111, kirt.costello-1@nasa.gov

ISS OCCUPANCY -- Annual Program Goal

12 September 2014 (Data through 31 August 2014) ***[POC: Rod Jones/OZ]***

Pre-decisional, for internal use only

Use of Laboratory Capacity (Increment 29-46, FY12-FY16)



Full Utilization Defined

ISS Laboratory facilities and resources are fully subscribed and have been expanded where possible to meet users needs*:

- Crew time for research is fully subscribed (Blue Bars)
- Facility duty cycles are fully subscribed and all research facility locations are occupied (Purple Bars)

* Transportation does not limit research at this time.

Note: FY15 and beyond not in tactical timeframe, and subject to change.

100% Utilization of crew time = 35 Hours/wk. (Baseline Revision under assessment SSPCB Action 127451)
100% Facility Occupancy = All Internal Racks at Assembly complete fully occupied and multiuse facilities operating at 100% duty cycle + All 16 External payload sites occupied.

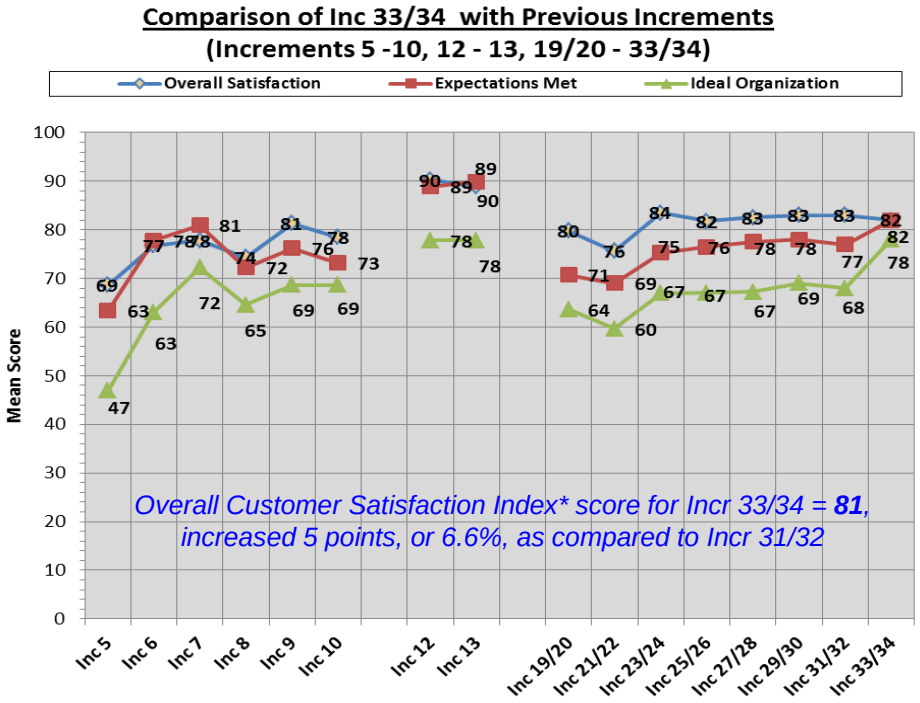
Chart prepared by Kirt Costello, NASA/JSC--OZ, kirt.costello-1@nasa.gov

ISS RESEARCH CUSTOMER SATISFACTION

12 September 2014 (Data through 31 August 2014)

Incr 33/34 Summary

[POC: Rod Jones/OZ]



- Survey interviews comprised 34 rating questions (3 @ 10-point scale; 28 @ 5-point scale, 3 open-ended) on various aspects of ISS Research development, integration, processes, interfaces, operation, and support.
- 21 investigation respondents (PIs, PDs, project mgrs) participated in phone-based survey interviews, notable increase from previous Incrs.
- Real-time operations support and amount of raw data collected from ISS continue to be strong areas of satisfaction in respondents' experiences.
- PI satisfaction responses were not consistently higher than PD satisfaction responses, as seen on previous increments.

BASIS TOP SURVEY QUESTIONS :

(1) Please rate your *overall satisfaction* with the ISS Utilization Program.
(2) Please rate the degree to which the ISS Utilization Program *met your expectations*.
(3) How close to your *ideal organization* for ISS utilization management would you rate the ISS Utilization Program.

**The Overall Satisfaction Index metric at left is calculated by taking the average of the mean scores of the 3 basis questions above (based on 10-point ratings for each), and recalculating it to a 0 to 100 scale. The basis for the questions are similar in form to those used in surveys for the American Customer Satisfaction Index (ACSI), a nationally recognized, long-standing index that compares customer satisfaction across commercial industry as well as public-sector organizations.*

Key Issues and Concerns	Resolution	Intent
Amount of Data and Documentation	The Systems Engineering and Integration team is performing a comprehensive review of all ICD requirements and processes for documenting and verifying to these requirements.	*With both efforts, the intent is to minimize impact to Payload Developers allow them to deliver the required data for successful payload integration.*
Accessing and Locating Information	The OZ Requirements Baselining and Integration Tool (ORBIT) is under development, and will integrate many different data sets to one location to be shared across multiple users in the program.	

Chart prepared by Jason Leblanc, (Barrios/MAPI), NASA/JSC, ISS-OP, jason.e.leblanc@nasa.gov, and Roger Weiss (Barrios/MAPI), NASA/JSC, ISS-OP, roger.h.weiss@nasa.gov

How do we know if we are at full utilization?

- Real estate bottom line:
  - Racks 69% occupied
  - EXRESS 60% occupied, expect 80% by the end of 2014
  - External Sites 35% occupied, expect 75% by end of 2014
  - Best external sites (best viewing with good Nadir or Zenith views) are mostly claimed through 2020
- Crew time bottom line:
  - Scheduled time oversubscribed (>100%)
  - Crew as human subjects oversubscribed (multi-year queue carefully managed by HRP, a big issue for our partners, limits CASIS research)
  - NASA and CASIS users are soon going to compete for this limited resource Underscores importance of adding the fourth crew
- Up mass/Down mass bottom line:
  - Up mass not limiting--No backlog on the ground today, projected mass capacity is good
  - Our on-orbit freezers are nearly full (>100%), dependent on regular SpaceX return, new transportation units in development with great volume efficiency being deployed this year

Additional Infrastructure for Full Utilization Being Pursued

Tactical Improvements

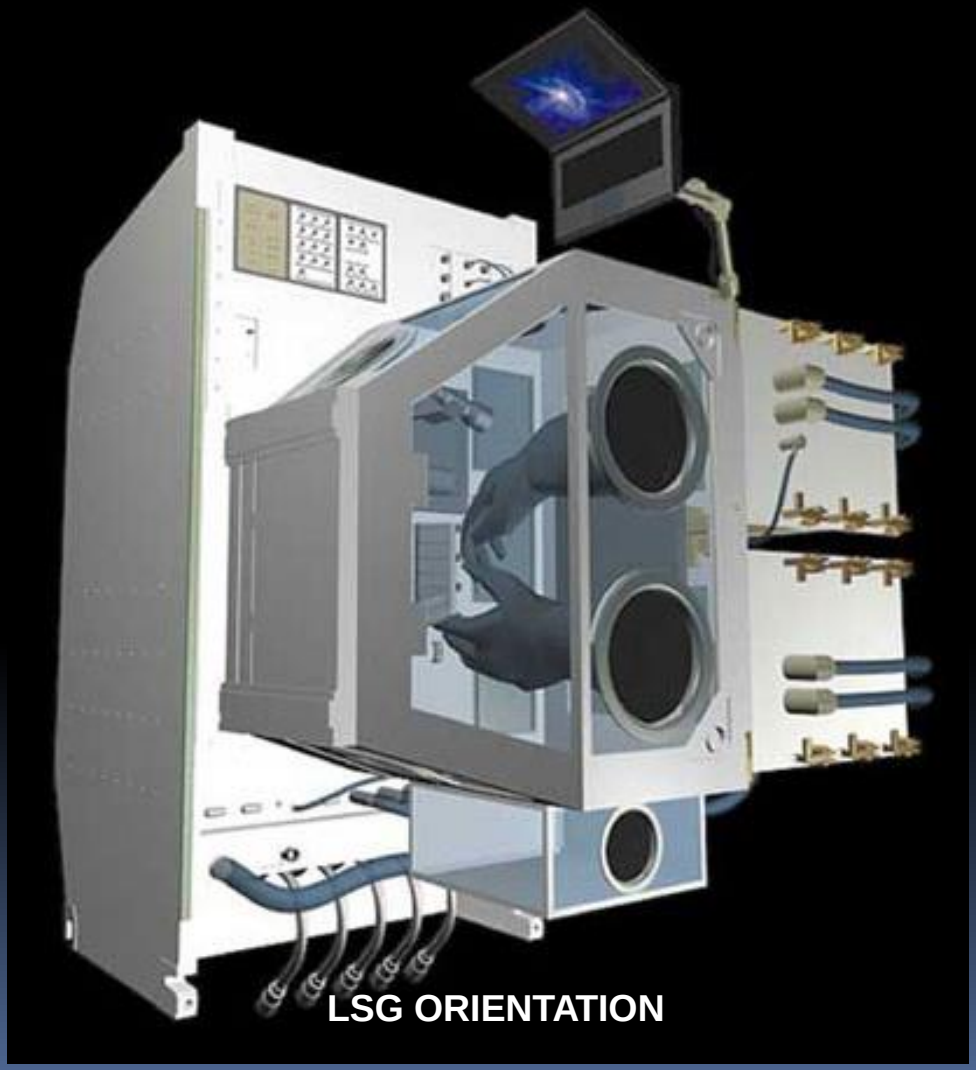
- MSG modifications for simpler access, big door
- Development of an additional full size glove box
- Development of simplified EXPRESS racks
- Additional external Payload sites
- External wireless data
- Provide more GSE/FSE (connectors, test equipment) to simplify and reduce payload integration schedule
- Improve transportation Services (power, data, environment's, mission flexibility)

Strategic Improvements

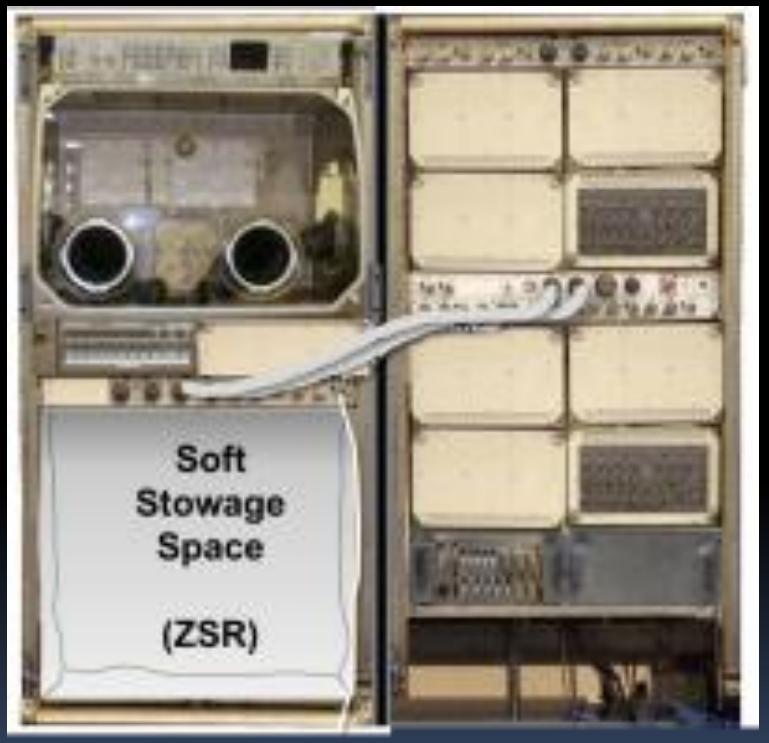
- 4th crew person
- Increase in data rates to 600 Mbps
- Expansion of external wireless
- Live animal return

Life Sciences Glovebox – Proposed Options

CR funded to SRR with 2 design options



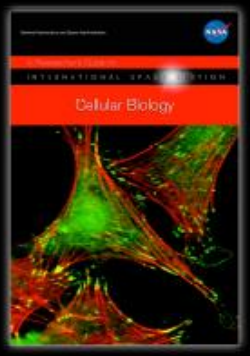
LSG ORIENTATION

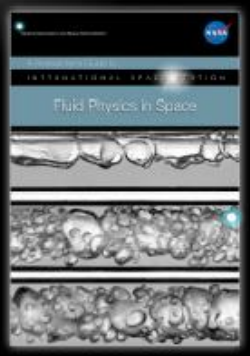


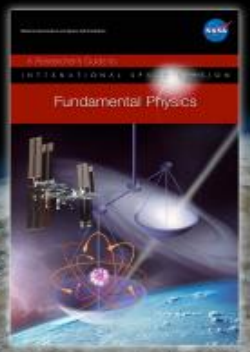
MSG-2 ORIENTATION

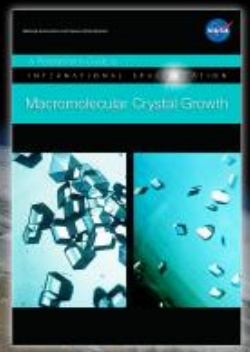
INTERNATIONAL SPACE STATION

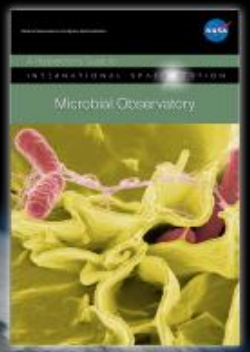
Researcher's Guide Series



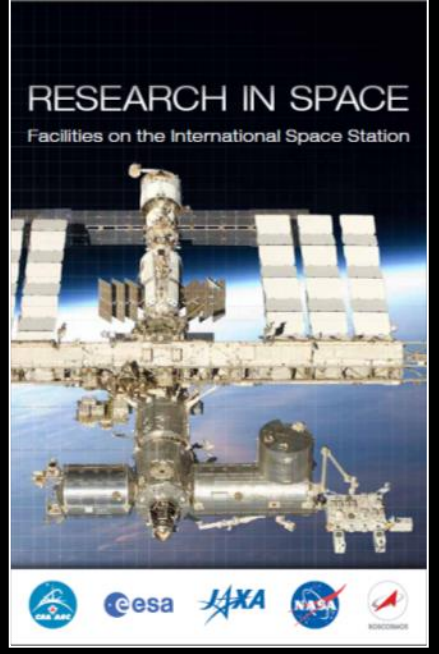








For More Information



World Wide Web

http://www.nasa.gov/iss-science/

Facilities Catalog

http://www.nasa.gov/mission_pages/station/research/facilities_category.html

Opportunities

http://www.nasa.gov/mission_pages/station/research/ops/index.html

Center for the Advancement of Science in Space

http://www.iss-casis.org/Home.aspx

CASIS™

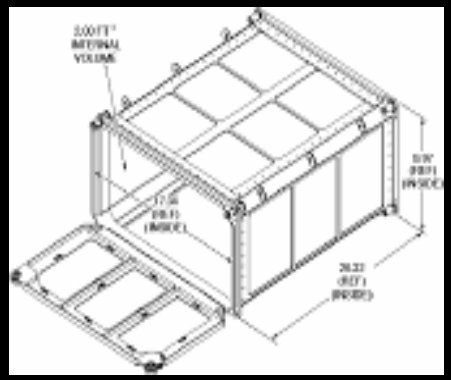
ISS Research Facilities and Capabilities

Multi Purpose Research Facilities
Physical & Material Sciences
Biology and Biotechnology
Human Research
Earth and Space Science Platforms
Technology Test Beds
Robotics Systems

ExPRESS Racks

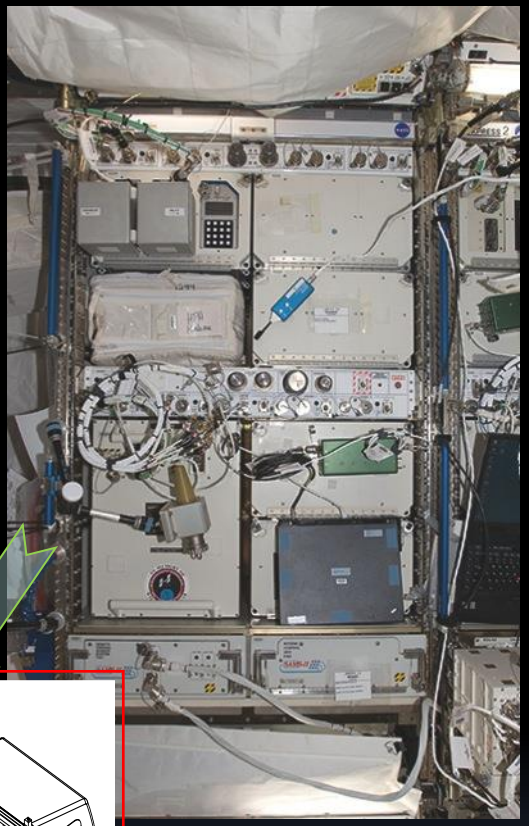
(Expedite the Processing of Experiments for Space Station)

Middeck Locker

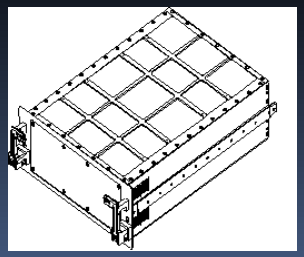


Features
- 4 rear captive fastener attachments
- Friction hinge
- Dual door locks
- Installation tool guides on 4 corners
- Weight – 12 lbs

Sub Rack size payload capability with standard utilities such as power, data, cooling and gases



International Sub rack Interface Standard Drawer



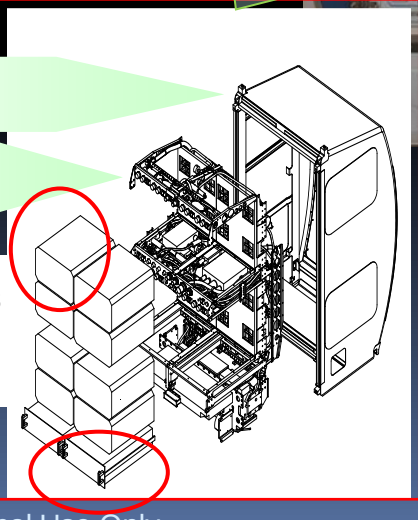
Features
- 4 PU (Panel Unit)
- Blind Connectors
- Locking Handles
- Weight – 27 lbs
- Rated to at least 37 lbs

EXPRESS 8/2 Configuration

International Standard Payload Rack

Secondary Structure & Subsystems

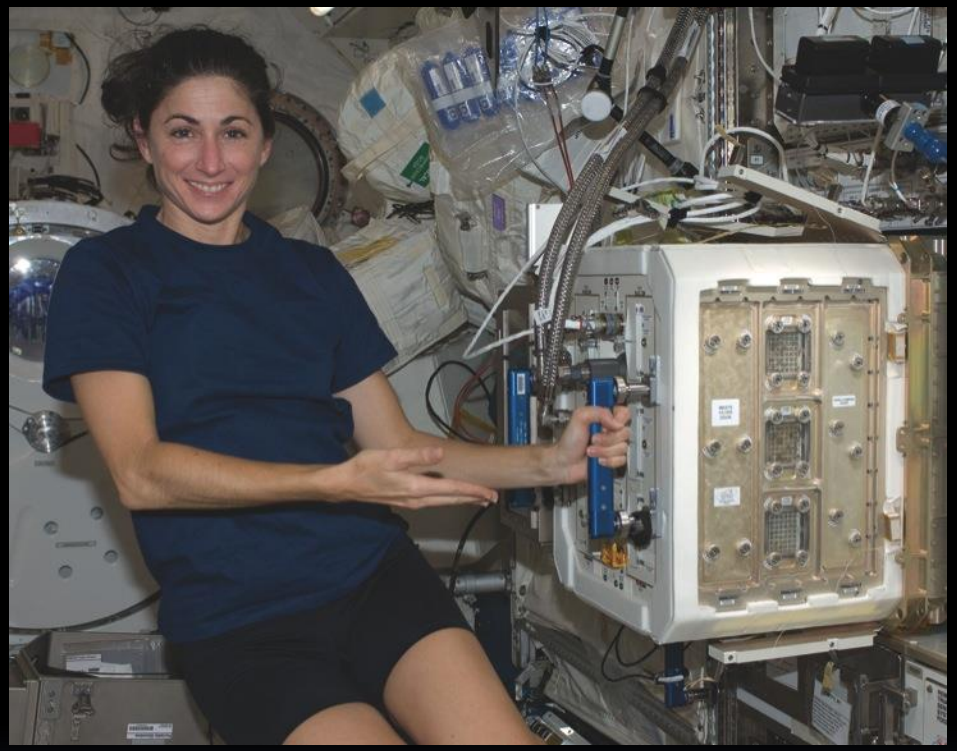
8/2 Payload Configuration (8 Middeck Lockers, 2 Powered ISIS Drawers)



ExPRESS Rack on-orbit

ExPRESS Sub Rack Payloads

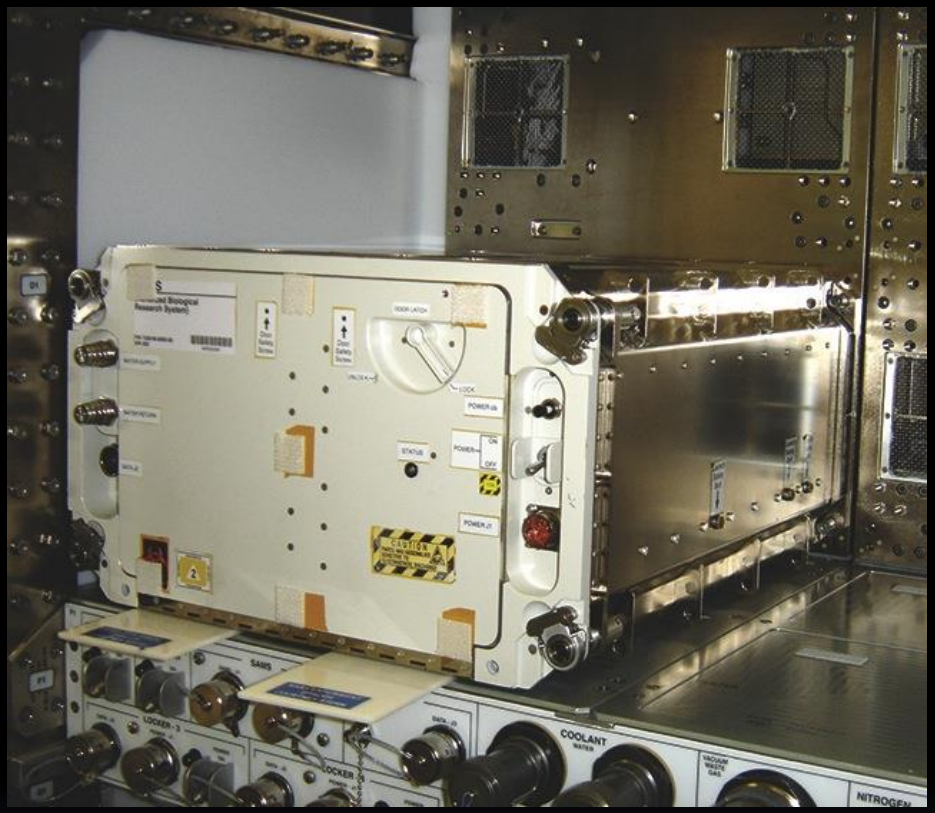
Space Dynamically Responding Ultrasound Matrix System (SpaceDRUMS)



ASI Mouse Drawer System (MDS)

Supported 6 mice on orbit for 90 days

ExPRESS Sub Rack Payloads



ABRS

Advanced Biological Research System

Two growth chambers; each chamber is a closed system capable of independently controlling temperature, illumination, and atmospheric composition to grow a variety of biological organisms.

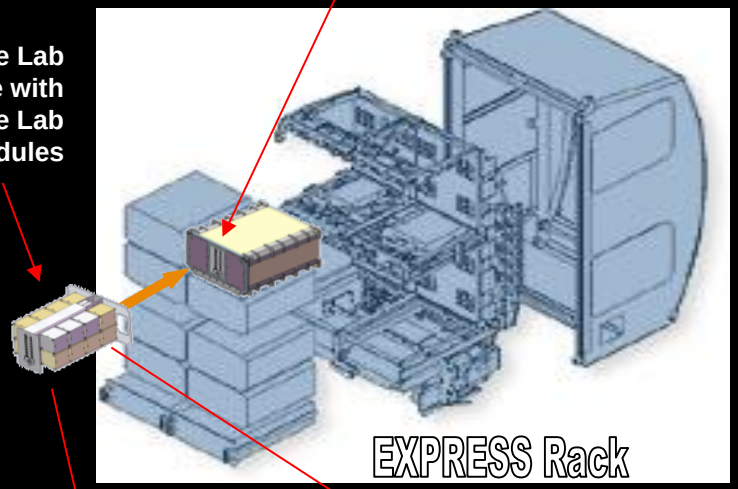
Cube Lab Sub-locker Payload

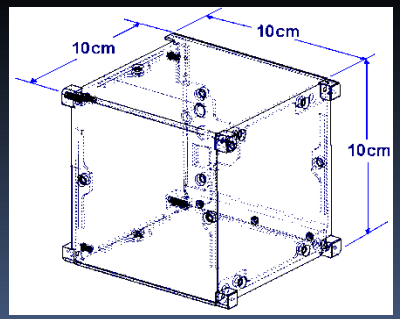
SCIENCE TEAM: NANORACKS, LLC

RESEARCH OBJECTIVES:

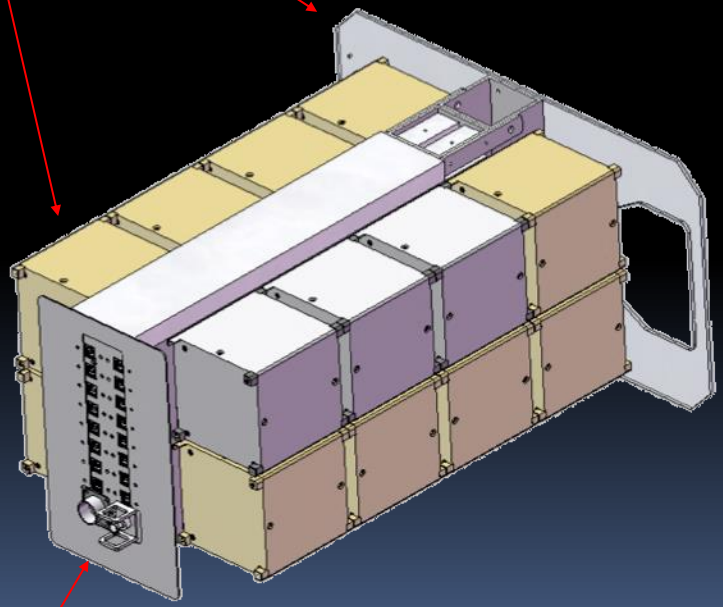
Cube Lab is a multipurpose research facility consisting of CubeSat platform experiment modules (Cube Lab Modules) and Cube Lab Frames. Three Cube Lab Frames are being installed as EXPRESS Rack inserts to supply power and USB data transfer capability for Cube Lab Modules on ISS. The Frames are made to house up to 16 standard-sized Cube Lab Modules (1 CU size = 10cmx10cmx10cm).

Each Cube Lab Module has different educational or industrial researcher(s). Each Module plugged into a Frame can provide USB data file transfer capability if an experiment requires it. The transfer is conducted with the Module plugged-into a Frame and use of a temporary Cube Lab Data Cable connection between the FRAME and an EXPRESS Laptop Computer. The Modules also come in multiples of the 1CU size: 4 CU = 40cmx10cmx10cm and 8 CU= 40cmx10cmx20cm.





Cube Lab Module



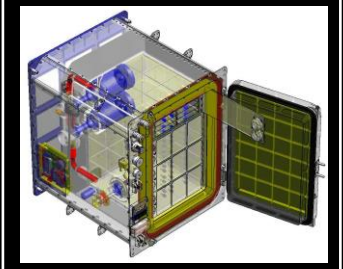
Cube Lab Frame

Minus Eighty-degree Laboratory Freezer for ISS (MELFI)

Provides thermal conditioning at +4°C, -26°C and -80°C for sample (blood, urine, tissue, etc) preservation

3 Units on-orbit

Cold Stowage Accommodations

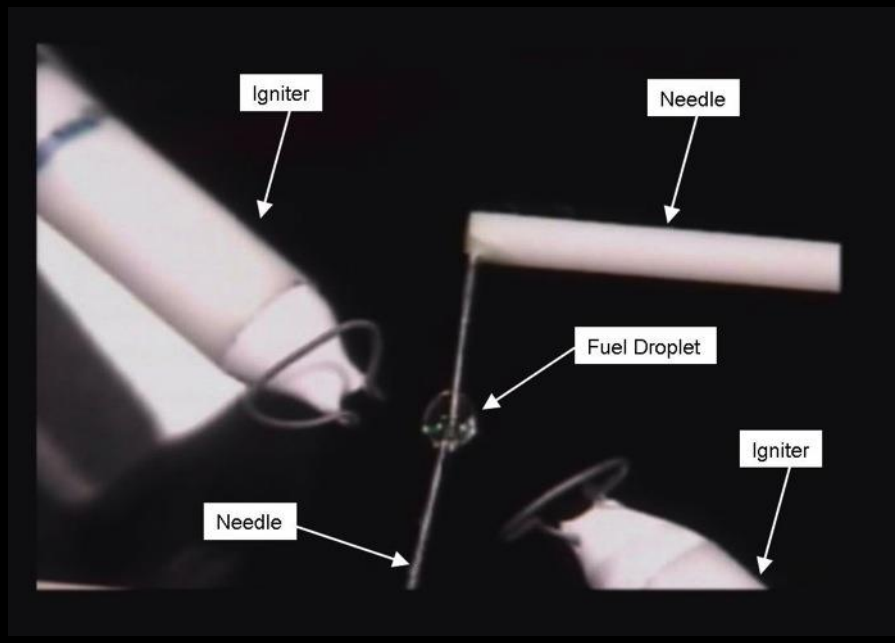
	MELFI	MERLIN	GLACIER	Single and Double Cold bag with ICEPAC's
				
Transport	No	Yes	Yes	Yes
Power	Yes	Yes	Yes	No
On-orbit temperature (ºC)	+4, -26, -80	+45 to -20	+4 to -185	N/A
Transport temperature (ºC)	N/A	+45 to -5	+4 to -160	+4 to -32
Useable volume (L)	175	19	30	6.8/18.7
External volume	1 rack	1 MLE	2 MLE	0.5/1 MLE

Material Science Glove Box

Provides a safe environment for research with liquids, combustion, and hazardous materials

Combustion Integrated Rack *(CIR)*

Facility used to perform sustained, systematic combustion experiments in microgravity



Sample during combustion

Materials Science Research Rack-1

(MSRR-1)

ESA Provides the furnace ‘s and sample cartridges

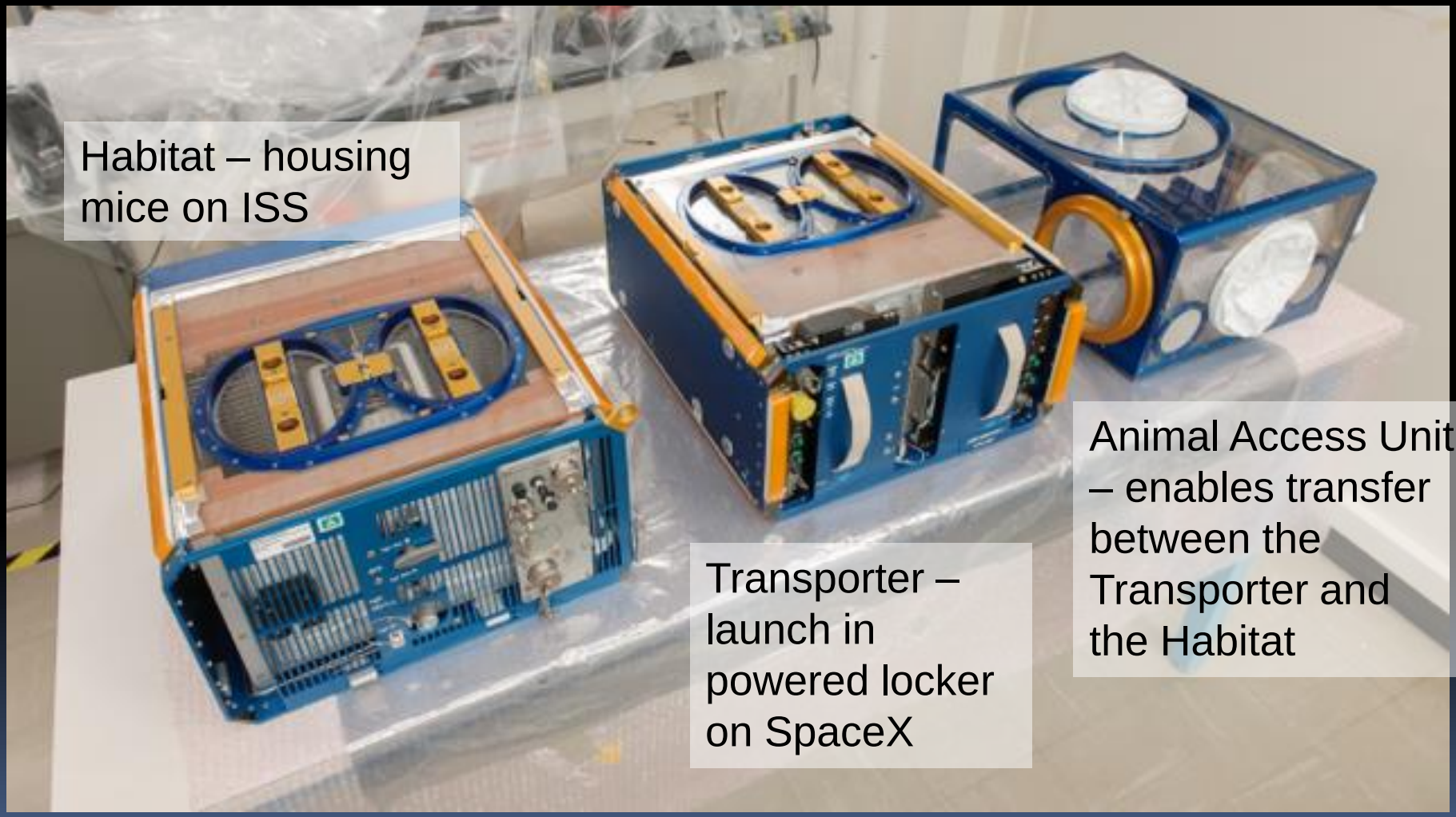
Solidification and Quenching Furnace in the ESA Material Science Laboratory (MSL)

NASA Provides the rack and on-orbit space

MICAST = Microstructure Formation in Casting of Technical Alloys under Diffusive and Magnetically Controlled Convective Conditions
Studies formation of microstructures during casting of technical alloys

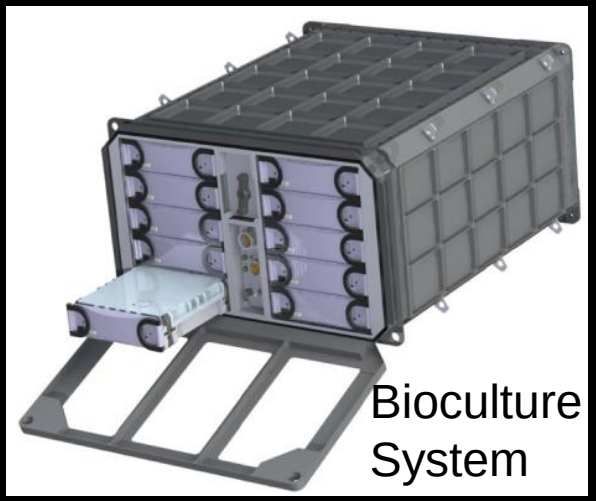
Investigations selected from both agencies

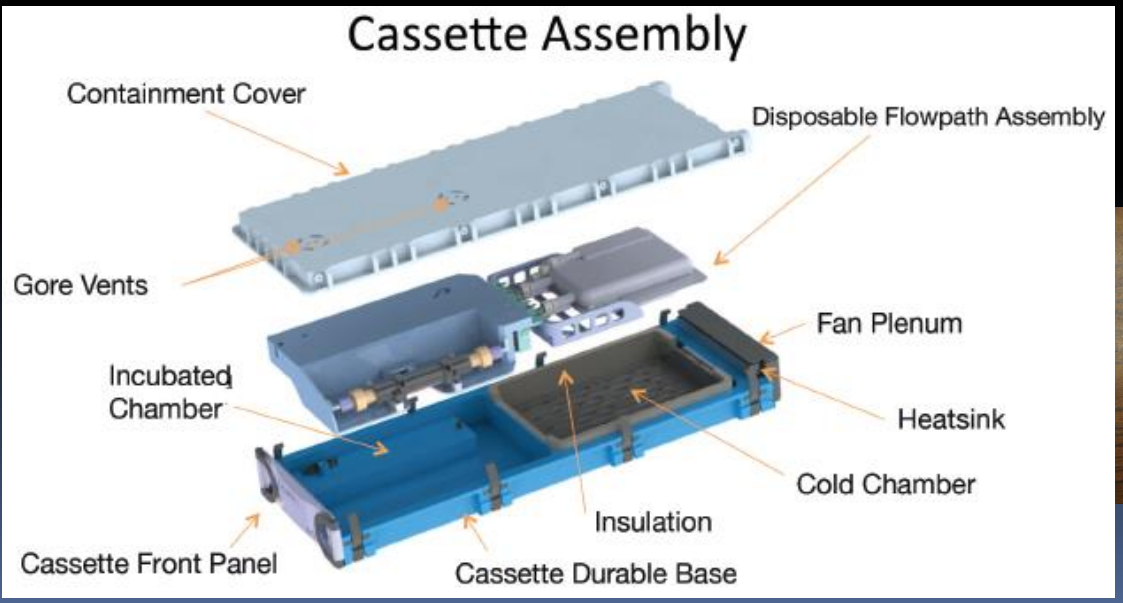
Rodent Research Flight Hardware

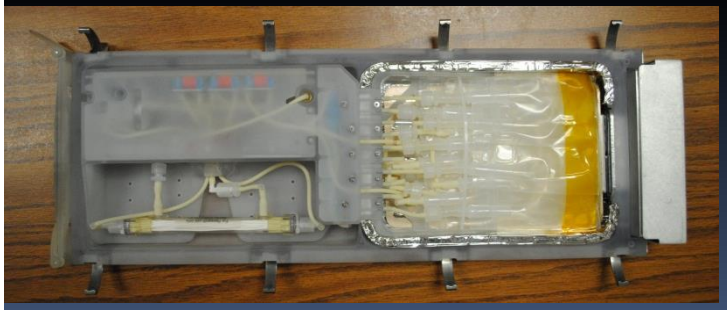


Cell Science Payloads

- Provides 10 individual cassettes containing hollow fiber bioreactors with media perfusion for a cell culture environment
- Supports adherent and non-adherent cell types, including 3-D tissues and micro-organisms



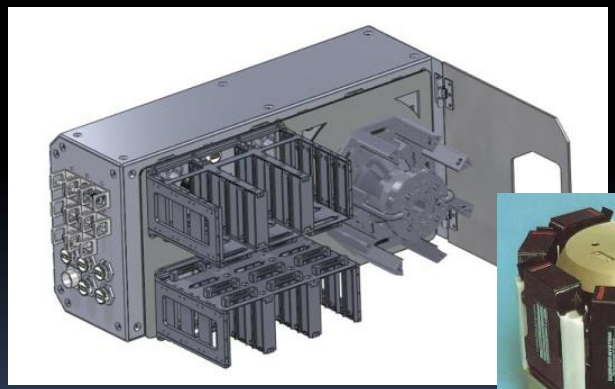




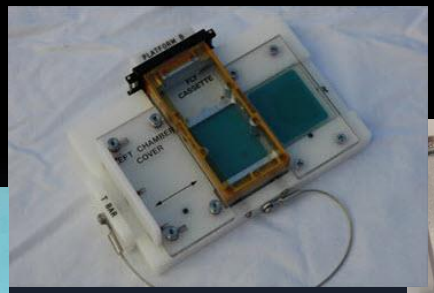
Disposable Flow Path Top View

Fruit Fly Lab Payloads

- Support *Drosophila* studies on ISS by re-flying existing h designs
- The Fruit Fly (*Drosophila Melanogaster*) has been an important biological model organism for over 100 years.
- 75% of disease-related genes in humans have functional orthologs in the fly (***Genome Res***. 2001 Jun; 11(6):1114-25).

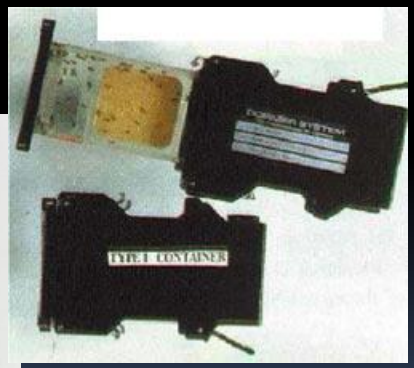


Astrium/Nanoracks Facility and Centrifuge for Housing FFL Containers



Transfer Tool

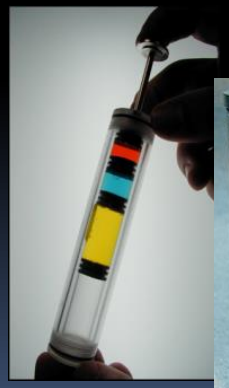
Observation System



Type I containers with Fruit Fly habitat

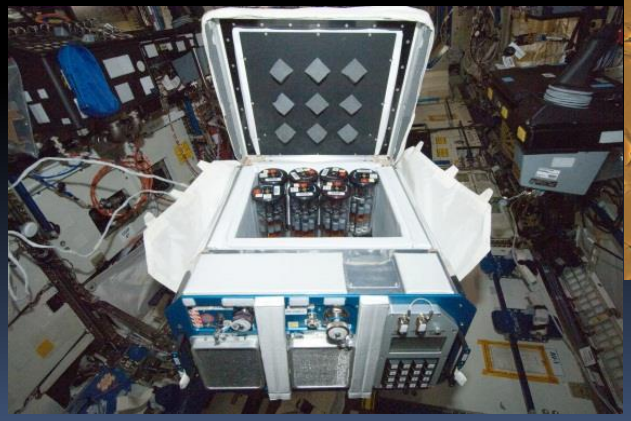
Micro Payloads

- Small payloads for molecular, cellular and small/micro-organism research on ISS
- PI&O is supported by BioServe Space Technologies
- No Sustaining Engineering Required
- 5 Successful Micro Payloads flown to-date and 3 additional payloads in process

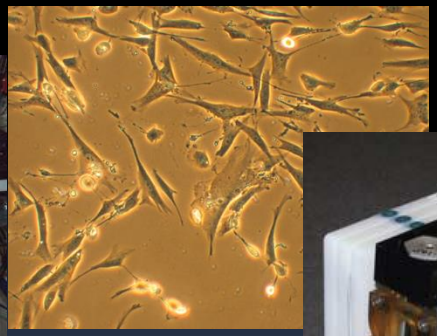


FPA

GAP

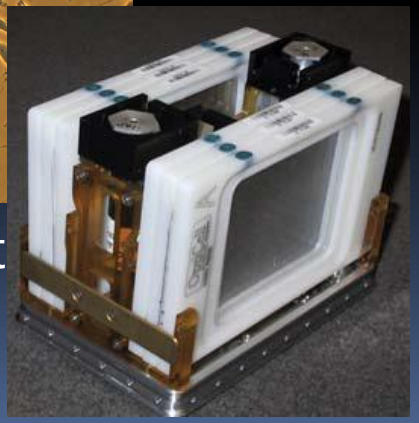


Incubator



Fibroblast Cells

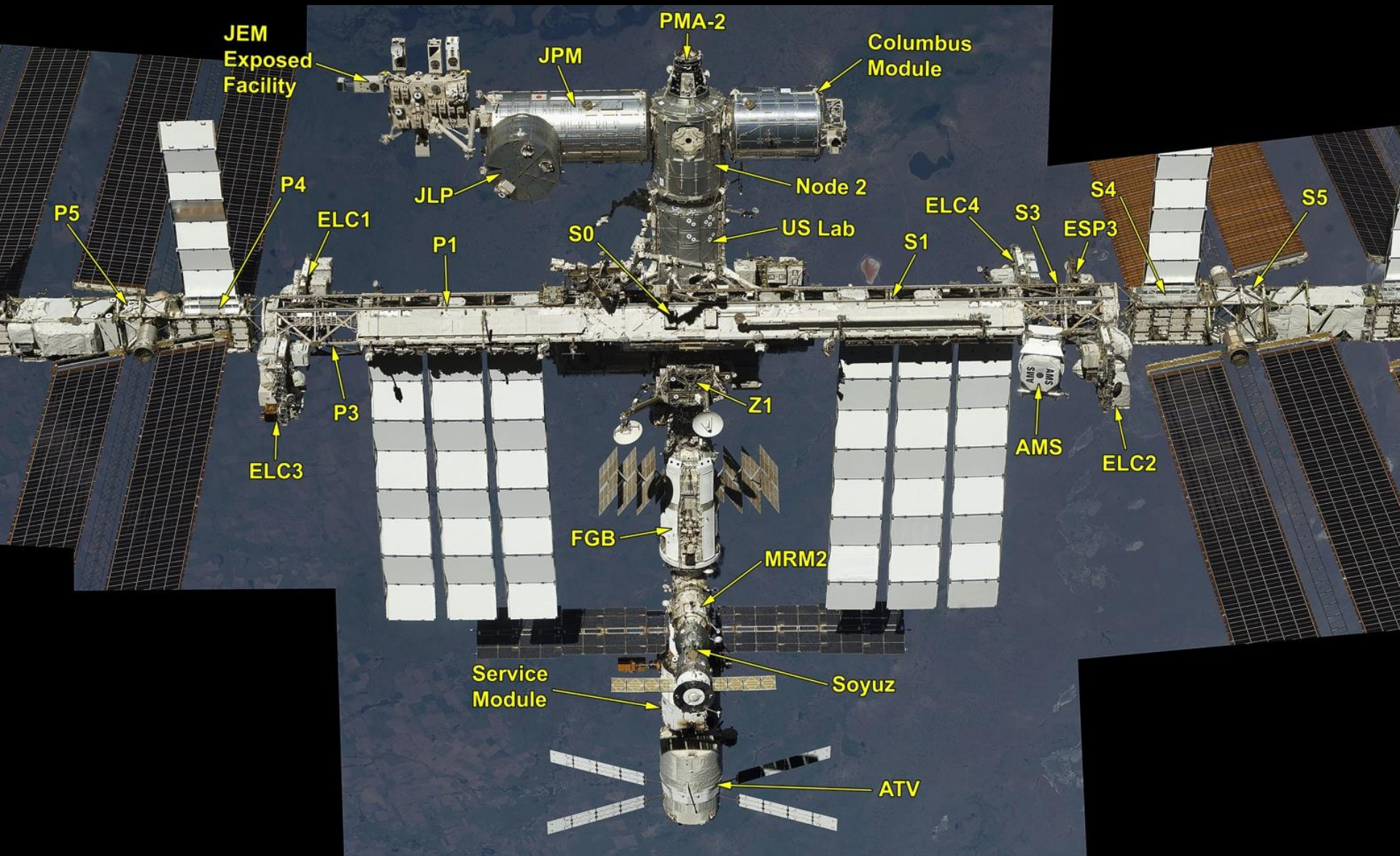
BioCell

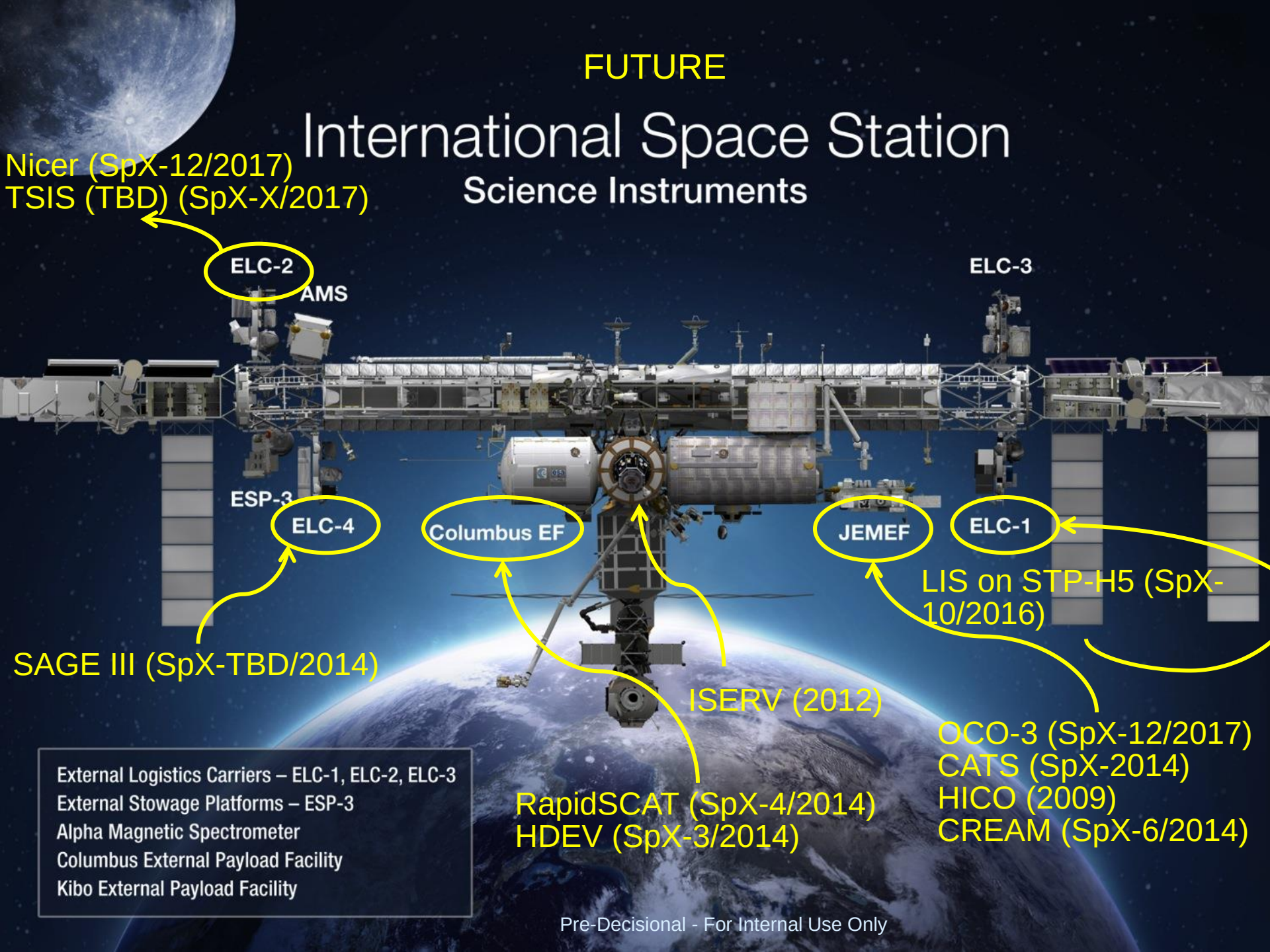


Earth and Space Science

- Space, Earth surface and Limb views
- External and Internal Payload sites
- Observation of transient atmospheric phenomena
- Planetary science sensor test beds

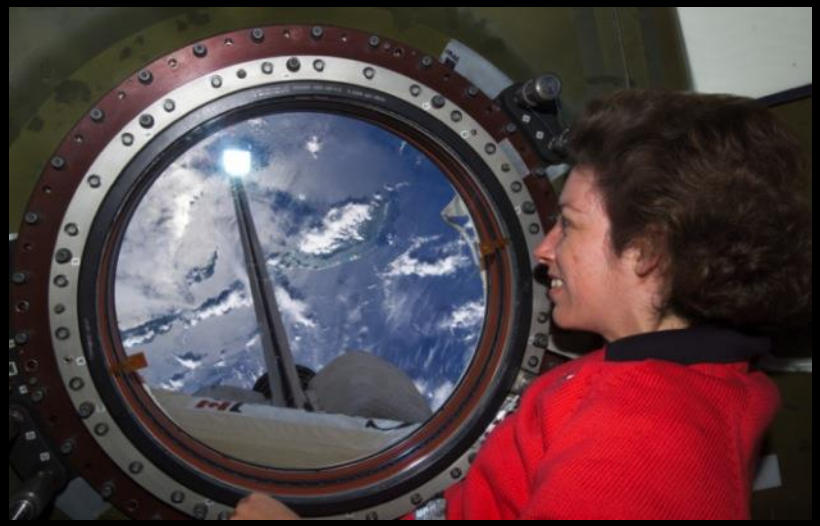
External Payload Attach Site's





Window Observation Research Facility

(WORF)



US Laboratory Window
50-cm diameter
Telescope-quality optical glass
NADIR view

WORF Rack

Facility to support visual and multispectral remote sensing using Lab Optical Window

ISERV Project Overview

ISS SERVIR Environmental Research and Visualization System (ISERV) is an automated Earth-observing system in the Destiny module aboard the International Space Station (ISS). It is primarily a means to gain experience and expertise in automated data acquisition from the ISS that also provides valuable data for use in disaster monitoring and assessment, and environmental decision making.

ISERV Launch Configuration

Chris Hadfield Installing ISERV in Destiny

ISERV in WORF Payload Volume

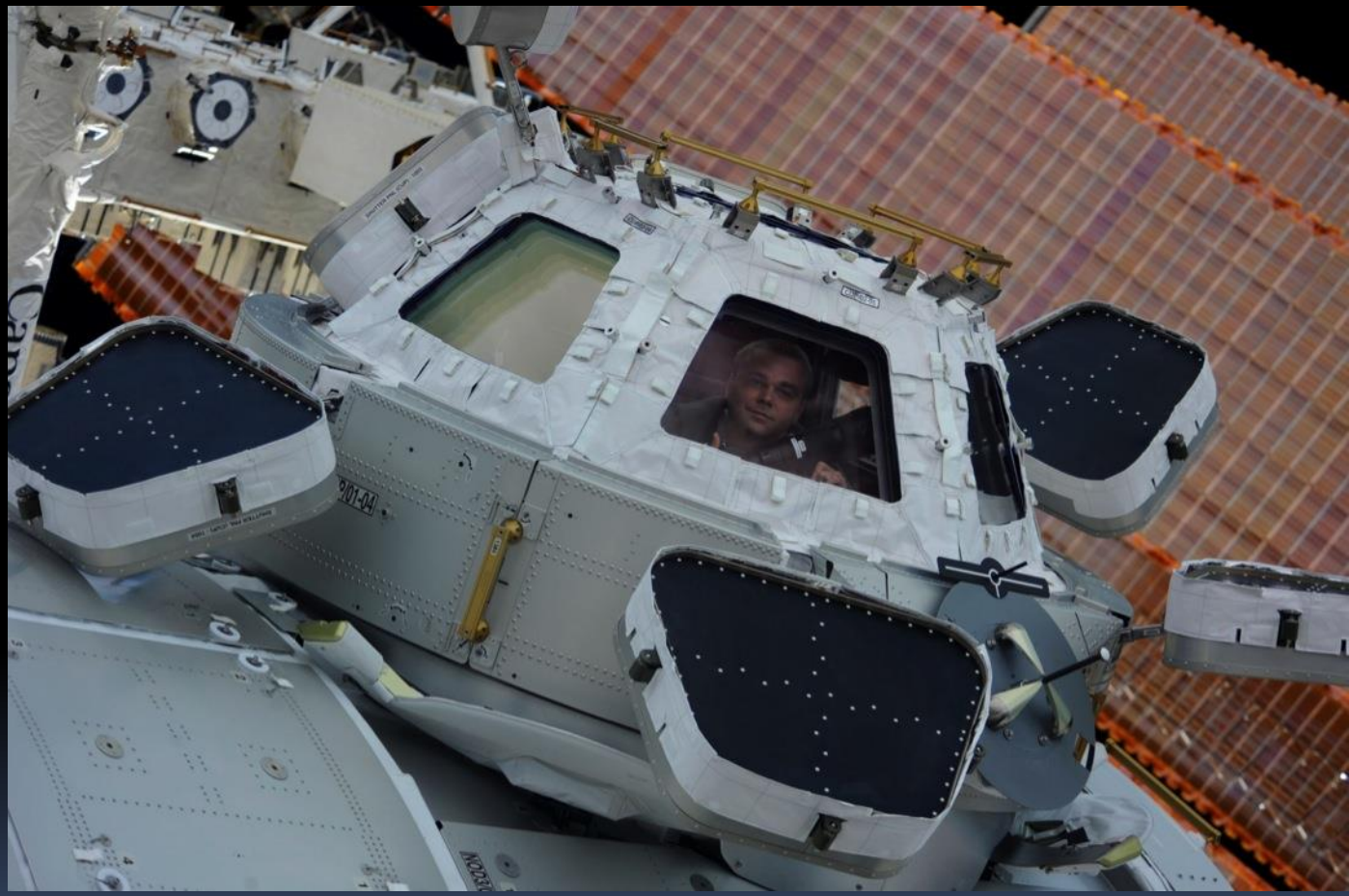
ISERV Optical Characteristics	*@ 420 km altitude*	Angular	Spatial
	Resolution	1.65 arcsec	~4 m
	FOV	2.36° x 1.58 °	~17 km x ~11 km
	Spectral	350nm to 800 nm	

Cupola

Bay window in space

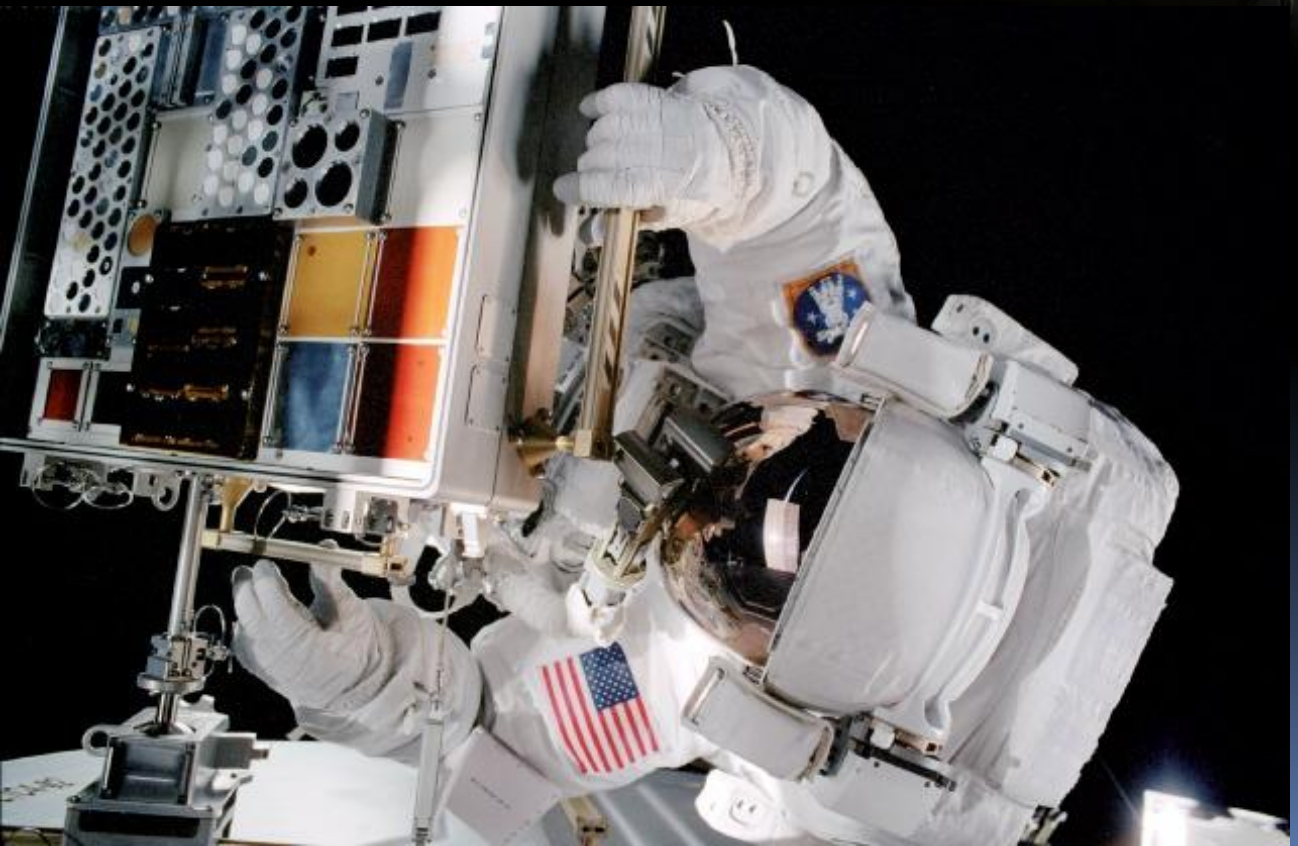
80-cm diameter top window

6 side windows



Materials Research

Materials International Space Station Experiment (MISSE)

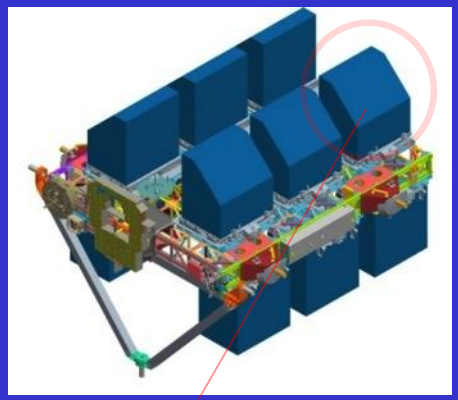


Deployed outside it is a test bed for materials and coatings attached to the outside of the International Space Station being evaluated for the effects of atomic oxygen, ultraviolet, direct sunlight, radiation and extremes of heat and cold outside

External Research Accommodations

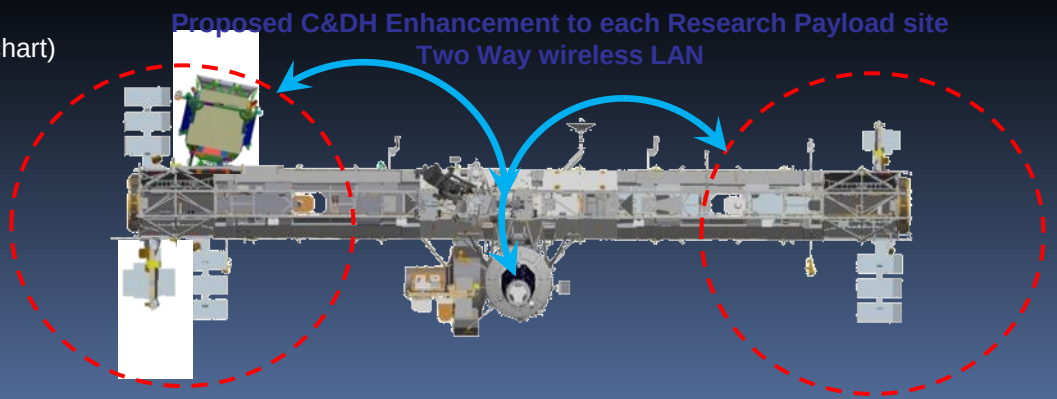
Express Logistic Carrier

ELC Single Adapter Resources (2 NASA payload sites per ELC)



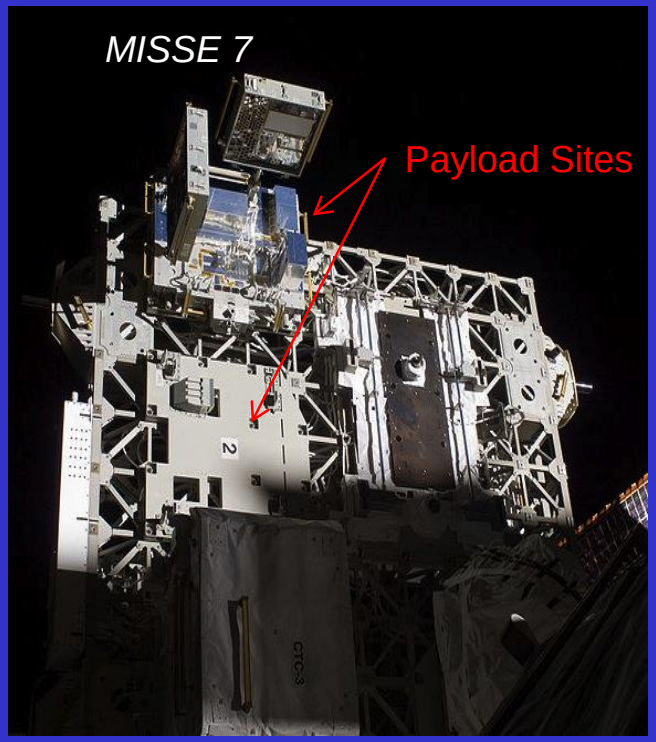
Mass capacity	227 kg (500 lb)
Volume	1 m^3
Power	750 W, 113 – 126 VDC; 500 W at 28 VDC/adapter
Thermal	Active heating, passive cooling
Low-rate data	*1 Mbps (MIL-STD-1553)
Medium-rate data	*6 Mbps (shared) - Return link (payload to ISS) only
Sites available per ELC	2 sites
Total ELC sites available	8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

Research Payload ExPA (see next chart)



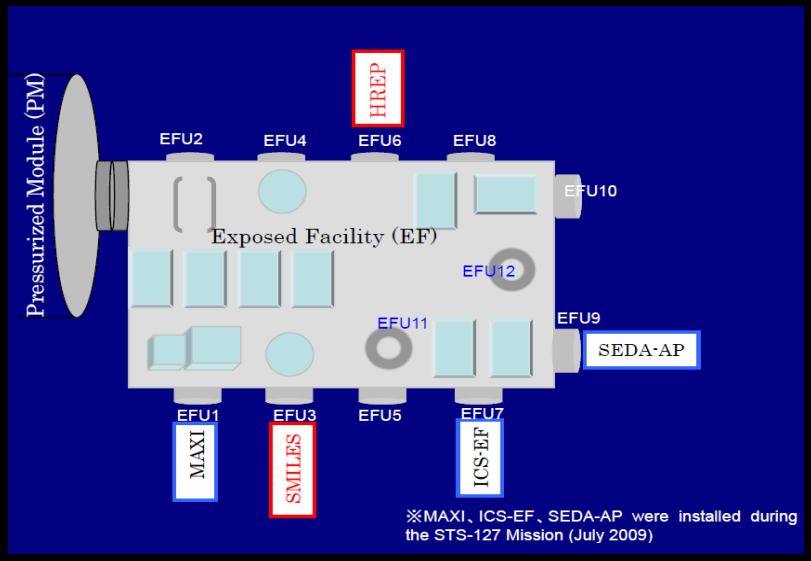
External Research Accommodations

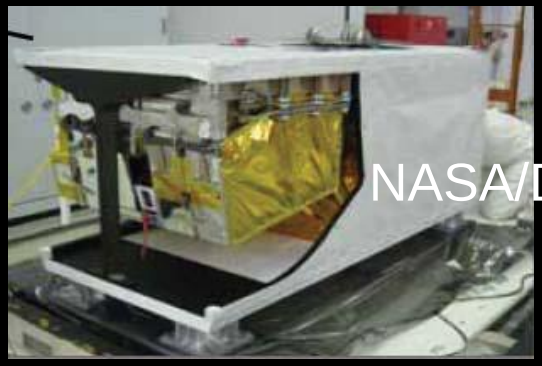
ExPRESS Logistics Carrier Payload Resources



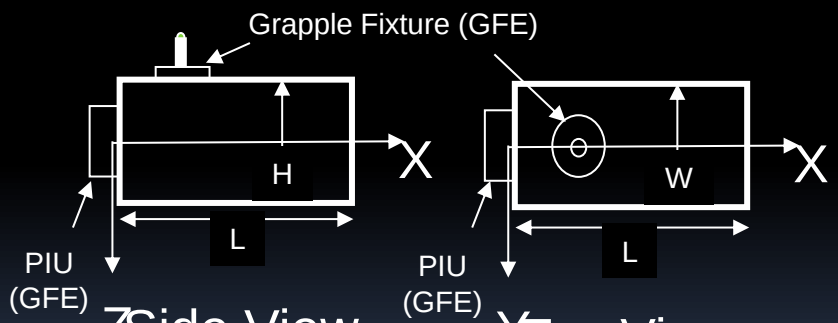
Mass capacity each site	**227 kg (500 lb)**
Volume	**1 m^3**
Power	**750 W, 113 – 126 VDC; 500 W at 28 VDC per adapter**
Thermal	**Active heating, passive cooling**
Low-rate data	**1 Mbps (MIL-STD-1553)**
Medium-rate data	**6 Mbps (shared)**
Sites available per ELC	**2 sites**
Total ELC sites available	**8 sites**

JEM EF External Research Accommodations





NASA/DOD HREP pa

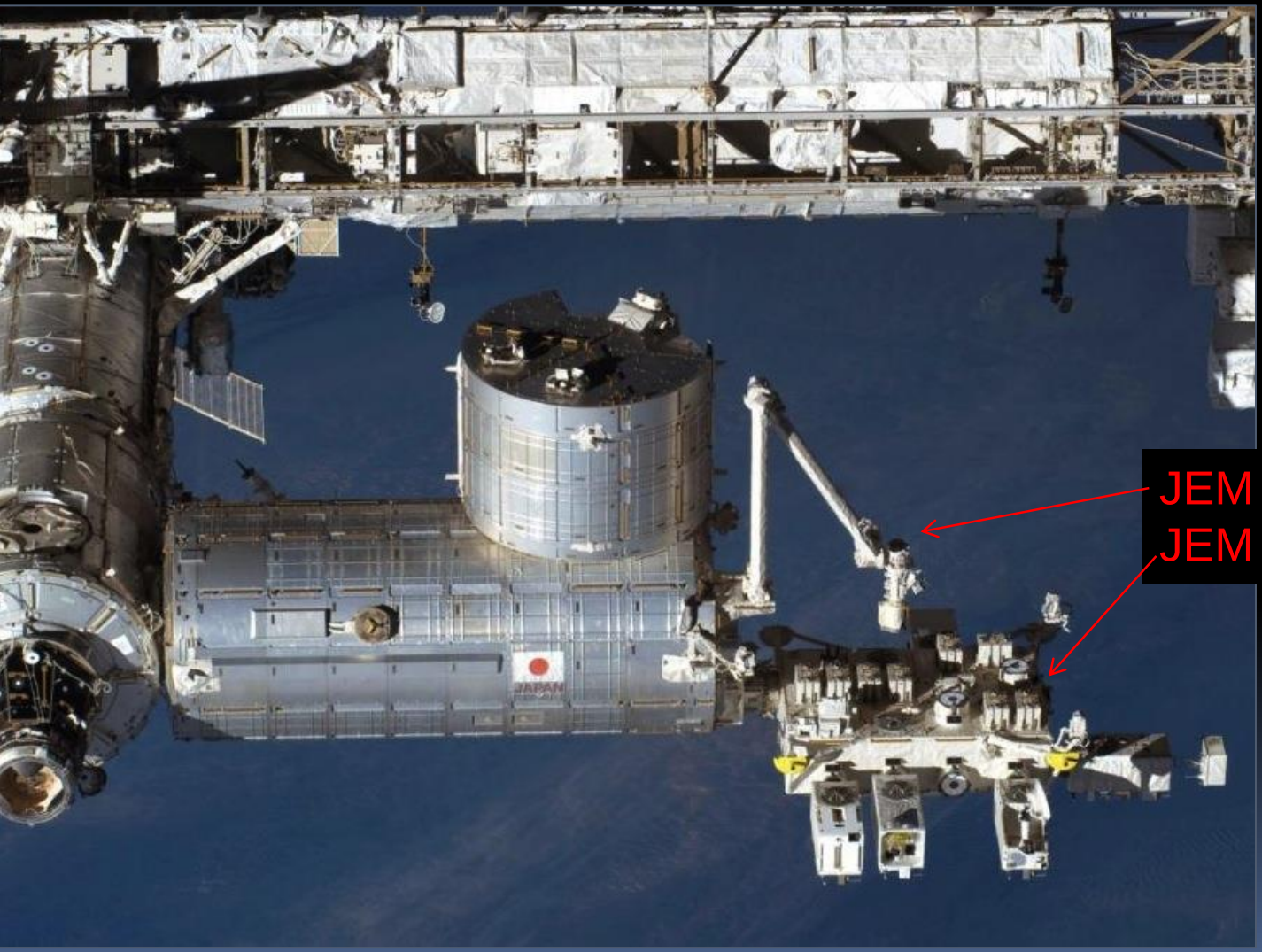


Axis	mm	ft	inch
W	800	2	7.50
H	1000	3	3.37
L	1850	6	0.83

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
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**

Japanese Experiment Module - *Kibo*



Orb-1 Research Highlights

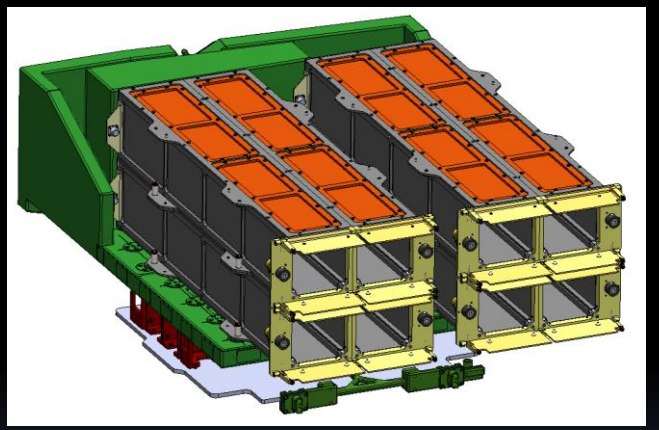
NanoRacks CubeSat Deployers (NRCSDs) & CubeSats

Sponsoring Space Agency: NASA

Research Objectives

NRCSD is a small satellite launching platform, providing containment and deployment mechanisms for several individual small satellites deployed from the International Space Station into Earth orbit. CubeSat investigations with ascent on Orb-1 include:

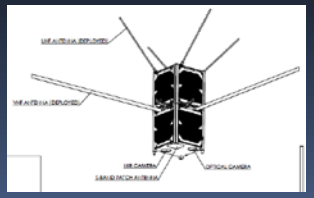
- **Dove**, from Planet Labs, will form a constellation of Earth-observing satellites.
- **LituanicaSat-1 & LitSat-1**, Lithuania's first satellites, provide real hands-on experience in satellite engineering.
- **ArduSat-2** serves as a platform on which students and private space enthusiasts may design and run their own space-based experiments.
- **UAPSat-1**, Peru's first satellite, will measure temperature and weather, and contribute data on the behavior and capabilities of satellites on orbit.
- **SkyCube** is a commercial imaging satellite.



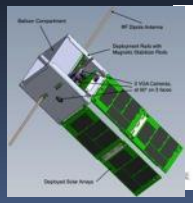
NRCSD launcher (installed on MPEP)

Dove

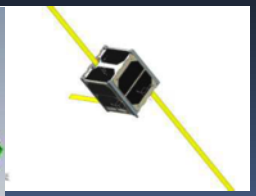
UAPSat-1



ArduSat-2



SkyCube

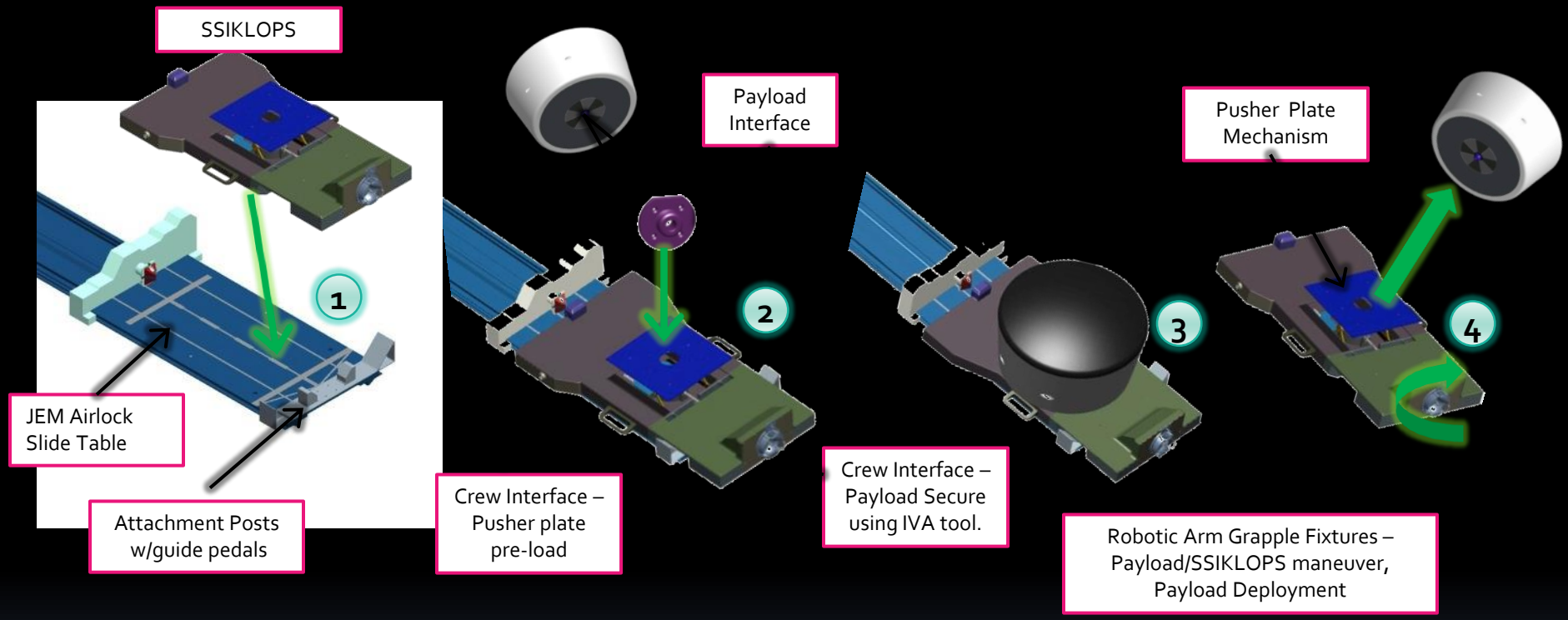


LitSat-1

LituanicaSat-1


NANORACKS

JEM Small Satellite Deployment Capabilities in Development



- Overall Platform: 52”L x 30”W x 3-9”H
- Max Payload: 44”L x 30”W x 11-21”H; 100 kg.
- Estimated Operations
  - IVA: 4.5 hrs (0.5 hrs J-SSOD removal, 0.5 hrs SSIKLOPS installation, 0.5 hrs Payload installation, 3 hrs airlock operation.)
  - EVR: 12 hrs (Ground Robotic Ops)
  - IVA: 4 hrs (3 hrs airlock operation, 0.5 hrs SSIKLOPS removal, 0.5 hrs J-SSOD installation)

Enhanced Capabilities Being Evaluated to Support Research to 2024

- High throughput materials science facility
- High throughput cell science facility
- Additional Earth pointing platforms
- Sun/space pointing platforms
- New freezers
- Upgrades to video, data systems
- Addition of non-standard external payload platforms

(e.g. Z1 with FRAMs, remove ESP to add final ELC, use S1 star tracker site or something that makes one FRAM site serve multiple payloads)

Additional Capabilities for Full Utilization Funded and In Development

- Cell science – multiple cell and tissue culturing systems and sample handling and analysis hardware
- Genomics – omics analytics and database development
- Fundamental Physics (Theory of Relativity) – atomic clocks and condensed atom lab
- Life science – protein crystal growth system and small mass measurement device, bone densitometer
- Materials science – granular materials research facility
- Physical science (combustion and fluids) – physical science informatics database
- Plant science – large plant growth chamber
- Rodent science – rodent transport and longer duration habitats (45 days)
- Earth/space science – hyper spectral instrument, lightning imaging sensor
- MSG modification to support life science research including rodent dissection and active facility decontamination