

International Space Station

Research Resource Planning



Sam Scimemi
February 2014 NAC Review

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 year's 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

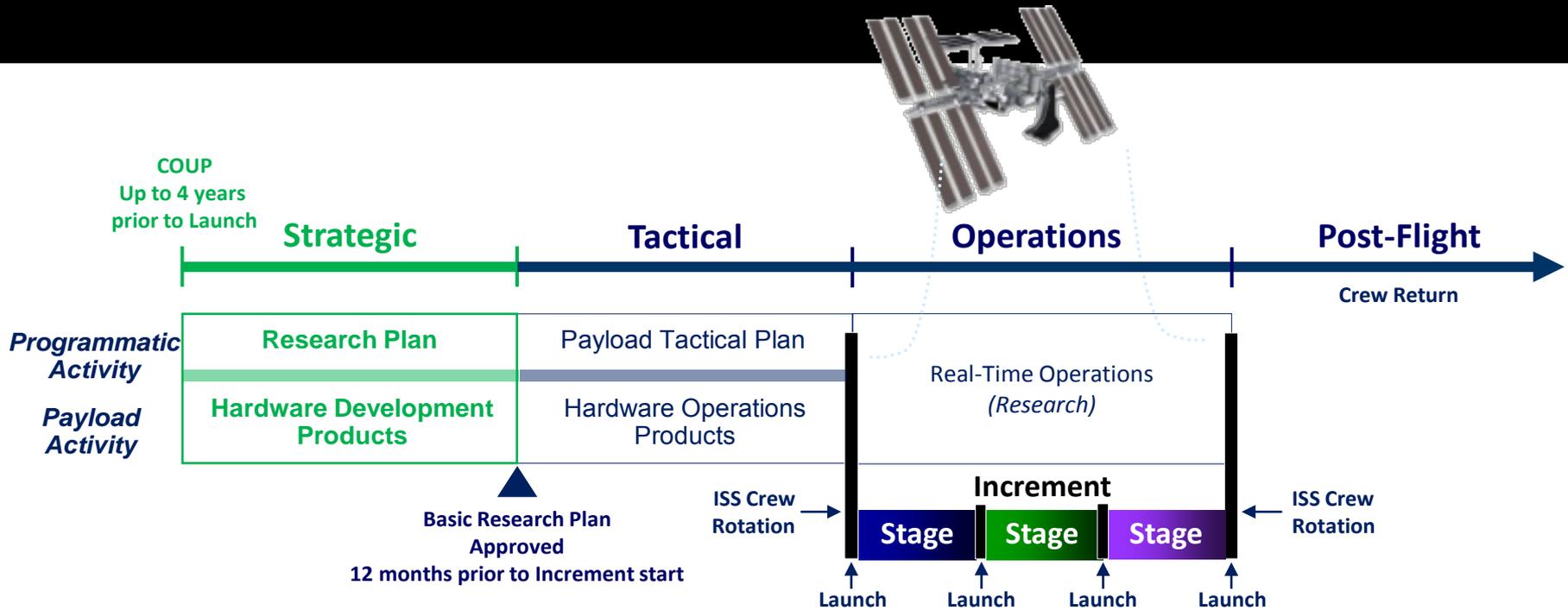
Tactical Research Planning

Increment specific Research Planning begins 18 months prior to the mission

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

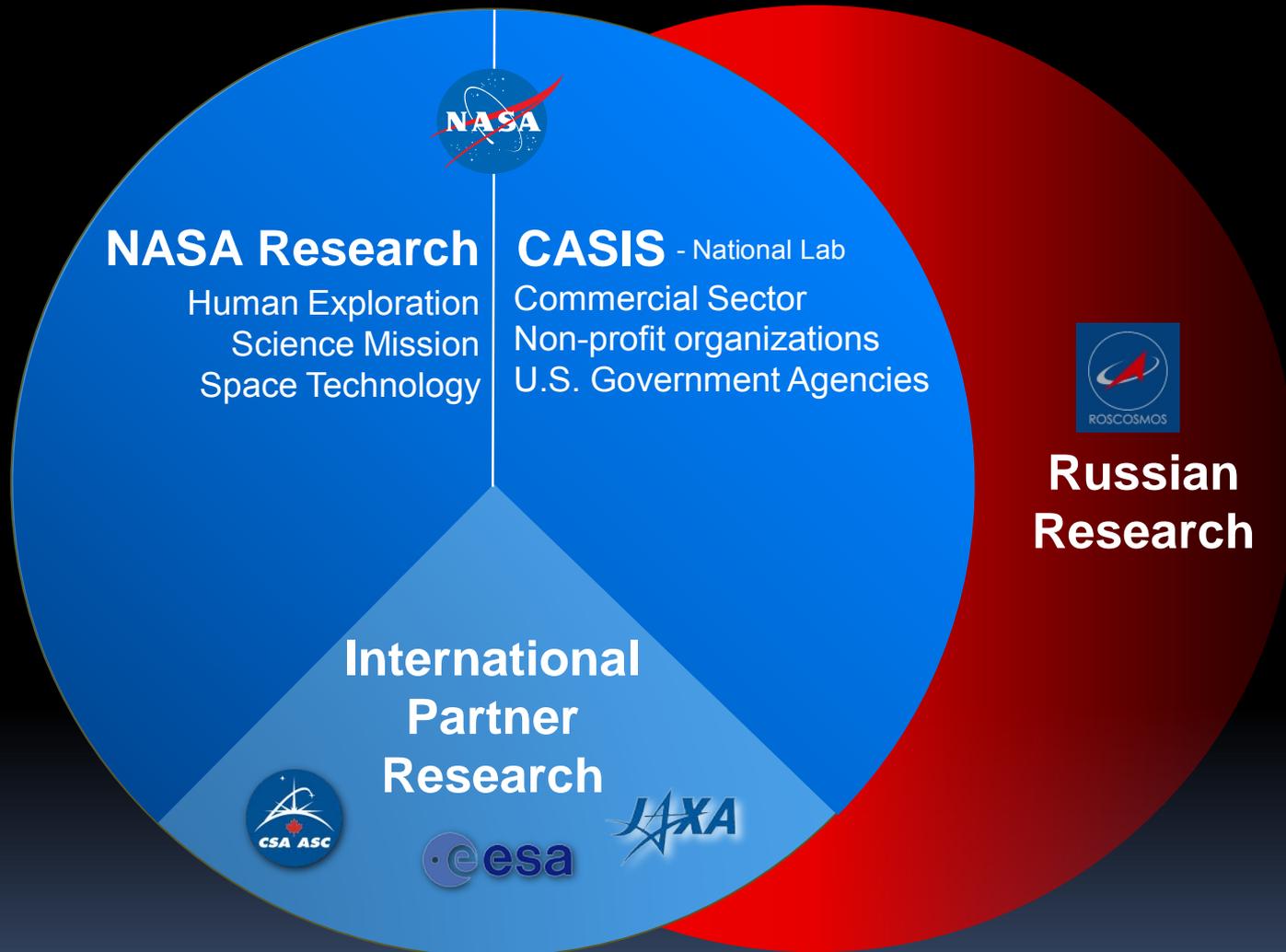
Depending on its complexity a Payload can be entered into the plan any where along the process

Planning and Operational Phases



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

Research Sponsors and Allocations on ISS



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

Full ISS 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

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 Full Utilization Status

Real estate bottom line:

USOS Racks 83.9% occupied

EXRESS 76% occupied, expect 78% by the end of 2014

External Sites 50% occupied, expect 56% 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 unless we are able to expand availability

Working on collaboration with Russian Scientists to augment crew time

Upmass/downmass bottom line:

There is no backlog on the ground today; however, starting in 2015, the ISS program will start to see a demand that outpaces capability based on current PPBE projections. It is predicted that there will be more pressurized utilization up mass requirements than there will be allocation.

On-orbit freezer availability is dependent on regular SpaceX return. Freezers routinely fill to capacity only during a SpaceX berthed period, during which time accumulated samples and new samples share temporary freezer space. Improvements in cold stowage return transportation allow the return of almost all frozen samples required.

User demand for powered launch and return cannot be met (>100%) due to Biotech and Biology interest.



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ISS OCCUPANCY -- INTERNAL RACKS

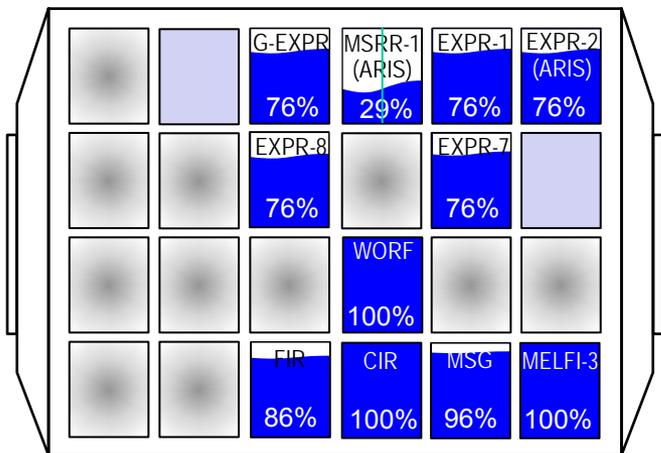
14 February 2014 (Data through 31 January 2014)

Overall ISS Research Occupancy for End of FY14 Breakdown by Facility (Internal)

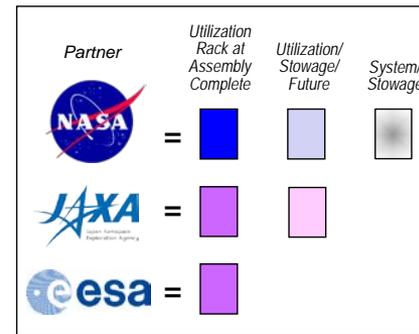
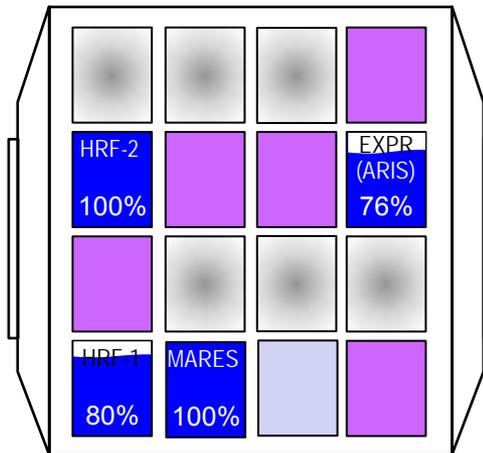
[POC: Rod Jones/OZ]



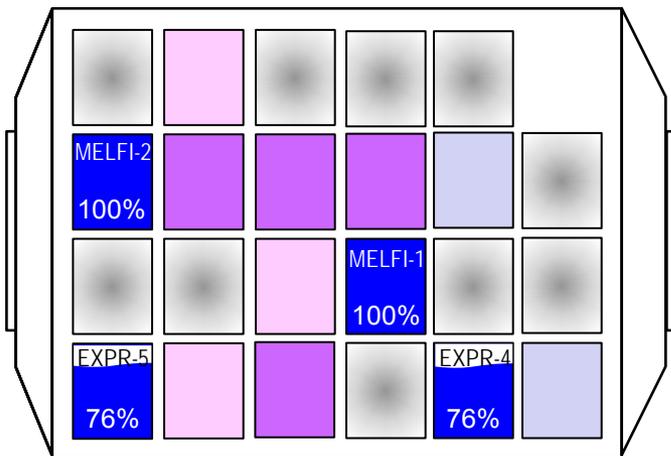
DESTINY



COLUMBUS



KIBO



U.S. Facility Occupancy – Current To Date and Planned by End of FY 2014

| Facility | Notes | FY14 To-Date Percentage | End of FY14 Planned Percentage | Number of Racks (Weighting Factor) |
|----------------------------|--|-------------------------|--------------------------------|--------------------------------------|
| EXPRESS | 44 of 58 lockers in Increment 38 | 76% | 78% | 7.25 Racks (excluding Galley & CUCU) |
| HRF | Standby equipment | 90% | 90% | 2 |
| MARES | | 100% | 100% | 1 |
| MSG | | 96% | 93% | 1 |
| CIR | | 100% | 100% | 1 |
| FIR | | 86% | 100% | 1 |
| MSRR/MSL | | 29% | 13% | 0.66 |
| MSRR Open Bay | Currently used for payload stowage but scarred for payload | 0% | 0% | 0.34 |
| WORF | ISERV | 100% | 100% | 1 |
| MELFI | 3 MELFIs full or standby | 100% | 100% | 3 |
| Total | | 15.31 | 15.43 | 18.25 |
| Weighted Percentage | | 83.9% | 84.6% | -- |

Update:

- Changes primarily reflect shift to when SpaceDRUMS comes home (now taken out of Express numbers for Inc 39/40 and still impacting 41/42).
- Some changes to external payload numbers due to tactical and MIPROM rephrasing. Impacts not big but overall hit was to 39/40, occupancy, and 45/46 numbers rose.
- FIR's To-Date % fell to 86% from 100%
- EXPRESS' End of Year Planned % dipped to 78% from 79%
- MSG's End of Year Planned % rose to 93% from 90%
- To-Date Weighted % slipped to 83.9% from 84.7%, and End of Year Planned dipped to 84.6% from 85.3%



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ISS OCCUPANCY -- EXPRESS RACKS

14 February 2014 (Data through 31 January 2014)

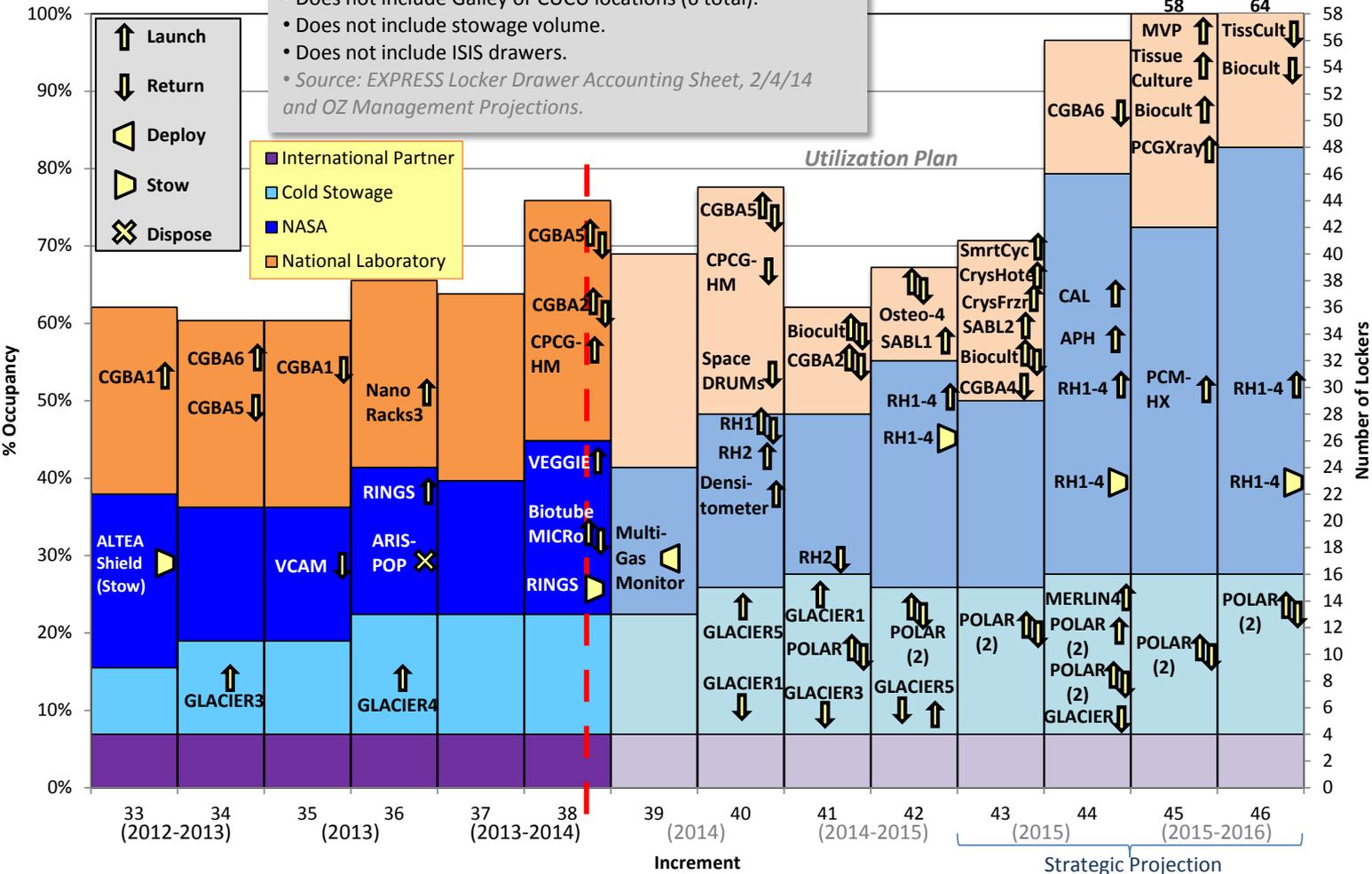
Number of EXPRESS Inserts
in Available EXPRESS Accommodations

[POC: Rod Jones/OZ]



Key Factors:

- Does not include Galley or CUCU locations (6 total).
- Does not include stowage volume.
- Does not include ISIS drawers.
- Source: EXPRESS Locker Drawer Accounting Sheet, 2/4/14 and OZ Management Projections.



- Update:
- Microbial Observatory/ Gene Expression Lab deleted (begin in Inc. 42)
 - Glacier 5 return added to Inc. 42 (SpX-6)
 - Glacier 5 added to Inc. 42 (Orb-4)



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ISS OCCUPANCY -- EXTERNAL SITES

14 February 2014 (Data through 31 January 2014)

Number of External Payload Sites Available
[POC: Rod Jones/OZ]

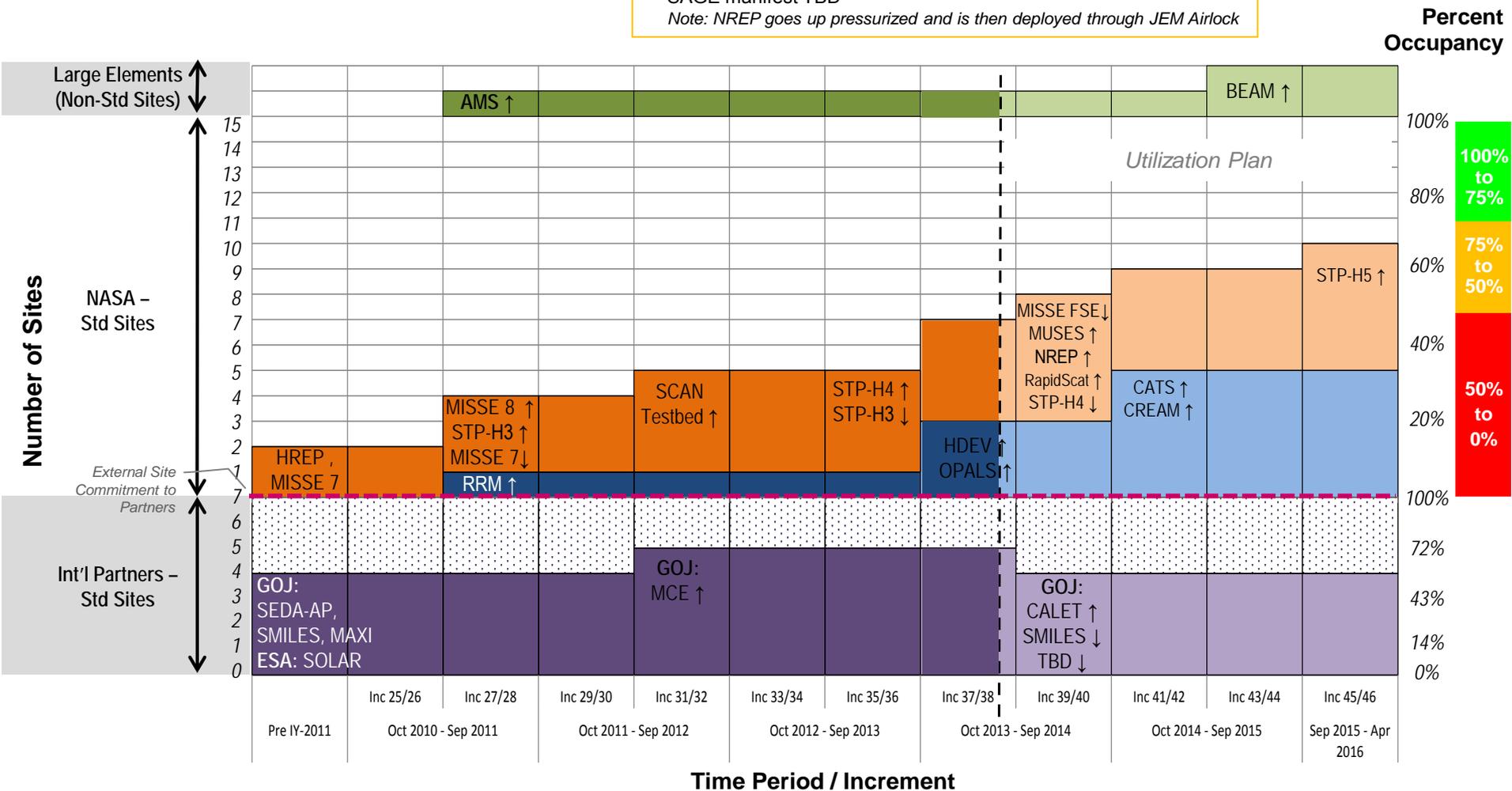


- NASA-National Laboratory
- NASA-All other customers
- International Partners (NASA Allocation)
- Large Elements

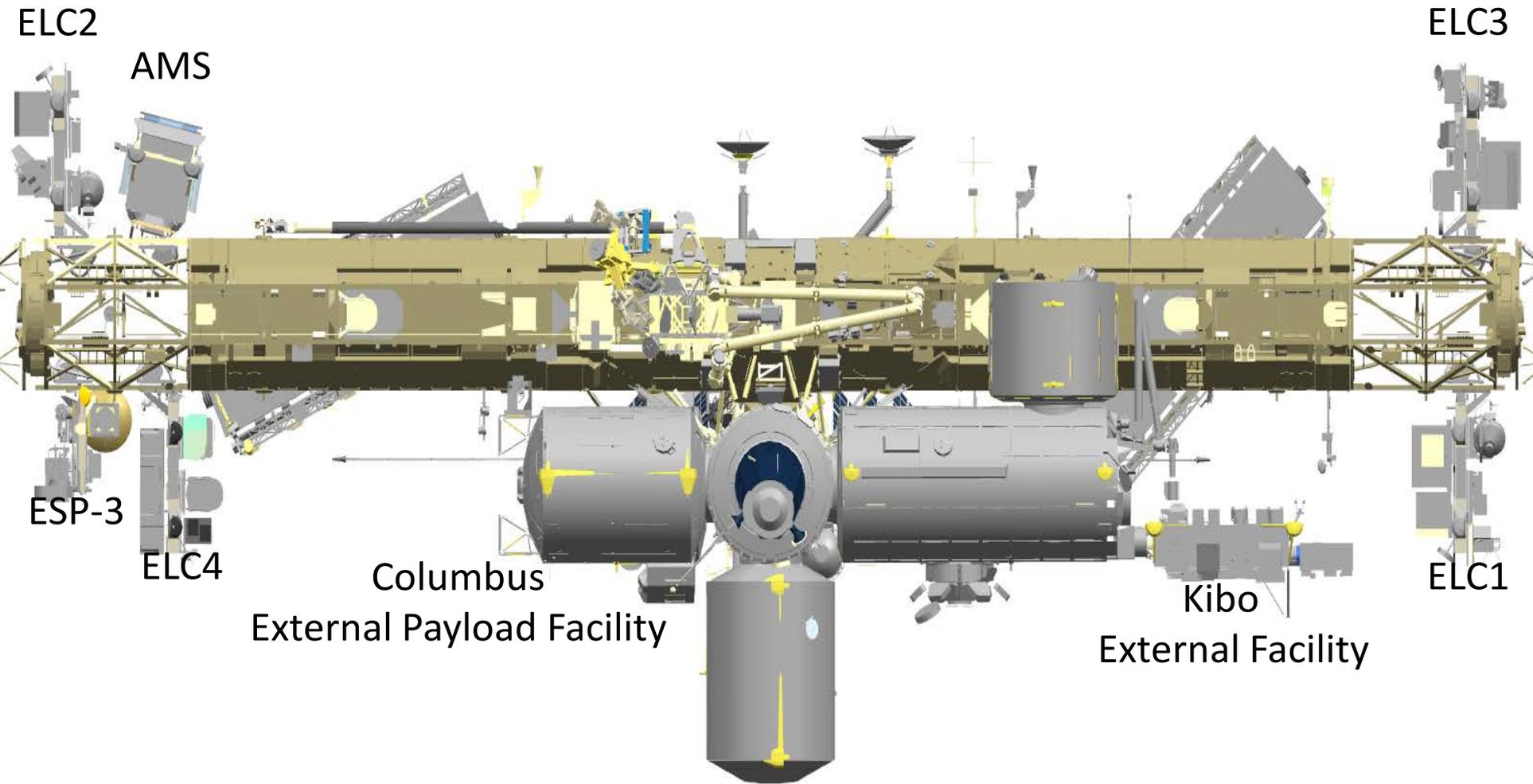
Update

- Corrected last month's chart by removing NASA TBD launch from Inc 39/40 and bringing current totals to date.
 - Additional decisions are anticipated toward end of February that will lead to updates to Inc 43/44.
 - SAGE manifest TBD
- Note: NREP goes up pressurized and is then deployed through JEM Airlock*

Reference:
MIPD Rev G
and SSCN 014004



ISS US Segment External Facility Locations

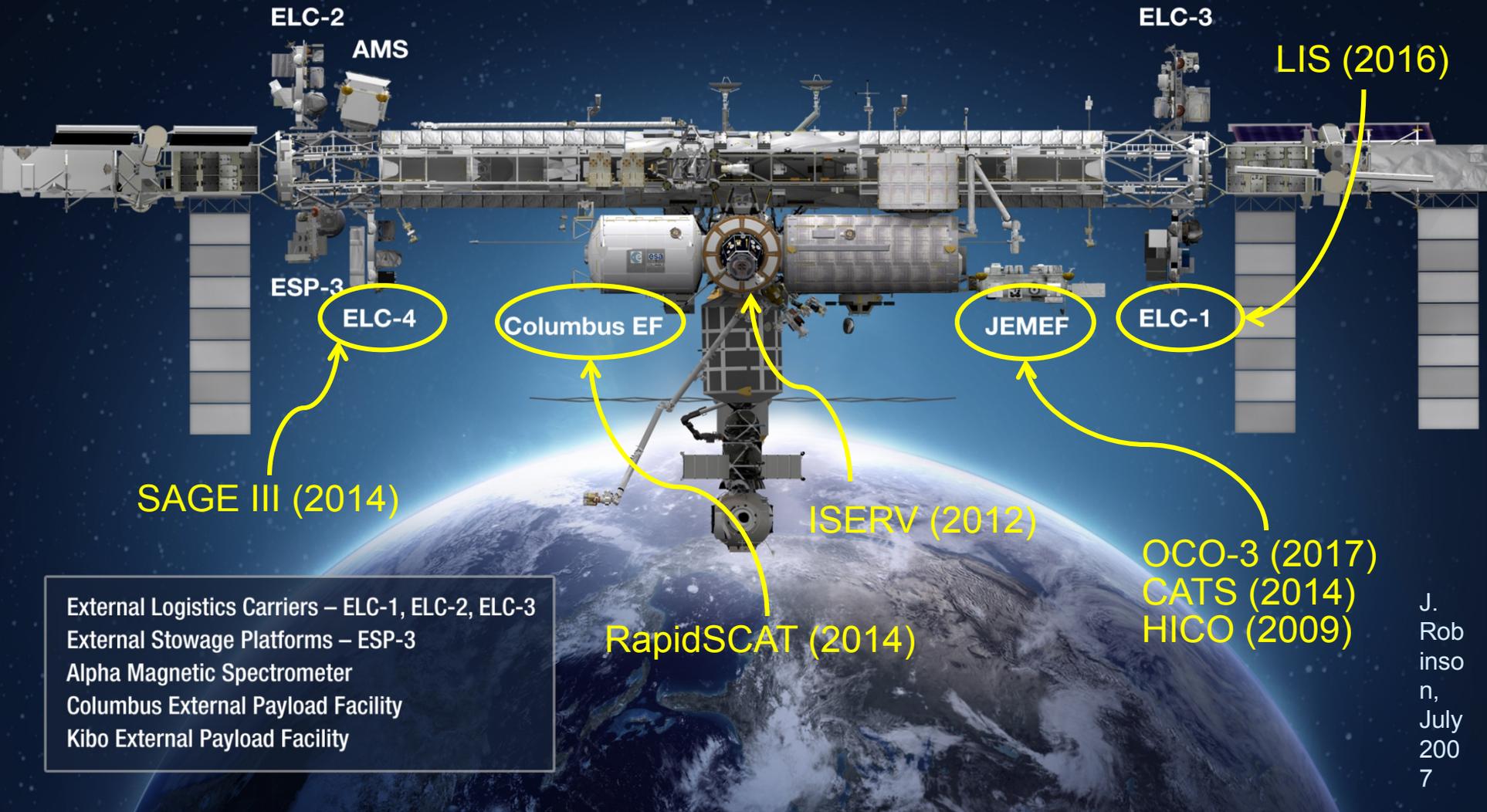


External Payloads (Current External P/L Configuration as of September 5, 2013):

- STP-H4: ELC1 Site 3
- SCAN Testbed: ELC3 Site 3
- RRM: ELC4 Site 3
- SOLAR: Columbus EPF SOZ
- MAXI: JEM-EF Site 1
- SMILES: JEM-EF Site 3
- HREP: JEM-EF Site 6
- ICS-EF: JEM-EF Site 7
- MCE: JEM-EF Site 8
- SEDA-AP: JEM-EF Site 9
- AMS: S3 Upper Inboard

International Space Station

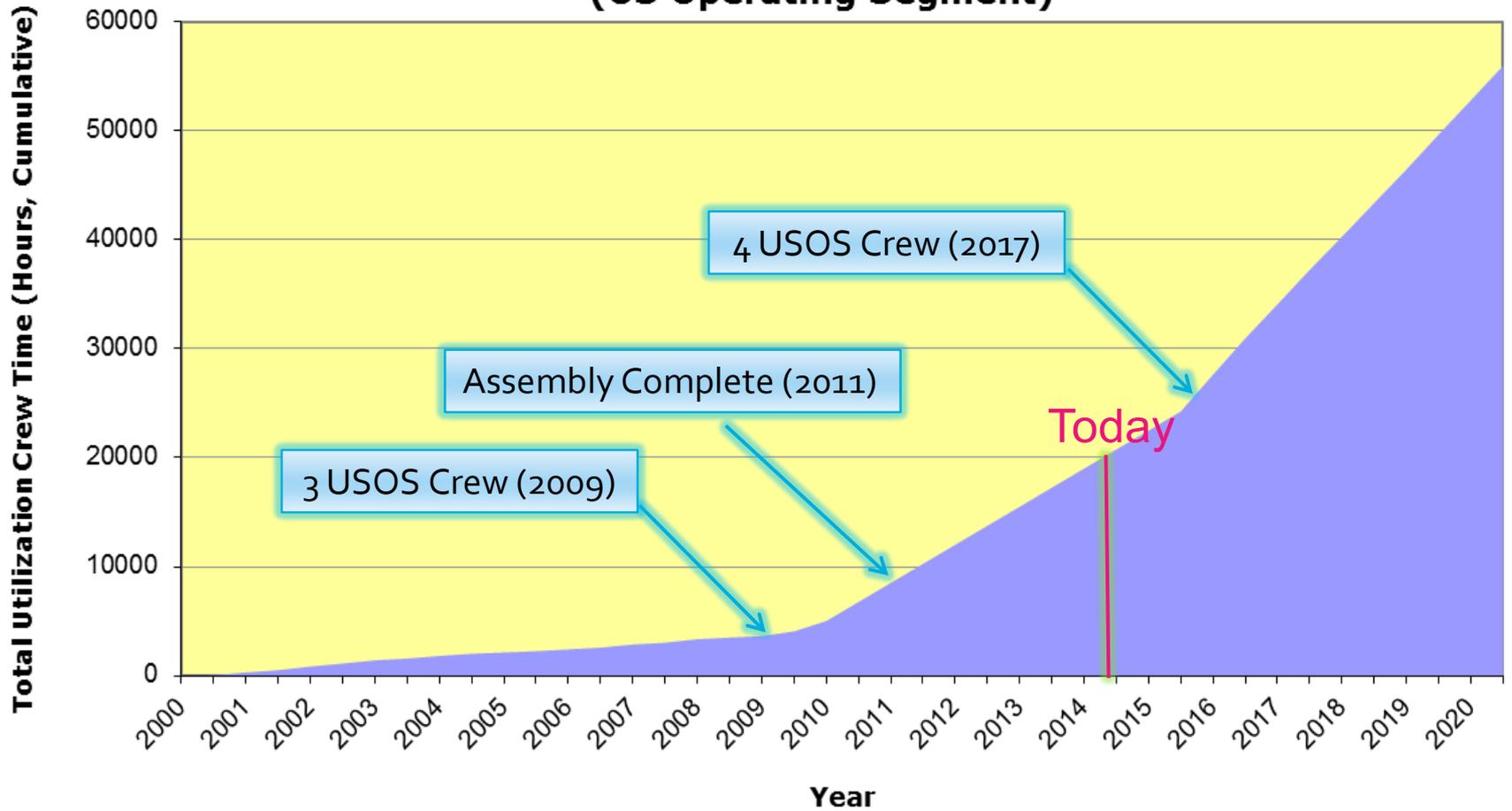
Earth Science Instruments



External Logistics Carriers – ELC-1, ELC-2, ELC-3
External Stowage Platforms – ESP-3
Alpha Magnetic Spectrometer
Columbus External Payload Facility
Kibo External Payload Facility

Accumulative Crew Time

Cumulative ISS Utilization Crewtime (US Operating Segment)





MLP

USOS RESEARCH CREW TIME

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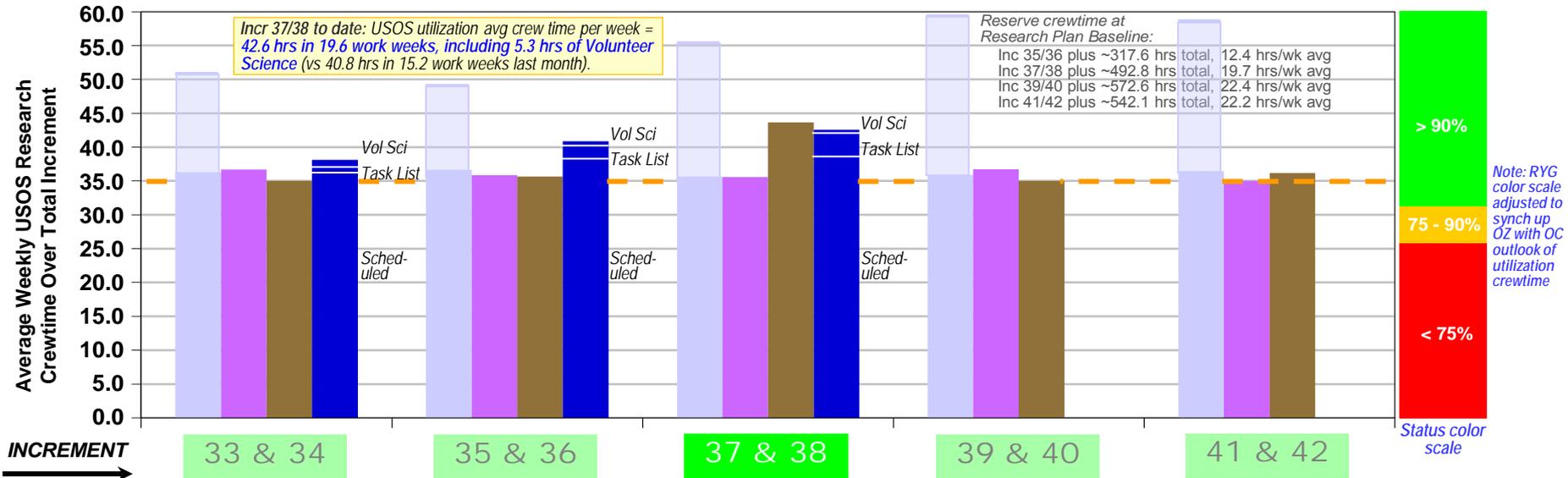
Average Weekly Utilization Actuals Compared to Minimum Requirements, Subscriptions, Allocations, and Scheduled

[POC: Rod Jones/OZ]

Legend

- Generic Groundrules, Requirements & Constraints (GGR&C) Minimum Requirement
- L-12 Month Increment Definition and Requirements Document Subscription (or Requirement)
- 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 sustenance of strong research activity and still ahead of OOS planned schedule. Robust throughput to continue in current and future Incrs. (Last month ➔)



| INCREMENT | 33 & 34 | | 35 & 36 | | 37 & 38 | | 39 & 40 | | 41 & 42 | | | |
|--|------------|---------|------------|-------|-------------------------|--------------------------|-------------------|--------------------|-------------------|--------------------|---------|---------|
| | Avg weekly | Total | Avg weekly | Total | Avg weekly | Total | Avg weekly | Total | Avg weekly | Total | | |
| GGR&C (Min Req ^t) | 35.0 | 875.0 | 35.0 | 875.0 | 35.0 | 875.0 | 35.0 | 875.0 | 35.0 | 875.0 | | |
| L-12 IDRD Subscription | 36.2 | 900.2 | 36.6 | 893.7 | 35.7 ^b | 884.2 ^b | 35.9 ^e | 918.7 ^e | 36.5 ^h | 889.5 ^h | | |
| L-12 IDRD Allocation | 36.7 | 910.0 | 35.9 | 876.0 | 35.6 ^c | 882.0 ^c | 35.0 ^f | 896.3 ^f | 35.0 ⁱ | 854.0 ⁱ | | |
| L-1 OOS Sched (or IDRD Alloc) | 35.0 | 868.0 | 35.6 | 869.5 | 43.6 ^d | 1082.0 ^d | 35.0 ^g | 896.1 ^g | 36.5 ^j | 882.0 ^j | | |
| Actuals (to date) | 38.1 | 945.2 | 41.3 | 949.0 | 42.6^a | 834.3^a | -- | -- | -- | -- | | |
| Int'l Partner Sub-Allocations and Actuals Breakdowns | IP | L-1 hrs | Percent | Final | IP | L-1 hrs | Percent | Final | IP | L-1 hrs | To Date | Percent |
| | NASA | 684.3 | 74.4% | 703.6 | NASA | 684.3 | 78.0% | 740.0 | NASA | 855.6 | 665.4 | 79.8% |
| | ESA | 71.9 | 10.0% | 94.7 | ESA | 71.9 | 9.0% | 85.2 | ESA | 87.3 | 75.9 | 9.1% |
| | JAXA | 92.7 | 12.8% | 120.7 | JAXA | 92.7 | 9.0% | 85.0 | JAXA | 116.4 | 69.8 | 8.4% |
| | CSA | 17.3 | 2.6% | 24.3 | CSA | 17.3 | 3.2% | 30.1 | CSA | 22.7 | 23.3 | 2.8% |

(includes 4.3 total hrs commissioning)

(includes 2.0 total hrs commissioning)

^aIncr 37/38 after 19.6 work weeks

^bPer Research Plan, baselined at MRICB/MMIOCB, 9/26/12

^cL-12 allocation per Planning Authorization Letter, Oct 2012

^dPer Incr 37&38 FINAL Preflight OOS, Sept 2013

^ePer Research Plan, baselined at MRICB/MMIOCB, 4/17/13; ^fL-12 allocation per Planning Authorization Letter, April 2013; ^gPer Preliminary OOS, December 2013

^hPer Research Plan, baselined at MRICB/MMIOCB, 10/30/13. ⁱPer draft Payload Authorization Letter, signed Nov 2013. ^jPer Annex-5 Payload Tactical Plan, Working Ver, 2/6/14

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

International Space Station Resources

- Sustainable microgravity platform for long term studies
- Continuous 30kw steady state power for payloads
- Access to vacuum of space
- External and internal research
- Automated, human, and robotic operated research
- Exposure to the thermosphere via external Platforms
- 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

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 each) |
| | ~8 Mbps of MRDL data (Science return) |
| | ~5 Mbps for payload still images |
| | ~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

Proposing 2 more 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 |

Research Facilities and Capabilities

Multi Purpose Research Facilities
Physical & Material Sciences
Biology and Biotechnology
Human Research
Earth and Space Science
Technology Test Beds
Robotics
Communication and Ground Control
Transportation



US sponsorship by scientific discipline



**National Lab
(Earth Benefits)**

**NASA
(Exploration)**

Biology and Biotechnology

Human Research

Physical Sciences

Tech Demos

Astrophysics

Earth Science

Education



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

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

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)

