International Space Station Status

NASA

esa

CSA ASC

ROSCOSMOS

Sam Scimemi
Director, International Space Station

HEO NAC
July 2015
Agenda

• Transitioning HSF from ISS to the Proving Ground and the Commercialization of LEO

• ISS Overview Status

• Visiting Vehicle Status

• Utilization Highlights
A proposed two pronged approach to ensuring that HSF transitions without a gap between ISS and cis-lunar space and research and technology development in LEO continues seamlessly between ISS end-of-life and commercially available capabilities
From Earth Dependent

~ 2 days transit time

Communications (near real-time) ← Crew exchanges →
Crew supplies and logistics ← Crew and atmosphere samples →
Modified hardware ← Emergency Crew Return →
Trash

~400 kilometers

“car camping in space”
To Earth Independent

~2 - 3 years transit time

Communications (up to 42 minutes)

~228,000,000 kilometers

“independent life”
So what do we want to accomplish Proving Ground by the end of the next decade from a HSF perspective?
First Prong:
A Primary Goal for Human Spaceflight in the Proving Ground

Prepare all the crew related capabilities for long duration transit missions to Mars that culminates in one year crewed expeditions in cis-lunar space

“shake down cruise”
Transitioning HSF from LEO to Cis-Lunar Space (Earth Dependent to the Proving Ground)

Earth Dependent

Long Duration Human Health & Habitation Research and Demonstrations

First half of the 2020’s

Second half of the 2020’s
Transitioning HSF from LEO to Cis-Lunar Space
(Earth Dependent to the Proving Ground)

Earth Dependent

- Long Duration Human Health & Habitation Research and Demonstrations

Proving Ground

- First half of the 2020’s
- Second half of the 2020’s

Goal:
One year crewed mission(s) in cis-lunar space
Transitioning HSF from LEO to Cis-Lunar Space (Earth Dependent to the Proving Ground)

Earth Dependent

- Long Duration Human Health & Habitation Research and Demonstrations

Proving Ground

First half of the 2020’s

- Short Duration Habitation & Transportation system validation
  - SLS/Orion performance
  - Deep space multi-body navigation with humans
  - Integrated crewed/robotic vehicle operations in deep space staging orbits
  - System and crew performance in deep space radiation environments
  - Advanced autonomous proximity operations and rendezvous in deep space and with non-cooperative objects
  - Astronaut EVA for sample selection, handling, and containment
  - Validating Earth return trajectories and emergency return strategies

Second half of the 2020’s

Goal: One year crewed mission(s) in cis-lunar space
Transitioning HSF from LEO to Cis-Lunar Space
(Earth Dependent to the Proving Ground)

Earth Dependent

- Long Duration Human Health & Habitation Research and Demonstrations

Proving Ground

First half of the 2020’s

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Second half of the 2020’s

- Long duration human health & habitation Validation for Mars transit
- Validate crew health and performance countermeasures developed on ISS
- Validate habitation system and crew performance in deep space radiation environment developed on ISS
- Simulate Mars transit crew operations – Limited interaction with MCC based on path finders on ISS
  Limited/No re-supply
  No crew exchanges
- Develop and validate the operational habitation, life support and environmental monitoring systems that were validated on ISS integrated with other systems (e.g. thermal, power, etc.)

Goal:
One year crewed mission(s) in cis-lunar space
Transitioning HSF from LEO to Cis-Lunar Space
(Earth Dependent to the Proving Ground)

**Earth Dependent**

- **Long Duration Human Health & Habitation**
  - Research and Demonstrations

**Proving Ground**

**First half of the 2020’s**

- **Short Duration Habitation**
  - & Transportation system validation

**Second half of the 2020’s**

- **Long duration human health & habitation**
  - Validation for Mars transit

**Knowledge & Capabilities**

- **ARM**
  - SLX/Orion performance
  - Deep space multi-body navigation
  - Integrated crewed/robotic vehicle operations in deep space staging orbits
  - System and crew performance in deep space radiation environments
  - Advanced autonomous proximity operations and rendezvous in deep space and with non-cooperative objects
  - Astronaut EVA for sample selection, handling, and containment
  - Validating Earth return trajectories and emergency return strategies

**Goal:**
One year crewed mission(s) in cis-lunar space
Implications for the next several years

• Having this goal of a “shake down cruise” (or multiple cruises) near the near the end of the 2020’s provides an anchor for other HSF activities and possibly broader scientific objectives

Human Spaceflight
– Drive SLS/Orion performance and EM mission objectives
– Provide the basis for ISS-to-PG transition discussions with IP’s
– Provides the pull for shorter duration missions – particularly ARM
– Provides focus for near-term policy and budgets
– Help drive requirements for other areas such as logistics, propulsion, etc.

Robotic/Science
– Lunar robotic exploration
– Lunar surface in-situ demonstration
– Cis-lunar space science objectives
Commercial and International Partnership

- There are many opportunities for public-private and international partnerships in achieving the goal of one year duration crewed missions in cis-lunar space
  - Habitation and habitation systems
  - Dissimilar redundancy
  - Logistical support
  - Communications
  - Navigation
  - Propulsion and re-fueling systems
  - Transportation
  - Other mission or scientific objectives
So What does this mean for ISS

• All the critical research and system demonstrations needed to validate long duration HSF must be completed on ISS...before they are applied in the Proving Ground...
  – Human research and performance
  – Habitation systems such as ECLSS, environmental monitoring, crew systems, etc.
  – All the other technologies and systems that need maturation
    • Docking, communication protocols, autonomous crew operations, etc.

• We are now in the process of determining specifically what transitional objectives we want to accomplish on ISS and what we expect to transfer to cis-lunar space
  – Human research, system performance, operational considerations, etc.

We are beginning to plan for the transition of HSF out of LEO and into the Proving Ground
Second Prong: Expand the full breadth of the US economy into LEO

Vision: Sustained economic activity in LEO enabled by human spaceflight, driven by private and public investments creating value and benefitting Earth through commercial supply and public and private demand

Goals

1.0 LEO commercialization enabled by leveraging ISS
- User-friendly ISS process improvements
- Maximize throughput
- Demonstrate & communicate value proposition of ISS
- Foster “success stories”
- Utilize more commercial acquisition strategies

2.0 The policy and regulatory environment promotes commercialization of LEO
- Establish interagency working group to address policy and regulatory issues
- Investigate economic cluster potential
- Address barriers such as IP retention, liability, ITAR

3.0 A robust, self-sustaining, and cost effective supply of US commercial services to/in/from LEO accommodates public and private demands
- Leverage NASA NEXTSteps BAA studies and follow-on to enable commercial LEO capabilities
- Enable Earth-similar laboratory capabilities for ISS that can transition to commercial platforms
- Transition from NASA-supplied to commercially-supplied services and capabilities once available

4.0 Broad sectors of the economy using LEO for commercial purposes
- Establish consortia for potential high-payoff, market-enabling microgravity applications with public and private funds to support development (e.g. protein crystallization, exotic fibers, lightweight alloys, 3D tissues)
- Establish commercial LEO utilization university curriculum and programs
So What does this mean for NASA and ISS

- Facilitate sustainable and growing demand for LEO research and applications across industry, academia and other government agencies through partnerships other means

- Today CASIS is already working with industry and OGA (NIH, NSF, NIST, etc.) to utilize the ISS…however, current activities are focused on individual project and not necessarily to establish long-term LEO investment and research

- To go beyond individual ISS projects, NASA is working with CASIS, industry and OGA’s to augment existing relationships and activities with focused initiatives in potential high-payoff market-enabling areas (e.g. materials development & manufacturing, pharmaceutical, tissue engineering, model organism research)

- ISS, CASIS and private industry are working together to drive the utilization of ISS toward the benefit of non-NASA users

- Working toward partnering with OGA’s (DOC, DOT, etc.) to establish long term policy and regulation that will span the life of ISS and commercially available capabilities

The next capabilities in LEO will be driven by national demand and interests – not only by NASA’s
Next HEO NAC

We hope to present a top level draft of the HSF ISS to Proving Ground transition plan and progress towards building the commercial and OGA demand for LEO
## Crew Rotation

<table>
<thead>
<tr>
<th>Year</th>
<th>Inc 43</th>
<th>Inc 44</th>
<th>Inc 45</th>
<th>Inc 46</th>
<th>Inc 47</th>
<th>Inc 48</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>N. S. Kelly (CDR-43) 1 Yr Crew</td>
<td>R. M. Kononenko (1 Yr Crew)</td>
<td>R. O. Padalka (CDR-44)</td>
<td>R. A. Shkaplerov 200 days</td>
<td>N. K. Lindgren</td>
<td>R. S. Volkov (44S)</td>
</tr>
<tr>
<td>2016</td>
<td>R. O. Padalka (CDR-44)</td>
<td>R. A. Shkaplerov 200 days</td>
<td>J. K. Voss</td>
<td>N. T. Kopra (CDR-45) 163 days</td>
<td>J. V. Volkov</td>
<td>R. S. Volkov</td>
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## Soyuz Landing

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<tr>
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<th>Inc 45</th>
<th>Inc 46</th>
<th>Inc 47</th>
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<tr>
<td>2015</td>
<td>04/15</td>
<td>05/19</td>
<td>06/04</td>
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<tr>
<td>2016</td>
<td>07/11</td>
<td>07/17</td>
<td>08/12</td>
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## Stage S/W

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## Port Utilization

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<td>2016</td>
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## Launch Schedule

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<th>Year</th>
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<th>Inc 44</th>
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<th>Inc 46</th>
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## Solar Beta >60

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<td>2016</td>
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## External Cargo

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<th>Inc 44</th>
<th>Inc 45</th>
<th>Inc 46</th>
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<td>2015</td>
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<tr>
<td>2016</td>
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</tbody>
</table>
43 Soyuz Launch/Increment 44
July – December 2015

Vehicle: 43 Soyuz
Launch: July 22, 2015 (planned 4 orbit rendezvous)
Docking: July 23, 2015
Undock/Landing: December 22, 2015

42 Soyuz crew
Genady Padalka, Soyuz and Increment 44 Commander
Scott Kelly, Increment 45/46 Commander
Mikhail Kornienko, Flight Engineer

43 Soyuz Crew
Oleg Kononenko, Soyuz Commander
Kjell Lindgren, Flight Engineer
Kimiya Yui, (JAXA) Flight Engineer
Increment 44 Overview

Major Stage Objectives

- Increment 44: 92 Days
  - Stage 44-3: 41S Undock to 43S Dock: 41 days
  - Stage 44-6: 43S Dock to 44S Dock: 41 days
  - Stage 44-9: 44S Dock to 42S Undock: 10 days
- EVAs
  - RS EVA 41 (8/10)
- Cargo vehicles:
  - 58P Undock from SM Aft (8/14)
  - HTV-5 Launch/Berthing (8/16, 8/20)
- Science/Utilization:
  - Original Inc 43/44 Utilization Target: 35 hrs per week average (1045 hours)
  - Maximizing onboard utilization
- Stowage Ops
  - Making room for Galley and MSPR racks launching on HTV-5
- Maintenance/Outfitting
  - EMU 3011 Return-to-Service
  - NORS AIK Install
  - N1 Nadir Prep for USOS Cargo VV Berthing
  - C2V2 Outfitting
## Total ISS Consumables Status

<table>
<thead>
<tr>
<th>Consumable – based on current, ISS system status</th>
<th>T1: Current Capability</th>
<th>T2: Current Capability + HTV5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date to Reserve Level</td>
<td>Date to zero supplies</td>
</tr>
<tr>
<td>Consumable – based on system failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water, if no WPA (Ag &amp; Iodinated)</td>
<td>October 15, 2015</td>
<td>December 17, 2015</td>
</tr>
<tr>
<td>O₂ if Elektron supporting 3 crew &amp; no OGA</td>
<td>September 02, 2015</td>
<td>December 15, 2015</td>
</tr>
<tr>
<td>O₂ if neither Elektron or OGA</td>
<td>July 31, 2015</td>
<td>September 22, 2015</td>
</tr>
<tr>
<td>LiOH (CDRAs and Vozdukh off)</td>
<td>~0 Days</td>
<td>~14 Days</td>
</tr>
</tbody>
</table>
## USOS Consumables Status

<table>
<thead>
<tr>
<th>Consumable – based on current, ISS system status</th>
<th>U1: Current Capability</th>
<th>U2: Current Capability + HTV5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date to Reserve Level</td>
<td>Date to zero supplies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Date to Reserve Level</td>
</tr>
<tr>
<td>Pre-Treat Tanks</td>
<td>December 31, 2015</td>
<td>February 14, 2016</td>
</tr>
<tr>
<td>Consumable - based on system failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDV + TUBSS (UPA Failed)</td>
<td>July 09, 2015</td>
<td>September 08, 2015</td>
</tr>
<tr>
<td>O₂ if neither Elektron or OGA</td>
<td>August 06, 2015</td>
<td>October 09, 2015</td>
</tr>
<tr>
<td>LiOH (CDRAs and Vozdukh off)</td>
<td>~0 Days</td>
<td>~13.3 Days</td>
</tr>
</tbody>
</table>
### New Pertinent ISS Vehicle Issues

<table>
<thead>
<tr>
<th>Issue</th>
<th>Impact to Stage Ops</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadvertent Soyuz Thruster Firing</td>
<td>No</td>
<td>Soyuz approach and attitude control thrusters fired inadvertently while conducting unique testing of the FGB KURS-P for 41S vehicle, saturating the USOS CMGs. Handover to RS attitude control was initiated for return to nominal TEA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• event caused by an error in the testing procedure that prematurely removed the free drift flag the Soyuz once the KURS test was completed while Soyuz was attached to ISS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>− Actions taken: RSC-E is upgrading the Software Verification Facility to enable performing test runs related to Soyuz vehicles with the ISS configuration (scheduled for July 2015)</td>
</tr>
<tr>
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<td></td>
<td>− RSC-E plans to publish the guidelines for developing, coordinating and validating the procedures not included in the nominal operational documentation (scheduled for August 2015).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ground validation testing is performed with the flight radiogram prior to any nominal usage of RS propulsion assets (maneuvers, DAMs, etc)</td>
</tr>
</tbody>
</table>
New Pertinent ISS Vehicle Issues

<table>
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<tr>
<th>Issue</th>
<th>Impact to Stage Ops</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>High TOC Levels</td>
<td>Yes</td>
<td>The Total Organic Carbon (TOC) readings of the WPA product water have been climbing for the last several weeks.</td>
</tr>
<tr>
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<td>• Indicates that the WPA MF Beds are saturated and require an R&amp;R.</td>
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<td>• There are no spare MF Beds on-orbit, two are targeted for launch on HTV 5.</td>
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<tr>
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<td>• To keep TOC levels steady, teams are processing only distillate from the UPA. Condensate will not be processed as it likely contains DMSD.</td>
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<td>• A 24 hour reprocess will continue to occur after every process cycle.</td>
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<tr>
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<td>• The Flight Rule TOC limit of 3000 ppb is being investigated.</td>
</tr>
</tbody>
</table>
Progress 59P Anomaly

- Launch of 59P occurred on April 28th but failed to reach proper orbit
  - Most telemetry lost and attempts to activate and gain control of Progress unsuccessful
  - Reentered on May 8, 2015
- Russian commission formed to investigate failure, determine cause, provide recommendations – Alexander Ivanov, First Deputy Head Roscosmos as chair
  - 10 versions analyzed, reduced to 1 most probable cause
- NASA formed independent team to review the anomaly, partners participated – similar to 44P investigation, detailed fault tree analyses aligned with Russian findings
- Most probable cause findings
  - Commission Report: “Design feature of the Soyuz-2.1a LV Stage 3-to-Progress M cargo vehicle stack, related to its structural response, which resulted in the LV oxidizer and fuel tank pressure integrity breach and damage to the Progress vehicle”
  - NASA Assessment: “Engine shutdown oscillations coincided with integrated vehicle longitudinal structural eigenmode as a dynamic interaction to cause structural failure
- One possible failure scenario
  - Structural failure resulted in oxidizer integrity breach after engine shutdown (shutdown is rapid, significant propellant remaining in tanks, large accelerometer spike reflected in data due to “hammer” effect)
  - Resulting pressure loads on fuel tank calculated at 167MT of force, enough to result in mechanical separation of Progress with 3rd stage pyro bolt system
Progress 59P Anomaly

- After each flight, Rocket & Space Center Progress analyzes the actual loads, including a comparison and verification of the structural response during ascent with the pre-flight analysis and previous flights
  - dynamic interaction upon engine shutdown not seen on FG/U 3rd stage configurations
- No changes have been introduced into the Soyuz FG 43S launch vehicle systems configuration
- Successful 60P launch with Soyuz U 3rd stage on July 2nd (nominal performance)
- Russian teams recently completed modal testing of the 2.1a / Progress configuration, analyses in work
- Plan to utilize the 2.1A 3rd stage for 62P in November (modal survey results and subsequent mods dependent)
  - No restrictions in place for other missions utilizing the 2.1A 3rd stage
- No planned crew missions on the 2.1a configuration thru 2020
SpX-7 Mission Anomaly

- SpX-7 successfully launched on time at 9:21am CT on 6/28/15
- At 139 seconds, the Falcon launch vehicle experienced an anomaly that ended in loss of vehicle
- SpaceX is leading the investigation with FAA oversight
- NASA supporting with LSP, CCP, and ISS Program personnel
  - Team collocated in Hawthorne, daily status meetings, independent assessments being performed by LSP
  - Excellent sharing of information
- Detailed fault tree developed with emphasis on second stage operation and performance
- Detailed timeline (to the msec’s) developed, taking into account video lag, sensor to computer latency, etc. to correlate timing of events
- Complete audit underway of as flown configuration, reviewing preflight approved issue tickets, component level acceptance packages, integrated stage testing results, etc.
SpX-7 Lost Cargo Summary

- **Crew Supplies**: 690 kg
  - 92 Food BOBs, 2 Bonus Food Kits, 2 Fresh Food Kits
  - Crew Provisions, Crew Care, ODF
- **Utilization**: 573 kg
  - CSA: Vascular Echo Exercise Band
  - ESA: Circadian Rhythms, KUBIK EBOXes, Interface Plate, EPO Peake, BioLab, Spheroids, EMCS RBLSS, Airway Mon. LiOH Cartridge
  - JAXA: Atomization, Biological Rhythms, Multi-omics, Cell Mechnosensing3, Plant Gravity Sensing3, SAIBO L&M, Space Pup, Stem Cells, MSPR LM, Group Combustion Camera
  - US: 2 Polars, 6 DCBs & Ice Bricks, 1 MERLIN, FCF/HRF Resupply, HRP Resupply [Kits, MCT, Microbiome, Twin Studies], IMAX Camera, Meteor, Micro-9, MSG resupply, Nanoracks Modules & 0.5 NRCSD #7, Universal Battery Charger, Veg-03, Microbial Observatory-1, Microchannel Diffusion Experiment, Wetlab RNA Smartcycler, SCK, Story Time, MELFI TDR Batteries
- **Computer Resources**: 36 kg
- **Vehicle Hardware**: 462 kg
  - CHECS CMS: HRM Watches, Bench Lock Studs, Glenn Harness for Kelly, Kopra, and Peake
  - CHECS EHS: CO2 Monitoring Assys, Filter Assys, CSA-CP/CDM Battery Assys, SIEVE Cartridge Assys, Water Kit, Petri Dish Packets
  - CHECS HMS: IMAKs, Oral Med Packs
  - C&T: C2V2 Comm unit (and HTV5 Unit Data Converter)
  - ECLSS: 3 Pretreat Tanks, Filter Inserts, 9 KTOs, UPA FCPA, CDRA ASV, IMV Valve, Wring Collector, Water Sampling Kits, OGS ACTEX Filter, ARFTA Brine Filter Assys, O2/N2 Pressure Sensor, NORS O2, 3 PBA Assys, 2 MF Beds, 2 Urine Receptacles, Toilet Paper Packages, H2 Sensor, Ammonia Cartridge Bag, PTU XFER Hose
  - EPS: 2 Avionics restart cables
  - Makita Drill, PWD Filter, N3 Bulkhead Connectors, Yellow/Red Adapters, IWIS Plates, 6.0 & 4.0 Waste Xfer Bags, BEAM Ground Straps, JEM Stowage Wire Kit
- **EVA**: 167 kg
  - SEMU, REBA, EMU Ion Filters (4), Equipment Tethers, Gas Grap, EMU Mirrors, Crewlock Bags, SEMU arms / legs
  - Lindgren / Yui ECOks & CCAs, Lindgren LCVG
  - Kelly LCVG, Padalka EMU Gloves
- **RS Cargo – RS Torque Wrench**: 526 kg
  - Unpressurized Cargo: IDA #1 (OB)
Orbital-4 Mission Status

- **Mission Planning**
  - Orbital has contracted with United Launch Alliance (ULA) for an Atlas V launch of Cygnus
  - First use of Atlas V401 with the Cygnus spacecraft
  - Integrated Mission Review (IMR) #1 was conducted on 4/9/15 with IMR #2 planned for 7/14/15
  - Integrated Ground Processing Technical Interchange Meeting (TIM) was completed on 5/20/15
  - Trilateral Joint Operations Panel (JOP) was conducted on 5/27/15; planning for a 60 day berthed capability
  - Cargo Integration Review (CIR) is planned for 7/29/15; upmass cargo capability is 3,513 kg
  - On track for late November/early December launch

- **Pressurized Cargo complement**
  - Final ISS cargo manifest will be due in Jul at Launch minus 5 (L-5) months

- **Unpressurized Cargo**
  - Cubesats manifested on this mission; scheduled post ISS departure for deployment operations

- **Cygnus Status**
  - First enhanced Cygnus with a longer Pressurized Cargo Module (PCM) and ultraflex solar arrays
  - Final Integrated Systems Test (FIST) began on 6/27/15
  - PCM was shipped to the Cape on 6/23/15 with arrival to the Cape on 8/7/15
  - Service Module planned to be completed in Aug with shipment to the Cape in Oct

- **Atlas V 401**
  - Serial Interface Test was completed on 4/22/15

- **Orb-3 Mishap Investigation Report** provided by Orbital ATK to the FAA last week
Increment 43 / 44
Utilization Crew Time

Color Key:
- Final OOS
- FPPIP Plan
- Completed

<table>
<thead>
<tr>
<th>3 crew</th>
<th>6 Crew</th>
<th>3 crew</th>
<th>6 Crew</th>
<th>9 Crew</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increment 43</td>
<td></td>
<td>Increment 44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Crew</td>
<td>6 Crew</td>
<td>3 Crew</td>
<td>6 Crew</td>
<td>9 Crew</td>
</tr>
<tr>
<td>March</td>
<td>April</td>
<td>May</td>
<td>June</td>
<td>July</td>
</tr>
</tbody>
</table>

Executed through Increment Wk (WLP Week) 18 = 16.4 of 25 work weeks 65.6% through the Increment

- USOS IDRD Allocation: 1,045.00 hours
- OOS USOS Planned Total: 1,045.10 hours
- USOS Actuals: 599.67 hours

- 57.38% through IDRD Allocation
- 57.38% through OOS Planned Total

- Total USOS Average Per Work Week: 36.57 hours/work week
- Voluntary Science Totals to Date: 0 hours (Not included in the above totals or graph)
- RSA/NASA Joint Utilization to Date: 48.25 Hours (not included in the above totals or graph)
ISS Research Statistics

Number of Investigations for 43/44: 298*

- 121 NASA/U.S.-led investigations
- 177 International-led investigations
- 84 New investigations
  - 1 CSA
  - 16 ESA
  - 12 JAXA
  - 47 NASA/U.S.
  - 8 Roscosmos

- Over 500 Investigators represented
- Over 1000 scientific results publications (Exp 0 – present)

*Preliminary data, pending baselined CEFs for SpX-7 loss adjustments

Expeditions 43/44 Research and Technology Investigations

Estimated Number of Investigations Expedition 0-44: 1915** **Pending Post Increment Adjustments

Working data as of June 30, 2015
**Increments 43 & 44 Research Plan - Investigation List**

### Human Research

**Bone & Muscle Physiology**  
Bisphosphonates (Control), Check-Saliva (Bone/Muscle Check) (ASI), IVD (P), Force Shoes, Hip QCT (P), Sprint, Marrow C/O, Tbome (P), Brain-DTI (P), CARTILAGE (P), EDOS-2, IMMUNO-2

**Cardiovascular & Respiratory Systems**  
Cardio Ox, Drain Brain (ASI), Orthostatic Tolerance (ASI), Wearable Monitoring (ASI), BP Reg, Vascular Echo C/O, IPVI

**Habitability & Human Factors**  
Astro Palate, Body Measures, Fine Motor Skills, Habitability, Training Retention

**Human Behavior & Performance**  
Cognition, Journals, Reaction Self Test, Sleep ISS-12, Space Headaches, Synergy (P)

**Human Microbiome**  
Microbiome, Myco

**Immune System**  
Salivary Markers, Multi-Omics (MAHM)↑

**Integrated Physiology & Nutrition**  
Biochem Profile, Field Test (P), FTT (P), Repository, Telomerizes, Twins Study, Circadian Rhythms, MARES Commissioning Part 1, Biological Rhythms 48hrs

**Nervous & Vestibular Systems**  
Manual Control (P), NeuroMapping, Straight Ahead in Microgravity (P), V-C Reflex (P)

**Vision**  
Fluid Shifts, Ocular Health

### Biology and Biotechnology

**Animal Biology**  
Micro-10, Rodent Research-2, Rodent Research-3 Eli Lilly, Embryo Rad. JAXA Mouse Habitat Unit, Nematode Muscles, Space Aging, Space Pup

**Macromolecular Crystal Growth**  
CASIS PCG 3, CASIS PCG-4, NanoRacks PCG↑, JAXA PCG-9, JAXA PCG Demo

**Plant Biology**  
BRIC-21, Veg-01, Aniso Tubule, Plant Gravity Sensing-2, Plant Rotation

**Microbiology / Cellular**  
CASIS Stem Cell-2, Cell Shape and Expression (ASI), Microbial Observatory-1, Nanoparticles and Osteoporosis (ASI), NanoRacks Module-28*, Osteo-4, RJR Microbial Sampling, Viable (ASI), CYTOSKELETON, ENDOTHelial CELLS, SPHEROIDs↑, Stem Cell Differentiation, TripleLux-A, TripleLux-B, Microbe-IV, Stem Cells, SDM: Melondau

### Physical Sciences

**Combustion Science**  
BASS-II, BASE-M↑, FLEX-2, FLEX-2J, Group Combustion↑

**Complex Fluids**  
ACE-H-1, ACE-H-2, ACE-M-3, OASIS, PK-4

**Fluid Physics**  
BCAT-KP-1, CFE-2, PBRE, Dynamic Surf-2, Dynamic Surf-3

**Materials Science**  
CSLM-4, Synthetic Muscle, NanoRacks Module-40↑, EML Batch 1, SpaceDRUMS↓, Soret Facet

### Earth & Space Science

**Astrobiology/Astrophysics/Heliophysics**  
AMS-02 (E), NanoRacks Module-24, EXPOSE-R2 (E), Solar-SOLACES/SOLSPEC (E), CALET (E), ExHAM#1(E), MAXI (E), MCE (E)

**Earth Remote Sensing**  
CATS(E), CEO, HICO-RAIDS (HREP) (E), IMAX, ISERV, ISS-RapidScat (E), NREP Inserts (E)↑, Tropical Cyclone

**Near-Earth Space Environment**  
SEDAP-A (E)

### Technology Development and Demonstration

**Air, Water, & Surface Monitoring**  
Multi-Gas Monitor, WISENET

**Avionics & Software**  
SNFM

**Characterizing Experiment Hardware**  
Capillary Beverage, MVIS Controller-1

**Communications & Navigation**  
OPALS (E), SCAN Testbed (E), Vessel ID System

**Food & Clothing Systems**  
ISSpresso (ASI)

**Life Support Systems & Habitation**  
AMO TOCA, UPA (PCPA/FCPA), UBNT

**Radiation Measurements & Shielding**  
REM, Radi-N2, DOSIS-3D, Area PADLES-14, -15, PS-TEPC, Free-Space PADLES

**Repair & Fabrication Technologies**  
3D Printing in Zero-G

**Other**  
SDM: 3D-VIT, Skin Suit, SUPVIS-E, MOBIPV, Mobile-HR

**Robotics & Imaging**  
3DAI Camcorder, HDEV (E), Moon Imagery, Robonaut, RRM-Phase 2 (E), Haptics-1, Haptics-2, INTERACT

**Spacecraft and Orbital Environments**  
REBR-W

**Space Structures**  
BEAM

**Small Satellites & Control Technologies**  
NRC5D CubeSats, NanoRacks-MicroSat-SIMPL↑, SPHERES-Slosh, SPHERES Docking Port (UDP), SPHERES-VERTIGO, JSSOD CubeSat

### Educational Activities

**Classrooms Versions of ISS Investigations**  
Windows on Earth

**Commercial Demo**  
JAXA Commercial

**Educational Competitions**  
NanoRacks Module-9, SPHERES-Zero Robotics

**Educational Demos**  
ISS Ham Radio, Tomatosphere-IV, JAXA Try Zero-G for Asia

**Student-Developed Investigations**  
NanoRacks Module-53

**Other**  
EPO CRISTOFORETTI, EPO IRISS (SDM), ESA-EPO-FLYING CLASSROOM, JAXA EPO

---

**Key:**  
- NASA  
- National Lab  
- CSA  
- ESA  
- JAXA  
- ROSCOSMOS

(P) Pre/Post only, (E) External Payload,  
*CEF approval pending, ↑/↓ Launch/Return only
# Increments 43 & 44 Research Plan - Research Lost on SpX-7

## Human Research

<table>
<thead>
<tr>
<th>Bone &amp; Muscle Physiology</th>
<th>Cardiovascular &amp; Respiratory Systems</th>
<th>Habitability &amp; Human Factors</th>
<th>Human Microbiome</th>
<th>Nervous &amp; Vestibular Systems</th>
</tr>
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</table>

- **Airway Monitoring ↑,**
- **Vascular Echo C/O**

## Biology and Biotechnology

<table>
<thead>
<tr>
<th>Animal Biology</th>
<th>Microbiology / Cellular</th>
<th>Macromolecular Crystal Growth</th>
<th>Plant Biology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Pup</td>
<td>Micro-9, Microbial Observatory-1, Cell Mechanosensing-3, Stem Cells</td>
<td></td>
<td>Veg-03, Plant Gravity Sensing-3</td>
</tr>
</tbody>
</table>

## Physical Sciences

<table>
<thead>
<tr>
<th>Combustion Science</th>
<th>Fluid Physics</th>
<th>Complex Fluids</th>
<th>Materials Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATOMIZATION, Group Combustion</td>
<td>Microchannel Diffusion</td>
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</table>

## Earth & Space Science

<table>
<thead>
<tr>
<th>Astrobiology/Astrophysics/Heliophysics</th>
<th>Earth Remote Sensing</th>
<th>Near-Earth Space Environment</th>
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## Technology Development and Demonstration

<table>
<thead>
<tr>
<th>Air, Water, &amp; Surface Monitoring</th>
<th>Life Support Systems &amp; Habitation</th>
<th>Robotics &amp; Imaging</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Microgravity Environment in ISS WetLab-2</td>
<td>Spacecraft and Orbital Environments</td>
</tr>
<tr>
<td></td>
<td>Power Generation/Distribution Services Universal Battery Charger</td>
<td>Small Satellites &amp; Control Technologies NRCSD CubeSats</td>
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<tr>
<td></td>
<td>Radiation Measurements &amp; Shielding</td>
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</table>

## Educational Activities

<table>
<thead>
<tr>
<th>Classrooms Versions of ISS Investigations</th>
<th>Commercial Demo ISS Investigations</th>
<th>Cultural Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Educational Competitions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Educational Demos</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Student-Developed Investigations</td>
<td>ESA-EPO-PEAKE ↑, Story Time from Space-3</td>
</tr>
</tbody>
</table>

## 43/44 Crew Time Impact (hours): Prime: 101.92, Reserve: 60.33 hours

<table>
<thead>
<tr>
<th>Key: NASA</th>
<th>National Lab</th>
<th>CSA</th>
<th>ESA</th>
<th>JAXA</th>
<th>ROSCOSMOS</th>
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<td>† Launch only</td>
</tr>
</tbody>
</table>

Pre-decisional, For Internal Use Only
### Inc 43 - 44 Utilization Crew Time

**Color Key:**
- **Final OOS**
- **FPiP Plan**
- **Completed**

**40S Undock 03/11/15**

**OP/OZ Reconciliation is complete through Week 2.**

**Pre-Decisional, For Internal Use Only**

<table>
<thead>
<tr>
<th></th>
<th>3-Crew</th>
<th>6-Crew</th>
<th>3-Crew</th>
<th>6-Crew</th>
<th>9-Crew</th>
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<tbody>
<tr>
<td>Color</td>
<td></td>
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<td></td>
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<tr>
<td>Final OOS</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>FPiP Plan</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Completed</td>
<td></td>
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</tbody>
</table>

- **US EVA 7/7/15**
- **Berth 8/23/15 N2N**
- **Relocate 8/24/15 N1N**
- **Undock 09/11/15**
- **SpX-7**
- **Berth 6/15/15**
- **Unberth 7/15/15**
- **RS EVA 41**
- **SpX-8**
- **Berth 4/10/15**
- **Berth 4/12/15**
- **Unberth 5/17/15**
- **Unberth 5/21/15**
- **HTV5**
- **Soyuz relo 8/28/15**
- **SpX-6**
- **Undock 09/11/15**

**USOS IDRD Allocation:** 1045.1 hours (41.8 hrs/week) 3.29% through IDRD Allocation

**OOS USOS Planned Total:** 1045.1 hours 3.29% through OOS Planned Total

**Total USOS Average Per Work Week:** 34.42 hours/work week

**Voluntary Science Totals to Date:** 0 hours (Not included in the above totals or graph)

**RSA/NASA Joint Utilization to Date:** 0 Hours (not included in the above totals or graph)

**Executive through Increment Wk (WLP Week) 2 = 1 of 25.0 work weeks (4% through the Increment) 1045.1 hours (41.8 hrs/week)**

Voluntary Science Totals to Date: 0 hours (Not included in the above totals or graph)

RSA/NASA Joint Utilization to Date: 0 Hours (not included in the above totals or graph)
“Benefits for Humanity” and ISS R&D Conference

- July 6 2015 Release Date
  - Human Health
  - Earth Observation & Disaster Response
  - Innovative Technology
  - Global Education
  - Economic Development of Space

http://www.nasa.gov/stationbenefits

ISS R&D Conference July 7-9, Boston, MA

http://www.issconference.org/
ISS R&D Conference

- 703 participants currently registered, expect to exceed 500 participants during the conference week.

- Plenary Sessions to include: the ISS a Catalyst for the Future; Leveraging ISS to Enable LEO Commercialization; and the Role of ISS in Support of Exploration

- Research Plenary Sessions to include: Biomedical Advancements on ISS; Stem Cell Research and Therapeutics; Precision Medicine on the ISS; Materials Science Research; STEM on the ISS; and Humans Survive 1,000 days in Space

- Technical Parallel Sessions to include: Biomedical Research; Earth Science Research; Advances in Communication; Sensors and Components; Drug Discoveries and Delivery Systems; Plants in Space; Developing Commercial Capabilities and Services; Crew Research and Performance; Technology Development on ISS; Space Biology Tools; Cell and Microbiology; Materials Manufacturing and Function in Space; STEM Programs and Processes; and Concepts for the Future
Center for the Advancement of Science in Space (CASIS) and National Laboratory

- NASA has a co-operative agreement with CASIS – not a contract
- To make the mission and goals of the ISS and the National Lab successful, NASA and CASIS have to work together
- CASIS remains funded at $15M/year
- CASIS has made considerable progress in finding users for their National Lab allocation
  - Breadth, but not necessarily depth
- NASA/CASIS relationship is transitioning to sustaining long-term relationships and investment with non-NASA users – private industry and other Government agencies
- NASA works closely with CASIS in Agency commercialization planning activities
- NASA/CASIS working together with National Science Foundation, National Institutes of Health, National Institute of Standards and Technology, U.S. Department of Agriculture
- Stepping up joint NASA/CASIS activities to find common research goals and data sharing

HISTORICAL ISS NATIONAL LAB USAGE

<table>
<thead>
<tr>
<th>Increment</th>
<th>Allocation</th>
<th>Actuals</th>
<th>Usage</th>
<th>Allocation</th>
<th>Actuals</th>
<th>Usage</th>
<th>Allocation</th>
<th>Request</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inc 37/38</td>
<td>287</td>
<td>334.7</td>
<td>117%</td>
<td>6</td>
<td>7.9</td>
<td>132%</td>
<td>427</td>
<td>95</td>
<td>22%</td>
</tr>
<tr>
<td>Inc 39/40</td>
<td>766</td>
<td>389.1</td>
<td>51%</td>
<td>244</td>
<td>197.8</td>
<td>81%</td>
<td>386</td>
<td>96.2</td>
<td>25%</td>
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<tr>
<td>Inc 41/42</td>
<td>539</td>
<td>716</td>
<td>133%</td>
<td>225</td>
<td>705.5</td>
<td>314%</td>
<td>346</td>
<td>178.9</td>
<td>52%</td>
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<tr>
<td>Inc 43/44</td>
<td>1202</td>
<td>1215</td>
<td>101%</td>
<td>537</td>
<td>359</td>
<td>67%</td>
<td>229</td>
<td>224</td>
<td>98%</td>
</tr>
</tbody>
</table>

(Data through 3/31/15)
From CASIS Quarterly Report
ISS NATIONAL LABORATORY PROGRESS

ISS National Laboratory Key Accomplishments

- **Commercial Engagement** – 60 percent of CASIS-sponsored research and development projects are from a wide range of commercial companies. Repeat customers include Eli Lilly, Merck and P&G
- **Balanced Portfolio** - CASIS has evaluated 206 proposals, awarded approx. $20M in grants to 77 research projects with a diverse mix of life sciences/tech dev/remote sensing/phys sciences
- **Leverage** - 7:1 External contribution to project cost versus CASIS seed funding for unsolicited projects
- **Sponsored Program Model** – Mass Life Sciences Center contributed $550,000 to be first-of-its-kind CASIS RFP funded 100% by an outside organization
- **Building Networks** – Stimulating demand with support of 45 partnerships across 6 targeted geographic ecosystems

ISS National Laboratory 2015 Emphasis

- **Expand Sponsored Programs** – Increase outside funding and commercial engagement with repeatable, customer-focused model
- **Strong Alignment with NASA** – LEO Commercialization; Crew time; OGA process; GeneLab/Good Health
- **Expect more than 12 peer-reviewed publications** across wide disciplines
- **Approve several projects under strategic collaborative campaigns** Good Earth & Good Health
- **ISS Research & Development Conference** – Transform annual conference into a dynamic ISS community platform to include strong attendance growth and increased industry investment