NASA and the International Space Station

Sam Scimemi
Director, International Space Station
Human Exploration and Operations
NASA Headquarters

HEO NAC
Kennedy Space Center
December 10, 2013
The International Space Station is essential to meeting the Nation’s goals in space

Returning benefits to humanity through research
Enabling a self-sustaining commercial LEO market
Laying the foundation for long-duration spaceflight beyond LEO
Leading the world in an exploration partnership
"Time works so hard for us, if only we can let it."

Tana French

Time to complete a study in orbit
– 2 weeks to 5+ years

Time from completion of study in orbit to first publication
– 1 to 3 years for majority of investigations

Time from publication or patent to product being in the marketplace
– 3 to 20 years (shorter for technologies, longer for drug development)
Historical Micro-G Research Perspective

**Exploratory**
1973-1979

**Survey**
1981-2011
1994-1998

**Application**
1998
2011 Assembly Complete

~1.5 years of productive on-orbit micro-g research
M. Uhran, Positioning the ISS for the Utilization Era
Some of the Benefits to Humanity To-date

- **Discoveries**
  - Cool flames vaporize without visible flame in space (*Combustion and Flame*)
  - Human immune cells adapt to weightlessness (*J. Leukocyte Biology*)
  - MAXI black hole swallowing star (*Nature*)
  - Vision impacts and intracranial pressure (*Ophthalmology*)
  - Microbial virulence (*Proc. Nat. Acad. Sci.*)

- **Technology Spinoffs**
  - NeuroArm image-guided robot for neurosurgery translates Canadarm technology to the operation room
  - Dusty plasmas applications for medical applications and neutralizing drug-resistant bacteria
  - “Smart” fluids (colloids) phase transition to solid-like states
  - TiO2 for filtering bacteria from the air in daycares
  - Remotely-guided ultrasound for maternal care in remote areas

- **Results with potential human benefits**
  - Amgen bone loss drug testing aided by ISS mouse research model
  - Hyperspectral imaging for environmental monitoring
  - YouTube Space Lab global contest for 14 – 18 year old students
  - Candidate vaccines for Salmonella and MRSA
  - Candidate treatment for prostate cancer
  - Candidate treatment for Duschenne’s muscular dystrophy
Science Mission Directorate Uses of ISS

• ISS Included as a platform in Science Mission DirectorateD solicitations since 2011
  • Explorer-AO; SALMON: Stand Along Missions of Opportunity; SMEX: Small Mission Explorer; ROSES-APRA: Research Opportunities in Space and Earth Sciences – Astrophysics Research Announcement; Earth Venture

• Selections based on decadal survey priorities among proposals on any platform
  • Astrophysics selected CREAM (Cosmic Ray Energetics and Mass) for ISS under ROSES-APRA
  • Astrophysics selected NICER (X-ray navigation) for ISS under Earth Venture-Instrument

• Funded by ESD with ISS support for integration and pointing device
  • SAGE-III (upper atmosphere composition)
  • OCO-3 (atmospheric CO2 sources and sinks)

• Instruments funded by ISS, support for science/ops from ESD
  • CATS (cloud lidar), technology demonstration
  • RapidScat (winds, hurricanes), etc., fills data gap following QuikScat end of life

• International Astrophysics instruments leveraging
  • CALET (Calorimetric Electron Telescope
  • JEM-EUSO (tentatively), JAXA/ESA/ASI/Roscosmos collaboration
Expansion of ISS Research Capabilities
Enabling Greater Scientific and Commercial Return

Rodent Research System

Drosophila (Fruit Fly) Habitat and Centrifuge

Advanced Plant Habitat

Cold Atom Laboratory

ACME Gaseous Combustion

Microbial Observatory

NanoRacks Enhancements

CubeSat Launchers
What would it mean if ISS were extended beyond 2020 for research
Cumulative Crew Time

Extension from 2020-2028 offers 103% more crew time for research

Increments 35-36 have averaged 40 hours/week
For Increments 37-38 expect to average 42 hours/week!

*HRP Crew Hours available starting in Increment 29.
Cumulative # of Internal Experiment Opportunities
Extension from 2020-2028 offers 85% more research

Experiments are calculated as any investigation going on during an increment. Many experiments could take multiple increments to be completed but for comparison purposes all experiments here are normalized to require one increment to complete.

Transition to 4 crew + 2 more racks

Two Rack Deliveries

Final Rack Delivery

Increment Number

Fiscal Year
Cumulative External Site Use and Opportunities
Extension from 2020-2028 offers 166% more research on ISS
Enable a commercial demand driven market in LEO

Over the next 10 years, the FAA predicts that commercial crew and cargo flight to the ISS will account for 57% of the non-GEO launch market

- FAA 2013 Commercial Space Transportation Forecasts, May 2013

Worldwide there are 14-15 flights to the ISS per year
- ISS represents a substantial demand for LEO launch access
- enables immediate access to space and ISS resources
- enables new and innovative use of the complete ISS system
Enable a commercial demand driven market in LEO

Extending ISS beyond 2020 enables a stable demand for commercial crew flights and a commercial demand for space research.

- ISS to 2020
- Commercial Crew: 1 – 2 years of contracted flights
- CASIS: <9 years of productive commercial utilization development

- ISS Operations and Utilization
- Commercial Crew: ~10 years of crewed flights
- CASIS: >17 years of commercial utilization

Years: 2015 to 2040
Enable a commercial demand driven market in LEO

ISS can also enable the demand for commercial uses and applications in LEO that could lead to a commercially provided LEO platform

- Utilize additional commercial crew seats and access to ISS for non-NASA uses including research, tourism or other private initiatives

It is likely that NASA will still have research needs in LEO beyond the life of the ISS

<table>
<thead>
<tr>
<th>ISS Operations and Utilization</th>
<th>~10 years of crewed flights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Crew</td>
<td>&gt;17 years of scientific discovery since assembly complete</td>
</tr>
</tbody>
</table>
Global Exploration Roadmap

International Space Station

General Research and Exploration Preparatory Activities

Note: ISS partner agencies have agreed to use the ISS until at least 2020.

Robotic Missions to Discover and Prepare

- LADEE
- Luna-25 Chandrayaan-2
- Luna 27 RESOLVE
- SELENE-2
- Luna 28/29 SELENE-3
- Rosetta
- Hayabusa2
- OSIRIS-Rex
- InSight
- ExoMars
- Mars 2020
- JAXA Mars Precursor
- Apophis
- MAVEN
- ISRO Mars
- ExoMars

Mars Sample Return and Precursor Opportunities

Human Missions Beyond Low-Earth Orbit

- Explore Near-Earth Asteroid
- Extended Duration Crew Missions
- Humans to Lunar Surface
- Missions to Deep Space and Mars System

Sustainable Human Missions to Mars Surface

Multiple Locations in the Lunar Vicinity
Critical path viewpoint for long duration, deep space human spaceflight

In-space segment
- *Life support*
- *Spacecraft reliability, supportability and maintainability*
- *Human performance for long durations in deep space*
- *Transportation system performance*

Access to the surface: landing on, operating on, and then ascending from Mars
Station is on the critical path to getting humans to Mars

In-space segment
- Life support
- Spacecraft reliability, supportability and maintainability
- Human performance for long durations in deep space
- Transportation system performance

Access to the surface: landing on, operating on, and then ascending from Mars

Critical path research and demonstration activities onboard the ISS will not be complete until about the mid-2020’s timeframe
Closing the gap in Human Health and Performance

The ISS is necessary to mitigate 21 of the 32 human health risks anticipated on exploration missions.

Some of the primary drivers for the length of research onboard ISS are:
- Number of subjects
- Pharmacology
- Visual Impairment and Intracranial Pressure
- Muscle
- Exploration Medical Capability
- Arrhythmia

Given the current number of subjects expected, HRP research and mitigations for long duration deep space missions should be mature enough by the mid-2020’s.
<table>
<thead>
<tr>
<th>MARS</th>
<th>FY13</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
<th>FY17</th>
<th>FY18</th>
<th>FY19</th>
<th>FY20</th>
<th>FY21</th>
<th>FY22</th>
<th>FY23</th>
<th>FY24</th>
<th>FY25</th>
<th>FY26</th>
<th>FY27</th>
<th>FY28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microhost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hab</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immune</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensor/motor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HARI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osteo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pharm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIIP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerobic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ExMC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bmed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IVD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrhythmia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DRAFT - Initial Assessment. Will be refined further as updated Integrated Research Plan is finalized.
Life support and habitation systems

ISS is the only platform to demonstrate the critical systems and technology needed to get humans to Mars

Some of the critical demonstrations unique to deep space/long duration missions are:
- onboard analysis of crew health and atmospheric samples
- ECLSS operations without maintenance for 1 year or more
- Crew exercise equipment operation for 1 year without maintenance
- Demonstration of exploration EVA suit before deep space missions
- Docking system
- Habitation materials

Based on current development and operational constraints, demonstrations will not be complete until the mid-2020’s
<table>
<thead>
<tr>
<th>Capability Gap</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
<th>FY17</th>
<th>FY18</th>
<th>FY19</th>
<th>FY20</th>
<th>FY21</th>
<th>FY22</th>
<th>FY23</th>
<th>FY24</th>
<th>FY25</th>
<th>FY26</th>
<th>FY27</th>
<th>FY28</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECLSS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO2 Removal with no bed maintenance</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
<td>▲</td>
</tr>
<tr>
<td>Reliable O2 Gen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High pressure O2 for EVA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliable urine processing &gt;85%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliable water processing w/ reduced expendables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common biocide with on orbit replenishment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tolerate dormancy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Universal compact commode</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional O2 recovery from CO2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional water from brine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trace Gas</td>
<td>▲</td>
<td>▲</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Targeted Gases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microbial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major Constituents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EVA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exploration Suit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified ACES Suit 0-g demo (incl nutrition deliv)</td>
<td>▲</td>
<td>▲</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Safety and Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency Mask (funding for single cartridge)</td>
<td>▲</td>
<td>▲</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contingency Air Monitor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoke Eater</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Mist PPE (scaled to Exploration size)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exercise Equipment and Sensors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cryo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPST</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZBOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Change Material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable Heat Rejection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High temp heat rejection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comm &amp; Nav</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DTN</td>
<td>▲</td>
<td>▲</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optical Comm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightweight Structures &amp; Materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiation Monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDL - Entry Heat Shield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autonomous Operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Robotics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Robotic refueling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human assist robots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telerobotics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

▲ Projected ISS demo
Basis for international exploration partnership

The ISS Program is sufficiently complex to engage the major spacefaring nations in a common endeavor.

If the ISS Partnership dissolves prematurely, it is not likely that a new partnership would be established anytime in the near future.
Countries that are following the U.S. leadership in space research, education, and exploration
Station is the glue that holds the international human spaceflight community together

With the ISS Program and Partnership fully engaged in human spaceflight beyond 2020, the Partnership can be maintained and enhanced to accomplishing our objectives.
How do we know when we are done with ISS

<table>
<thead>
<tr>
<th>Advance benefits to humanity through research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has the ISS life been fully exploited to the benefit of science and research?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Enable human missions beyond LEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has the critical technologies to conduct human and robotic exploration mission been demonstrated?</td>
</tr>
<tr>
<td>Has the fly off plan to reduce human health and performance risk for long duration deep space mission been completed?</td>
</tr>
<tr>
<td>Has extended crew health and performance operations been fully demonstrated?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Enable commercial demand driven LEO market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has a non-government commercial crew/cargo transportation market DEMAND been established in LEO?</td>
</tr>
<tr>
<td>Has a commercial LEO platform been established that could satisfy government needs?</td>
</tr>
<tr>
<td>Has a non-government commercial demand for micro-gravity research and application been established?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basis for international exploration cooperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has an exploration partnership been established?</td>
</tr>
</tbody>
</table>
Programmatics to 2020

All the ISS Partners have certified the life of ISS up to 2020
  - nearly complete certification to 2028

Soyuz crew flights are contracted thru 2017 Spring return

Currently expect commercial crew flight to begin late 2017

Expect Orbital and SpaceX to develop a regular flight rhythm in 2014-2015

Continue to enhance utilization support equipment
  - Additional racks, common support equipment – CAL, rodent habitats, others

Accommodating Science Mission Directorate instruments for Earth and Space Science

Continue exploration research and technology/system demonstration activities
  - Execution of HRP roadmap, 1-year crew, ECLSS, environmental monitoring, exercise equipment, etc.

Refining de-orbit plan with International Partners
37 Soyuz Launch/Expedition 38
November 2013 – May 2014

Vehicle: 37 Soyuz, TMA-11M
Launch: November 7, 2013 (with 4 orbit rendezvous)
Docking: November 7, 2013
Undock/Landing: May 14, 2014

37 Soyuz Crew Expedition

Mikhail Tyurin Soyuz Commander & ISS Flight Engineer
Rick Mastracchio ISS Flight Engineer
Koichi Wakata (JAXA) ISS Flight Engineer & Expedition 39 Commander

37 Soyuz crew joined 35 Soyuz and 36 Soyuz crew already on orbit

Oleg Kotov Soyuz Commander & Expedition 38 Commander
Michael Hopkins ISS Flight Engineer
Sergey Ryazanskiy ISS Flight Engineer
**Expedition 37**

**9-Crew (3 Soyuz) Operations**

- **Vehicle Traffic:** 3 Soyuz vehicles were docked to RS from 11/7-11/11/13 (9 crew on board)
  - 35S relocation from MRM1 → SM Aft on 11/1/13 to enable 9-crew period and 37S docking
  - 37S docking to MRM1 on 11/07/13
  - RS EVA 36 (Kotov, Ryazanskiy) performed on 11/9/13
    - Olympic Torch being taken put for EVA
  - 35S undocking (ISS CDR Yurchikhin) from SM Aft, landed on 11/11/13

- **ECLSS - Water, CO2, and O2:** No issues
  - Water Processing Assembly (WPA) and Urine Processing Assembly (UPA) operational with ~1,800 L of water in CWC-I storage
  - Node3 and Lab CDRAs operational and can operate in dual bed mode; Vozdukh operational
  - OGA operating to build up stack for 9-crew with ~28kg reserve O2 in 52P (hatch closed during 9-crew)
Performed an average of 44 hrs/week for payload investigations. New investigations include:

- **Biochem Profile** - Will provide critical information about the time course of inflight biochemical changes for multiple physiological systems, allowing better insight into countermeasure effectiveness. Blood and urine samples obtained during pre-, in- and post-flight phases of ISS missions will be collected, processed and stored. A database of the sample analysis results will support metabolic profiles of the effects of spaceflight on human physiology.

- **Salivary Markers** – Is aimed at determining if spaceflight induced immune system dysregulation increases infection susceptibility or poses significant risk to crewmembers onboard the International Space Station. The data from this study will serve as a foundation for future countermeasure developments and detection technology for exploration, and may lead to a greater understanding of how the immune system is affected by different factors.

- **NanoRacks Module 9 S/N 1007** - Consists of seven experiments in areas such as antibacterial resistance, hydroponics, cellular division, microgravity oxidation, seed germination, and bacterial growth.

- **NanoRacks Module 9 S/N 1009** - Includes four experiments in areas such as photosynthesis, antibacterial products, and food making processes in microgravity.

- **Body Measures** - Will quantify the impacts of microgravity on anthropometry to ensure optimal crew performance, fit, and posture. In addition, this study will assess in-flight physical changes of neutral body postures during extended exposure to microgravity.

**Expedition 37 Objectives**

**(September 2013 – November 2013)**

- Supported planned visiting vehicle traffic:
  - Orb-D1 launch, Sept 18
  - 36S launch, Sept 25
  - 36S dock, Sept 26
  - Orb-D1 berth, Sept 29
  - Orb-D1 unberth, Oct 22
  - ATV4 undock, Oct 28
  - 35S relocation, Nov 1
  - 37S launch and dock, Nov 7
  - 35S undock, Nov 11

- Significant tasks:
  - RS EVA 36, conducted Nov 10th (Relaying the Olympic torch, disconnect the DC1 Kurs-P antenna feeder unit from the SM Kurs-P system, connect SM Kurs-P to Kurs-P antenna feeder unit, remove the third Biorisk-MSN container on DC1, replace the adaptor frame (17KC.600I01110A-0) with the adapter beam (17KC.600I01135A-0) and re-installing TMTC units (17KC.600I0), remove PK-21-8 unit and cables
  - 4K Ultra HDV System checkout
  - New Emergency Mask deployment (replaces existing ammonia respirators)
Expedition 38 Objectives
(November 2013 – March 2013)

Perform an average of 44 hrs/week for payload investigations. New investigations include:

- **SODI-DCMIX 2 (Selective Optical Diagnostic Instrument – Diffusion Coefficient in Mixtures 2)** - Will measure diffusion coefficients of selected ternary mixtures taking advantage of the reduced gravity environment available onboard the ISS. Understanding the fundamentals of thermodiffusion and thereby being able to predict its effects is of direct interest, for example, to oil companies that use computer simulations to model underground oil reservoirs and to optimize their exploitation.

- **Space Pup** - Represents the first step towards studying the effects of space radiation on mammalian reproduction, which must be understood to sustain life beyond Earth. This starts by holding freeze-dried mouse sperm aboard the International Space Station for one, 12, and 24 months, and then fertilizing mouse eggs on Earth to produce mouse pups to study the effects of space radiation.

- **Cardio Ox (Cardiovascular Oxidative Damage)** - Is aimed at measuring levels of substances in blood and urine that are affected by oxidative and inflammatory stress and correlate them to the risk of developing atherosclerosis (hardening of the arteries) before, during, and after long duration spaceflight.

- **T-Cell Activation in Aging** - Seeks the cause of a depression in the human immune system while in microgravity. T-cells, a type of white cell, are coated with chemical receptors that must trigger together to activate the body’s immune system properly. T-cells from flight crews and ground volunteers in a range of ages are analyzed to determine changes in protein production and gene response on the ground and in microgravity.

- **Multi-Gas Monitor** - Is a portable, laser spectroscopy device that can simultaneously measure oxygen, carbon dioxide, ammonia, and water vapor. Future space exploration vehicles and habitats would benefit from similar low-power, real-time air sensors.

- **Gravi 2 (Threshold Acceleration for Gravisensing – 2)** - Grows lentil seedling roots under various gravity conditions on board the International Space Station (ISS) to determine the amount of acceleration force sufficient to stimulate the direction of root growth.

- **Soret-Facet** - Studies Soret physics under steady/non-steady conditions including supercooled liquid phase on the ISS, providing the first verification results to link Soret physics and thermodynamics, with applications to mass transport phenomena such as crystal growth, crude oil refinement, planet formation, etc.

Support planned visiting vehicle traffic:
- 53P Launch, Nov 25
- 53P Dock, Nov 29
- Orb-1 Launch, NET Dec 15
- Orb-1 Berth, Dec 18
- Orb-1 Unberth, Jan 30
- 52P Undock, Feb 2
- 54P Dock, Feb 5
- SpX-3 Launch, Feb 22
- SpX-3 Berth, Feb 24
- 36S Undock, Mar 12

Significant tasks:
- SM 8.07 transition
- SSC 5
- COL Cycle 14
- US EVA 3011 suit checkout
- RS EVA 37, planned in December
- Deploy HDEV and OPALS
- RS EVA 38, planned in February
- 4K Ultra HDV System checkout
- JEMRMS SFA Demo #2
## Inc 37 - 38 Utilization Crew Time

<table>
<thead>
<tr>
<th>3-Crew</th>
<th>6-Crew</th>
<th>9-Crew</th>
<th>6-Crew</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Increment 37</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept 1</td>
<td>Oct 2</td>
<td>Nov 3</td>
<td>Dec 4</td>
</tr>
<tr>
<td><strong>Increment 38</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berth 9/22/13</td>
<td>Berth 12/11/13</td>
<td>Berth 01/10/14</td>
<td>Berth 2/24/14</td>
</tr>
<tr>
<td>Undock 10/28/13</td>
<td>Berth 12/18/13</td>
<td>Unberth 02/25/14</td>
<td></td>
</tr>
</tbody>
</table>

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

**OC/OZ reconciliation is completed as of Week 11.**

There are 40 minutes included in week 8 for OCT tech demo if OZ approves.

**Executed through Increment Wk 12 (WLP Week 11):**
- 11.0 hours (42.9 hrs/week)

**USOS IDRD Allocation:** 1082.00 hours (43.65% through the Increment)

**OOS USOS Planned Total:** 1083.41 hours

**USOS Actuals:** 508.67 hours

47.01% through IDRD Allocation

46.95% through OOS Planned Total

**Total USOS Average Per Work Week:** 46.24 hours/work week

**Voluntary Science Totals to Date:** 5.25 Hours (not included in the above totals or graph)
USOS ISS Consumables Status: USOS On-orbit Capability
21-Nov-13 Orb-1 SORR, Orb-1 (Berth 18-Dec-2013)

<table>
<thead>
<tr>
<th>Consumable – based on current, ISS system status</th>
<th>U1: Current Capability with 53P</th>
<th>U2: Current Capability with 53P and Orb-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date to Reserve Level</td>
<td>Date to zero supplies</td>
</tr>
<tr>
<td>Toilet (ACY) Inserts</td>
<td>February 26, 2015</td>
<td>April 18, 2015</td>
</tr>
<tr>
<td>EDV (UPA Operable) (2)</td>
<td>September 18, 2014</td>
<td>March 31, 2015</td>
</tr>
<tr>
<td>Utilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumable - based on system failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water, if no WPA (Ag &amp; Iodinated) (3)</td>
<td>February 17, 2014</td>
<td>April 7, 2014</td>
</tr>
<tr>
<td>LiOH (CDRAs and Vozdushk off)</td>
<td>~0 Days</td>
<td>~13.3 Days</td>
</tr>
</tbody>
</table>

(1) Includes food on Soyuz. (2) A-RFTA operations assume 75% recovery rate and no RS urine processing. (3) RS processes all condensate in event of WPA failure. (4) Includes metabolic O₂ for 45 day/6-crew reserve and the O₂ for greater of CHeCs or 4 contingency EVAs.
USOS System Challenges / Update

- Ku – Band Antenna Group 2 (AG2) Forward Link Anomaly
  - EVA 22 conducted on July 9th and performed an R&R of the transmitter/receiver controller. Nominal operations restored.

- Loss of Columbus Water Pump Assembly
  - Spare pump was flown on ATV-4 in June. New pump installed successfully and nominal operations restored.

- Advanced Resistive Exercise Device (ARED) Cylinder leakage
  - Over the past several months, higher than expected cylinder evacuations were required for proper exercise (almost daily)
  - Replacement cylinders accelerated for deployment in early 2014
  - Self healed – over the past month, leakage has stopped and nominal evacuations are being conducted, continuing to monitor

- 2B Photo-Voltaic Thermal Control System (PVTCS) leak
  - EVA 21 conducted with a successful R&R of the pump, continuing to monitoring but all indications are that this “fixed” the leak
USOS System Challenges / Update

- Node 3 Carbon Dioxide Removal Assembly (CDRA)
  - Excessive sticking of the ASV 102 led to significant ground operations overhead to perform nominal scrubbing cycles
  - 2 valves were onboard that required cleaning prior to installation
  - Cleaning performed and ASV 102 valve was R&R’d, restoring nominal operations to N3 CDRA
  - 2 spare ASV valves in preparations for launch (Orb-1 and SpaceX-3)
EVA 23 – Water in the Helmet Anomaly

- EV2 (Parmitano) experienced a build-up of free water in the EMU helmet during US EVA #23
  - Crew report of ~1.5 liters of water in the helmet at helmet doffing was confirmed by the Post-EVA water recharge of the EMU feedwater tanks
  - Post-EVA, crew reported water was very cold indicating that it came from the EMU cooling loop, not the in-suit drink bag
- EVA was terminated at 1:05 PET with a final PET of ~ 1.5 hours
  - During translation to the Airlock, water migrated to EV2’s face affecting his eyes, ears and nose
  - As a result, EV2’s communications and vision were degraded
- An expedited suit doffing was performed, removing EV2’s helmet at 1:41 PET
- Failure is out of family with previous water in helmet experience which manifests as streaks or “rain” on the visor, not as a significant amount of water in the helmet
- EV2 was using EMU s/n 3011
  - EMU 3011 launched to ISS on STS-132 (May 2010)
  - EMU 3011 had been used on 5 EVAs prior to US EVA 23
Contingency EVA Status

- Operational response to water in helmet and additional risk mitigations developed to restore contingency EVA capability
  - Helmet Absorption Pad (HAP) and snorkel developed as additional risk mitigation
    - HAP Velcroed to inside of helmet vent pad and absorbs ~800 mls of water
    - Snorkel placed between drink bag and Hard Upper Torso (HUT) and used as a last resort if water surrounds the nose/mouth
  - If crewmember notes water pooling/increasing in helmet or senses water in HAP, helmet purge valve is opened, fan is turned off (isolates water and ventilation circuits) and EVA is terminated
    - Operational response based on crewmember’s ability to determine magnitude of the water problem prior to taking action, at which time existing water can migrate in helmet
  - Unknown root cause, so could be EMU fleet-wide issue (e.g., water contamination)
  - Can get affected crewmember inside, need to tightly manage margins considering the four hazards (excess water/drowning, excess CO2, overheating and insufficient O2)
- Residual risks are captured in ISSP NCR and will be weighed against failure impact to ISS and need for contingency EVA
Fault Tree Investigation

- Fault tree contains 44 possible failures/events
- On-orbit testing and component R&R points to failure in water separator circuit (Item 123 fan/pump/separator or surrounding manifold blockage)
- Fault tree closure follows same process as other major ISS anomalies
  - Three independent reviewers (EA, EC, NA) required for closure
  - Higher likelihood failures (14 of 44) are also reviewed by EVA Recovery Team
- All fault tree legs that aren’t directly associated with water separator circuit have been closed
Item 123 Fan/Pump/Separator R&R

- EMU 3011 Item 123 FPS R&R successfully completed on 10/24
  - Subsequent EMU screening test performed and resulted in no water carryover
  - Test pressurizes cooling loop and runs fan/pump/sePARATOR
- FPS removal exposed areas of the suit that allowed for additional inspections and FOD clearing opportunities
  - Small piece of FOD (couple mm) found inside FPS cavity
  - Other observations were in family with ground suit experience
  - Wipes and FOD were packaged with FPS for return on 35S (11/11)
- Following the 123 R&R, all parts of the water separator circuit on the fault tree were changed out, probed, inspected or flushed
- Post return FPS evaluation plan includes CT scan, teardown, test, inspection and possible N-Ray scans
EMU Sparing and Redundancy

- Four EMUs are flown/maintained on-board to provide redundancy and to meet crew sizing needs while minimizing HUT changeouts.
- On-board EMUs
  - Two are functional (S/N 3005 and 3010)
  - 3011 has a water cross-over failure (No-Go for EVA)
  - 3015 has a failed/clogged sublimator (No-Go for EVA) and is planned for return on SpaceX-3.
- EMU 3011 will be returned to service with a series of on-orbit checkouts
  - EMU 3011 is no longer in its pre-flight certified/tested configuration
    - Working to repair and replace several items
  - On-orbit analog checkouts developed based on ground procedures for testing following R&R of the above items
    - Safety review and hazard assessment will be conducted for EMU 3011 following on-orbit checkouts
- EMU 3003 manifested on SpaceX-3
  - Two additional EMUs can be flown this year (Summer and Fall)
    - If proximate or root cause is determined to be a fleet concern, this is the first opportunity for FPS corrective action.
Orbital Demonstration Mission

- Orbital successfully launched on 9/18 and berthed to ISS on 9/29
- Delivered 589 kilograms (about 1,300 pounds) of cargo
- Unberthed successfully on 10/22 carrying 1293 kg of disposal cargo
Orbital Demonstration Flight Anomaly that delayed berthing

Space Integrated GPS (Global Positioning System) INS (Inertial Navigation System) (SIGI) Incompatibility Anomaly

- Problem was traced to a difference in the GPS week outputs for the JEM SIGI and the Orbital SIGI
  - The GPS constellation broadcasts GPS week number as 1 to 1023
  - JEM SIGI GPS receivers outputs GPS week number exactly as the GPS constellation broadcasts it, only as a number between 0 and 1023
  - Orbital SIGI GPS receivers output the GPS week number as true weeks since Jan 6, 1980, meaning the GPS week can be >1023

- Resolution/Mitigation
  - Cygnus flight SW patch (essentially 1 line of code) created to add 1024 to the received JEM GPS week output, thereby making it match the Cygnus SIGI
  - Orb-1 will re-use same SW patch used on Demo. Orb-2 and subsequent missions will have code change in new SW release
Orbital-1 Mission Status

- Pressurized Cargo complement, 1,288 kg / 102 CTBE
  - Commercial Generic Bioprocessing Apparatus (CGBA) active payload (late load)
  - 2 passive lockers (late load)
  - 1 double cold bag (late load)

- Mission Status
  - Joint Multi Segment Trainings (JMSTs) #1 – 4 were completed in Nov and Dec
  - Joint Software Stage Testing was completed on 11/15
  - Orbital Flight Readiness and Certification Review (FRCR) was conducted on 11/19
  - Stage Operations Readiness Review (SORR) was conducted on 11/21
  - PROX checkout is scheduled from 12/9 – 12/10
  - Final Mission Dress Rehearsal is scheduled for 12/13

- Cygnus Status
  - Cygnus completed fueling and was transported to the HIF
  - Mate to Antares is scheduled for 12/9
  - Late/final cargo load is scheduled for 12/13
  - Rendezvous with ISS is planned for 12/21

- Antares Status
  - Transfer to Transport Erector Launcher (TEL) is planned for 12/6
  - Rollout to the pad is scheduled for 12/14

- Completed Orb-1 milestones
  - Authority To Proceed
  - Long Lead Order Placement
  - Vehicle Baseline Review
  - SM Propulsion Sys Manufacturing Readiness Review
  - Mission Integration Review
  - Service Module Integration and Test
  - Receipt of Long Lead Items
  - Cargo Integration Review
SpaceX-3 Mission Status

- **Pressurized cargo (Expecting full launch/return complement of 1580kgs, 3476 lbs)**
  - Powered Middeck Lockers:
    - **Launch**: 1 GLACIER; Micro-7 and Biotube Micro; 2 MERLINs, and 5 Cold Bags
    - **Return**: 2 GLACIERs; Micro-7 and Biotube Micro Experiments, and 5 Cold Bags
  - Launching a T-Cell experiment used to test the immune system
  - Launching a Short Extravehicular Mobility Unit (SEMU)

- **External Cargo**
  - High Definition Earth Viewing (HDEV) Camera on NASA Columbus External Payloads Adapter (CEPA)
  - Optical PAyload for Lasercomm Science (OPALS) on SpX Express Payload Adapter (ExPA) (first use of SpX built ExPA)
  - Poly-Picosatellite Orbital Deployer (P-POD) is secondary payload

- **Dragon 5 Status**
  - Trunk is scheduled for shipment to the Cape on 12/3
  - HDEV/OPALS integration to trunk is planned for 12/12
  - Dragon capsule arrival at the Cape is planned for 12/17
  - Final software Stage Test is planned for early Jan 2014

- **F9v1.1 (F9-9) Status**
  - Second Stage and Interstage are planned to be at the Cape in early Jan 2014
  - First Stage is planned to be at the Cape in mid Jan 2014

- **Completed SpX-3 milestones**
  - Authority To Proceed
  - Vehicle Baseline Review
  - External Cargo Baseline
  - FRAM LON
  - Mission Integration Review
  - External Integration Review
  - Cargo Integration Review
International Space Station
Commercial Resupply Services Status

- SpaceX
  - Completed demonstration flight on May 31, 2012; completed first and second Commercial Resupply Services (CRS) missions (SpX-1 and SpX-2) on Oct 28, 2012 and Mar 27, 2013, respectively
  - Seven missions currently in flow (SpX-3 through SpX-9)
    - Final milestone for SpX-1 met in December 2012
    - Final milestone for SpX-2 met in June 2013
    - Hardware production, cargo integration, and external hardware manufacturing and integration activities are proceeding for the future flights

- Orbital Sciences Corporation (OSC)
  - Demonstration status: Maiden test flight successfully completed on Apr 21, 2013; Demo flight successfully launched to ISS on Sep 18, 2013, berthed on Sep 29, 2013, and unberthed on Oct 22, 2013
  - Seven missions currently in flow (Demo (post-flight review) + Orb-1 through Orb-6)
    - Hardware production and cargo integration activities are proceeding
  - OSC is relying on NASA assets at Stennis Space Center (SSC) for engine testing and Wallops Flight Facility (WFF) for launch vehicle processing and integration
ISS Top Program Risk Matrix
Post October 25, 2013 PRAB

Score: 2 x 2
▲ 6347 - Temporary Urine and Brine Stowage System
Catastrophic leak of a Tox-2 Fluid - (OB) - (C,S,T,Sa)
▲ 6039 - Carbon Dioxide Removal Assembly (CDRA)
Function - (OB) - (C,T,Sa)
▲ 6032 - On-Orbit Stowage Short-Fall (Pressurized Volume)
- (OC) - (T,Sa)

Corrective/Preventative Actions

None

Watch Items

None

Continual Improvement

None

Score: 5 x 5
▲ 6352 – Lack of Assured Access to ISS - (OH) - (C,S,T,Sa)

Score: 5 x 4
▲ 6370 - ISS Pension Harmonization - (OH) - (C)
▲ 6344 - ISS Operations Budget Reduction - (OH) - (C)

Score: 4 x 4
▲ 6475 - ISS Budget and Schedule - (OH) - (C,S,T)
▲ 6372 - Full ISS Utilization at 3 Crew - Level 1 - (OZ) - (C,S)
▲ 6169 - Visual Impairment / Intracranial Pressure - (SA) - (C,S,T,Sa)

Score: 3 x 5
▲ 6450 - Potential Inability to Support ISS Critical Contingency (&
other) EVA Tasks - (XA) - (C,S,T,Sa)
▲ 6444 - ISS Cascading Power Failure - (OM) - (C,S,T,Sa)
▲ 6382 - Structural Integrity of Solar Array Wing (SAW) Masts due
to MMOD Strikes - (OB) - (S,T,Sa)
▲ 5688 - ISS Solar Array Management Operations Controls and
Constraints - (OM) - (C,S,T,Sa)
▲ 2810 - Russian Segment (RS) capability to provide adequate
MM/OD protection - (OM) - (C,S,T,Sa)

Score: 3 x 3
▲ 6438 - C2V2 Comm Unit Vendor Misinterpreting ISS
Requirements - (OG) - (C,S,T,Sa)
▲ 5269 - The Big 13 Contingency EVA’s - (OB) - (S,T,Sa)

Score: 3 x 2
▲ 6452 - Lack of Sufficient Sparing for the Ku-Band Space to
Ground Transmitter Receiver Controller (SGTRC) to reach
2020 - (OD) - (S,T)
▲ 6439 - EPROM Memory Leakage - (OD) - (T,Sa)
▲ 6420 - NDS Qualification Schedule - (OG) - (C,S,T,Sa)

▲ 5184 – USOS Cargo Resupply Services (CRS) Upmass Shortfall -
2010 through 2016 - (ON) - (C,S,T,Sa)

- Top Program Risk (TPR)

Added: 6475, 6452, 6439, 6438, and 6039

Removed: 6413 – ELC ExPCA Low Voltage Power Supply (LVPS) Board Design Flaw, 6399 – Budget and Schedule (FY13), and 6368 – NORS Development.

Rescored: 6420