ISS Utilization Status and Plans

NASA Advisory Council
Commercial Space Committee

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NASA
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International Space Station

- **Spacecraft Mass**: 409,194 kg (902,119 lb)
- **Spacecraft Pressurized Volume**: 917 m³ (32,333 ft³)
- **Velocity**: 28,164 km/h (17,500 mph) = 7823.2 m/s (a bullet from a high powered rifle travels at ~1500 m/s)
- **The solar array surface area**: 3567 m² (38,400 ft²) = 0.88 acre
- **Science Capability**: Laboratories from four international space agencies - US, Europe, Japan, and Russia
- **On-orbit construction**: Began in 1988, 37 space shuttle flights, 4 Russian assembly launches, and over 150 spacewalks
U.S. Led International Operations

- MSS Control Saint-Hubert, Canada
- Columbus Control Center Oberpfaffenhofen, Germany
- ISS Mission Control Moscow, Russia
- JEM/HTV Control Center Tsukuba, Japan
- H-IIB Launch Control Tanegashima, Japan
- NASA ISS Mission Control Houston, Texas
- Payload Operations Center Huntsville, Alabama
- ATV Control Center Toulouse, France
- Russian Launch Control Baikonur, Kazakhstan
- Space Shuttle Launch Control Kennedy Space Center, Florida
- Ariane Launch Control Kourou, French Guiana

United States  Russia  Canada  Europe  Japan
Transportation to Space Station

- More than 100 launches by five agencies
  - By Canada, Europe, Japan and Russia
  - Russian transportation
    - Four Soyuz trips annually w/ 3 crew members
    - 12 Crew members for expeditions through 2014
    - 15 resupply vehicles over next three years
    - 33 Soyuz and 50 Progress flights completed
    - 2 commercial cargo flights, SpaceX demo and SpaceX 1
Presentation Overview

• What are we doing on ISS today?
  – Disciplines
  – Record throughput
  – Growth of ISS National Lab/CASIS-sponsored research

• What is “full utilization” of ISS and what role does commercial space play?

• Enabling greater scientific return

• Communicating about ISS and its accomplishments
What are we doing on ISS today?

National Lab (Earth Benefits)
- Biology and Biotechnology
- Human Research
- Physical Sciences
- Tech Demos
- Astrophysics
- Earth Science
- Education

NASA (Exploration)

*Numbers are under review
Record ISS Throughput

Research and Technology Investigations
December 1998 - September 2012

* Post- Columbia
† Japanese investigation surge in protein crystal growth
‡ Shuttle Return to Flight
φ Estimated Numbers

- NASA
- ESA
- CSA
- JAXA
- Roscosmos

Mar 2001 - Dec 2001
Dec 2001 - Oct 2003
Oct 2003 - Oct 2004
Oct 2004 - Sept 2006
Sept 2006 - Oct 2007
Oct 2009 - Sept 2010
Sept 2010 - Sept 2011
Sept 2011 - Sept 2012
ISS National Laboratory as a portion of the US research portfolio
Growth of ISS National Lab

• From 2005-2012 “National Lab Pathfinders”
  – By 2011, Approximately 25% of ISS investigations were National Lab Pathfinders

• 2011-2013 Transition to CASIS management
  – First research solicitations open now
  – First CASIS-selected experiments will fly in Expeditions 37/38 (about 1 year from now)
  – Some pathfinders will end, some will transition to CASIS management
External Facilities
Overview of External Payload Attachment Sites

External Workstations (9) on the Russian Service Module
External Instrument Sites
All good Earth- and nadir-viewing sites full by 2016
Facilities in Express Racks

Key Factors:
- Based on total of 58 lockers (64 total minus 6 for galley and CUCUs).
- Includes all payloads that were either locker replacements or locker inserts.
- Does not include Galley or CUCU locations (6 total).
- Includes all Glacier units.
- Does not include storage volume.
- Does not include ISIS or utility drawers.
- Partner commitment is EMCS (4-locker unit in Rack 3).
- Source: EXPRESS Locker Drawer Accounting Sheet, 2/513

Update:
- CGBA5 & 8 no longer simultaneously installed in Inc 34/35
- CGBA5 launched in Inc 37 instead of CGBA1
- SPHERES RINGS remain deployed in Inc 37/38

There is no up or down arrow because the National Lab value (maximum occupancy) is constant from Inc 35 to 36. The arrows typically reflect an increase or decrease from the previous increment value and the label reflects cause of change.

Utilization Plan
USOS Crew Time
Now at strategic goal (USOS 35 hrs/wk), but our users need more
How do we know we are at full utilization?

• **Real estate bottom line:**
  – Racks 71% occupied
  – EXPRESS 60% occupied, expect 80% by the end of 2014
  – External Sites 35% occupied, expect 75% by end of 2014
  – Best external sites (best viewing with good Nadir or Zentith 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

• **Upmass/downmass bottom line:**
  – Mass not limiting--No backlog on the ground today, projected mass capacity is good
  – Our on-orbit freezers are nearly full (>100%), dependent on regular SpaceX return
  – User demand for powered launch and return cannot be met (>100%) due to Biotech and Biology interest
Major factors influencing research use of ISS

Lack of research funding

Resource limitations (e.g., upmass, downmass, crewtime)
- Flight delays to resupply and return plan
- Operations scenarios that reduce crew time for research

Cost to use the platform
- Transportation costs (now provided for all)
- Costs of payload development (National Lab enabling funding)

Strategies to tip the balance: diverse transportation providers, procure upmass for more users, simplify integration, communicate successes

Research Demand
- NASA Funding
- Non-NASA Funding
- Research breakthroughs that drive funding (Earth benefits & applications)
Enabling greater scientific return

- Rodent Research System
- Drosophila Habitat and Centrifuge
- “Microbial Observatory”
- Advanced Plant Habitat
- ACME Gaseous Combustion
- Cold Atom Laboratory
ISS Role in Commercial Space

- Customer for commercial launches
  - Cargo
  - Crew
- Enable future commercial research platforms that could follow in LEO
- Access to ISS as a research and development platform for commercial users
  - Biotech/Pharma
  - Aerospace Industry
  - Materials Industry
  - Commercial Remote Sensing
Technology Demonstration on ISS
Robotics

Robotic Refueling Mission (RRM) is an external International Space Station experiment that paves the way for future robotic refueling missions. It demonstrates robotic refueling tasks and servicing technologies in a zero-g environment. It uses of the ISS Special Purpose Dexterous Manipulator (also known as “Dextre”) to validate tasks, tools, and techniques needed to repair “legacy” satellites not designed to be refueled in orbit. Robotic refueling extends the lifetime of satellites, allowing owners and operators to gain additional years of use from assets already operating in space.

Source: ISS Program Scientist, NASA
Software Communications and Navigation (SCaN Testbed) is an external International Space Station that will provide an orbiting laboratory on space station for the development of Software Defined Radio (SDR) technology. It includes three SDR devices, each with different capabilities. These devices will be used by researchers to advance a new generation of space communications so that future NASA space missions will be able to return more scientific information and add new functions to accommodate changing mission needs.

Source: ISS Program Scientist, NASA
Software Communications and Navigation (SCaN Testbed) is an external The Forward Technology Solar Cell Experiment (FTSCE), part of Materials ISS Experiment-5 (MISSE-5) spent International Space Station characterized the durability and the electrical output of 39 advanced solar cell samples that could be used on future space exploration vehicles. Solar cells degrade over time when exposed to the space environment. Some samples flown had two orders of magnitude better performance than solar cell materials currently in use.

Source: ISS Program Scientist, NASA
Zero Boil-Off Tank Experiment (ZBOT) is an International Space Station demonstration to be conducted in the Microgravity Sciences Glovebox in late 2014. It will aid the design of long-term storage systems for cryogenic fluids. Simulated by Perfluoro-normal-Pentane (P-n-P), it will validate a Computational Fluid Dynamics (CFD) model for cryogenic storage in 1g and microgravity. This will support reductions in launch mass while insuring cost effective and reliable cryogenic storage for both life support and propulsion systems.

Source: ISS Program Scientist, NASA
Amine Swingbed is a prototype Carbon Dioxide removal system being tested on the International Space Station. Vacuum Regenerated Amine Systems have traditionally been applied to relatively short duration human space flight missions because water vapor is removed along with the CO2. Long duration missions need to recycle water. This system combines water recovery with the vacuum regeneration approach to measure its performance. This combined system uses less power and it is smaller in size than current technologies (note the small size compared to the fingers in the photo).
Fire Safety

The Smoke Aerosol Measurement Experiment (SAME) on the International Space Station has revolutionized our understanding of the nature of smoke and soot in spacecraft fires, defining new requirements for future fire safety systems. Now ongoing on ISS, Burning and Suppression of Solids in Space (BASS) is looks at flames from a variety of burning materials with different shapes. Researchers use this investigation to assess the effectiveness of nitrogen in suppressing microgravity fires.
Current, Planned, or Proposed ISS Technology Demonstrations

Italic = NRC High Priority Technology that would benefit from ISS access
Underline = NRC High Priority Technology (focus for next 5 years)

• Robotics
  – Next Gen Canadarm testing (CSA)
  – Robotic Assisted EVA’s (Robonaut, NASA)
  – METERON (ESA) and Surface Telerobotics
  – Delay Tolerant Network Robotic Systems
  – Robotic Refueling Mission (CSA, NASA)
  – Robotic assembly to optical tolerances (OPTIIX, NASA)

• Comm and Nav
  – OPALS – Optical Communication
  – Software Defined Radio (CoNNeCT/SCAN, NASA)
  – Delay tolerant space networks
  – Autonomous Rendezvous & Docking advancements (ESA/JAXA)
  – Advanced optical metrology (sensing/mat’ls)

• Power
  – Regenerative fuel cells
  – Advanced solar array designs [FAST, IBIS, or other]
  – Advanced photovoltaic materials
  – Battery and energy storage advancements [Li-Ion or other]

• Thermal Control
  – High efficiency radiators
  – Cryogenic propellant storage & transfer
  – Advanced materials testing

• Closed Loop ECLSS
  – Atmospheric monitoring: ANITA2 (ESA), MIDASS (ESA), AQM (NASA)
  – Air Revitalization: Oxygen production, Next Gen OGA [Vapor Feed or other] (NASA)
  – Contaminated gas removal
  – Carbon Dioxide recovery: Amine swingbed and CDRA bed advancements
  – Advanced Closed-loop Life Support ACLS (ESA), MELiSSA (ESA),
  – Water/Waste: Electrochemical disinfection, Cascade Distillation System, Calcium Remediation, [Electrodialysis Metathesis or other]

• Other
  – Spacecraft Fire Safety Demonstration
  – Radiation protection/mitigation/monitoring
  – On-board parts repair and manufacturing
  – Inflatable Module (BEAM)
As of 10/5/12 a total of 783 results publications have been collected for ISS investigations for all of the partners.

Of these:
- 588 Journals
- 159 Conferences
- 36 Gray Literature (patent, book, magazine, technical paper, DVD)
## Top Journals with ISS Results by Impact Factor/Eigenfactor

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<th>Journals</th>
<th>1Year Impact Factor</th>
<th>5 year Impact Factor</th>
<th>Eigenfactor</th>
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<td>Nature</td>
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<td>Proceedings of the National Academy of Sciences of the United States of America</td>
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<td>Physical Review Letters</td>
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<td>Journal of Biological Chemistry</td>
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<td>PLoS ONE</td>
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<td>Applied and Environmental Microbiology</td>
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<td>Brain Research</td>
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* Does not include the patents from ISS systems development
What kind of benefits come from ISS research?

- Discovery
- Earth Benefits
- Space Exploration

Spinoffs → Research Benefits

Julie A. Robinson, ISS Program Scientist
**Human Helpers** - Co-developed with General Motors (GM), Robonaut is the first humanoid robot in space, and its primary job for now is demonstrating how a dexterous robot can manipulate mechanisms in a microgravity environment, operate in the space environment for extended periods of time, assist with *International Space Station* tasks, and eventually interact with astronauts. GM plans to use the results in future advanced vehicle safety systems and manufacturing plant applications.

Source: ISS Program Scientist, NASA
Portable Test System - Handheld devices enable crew on the International Space Station to rapidly detect a variety of biological and chemical substances of concern to crew safety. This type of environmental testing technology has Earth-based, as well as future exploration missions and planetary protection applications.

Source: ISS Program Scientist, NASA
Multi-body Maneuvering in Space – The Massachusetts Institute of Technology (MIT) is using color coded bowling-ball sized spherical satellites to demonstrate space-based autonomous rendezvous and docking on the International Space Station. The results have applications for satellite servicing, space-based vehicle assembly and formation flying spacecraft configurations.

Source: ISS Program Scientist, NASA
Regen ECLSS – Water recycling, oxygen generation, and carbon dioxide removal are critical technologies for reducing the logistics re-supply requirements for human spaceflight. The *International Space Station* demonstration project is applying lessons learned from operational experiences to next generation technologies. The resin used in the ISS water processor assembly have been developed as a commercial water filtration solution for use in disaster and humanitarian relief zones.
Space Insights into Drug Function – In an investigation performed on a flight to the International Space Station by BioServe Space Technologies and Amgen Inc., found the use of the protein Osteoprotegerin (OPG) as a bone loss treatment nearly reversed bone resorption and declinations in bone strength in a rodent model. Results of this study also yielded fundamental insight into mechanisms of OPG function. An OPG pharmaceutical (Prolia™) was released in 2011 for use in severe bone loss in cancer patients.

Source: ISS Program Scientist, NASA
Medical Technology - The development and use of the robotic arm for space missions on the Space Shuttle and the International Space Station has led to the world’s first MRI (Magnetic Resonance Imaging) compatible image-guided, computer-assisted device specifically designed for neurosurgery. The device now being used to augment surgeons’ skills to perform neurosurgeries that are traditionally considered difficult or impossible, thus leading to better patient outcomes.

Source: ISS Program Staff
Examples of Major ISS Benefits from the Decade of Assembly

• Discoveries
  – MAXI black hole swallowing star (Nature)
  – Vision impacts and intracranial pressure (Ophthalmology)
  – Microbial virulence (Proc. Nat. Acad. Sci.)

• Results with potential Earth benefit
  – Candidate vaccines for Salmonella and MRSA
  – Candidate treatment for prostate cancer
  – Candidate treatment for Duschenne’s muscular dystrophy

• NASA Exploration Mission
  – Life support sustaining and reliability
  – Success in bone health maintenance resistive exercise (J. Bone Mineral Res.)
  – Models for Atomic Oxygen erosion in orbit

• Technology Spinoffs
  – Robotic assist for brain surgery
  – TiO2 for filtering bacteria from the air in daycares
  – Remotely-guided ultrasound for maternal care in remote areas
ISS is a stepping stone to future human exploration

- Testing human endurance, equipment reliability, technologies, and life support systems essential for space exploration.
- The global partnership, which constructed the space station, represents the foundation for the international technological collaboration needed to further humankind’s reach into space.
Program Focus

Tactical
- Maintain/increase crewtime & resources for utilization
- Continue preparations for 1 year Increment
- FY13 budget posture
- Execute Space X2 Mission & complete Orbital 5K, 7K, and test flight
- ATV 4 launch
- HTV 4 launch
- Better utilize On-orbit stowage to improve crew time efficiency
- Commercial Crew Integration

Strategic
- Increase utilization of ISS as a National Lab
- Technology development and demonstration
- Increase utilization on ISS as a test bed for exploration
- Crew transportation plan
- Technical analysis & planning of ISS life extension
- Budget formulation to address challenges over the budget horizon.
ISS benefits for Humanity Document
ISS Research & Technology
http://www.nasa.gov/iss-science/

@ISS_Research

ISS Research Blog “A Lab Aloft”
http://go.usa.gov/atl