Science on the International Space Station: Stepping Stones for Exploration

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ISS Program Scientist
May 2007

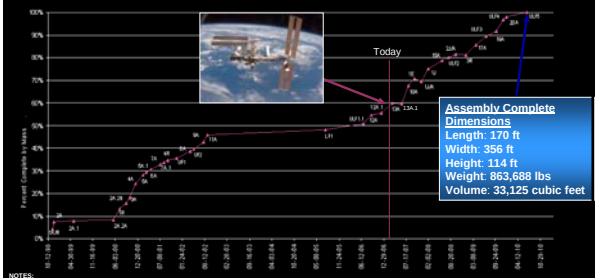
Introduction to ISS

14 ISS Expeditions Completed

Over 6 years of active human presence

ISS Percent Complete by Mass

Item		Today (Post 12A.1)	US Complete To Node 2	US Complete To Node 2 %	International Core Complete	International Core Complete %
Mass On-orbit	(lbm)	475,363	578,629	82%	863,688	55%
Air Volume	ft^3	14,791	18,520	80%	33,125	56%



NOTES:
•Based on (SSP 50110) Multi-Increment Manifest Rev H
•The mass totals are representat from Shuttle flight to Shuttle flight and include all visiting vehicles.
•The mass reduction at the 13A.1 timeframe is due to an undocked Progress.
•The mass reduction at the 13A timeframe is due to an undocked ATV.
•The mass reduction at the 3R timeframe is due to an undocked ATV.

International Space Station Program Office

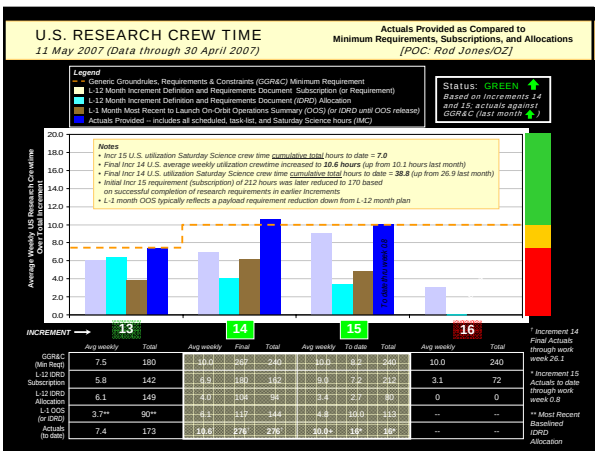
February 12, 2007

U.S. RESEARCH CREW TIME

11 May 2007 (Data through 30 April 2007)

Actuals Provided as Compared to Minimum Requirements, Subscriptions, and Allocations

[POC: Rod Jones/OZ]

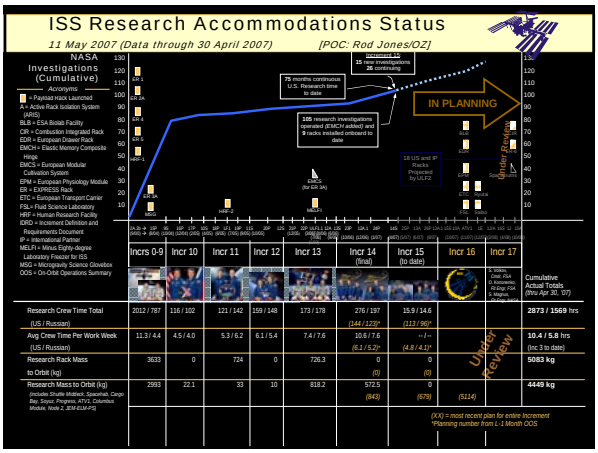


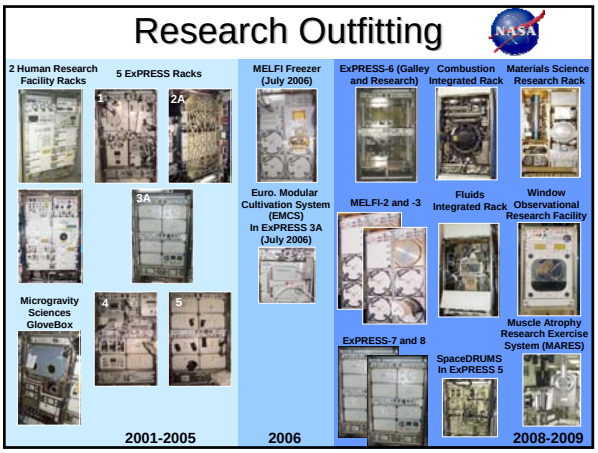
	13 Avg weekly	13 Total	14 Avg weekly	14 Final	14 Total	15 Avg weekly	15 To date	15 Total	16 Avg weekly	16 Total
GGR&C (Min Req)	7.5	180	10.0	240	240	10.0	212	240	10.0	240
L-12 IDRD Subscription	5.8	142	4.0	170	212	8.8	212	212	3.1	72
L-12 IDRD Allocation	6.1	149	4.0	104	96	2.4	27	80	0	0
L-1 OOS (or IDRD)	3.7**	90**	4.3	112	144	4.8	19.0	163	--	--
Actuals (to date)	7.4	173	10.6	275	276	30.0+	38*	38*	--	--

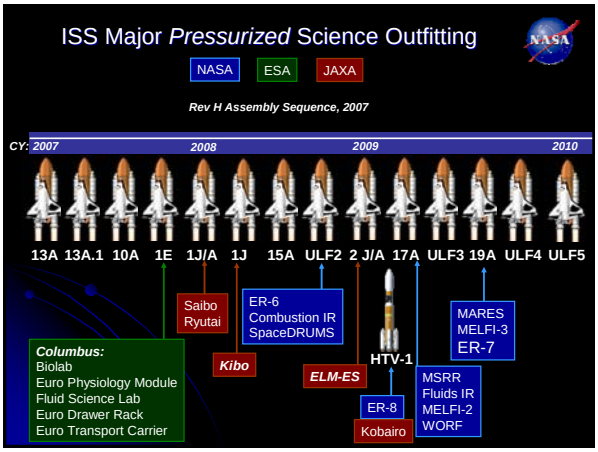
† Increment 14 Final Actuals through work week 26.1

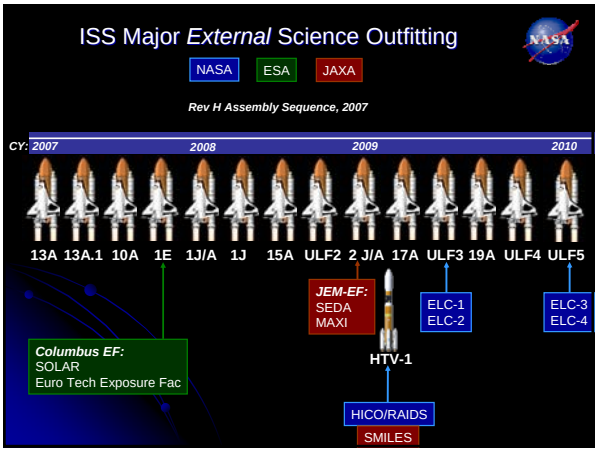
* Increment 15 Actuals to date through work week 0.8

** Most Recent Baselined IDRD Allocation


ISS Research Accommodations Status
11 May 2007 (Data through 30 April 2007)
[POC: Rod Jones/OZ]
NASA Investigations (Cumulative)
IN PLANNING
Incrs 0-9
Incr 10
Incr 11
Incr 12
Incr 13
Incr 14 (final)
Incr 15 (to date)
Incr 16
Incr 17
Cumulative Actual Totals (thru Apr 30, '07)
Research Crew Time Total (US / Russian) 2873 / 1569 hrs
Avg Crew Time Per Work Week (US / Russian) 10.4 / 5.8 hrs (Inc 3 to date)
Research Rack Mass to Orbit (kg) 5083 kg
Research Mass to Orbit (kg) 4449 kg
Under Review


Research Outfitting
2 Human Research Facility Racks
5 ExPRESS Racks
MELFI Freezer (July 2006)
ExPRESS-6 (Galley and Research)
Combustion Integrated Rack
Materials Science Research Rack
Euro. Modular Cultivation System (EMCS) In ExPRESS 3A (July 2006)
MELFI-2 and -3
Fluids Integrated Rack
Window Observational Research Facility
Microgravity Sciences GloveBox
Muscle Atrophy Research Exercise System (MARES)
ExPRESS-7 and 8
SpaceDRUMS In EXPRESS 5
2001-2005
2006
2008-2009


ISS Major Pressurized Science Outfitting
NASA
ESA
JAXA
Rev H Assembly Sequence, 2007
CY: 2007 2008 2009 2010
13A 13A.1 10A 1E 1J/A 1J 15A ULF2 2 J/A 17A ULF3 19A ULF4 ULF5
Columbus:
Biolab
Euro Physiology Module
Fluid Science Lab
Euro Drawer Rack
Euro Transport Carrier
Saibo
Ryutai
Kibo
ER-6
Combustion IR
SpaceDRUMS
ELM-ES
HTV-1
ER-8
Kobairo
MSRR
Fluids IR
MELFI-2
WORF
MARES
MELFI-3
ER-7


ISS Major External Science Outfitting
NASA
ESA
JAXA
Rev H Assembly Sequence, 2007
CY: 2007 2008 2009 2010
13A 13A.1 10A 1E 1J/A 1J 15A ULF2 2 J/A 17A ULF3 19A ULF4 ULF5
Columbus EF:
SOLAR
Euro Tech Exposure Fac
JEM-EF:
SEDA
MAXI
HTV-1
HICO/RAIDS
SMILES
ELC-1
ELC-2
ELC-3
ELC-4


Nine NASA Research Racks On Orbit
2 Human Research Facility (HRF) Racks
Biomedical investigations, including ultrasound, body mass measurement, metabolic gas analysis, pulmonary monitoring, ambulatory blood pressure measurement, Holter monitor, and experiment unique hardware
5 Multi-User (EXPRESS) Racks
Middeck locker scale instruments in various research disciplines such as biotechnology and plant research
Microgravity Sciences Glovebox (MSG)
Principally materials and fluid physics experiments to date
Minus Eighty-degree Laboratory Freezer for ISS (MELFI)
Provides thermal conditioning at +4°C, -26°C and -80°C
Expedition 2 crewmember Susan Helms activating the HRF 1 rack
Expedition 12 crewmember Bill McArthur activating the SLAMMD in the HRF 2 rack
Expedition 3 crewmember Frank Culbertson conducting cell culture experiment in CBOSS in EXPRESS Rack 4
Expedition 14 crewmember Mike Lopez-Alegria conducting TROPI plant growth experiment in EMCS in EXPRESS Rack 3
Expedition 14 crewmember Thomas Reiter removing frozen samples from MELFI
Expedition 13 crewmember Jeff Williams performing the PFMI experiment in the Microgravity Science Glovebox


Planned NASA Research Facilities
NASA pressurized payload rack facilities awaiting launch
Combustion Integrated Rack (CIR) (2008)
Facility dedicated to research in combustion science
Space Dynamically Responding Ultrasound Matrix System (SpaceDRUMS) (2008)
EXPRESS-based containerless (ultrasound) processing facility
EXPRESS Rack 6 (2008)
Multipurpose payload facility, may also house ISS Galley elements
CIR
EXPRESS 6
SpaceDRUMS

Planned NASA Research Facilities

NASA pressurized payload rack facilities awaiting launch

- Microgravity Science Research Rack (MSRR) (2009)
  - Facility to support ESA Microgravity Science Lab furnace
- Fluids Integrated Rack (FIR) (2009)
  - Facility dedicated to fluid physics research, with Light Microscope Module
- Window Observation Research Facility (WORF) (2009)
  - Facility to support visual and multispectral remote sensing using Lab Optical Window
- Muscle Atrophy Research Exercise System (MARES) (2009)
  - Facility for musculoskeletal, biomechanical, neuromuscular and neurological physiology measurements


MSRR


FIR


WORF


MARES

Columbus

1E flight, December 2007


***Columbus* Module at KSC**


European Technology Exposure Facility (EuTEF)


SOLAR


Biolab


European Drawer Rack


European Physiology Module


European Transport Carrier


Fluid Science Lab

Columbus
European Space Agency (ESA)

Research racks launched in Columbus

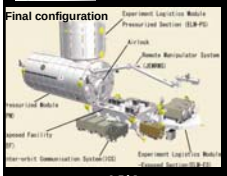
- **European Physiology Module**
  - Facility for human physiology research in neurosciences, cardiology, bone and muscle metabolism
- **Fluid Science Lab**
  - Multi-user facility for fluid physics research
- **Biolab**
  - Facility for cell culture, tissue, microorganisms, small plants and animals research, includes glovebox, incubator, microscope
- **European Drawer Rack**
  - Provide for middeck-class experiments and stowage
- **European Transport Carrier**
  - Stowage and transportation rack for experiments

External facilities launched with Columbus

- **European Technology Exposure Facility (EuTEF)**
  - Provides a platform for investigators to gather science data on the ISS space environment
- **SOLAR**
  - A platform with coarse pointing capability for three science instruments to monitor the solar flux in different wavelengths

Kibo

Flights: 1J/A Feb 2008, 1J Apr 2008, 2J/A Jan 2009


Final configuration


***Kibo* at KSC**


JEM-EF at TkSC

1J/A


Ryutai (Fluids)


Saibo (Cell Biology)

HTV1 Feb 2009


Kobairo (Materials)


Space Environment Data Acquisition **(SEDA)**


Monitor All-sky X-ray Image **(MAXI)**


Superconducting Sub millimeter-wave Limb-Emission Sounder **(SMILES)**

Kibo

Japanese Aerospace Exploration Agency (JAXA)

Research racks launched with pressurized elements or later on HTV

- **Ryutai (2008)**
  - **Fluid physics and solution/crystal growth research, including image processing unit**
- **Saibo (2008)**
  - **Cell biology facility, contains Clean Bench and Cell Biology Experiment Facility, including glovebox, incubator, microscope, centrifuge**
- **Kobairo (2009)**
  - **Gradient Heating Furnace for materials processing research**

External payloads launched with JEM-EF or later on HTV

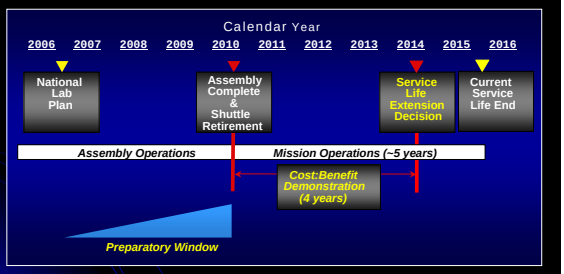
- **Space Environment Data Acquisition (SEDA) (2009)**
  - **Monitor neutron, plasma, atomic oxygen, and heavy ions**
- **Monitor All-sky X-ray Image (MAXI) (2009)**
  - **Observe X-ray bursts by Gas Slit Camera and X-ray CCD Slit Camera**
- **Superconducting Sub millimeter-wave Limb-Emission Sounder (SMILES) (2009)**
  - **Demonstrate sub-millimeter sensor technology and conduct sub-millimeter limb-emission sounding of the atmosphere and perform global observation of trace gases in the Stratosphere**

The NASA Authorization act of 2005 designated the U.S. facilities and resources on the ISS as a "national laboratory" (Public Law 109-155, Sec. 507)

- Directed NASA to develop a plan to "increase the utilization of the ISS by other Federal entities and the private sector…"
- As the Nation's newest national laboratory, the ISS will further strengthen relationships among NASA, other Federal entities, and private sector leaders in the pursuit of national priorities for the advancement of science, technology, engineering, and mathematics.
- The ISS National Laboratory will also open new paths for the exploration and economic development of Space.

- Opportunity to expand the US economy in space-based research, applications and operations.
- Unique and highly visible national asset with surplus capacity available for a wide spectrum of applications.
- NASA will continue to cover cost of operating and maintaining the ISS, and is highly motivated to work with other agencies and organizations to pursue applications.

ISS Event Horizon for National Laboratory Implementation



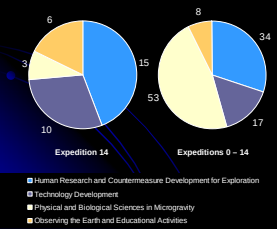
Science Accomplishments on ISS

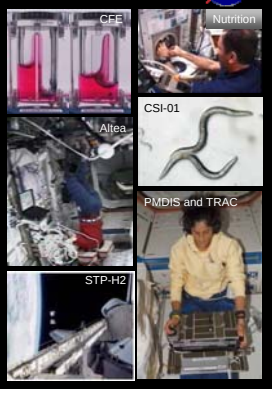
"Early utilization" on ISS

- Science completed during assembly
  - Early returns during the course of assembly
  - Takes advantage of assembly delays, extra crew time
  - Means that every crewmember on ISS can be a subject for human research experiments
    - More human experiments and larger sample sizes over the life of ISS
- Provides information on the potential uses of ISS after assembly is complete

Expedition 14 Research Accomplishments
(September 2006 – April 2007)

- Expedition 14
  - 34 U.S.-integrated investigations
    - 13 new investigations
    - 8 completed investigations
  - 136 scientists
- Expeditions 0-14 (Nov 2000-Apr 2007)
  - 112 U.S.-integrated investigations
    - 80 completed investigations
  - 373 scientists



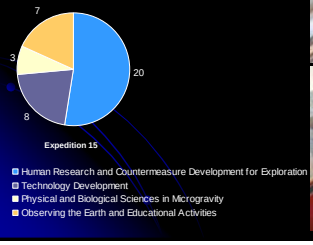


U.S. Investigations on ISS
317 Principal Investigators and Co-Investigators by State (2000- 2006)

Outside U.S.: 39

Expedition 15 Research Accomplishments
(Oct 2007 – Apr 2008, data as of May 2007)

- Expedition 15 Plans
  - 38 U.S.-integrated investigations
    - 11 new investigations
    - 1 reserve investigation
  - 139 scientists



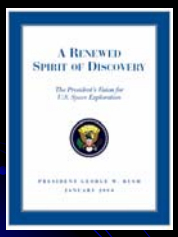
ISS Educational Accomplishments

- K-12 Student participation on ISS 2000-2006
  - 66,000 students in inquiry based learning with ISS data
  - 800,000 students with classroom versions of ISS experiments
  - 31 million had the opportunity to see telecasts from ISS
- 470 undregraduate students
- 251 graduate and posdoctoral students

The Vision for Space Exploration and The ISS National Laboratory

1. Complete assembly of the ISS
2. Develop Orion (Crew Exploration Vehicle)
3. Utilize ISS

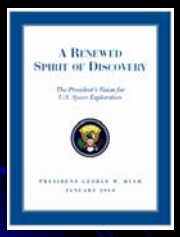
The Vision for Space Exploration



On January 14, 2004, the focus of NASA research on ISS was fundamentally changed with President Bush's *Vision for U.S. Space Exploration*

- ISS Focus for NASA before Exploration Vision: Diverse, multi-discipline research
  - Human Life Sciences
  - Biological Sciences
  - Materials Science
  - Fluids Science
  - Combustion Science
  - And all other sciences!

The Vision for Space Exploration



On January 14, 2004, the focus of NASA research on ISS was fundamentally changed with President Bush's *Vision for U.S. Space Exploration*

- NEW ISS Focus for NASA
  - Astronaut health and countermeasure development to protect crews from the space environment during long duration voyages
  - Testing research and technology developments for future exploration missions
  - Developing and validating operational procedures for long-duration space missions

ISS Medical Project

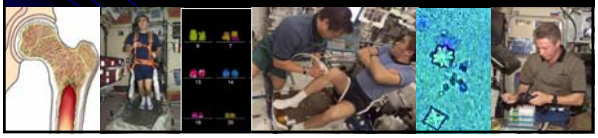
Experiments on ISS can address:

SPACE SYSTEM

- Advanced life support
- Exercise systems
- Clinical capabilities
- Radiation
- Dust

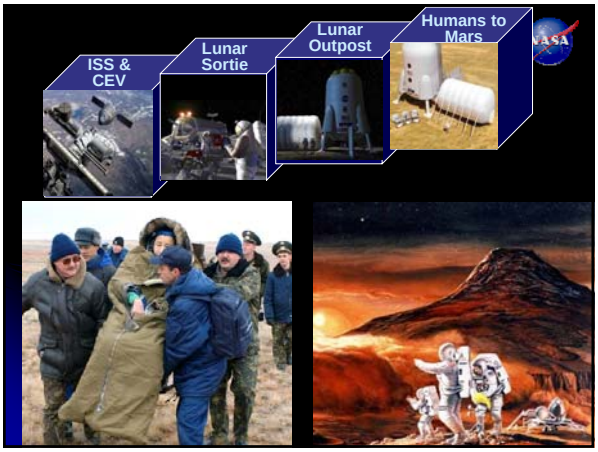
HUMAN SYSTEM

- Integrated physiology
- Cardiovascular
- Bone & Muscle
- Neurovestibular
- Food and nutrition
- Immunology & infection
- Human behavior & performance



ISS Medical Project

- ISSMP has been developed to maximize the utilization of ISS to obtain solutions to the human health and performance problems and the associated mission risks of exploration class missions
- Complete programmatic review with medical operations (space medicine/flight surgeons) to identify:
  - Evidence base on risks
  - Gap analysis
- Rapid implementation of key studies to optimize human research return



Disciplines Represented in early ISS Research

- Human Research
- Cell Biology and Biotechnology
- Plant Biology
- Physical Sciences
- Technology Development
- Environmental Monitoring
- Earth Observation
- Education

NASA mission-driven Research and the National Laboratory

- ISS for Exploration (NASA mission)
  - Human Research for Exploration
  - Exploration Technology Development
  - Space Operations Improvement
- ISS National Laboratory (Missions of many agencies and organizations)
  - Basic physiology
  - Biology and Biotechnology
  - Physical Sciences
  - Education
- Bridging work:
  - Microgravity Set-aside
  - Education
  - Earth Observations