International Space Station

Past and Future Research

Julie A. Robinson, Ph.D., ISS Program Scientist
NIH Pre-Application Meeting, 16 June 2009

The NASA Research Infrastructure

2 Human Research Facility Racks

Microgravity Science Glovebox (MSG)

6 ExPRESS Racks

Minus Eighty-Degree Laboratory Freezer for ISS (MELFI)

Combustion Integrated Rack (CIR)

2001-2008

Materials Science Research Rack

Fluids Integrated Rack (FIR)

MELFI-2

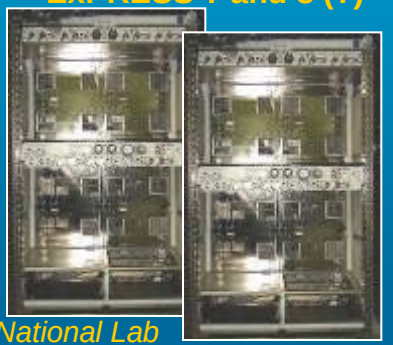
2009

Window Observational Research Facility

MELFI-3

Muscle Atrophy Research Exercise System (MARES)

ExPRESS-7 and 8 (?)



Added for National Lab

2010

Incubators, Culture Systems & Centrifuges

Multi-user EXPRESS Racks

- **Middeck locker scale instruments in various research disciplines such as biotechnology and plant research**
  - **Sub-rack class payloads and facilities**
- **At this time the NASA funded science program is projected to utilize only approximately 50% of the U.S. internal payload accommodations**
  - **The remaining 50% is available for National Lab investigations or an expanded number of NASA-supported investigations**
- **7 Express Racks physical capacity**
  - **59 Lockers total, 25 have planned use, 34 available**
  - **13 Drawers total, 7 have planned use, 6 available**

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

European Space Agency Astronaut Thomas Reiter, Expedition 13 Flight Engineer, installing the EMCS facility into the EXPRESS Rack 3A.


Gloveboxes

Microgravity Sciences Glovebox (MSG)

- Provides containment for a variety of experiments
  - Combustion
  - Physical processes
  - Materials
  - Secondary containment for liquid samples
  - Harvesting
- Provides 2 levels of containment

European Space Agency (ESA) Astronaut Pedro Duque as he works at the Microgravity Science Glovebox for the Cervantes mission experiment PromISS 2

Astronaut Garrett Reisman during a training session at JSC harvests plants from the CWRW investigation inside the MSG.

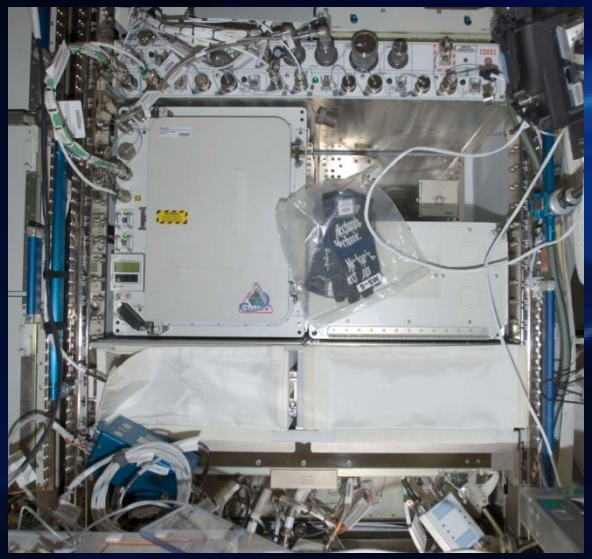
Expedition 13 crewmember Jeff Williams performing the PFMI experiment in the Microgravity Science Glovebox

Freezers & Refrigerators

Freezers and Incubators

- Minus Eighty-degree Laboratory Freezer for ISS (MELFI)
  - Provides thermal conditioning at +4ºC, -26ºC and -80ºC
  - 1 unit currently on orbit
  - 1 will launch in 2009, and 1 more in 2010
- GLACIER Freezer
  - + 4 ºC to -185 ºC
- CGBA (Commercial Generic Bioprocessing Aparatus)
  - -10ºC to +37 ºC.
- ABRS (Advanced Biological Resarch System)
  - Includes imaging of green fluorescent protein
- EMCS (European Modular Cultivation System)
  - Two centrifuges for plants and small animals spin from 0 to 2 G

Expedition 19 crewmember Michael Barratt inserts samples into the MELFI



General Laboratory Active Cryogenic ISS Experiment Refrigerator (GLACIER)

Centrifuges of EMCS

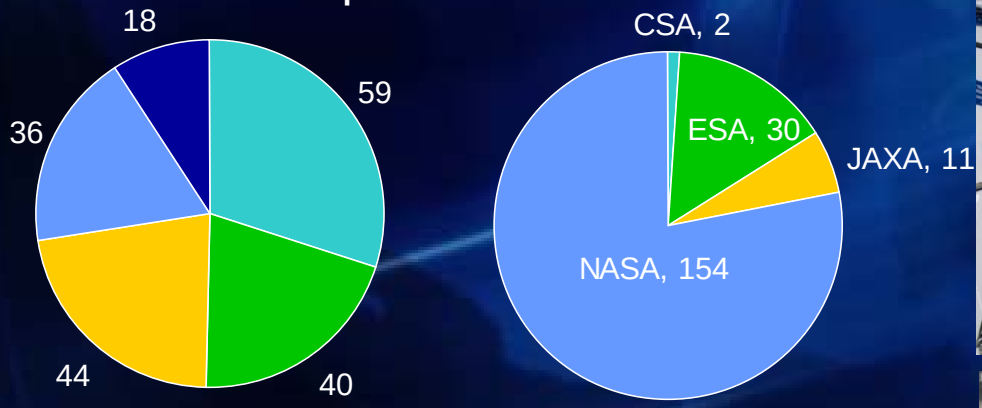
Commercial Generic Bioprocessing Apparatus (CGBA)

ISS Research Accomplishments

(Expeditions 0-18, September 2000 – April 2009, data as of April 21, 2009)

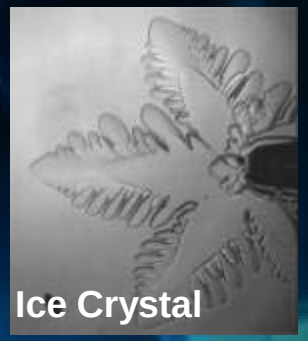
- Expeditions 0 -18 (Sept 2000-Apr 2009)
  - 197 U.S.-integrated investigations
    - 115 completed investigations
    - 43 International Partner investigations
  - > 600 scientists

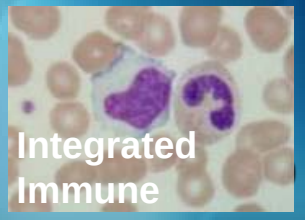
Number of Investigations, Expeditions 0 – 18



Disciplines for U.S.O.S.-integrated Science

- Human Research
- Technology Development
- Physical Sciences
- Biological Sciences
- Earth Observation & Education

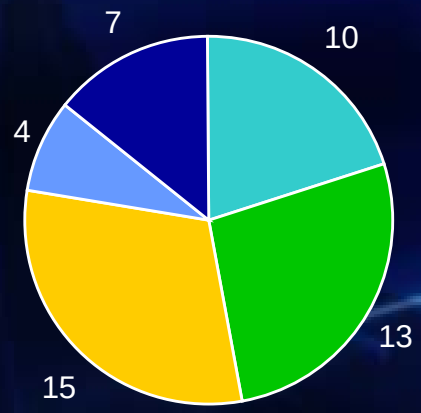




Current Research

Expedition 19/20, April 2009 – October 2009, data as of Feb 17, 2009

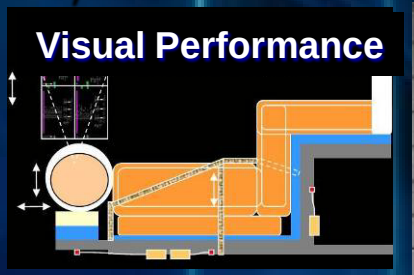
- Expedition 19/20
  - 98 U.S.O.S.-integrated investigations
    - 39 new investigations
    - 49 International Partner investigations
      - 5 CSA
      - 28 ESA
      - 16 JAXA
  - > 400 scientists



Expedition 19/20

Disciplines for U.S. Science

- Human Research for Exploration
- Technology Development
- Physical Sciences
- Biological Sciences
- Earth Observation & Education



Examples of Recent Life Science Research on ISS

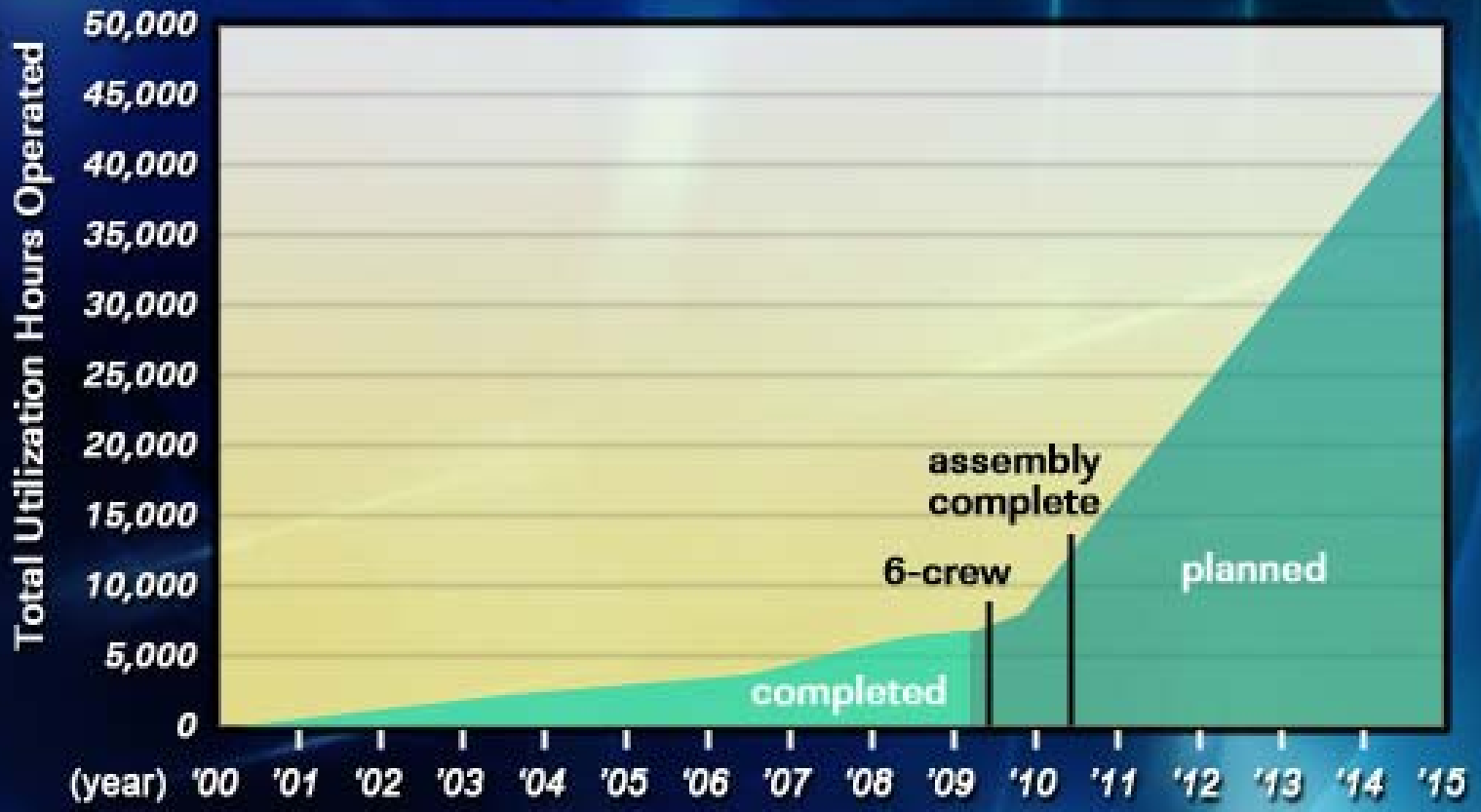
- **MDRV: Microbial Drug Resistance Virulence** (D. Niesel, M. McGinnis, B. Pyle, C. Nickerson)
  - Effect of space flight on the gene expression and virulence potential of four model organisms
  - *Salmonella typhimurium*, *Streptococcus pneumoniae*, *Saccharomyces cerevisiae* and *Pseudomonas aeruginosa*

- **Sample: Study of Microbial Communities Exposed to Weightlessness** (H. Harmsen, U. Gronigen)
  - Study of changes in adhesion abilities of microbes associated with the human body after being in a microgravity enfironment

Examples of Recent Life Science Research on ISS

- **DomeGene** (M. Asashima)
  - Cell differentiation and morphogenesis in microgravity using two kinds of amphibian cultured cell lines
  - Kidney-derived and liver-derived cell lines
- **LOH-RadGene (**F. Yatagai, RIKEN Institute)
  - LOH uses lymphoblastoid (immature immune) cells to detect potential changes on the chromosome after exposure to cosmic radiation.
  - RadGene looks for changes in gene expression of p53 (tumor suppressive protein) after cosmic radiation exposure.
- **NeuroRad** (H. Majima, Kagoshima U.)
  - Biological effects of Space Radiation on mammalian Cells
- **Cerise: RNA interference and protein phosphorylation** (A. Higashitani, Tohoku U.)
  - C. elegans as a model of muscle fiber
  - RNA interference used to affect gene expression
  - Study protein phosphorylation and signal transduction

Cumulative ISS Utilization Crewtime by All Partners



Biotechnology Results

Early research results suggest compelling new knowledge can be gained on ISS to benefit Human Health

Macroencapsulation – Microcapsules (micro-balloons) for drug delivery produced on the *International Space Station* were successful in targeting delivery of anti-cancer drugs to successfully shrink tumors in ground tests using a rodent model. A device to produce similar capsules on Earth has now been patented, and clinical trials of the drug delivery method will begin soon.

Microbial Vaccine Development – Scientific findings from ***International Space Station*** research have shown increased virulence in *Salmonella* bacteria flown in space, and identified the controlling gene responsible. AstroGenetix, Inc. has funded their own follow-on studies on ISS and are now pursuing approval of a vaccine an Investigational New Drug (IND) with the FDA. They are now applying a similar development approach to methycillin-resistant *Staph aureus* (MRSA).

A few practical lessons learned from early life science investigations

- Lack of density/buoyancy driven convection in microgravity
  - Can affect ion transfer/mixing through liquid media
  - Can affect gas perfusion through media
- "The Bubble Problem"
  - Formation of bubbles in media affects ion transfer in fluids
  - Affects many fluid systems in microgravity
  - Seals sometimes aren't as tight as you expect
  - Can be solved operationally
- Your laboratory in space
  - Timing parameters can make experiment requirements risky
    - Narrow tolerance for time between loading samples, and operations in orbit can endanger your success since launch delays for weather, delayed dockings are common
    - Timing between termination of experiment and return (even with conditioned stowage), RNAlater
  - Ambient transportation is less limiting that conditioned/cold transport
  - Smart flexibility is key

For More Information

ISS Reference Guide

Cumulative Results Reports:

- NASA/TP-2006-213146
- NASA/TP–2009–213146–REVISION A

Education on ISS 2000-2006:

- NASA/TP-2006


NASA/TP–2006–213146

NASA

International Space Station Research Summary Through Expedition 10

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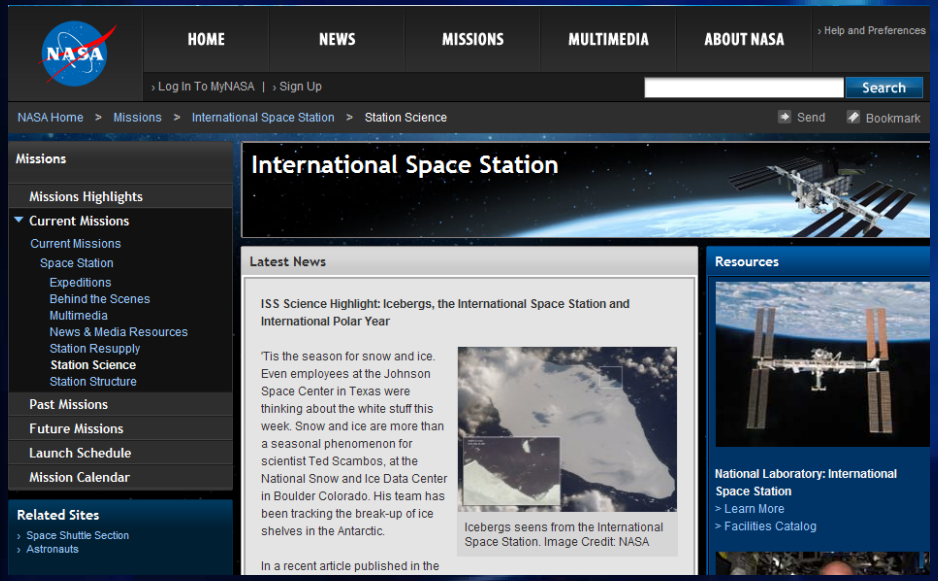
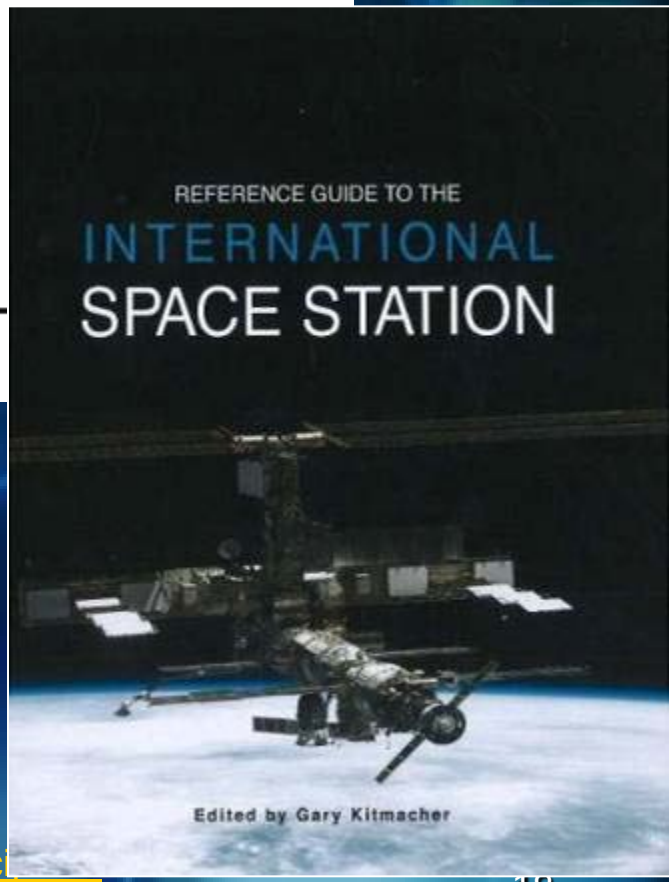
In press





Space Station Science Webpages

http://www.nasa.gov/mission_pages/station/science/

Facilities Webpages

http://www.nasa.gov/mission_pages/station/science/experiments/Disci
html