International Space Station Research Accomplishments Overview

Julie A. Robinson, Ph.D.,
ISS Program Scientist, NASA

Outreach Seminar on the ISS
United Nations
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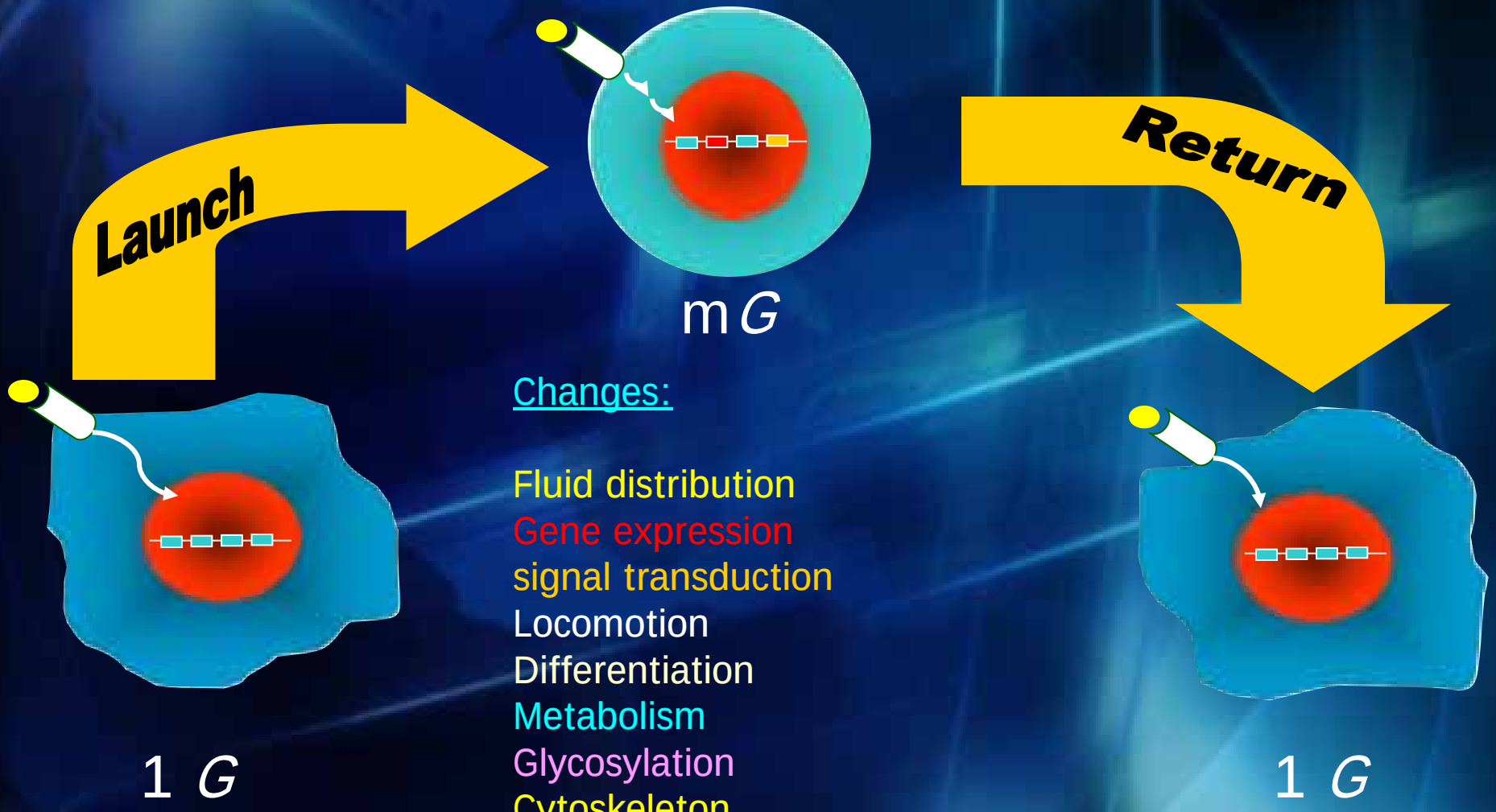
Outline

- Why space research?
  And why on the International Space Station?
- What has been done?
- What are the most important results?
- How have non-partners participated?

Disciplines that use the Laboratory

- Biology & Biotechnology
- Human Physiology & Performance
- Physical Sciences
- Technology Development & Demonstration
- Earth and Space Science
- Education

Biology: Animal Cells in Space



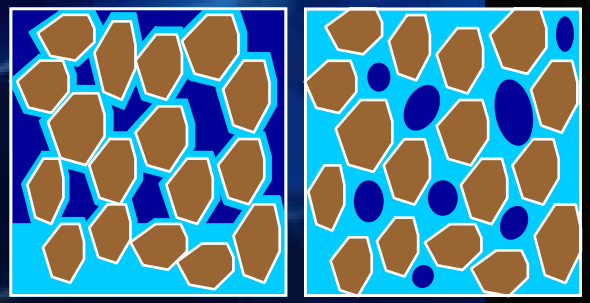
Changes:

Fluid distribution
Gene expression
signal transduction
Locomotion
Differentiation
Metabolism
Glycosylation
Cytoskeleton
Tissue morphogenesis

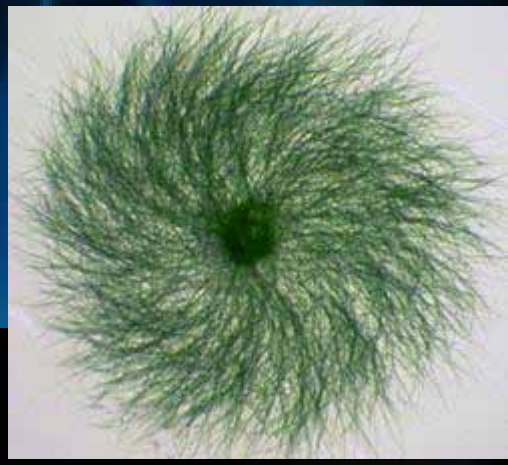
Courtesy of Neal Pellis

Biology: Plant Research in Space

- Discovery potential for plant biology
  - Growth and development
  - Gravitropism, Circumnutation
  - Plant responses to the environment: light, temp, gases, soil
  - Stress responses
  - Stem cells/pluripotency
- Plants as a food source
- Plants for life support



Soil structure



Moss grown in the dark
On the Space Shuttle

Peas grown on ISS

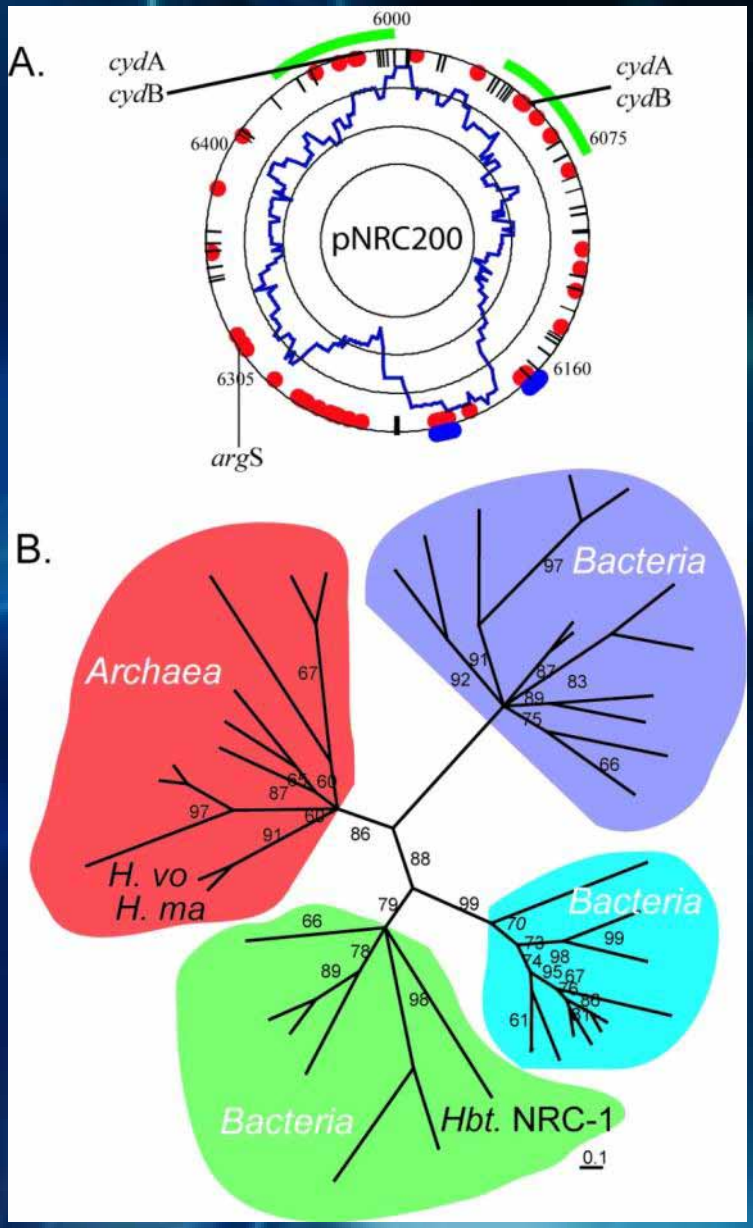
Biology: Microbes in Space

3 modes of response

More virulent

Multiply more rapidly

No change



Human Physiology: Response to Spaceflight

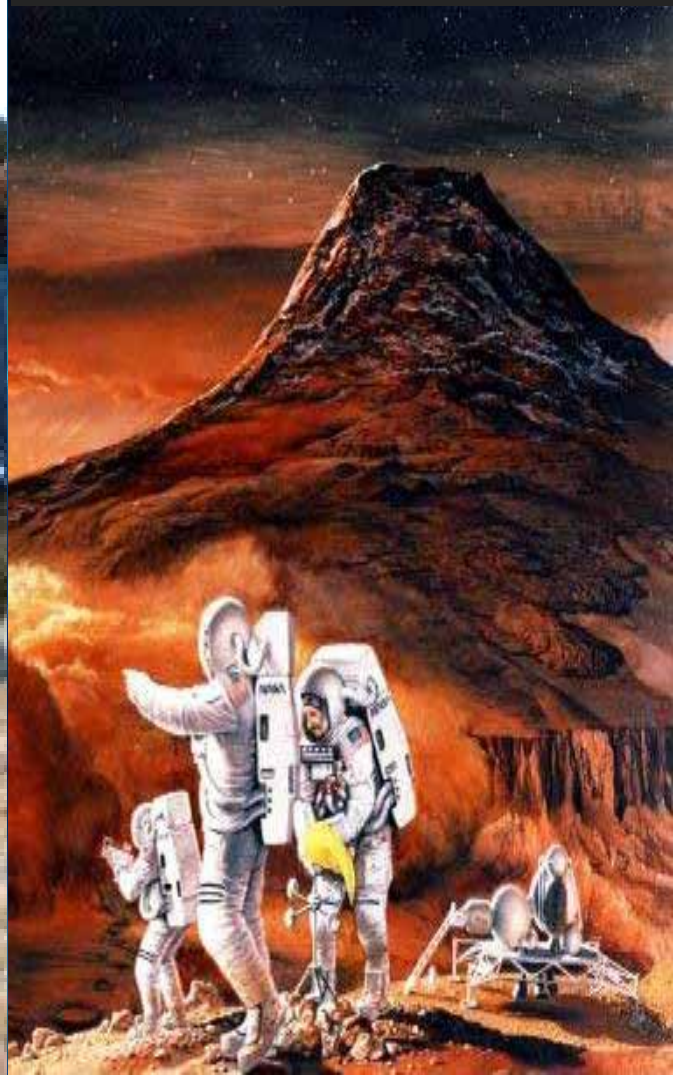
Astronauts experience a spectrum of adaptations in flight and postflight

Balance disorders
Cardiovascular deconditioning
Decreased immune function
Muscle atrophy
Bone loss

- Neurovestibular
- Cardiovascular
- Bone
- Muscle
- Immunology
- Nutrition
- Behavior
- Radiation

ISS includes international research on medical risks to astronauts

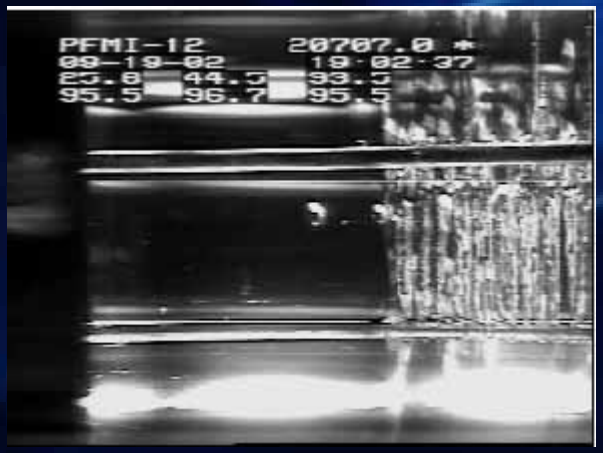
So that humans can explore outside Earth orbit



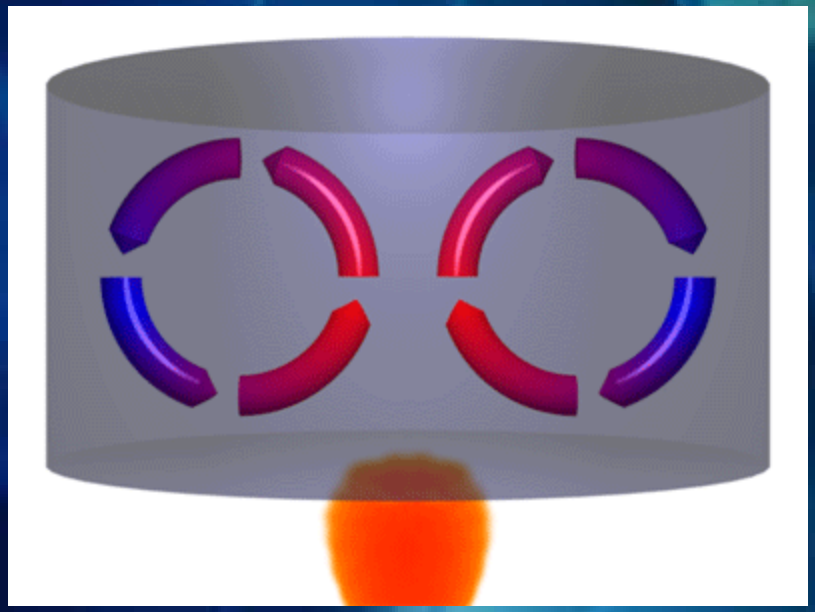
Physiology and Medical Technology research in space can also benefit health on Earth

Physical Sciences: Convection

Combustion

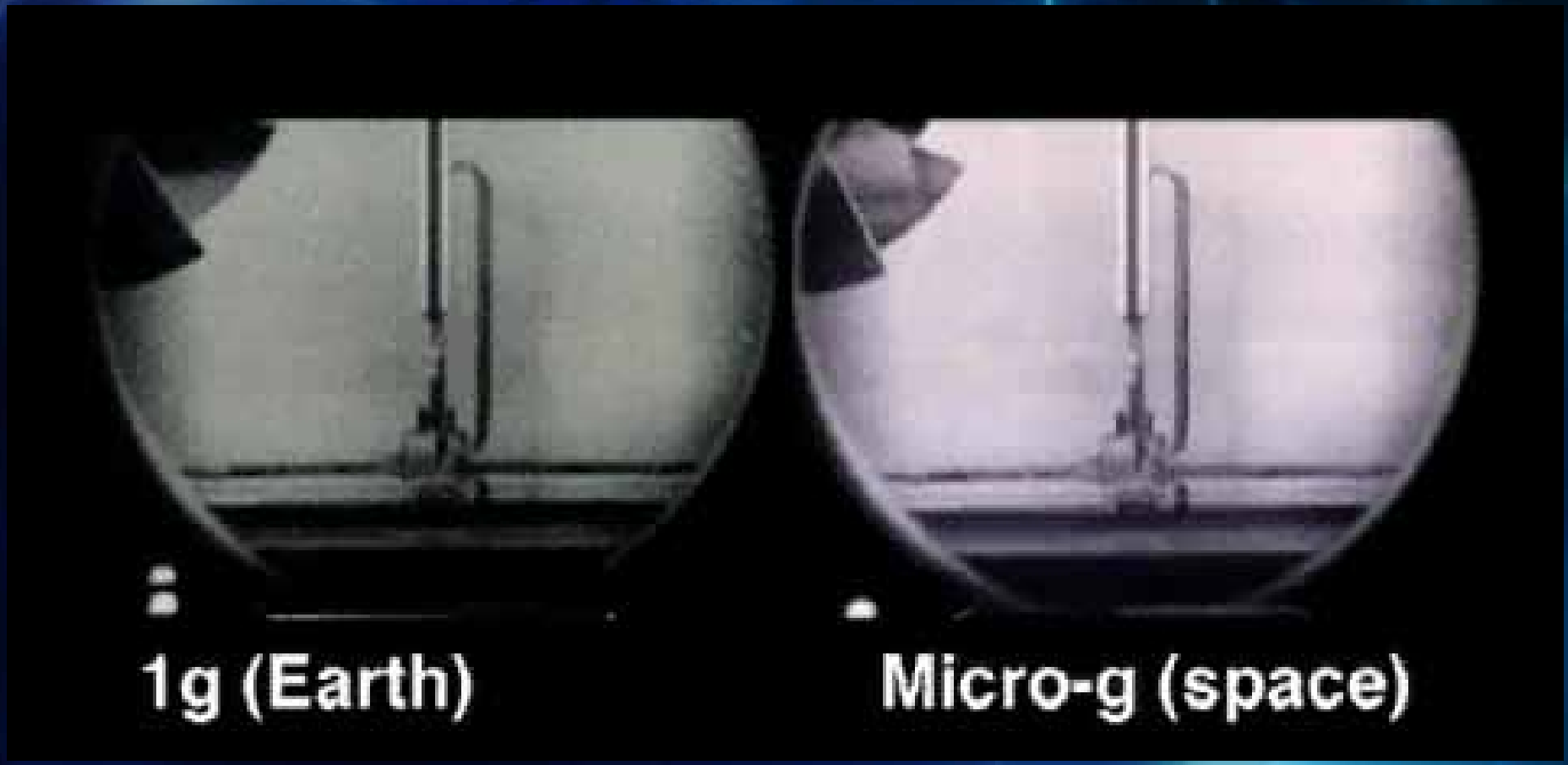


Pore formation and Coarsening



Fluids: No density or buoyancy driven Convection!

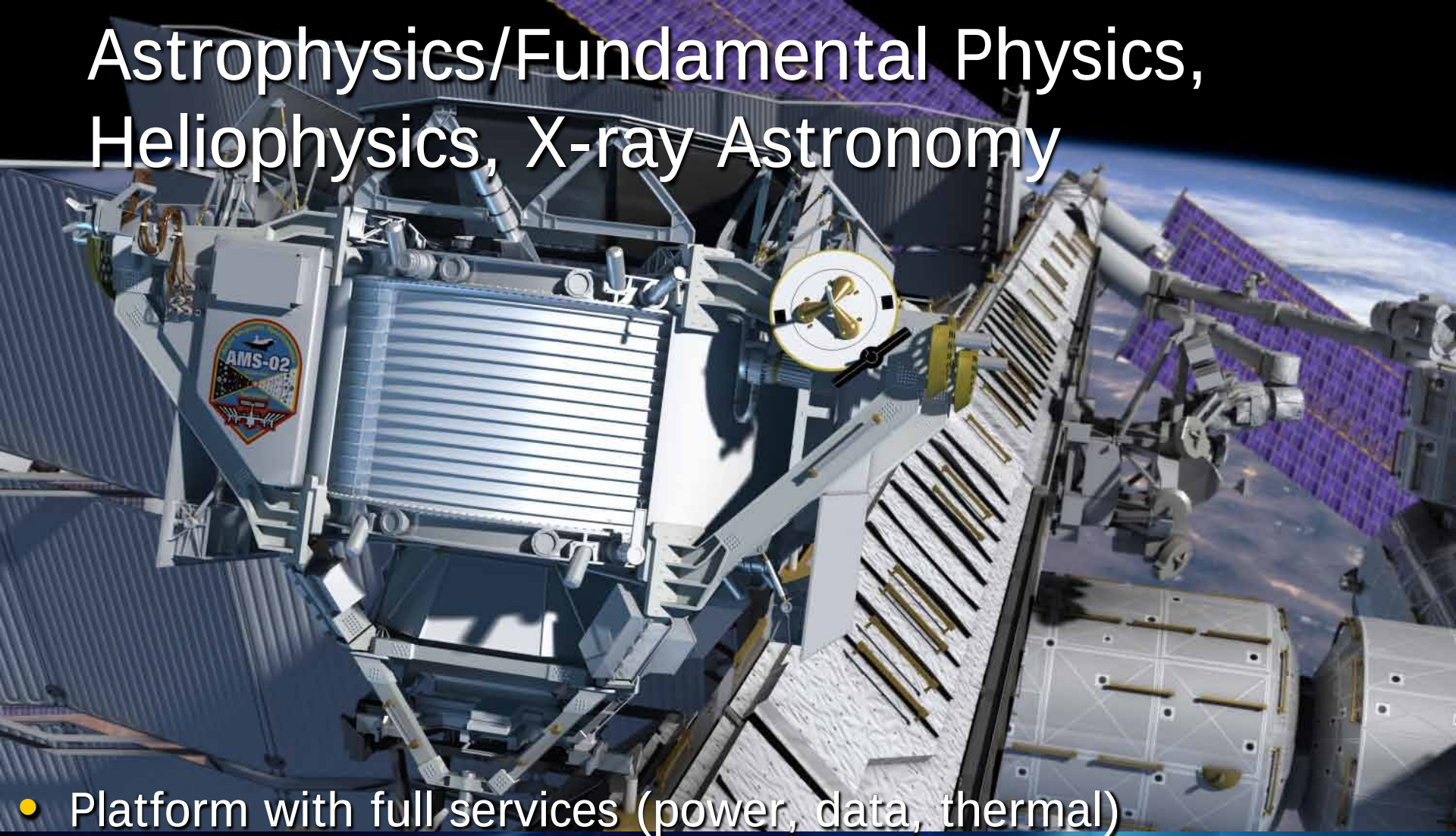
Boiling on Earth and in Microgravity



Earth Science

- Platform with full services (power, data, thermal) in low earth orbit (~400 km)
  - All geographic locations between 51.6 North and South latitude
  - 85% of the Earth's surface
  - 95% of the world's populated landmass every 1-3 days
  - External sites for nadir, zenith, ram and wake
  - Variable (and precessing) lighting (changes with subsequent passes)
  - Well-suited for test bed concepts with hardware change out and upgrades

Astrophysics/Fundamental Physics, Heliophysics, X-ray Astronomy



- Platform with full services (power, data, thermal)
  - Positioned above atmospheric interference
  - External sites for zenith, ram and wake
  - Stability, contamination, and vibration can be managed for many users
  - Well-suited for test bed concepts

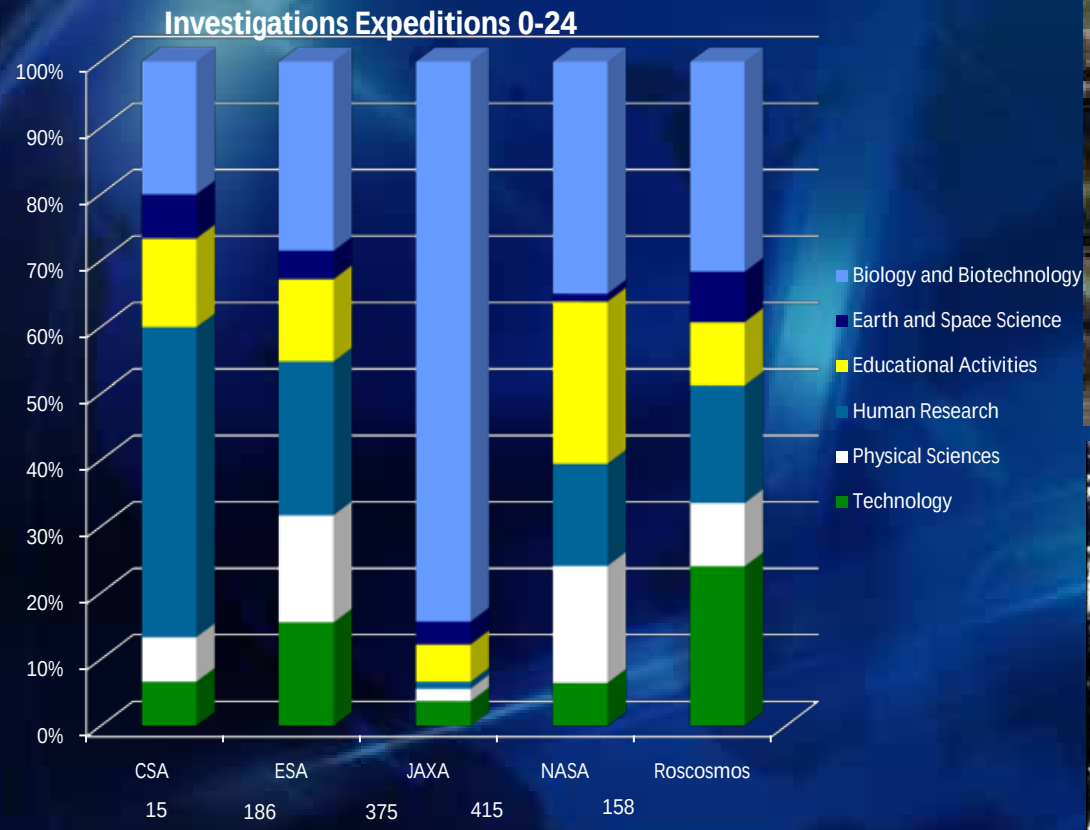
Technology Development and Demonstration

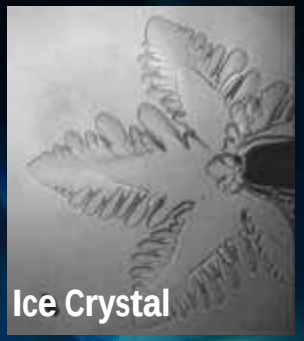
- Long term space environment (microgravity, radiation, etc.)
- Prove reliability in relevant environment (advance TRL-technology readiness level)
- Prove logistics, maintenance, consumables, and operations models (advance IRL-integration readiness level, SRL-systems readiness level)
- Reduce risk to performance when system is implemented elsewhere

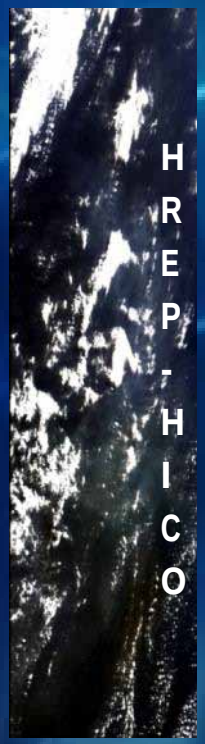
Our Accomplishments

ISS Research Accomplishments

(Expeditions 0 – 24, September 2000 – October 2010, data as of January 20, 2011)

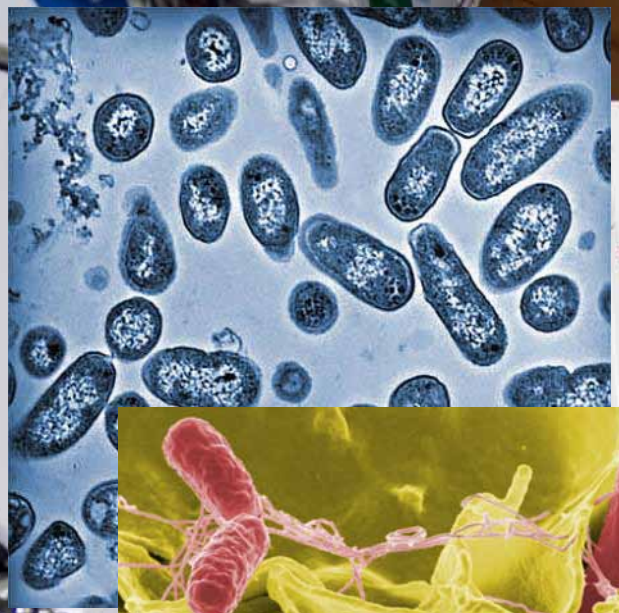


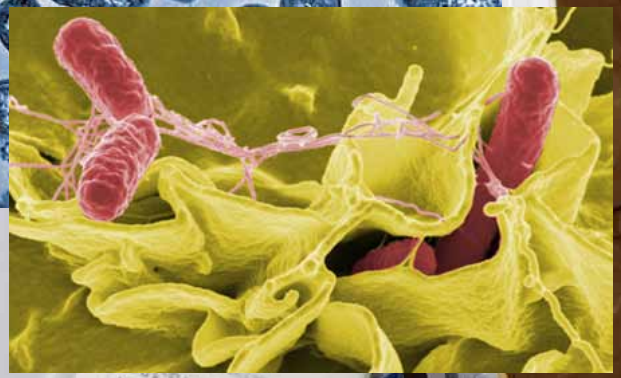




- Expeditions 0 – 24
  - 1149 Investigations
    - 454 completed investigations
    - 734 International Partner investigations
    - 25 National Lab investigations

  > 1600 scientists
  - 310+ scientific publications (international count ongoing)





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 as an Investigational New Drug (IND) with the FDA. They are now applying a similar development approach to methycillin-resistant *Staph aureus* (MRSA).

Top image credit: Pacific Northwest National Laboratory

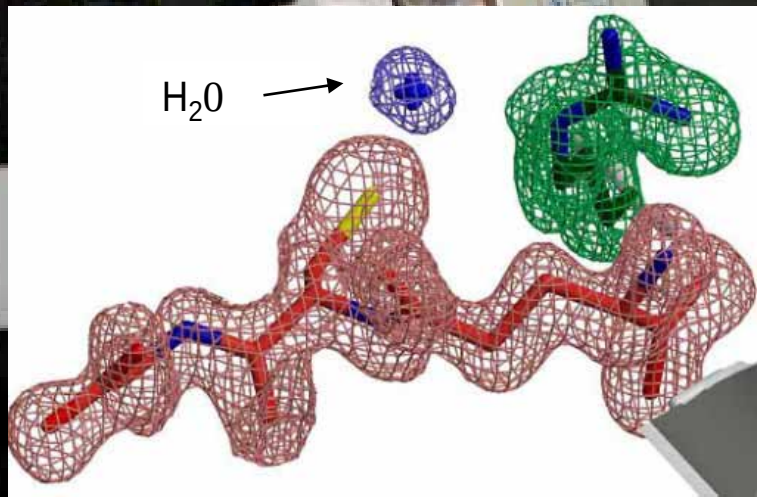
Bottom image credit: Rocky Mountain Laboratories

Source: ISS Program Scientist, NASA

Cancer Treatment Delivery– Microcapsules (micro-balloons) for drug with desirable properties developed on the ***International Space Station*** were reproduced on Earth and were successful in targeting delivery of anti-cancer drugs to successfully shrink tumors in ground tests. A device to produce similar capsules on Earth has now been patented, and clinical trials of the drug delivery method are beginning.

Source: ISS Program Scientist, NASA

Macromolecular Crystallization– A Japanese scientist crystallized HQL-79 (human prostaglandin D2 synthase inhibitor protein) on the ***International Space Station***, identifying an improved structure and an associated water molecule that was not previously known. This protein is part of a candidate treatment for inhibiting the effects of Duchenne's muscular dystrophy. Continuing work is looking at other proteins and viruses.



Source: ISS Program Scientist, NASA

Plant Growth – Numerous plant growth experiments have investigated both the effects of microgravity, as well as the capability for growing regenerable food supplies for crew. In addition, technology developed for the ADVASCÔ greenhouse flown on the *International Space Station* led to a new technology that is widely used on Earth, killing 98% of airborne pathogens (including Anthrax) for food preservation, doctors' offices, homes and offices.

Source: ISS Program Scientist, NASA

Insight into Immune Function– Human T-Lymphocyte s cultures flown to the ***International Space Station*** have shown altered genetic expression of Interleukin-2 and/or its receptor, and, combined with ground studies , suggests a role in the suppressed immunity seen in astronauts. These space flight results aid clinical researchers in identifying the cellular and genetic mechanisms involved in immuno-suppression as they search for potential treatments.

Source: ISS Program Scientist, NASA

Mitigating Bone Loss

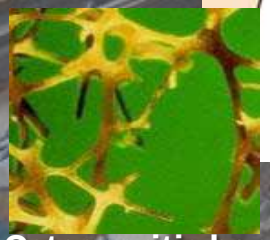
Phase 1 studies (~ 11 major publications)

- Astronauts lost an average of 1.5% bone/month (similar to loss in post-menopausal women per year)
- Took 3 years to get back to pre-flight bone density
- Crew loaded to less than 60% with harnesses
- Many crew Vitamin D deficient

Phase 2 studies

- More effective exercise hardware (COLBERT, ARED, harnesses)
- New studies of countermeasures: Bisphosphonates (pharmaceutical), Pro K (nutritional)

Normal bone



Osteoporitic bone

Source: ISS Program Scientist, NASA

Maintaining Bone Health through Nutrition – Results from the Nutritional Study on the *International Space Station*, bed rest analogs, and laboratory cellular experiments have shown that Omega-3 fatty acids counteracted bone loss, indicating that diet changes to include more fish may protect bone loss both in space and on Earth.

Source: ISS Program Scientist, NASA

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Space Materials Technology – Studies of how materials withstand the harsh space environment (atomic oxygen, direct sunlight, radiation and extremes of heat & cold) provide a better understanding of the durability of various materials with important applications in the design of future spacecraft. The Naval Research Laboratory and Boeing have used the ***International Space Station*** materials test bed to shorten development time for satellite hardware components by as much as 50%

Source: ISS Program Scientist, NASA

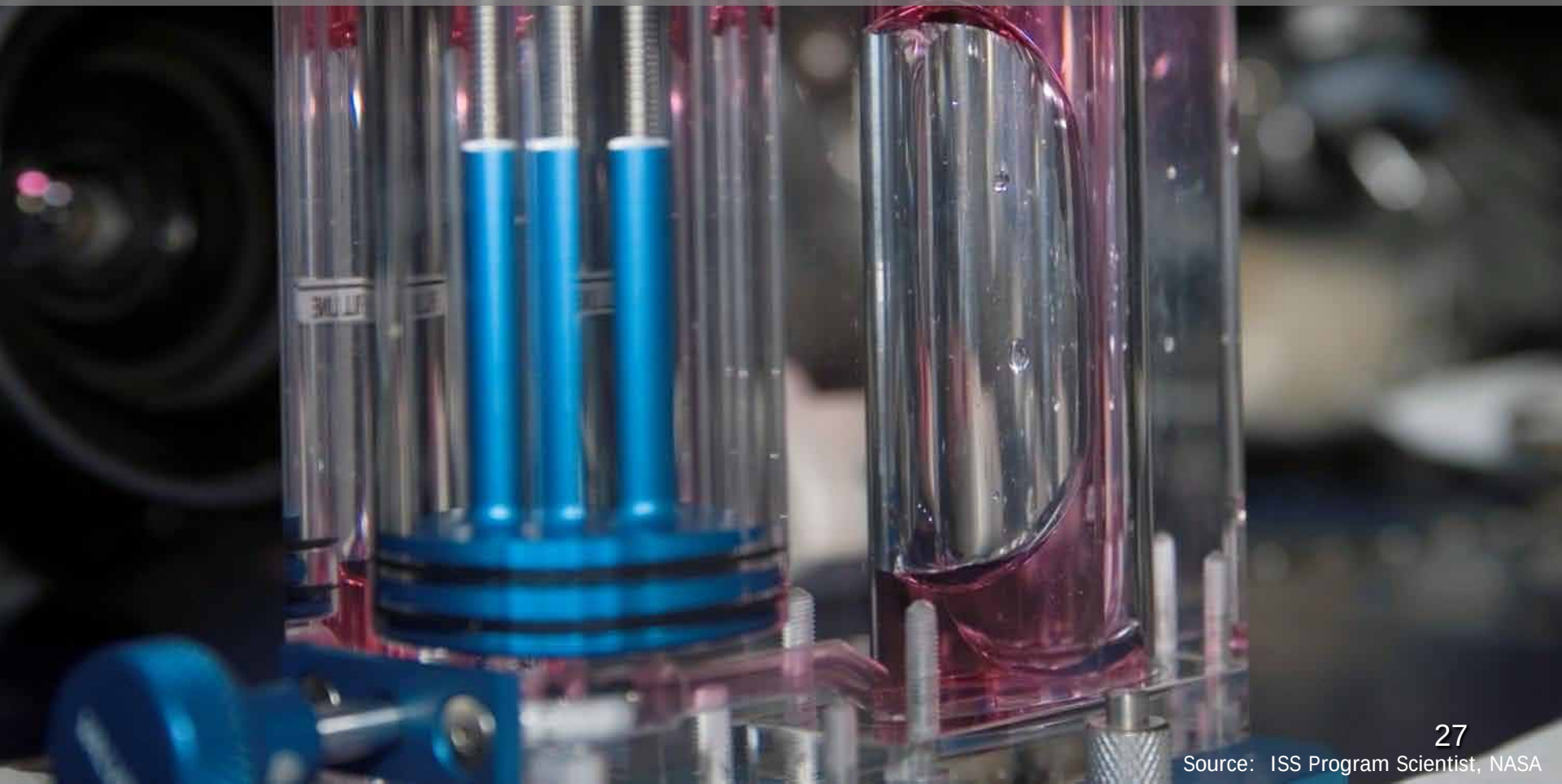
Regen ECLSS – Water recycling, oxygen generation, and carbon dioxide removal are critical technologies for reducing the logistics re-supply requirements for human spaceflight. The ***International Space Station*** demonstration project is applying lessons learned form operational experiences to next 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.

Source: ISS Program Scientist, NASA

Spinal Cord Changes– Studies on the *International Space Station* have shown that spinal cord reflexes and nerve cell activity diminished by about 35% in space, implicating the role nervous system has in maintaining muscle health in space. These implications are critical to understanding the effects of long-duration spaceflight on muscle and bone systems.

Source: ISS Program Scientist, NASA

Fluid Flow – Controlling the flow of fluids in the absence of gravity is a challenge for designing spacecraft liquid propellant, water and recycling systems. In space, liquids can climb container walls, making it hard to empty containers, measure the contents of storage vessels, and obtain consistent performance in devices where liquids and vapor mix. Capillary flow experiments on the ***International Space Station*** produced the first space-validated models describing fluid behavior in space. Three patents have been filed.

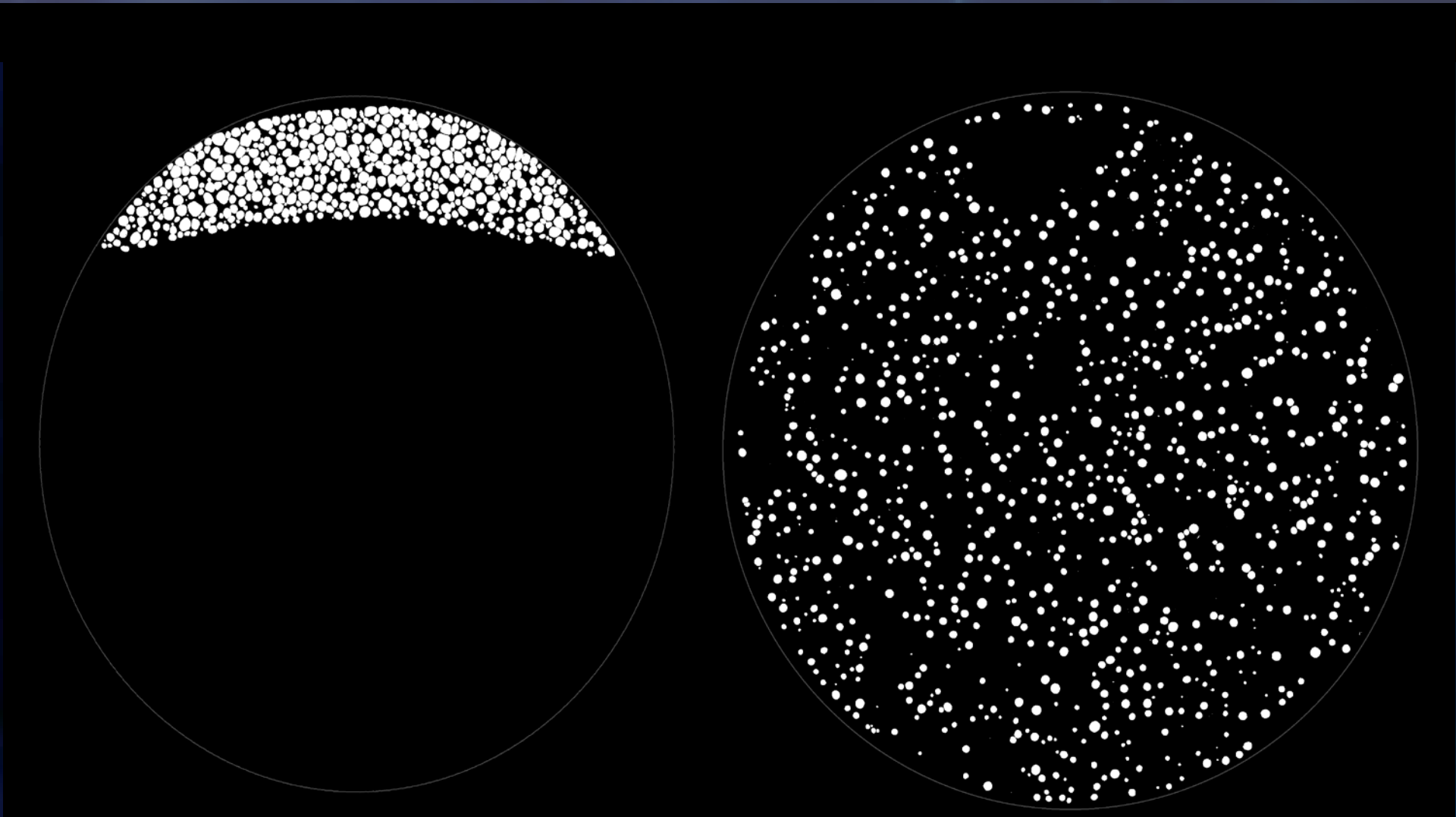


Source: ISS Program Scientist, NASA

Source: ISS Program Scientist, NASA

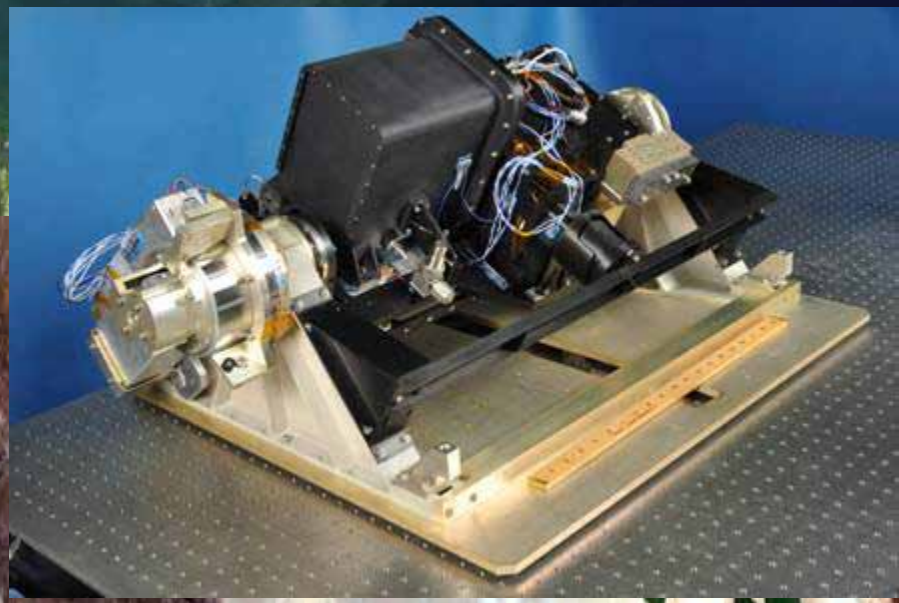
Smart Materials – Studies on the *International Space Station* have investigated the internal structure of fluids that change properties in response to magnetic fields, without additional gravitational effects. Resulting technology has promise to improve the design of structures, such as buildings and bridges, to better withstand earthquakes.

Metal Alloy processing – The reduced gravity on the *International Space Station* allows even distribution of particles in solid-liquid mixtures, thus providing a platform to understand the coarsening process in the development of metal alloys. The results of the CSLM-2 experiment will will provide data that will guide the design of new alloys on Earth at reduced development costs and improved materials properties.



Source: ISS Program Scientist, NASA

Earth Imaging – HREP-HICO operates a visible and near-infrared Maritime Hyperspectral Imaging system, to detect, identify and quantify coastal geophysical features from the ***International Space Station***.



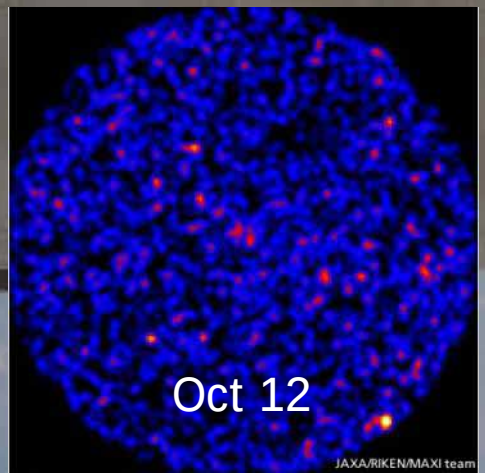
Source: ISS Program Scientist, NASA

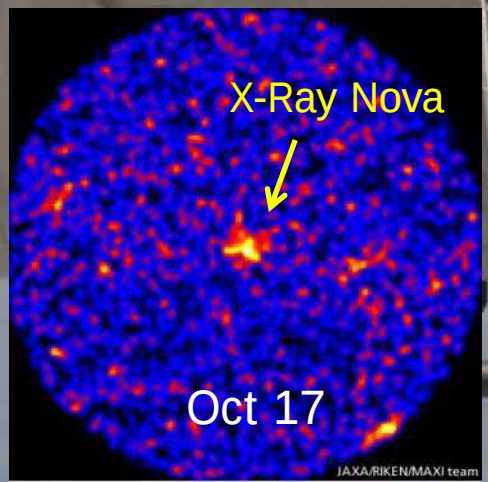
Earth Observations – Photographs taken from the *International Space Station* document global change, weather and geological events and urban growth. Researchers with the National Snow and Ice Data Center monitor the breakup of large icebergs as they drift into the South Atlantic Ocean.

ISS015E10125

Source: ISS Program Scientist, NASA

X-ray Monitoring – MAXI is a highly sensitive X-ray slit camera externally-mounted to the *International Space Station* for monitoring more than 1,000 X-ray sources in space, including black holes and neutron stars. In 2010, MAXI found two new X-ray sources from its sky scans.





New Smoke Detector Concepts– Research on the *International Space Station* has shown that soot particle sizes can differ substantially in microgravity, and that other forms of smoke show increases in particulate size by as much as a factor of 10 in space. These results have led to the development of new smoke detector technologies that are currently being tested on the space station that offer improvements in the discrimination between smoke particulate from fire and other airborne particulates (dust, vapors, etc) currently on the commercial market.

ISS013E26253

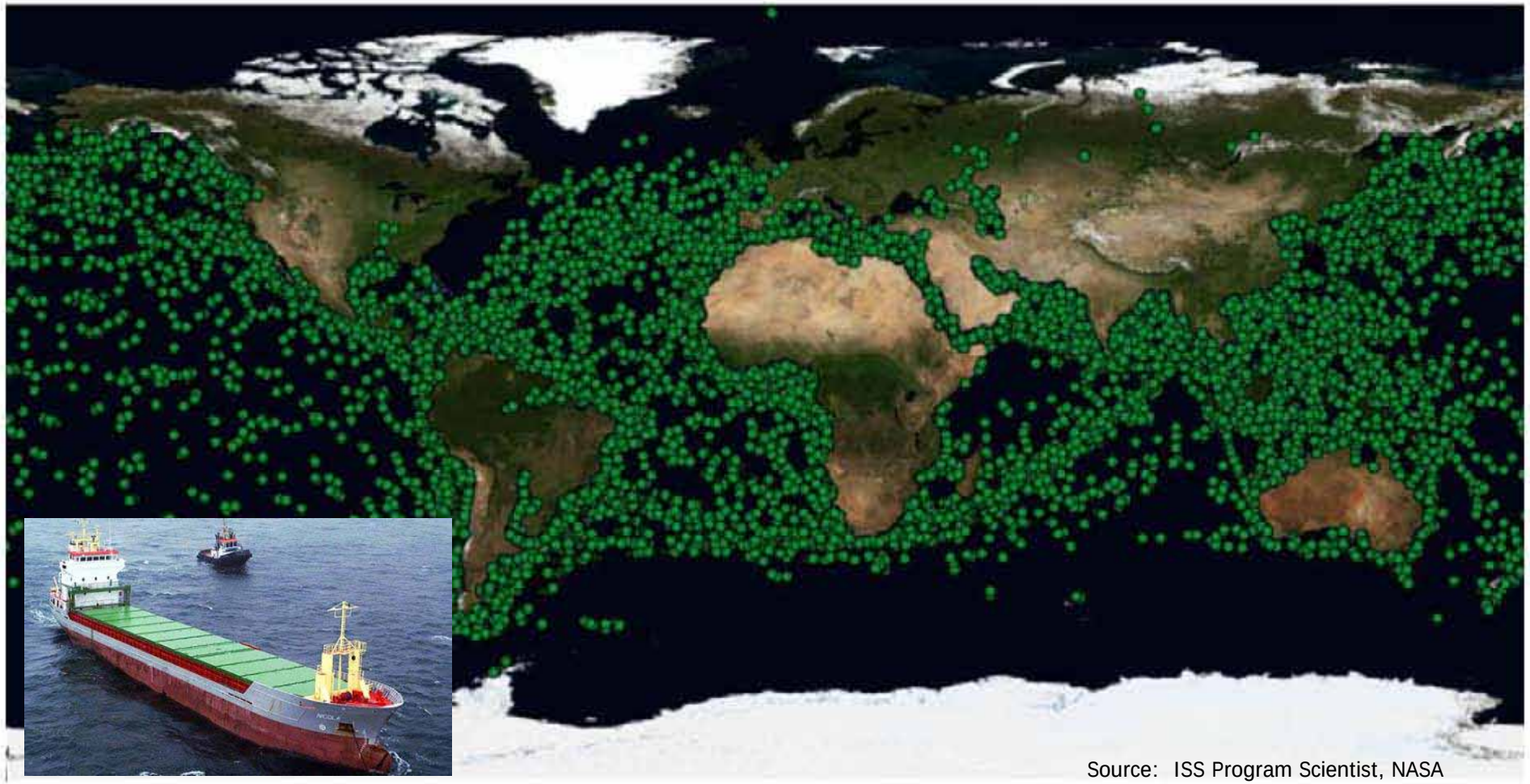
Multi-body Maneuvering in Space – The Massachusetts Institute of Technology (MIT) is using color coded bowling-ball sized spherical satellites to demonstrate space-based autonomous rendezvous and docking on the ***International Space Station***. The results have applications for satellite servicing,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

Source: ISS Program Scientist, NASA

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

Global Maritime Traffic Tracking – The first space-based method of tracking global maritime traffic from space is mounted outside the Columbus Laboratory on the *International Space Station.* It can track ships' speed, position, course, cargo, and voyage information to and from other vessels and shore. This autonomous system can monitor traffic in open waters, whereas Earth-based systems can only monitor maritime vessels in coastal waters.

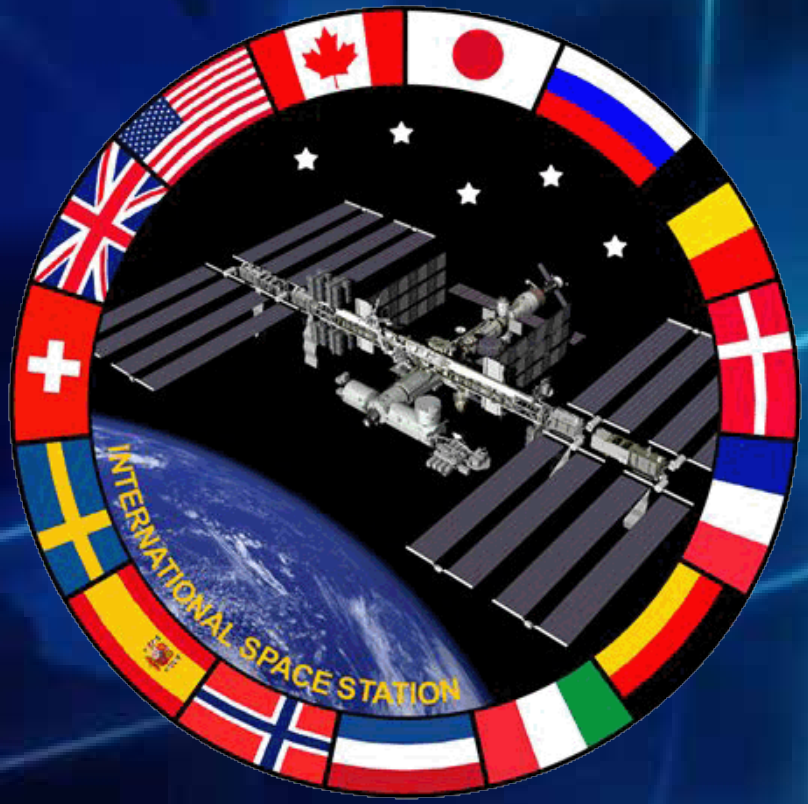


Source: ISS Program Scientist, NASA

First Summary Plot of Data from NORAIS Receiver (after first hours) (Image: FFI)

59 Countries Have Participated in ISS Utilization through 2010

Argentina
Australia
Austria
Brazil
Bulgaria
Byelorussia
Chile
China
Columbia
Croatia
Czech Republic
Dominican Republic
Ecuador
Egypt
Fiji
Finland
Greece
Guatemala
Hungary
Ile de La Reunion
India
Ireland



Flags= ISS Partners
Names=ISS Non-partner Countries

Israel
Kazakhstan
Kenya
Kuwait
Lebanon
Malaysia
Mali
Mexico
New Zealand
Peru
Poland
Portugal
Puerto Rico
Republic of Korea
Romania
Senegal
Slovenia
South Africa
Taiwan
Thailand
Turkey
Ukraine

Highlights/examples of Non-Partner ISS Research

- Brazil (implemented through Roscosmos)
  - Effects of Micro-g on Fermentative Kinetics (MEK): kinetic rates of enzymatic reaction with lipase and invertase
- India (implemented through JAXA)
  - JAXA – ISRO Cooperation agreement to develop Japan-India Microorganism Cultivation Unit for cultivation of cyanobacteria, launch expected in 2011
- Kazakhstan (implemented through Roscosmos)
  - Investigation of a Closed Ecological System (Biosfera): investigation of a closed ecological system under space conditions.
- Malaysia (implemented through NASA and JAXA)
  - Commercial Generic Bioprocessing Apparatus Science Insert - 01 (CSI-01): Malaysian seeds (orchids, Malaysian red sandalwood and rosewood) exposure to the space environment.
  - JAXA and Malaysian Government have an agreement on cooperation for hight quality protein crystal growth with a tital of 6 investigations planned from 2009-2012
- Republic of South Africa (Implemented through Roscosmos)
  - Soluble Protein Crystallization: Obtaining Crystals of Soluble Proteins FcgIII and FcgeII (SPC)
- South Korea (Implemented through Roscosmos, NASA, and JAXA)
  - Korean Astronaut Program-13 Measuring of Small Mass in Microgravity (KAP-13): testing of small mass measurement system in microgravity
  - JAXA and KARI have a protocol for feasibility studies for Kibo utilization and will select investigations jointly
  - NASA-Korean collaboration in physical sciences is under development

For More Information

ISS Reference Guide

Cumulative Results Reports:

NASA/TP–2009–213146–REVISION A

Education on ISS 2000-2006:

NASA/TP-2006-213721

World Wide Web

http://www.nasa.gov/iss-science/

Facilities Catalog

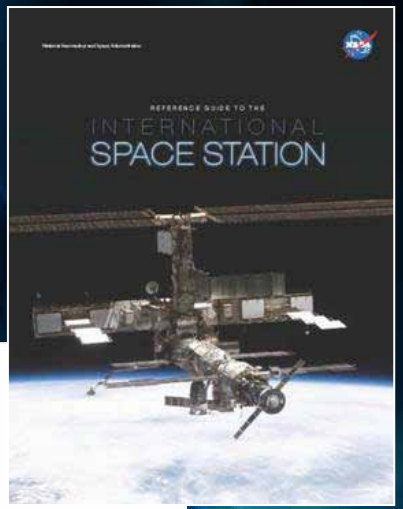
click on “Facilities” at web link above

ISS Research Blog “A Lab Aloft”

http://go.usa.gov/atI

Twitter @ISS_Research

http://twitter.com/@ISS_Research




NASA/TP–2009–213146–REVISION A

NASA

International Space Station Science Research Accomplishments During the Assembly Years: An Analysis of Results from 2000-2008

Cynthia A. Evans and Julie A. Robinson
Office of the International Space Station Program Scientist
NASA Johnson Space Center, Houston, Texas

Judy Tate-Brown, Tracy Thumm, and Jessica Crespo-Richey
Engineering & Science Contract Group, Houston, Texas

David Baumann and Jennifer Rhatigan
NASA Johnson Space Center, Houston, Texas