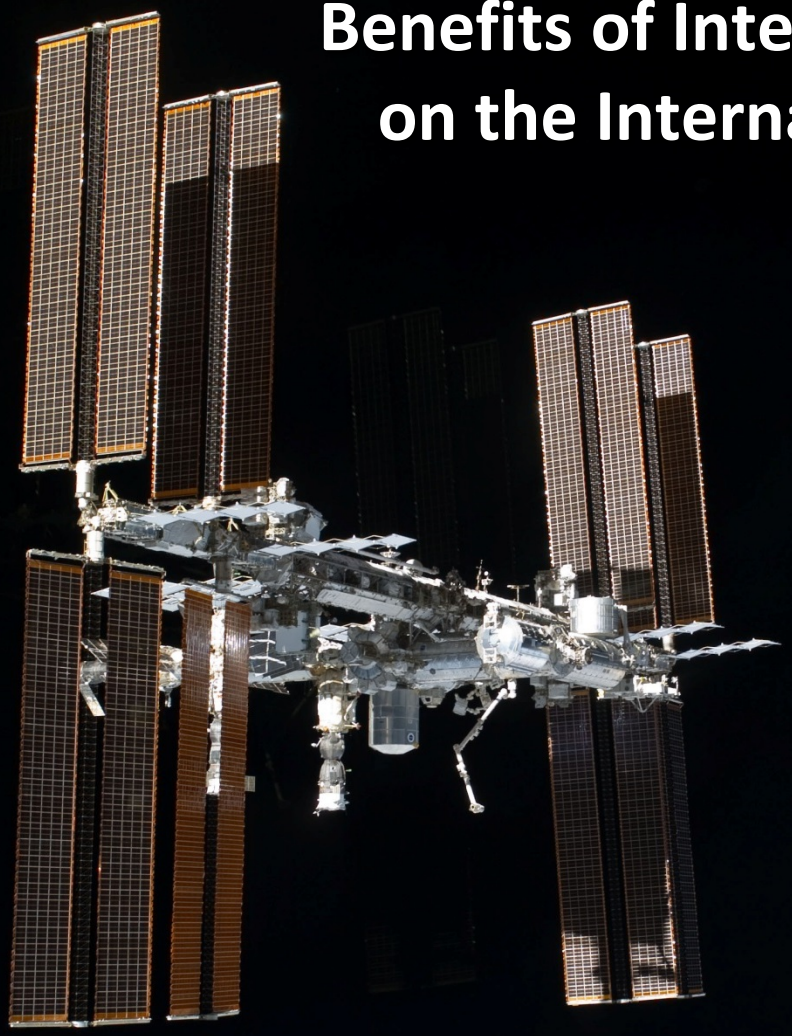
Benefits of International Collaboration on the International Space Station



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with the ISS Program Science Forum

Hasbrook, Tate-Brown, Thumm, Cohen, Marcil, De Parolis, Hatton, Umezawa, Shirakawa, Karabadzhak, Sorokin, Valentini

Through international science working groups and interagency cooperation, international collaboration on the ISS has expanded as ISS utilization has matured.

ISS Program Science Forum

ISLSWG: International Space Life Sciences Working Group

IMSPG: International Microgravity Planning Group

US-Russia Joint Working Group

Cooperative Facilities have avoided duplication of effort and facilitated collaboration

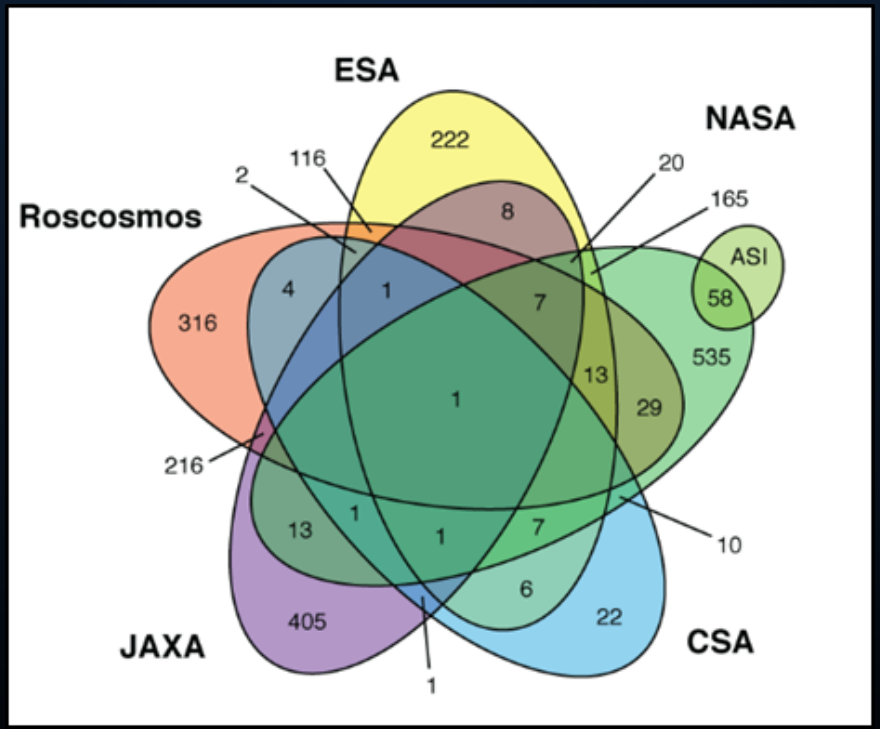
ISS050e042167. Thomas Pesquet (ESA) and Peggy Whitson (NASA) setting up the Microgravity Expanded Stem Cells (MESC) Life Science Ancillary Hardware (LSAH) in the Microgravity Science Glovebox (MSG).

ISS050e058812. Thomas Pesquet (ESA) during Protein Crystal Growth (PCG) -5 hardware deactivation and stow, from Microgravity Experiment Research Locker Incubator (MERLIN) on Expedite the Processing of Experiments to the Space Station (EXPRESS) Rack 5. Pesquet is removing the JAXA Handheld Protein Crystallization Facility (PCF).

Russian students participate in the Zero Robotics Competition on ISS
Image credit: zerorobotics.mit.edu

ISS partners increase their effectiveness by collaboration in facilities and investigations.

- Emphasize and encourage true collaboration to increase scientific return and improve efficiency
  - Data sharing, tissue sharing and experiment exchanges
  - Increase scientific return, numbers of scientists, numbers of publications, QUALITY of publications



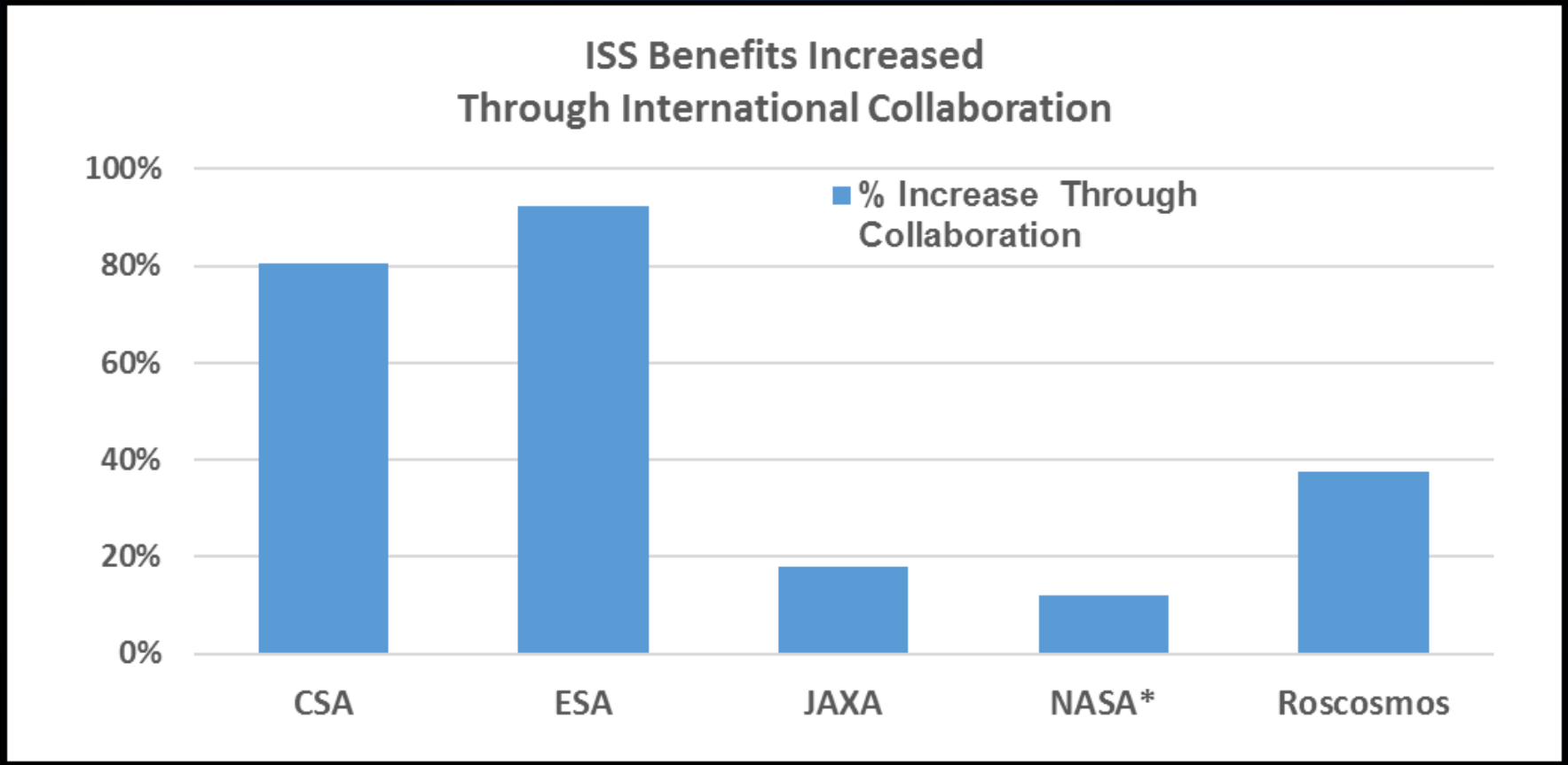
Combinations of ISS Agencies' International Collaboration During Expeditions 0-48.

International Collaboration – ISS Investigations Expeditions 0-48

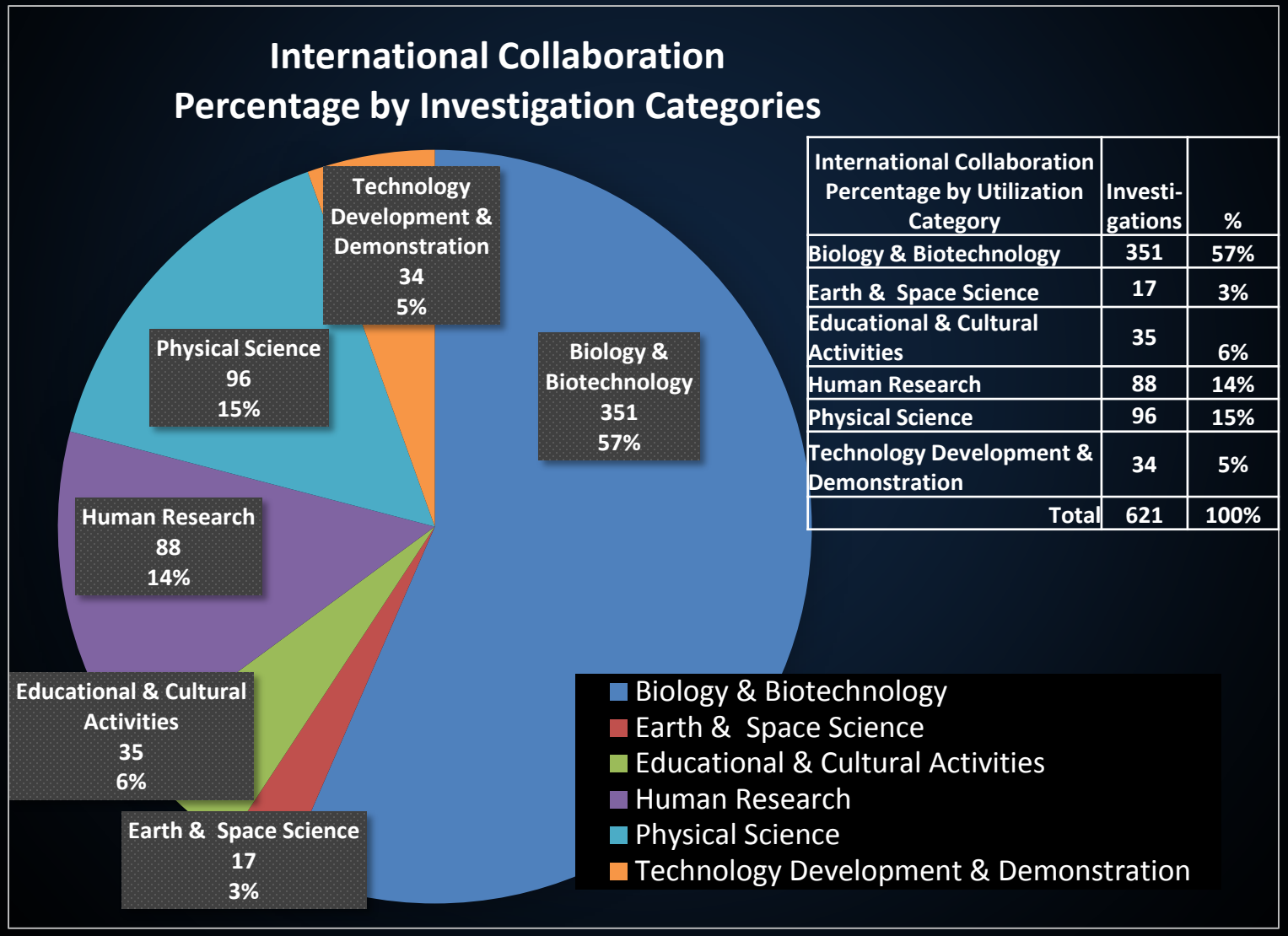
December 1998 - September 2016

Agency	Agency Only	Collaboration (Hosting)	Investigations Implemented	Collaboration (Participating)	Total Agency Impact	% Increase Through Collaboration
CSA	22	9	31	25	56	81%
ESA	222	74	296	273	569	92%
JAXA	405	167	572	102	674	18%
NASA*	593	174	767	93	860	12%
Roscosmos	316	197	513	192	705	37%
Totals			2179	685	2864	31%

Percent Increase in Agency Utilization "Impact" due to International Collaboration

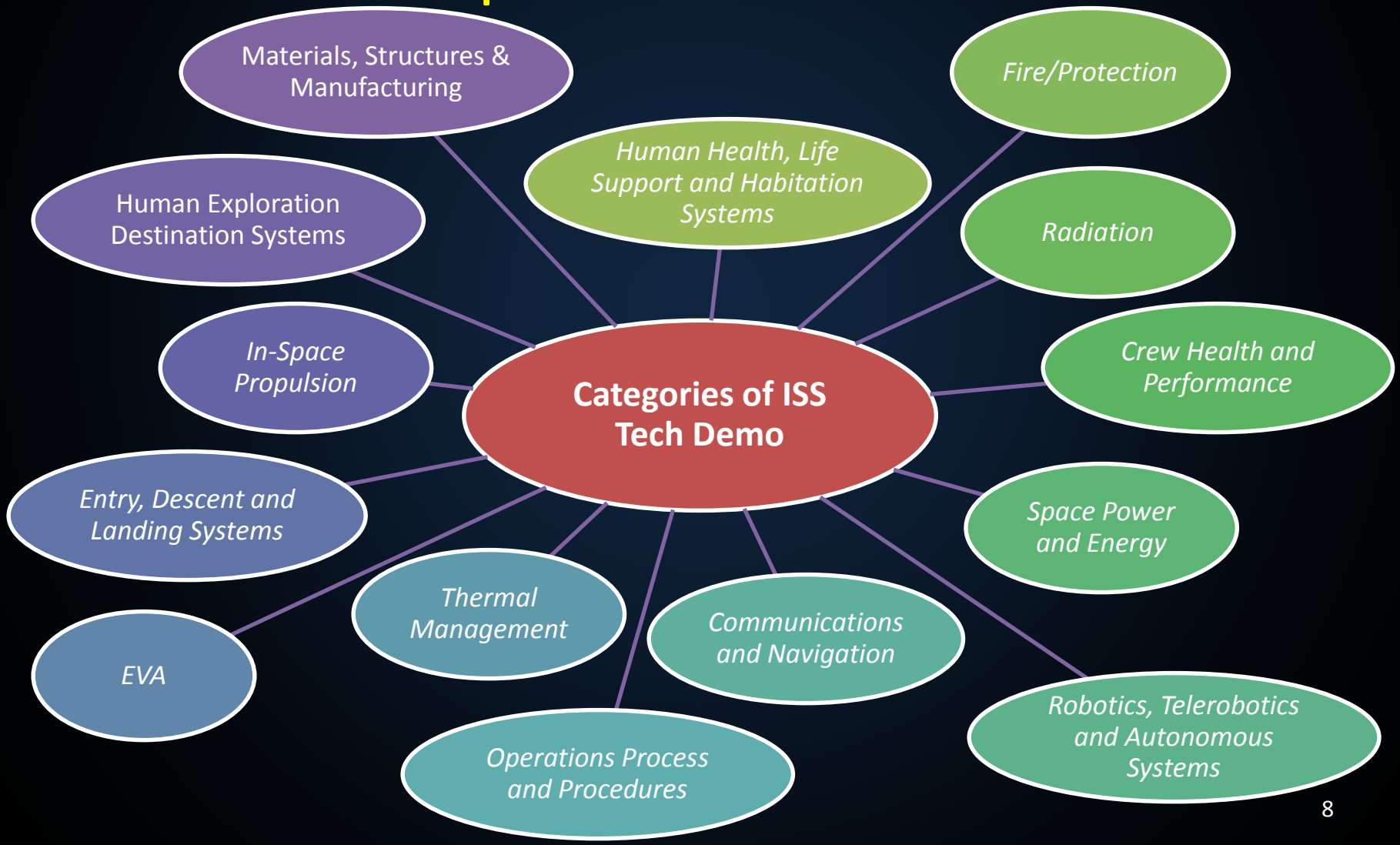


International Collaboration – Categories Distribution - Expeditions 0-48



International Collaboration Percentage by Utilization Category	Investi-gations	%
Biology & Biotechnology	351	57%
Earth & Space Science	17	3%
Educational & Cultural Activities	35	6%
Human Research	88	14%
Physical Science	96	15%
Technology Development & Demonstration	34	5%
Total	621	100%

ISS research and technology demonstrations are critical for the next exploration missions

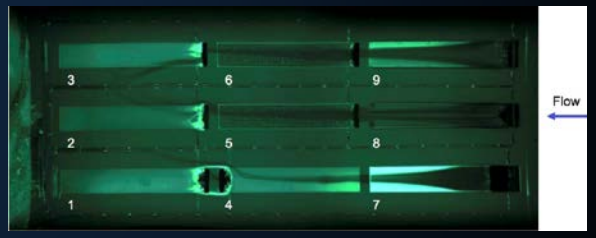


ISS Technology Demonstration Highlights

- Successfully installed and expanded **Bigelow Expandable Activity Module** (BEAM)
- Began monitoring microbial species using the **Razor and MinIon** technology demonstrations
- Characterized the particulate environment of ISS using the **Aerosol Sampler**
- Implemented **alternate urine pretreat formula** to increase urine processing water recovery rate
- Tested wearable **personal CO_2 monitor**
- Tested flammability of different materials and behavior of large fires in low gravity on the **Spacecraft Fire Safety** Demonstrations (SAFFIRE)
- Installed **RFID-Enabled Automated Logistics Management (REALM)** flight reader

RAZOR PCR & MinIon DNA Sequencer

Aerosol Sampler



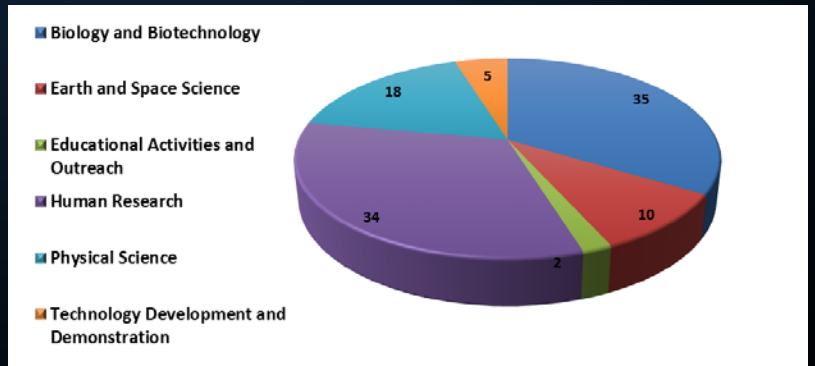
Saffire II

Peggy Whitson installing REALM flight reader

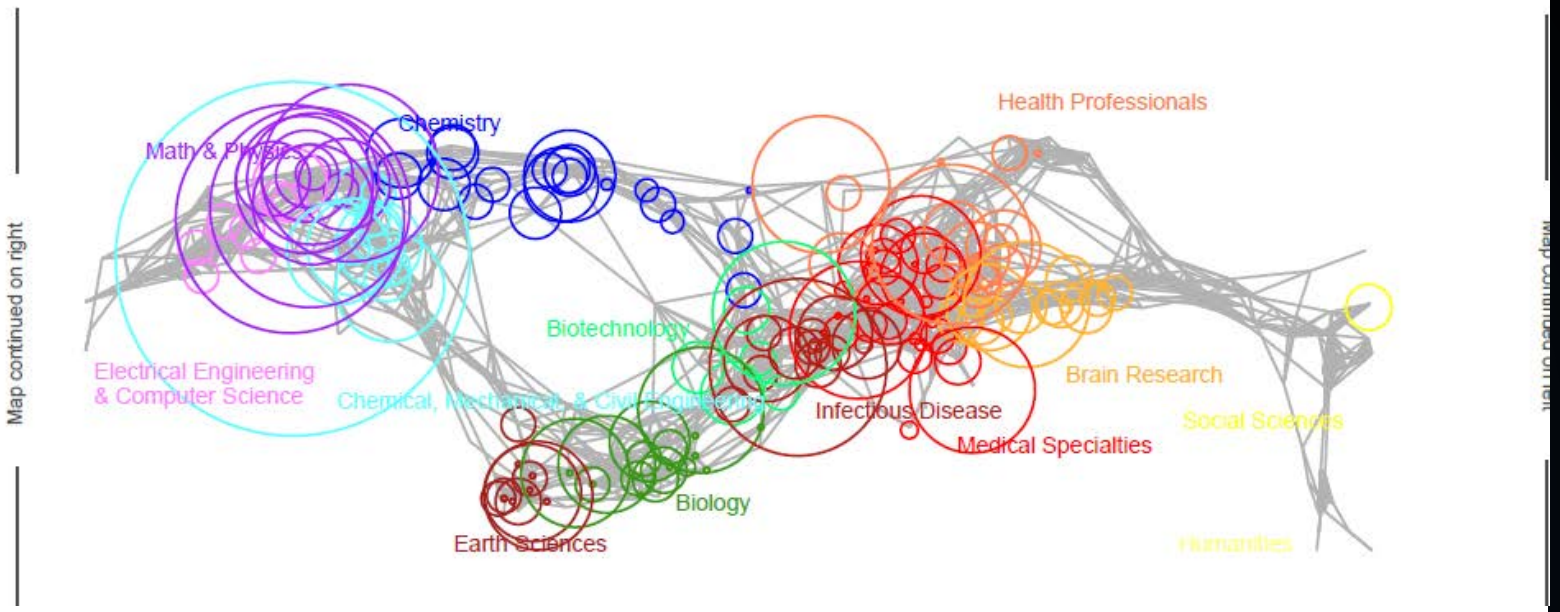
BEAM Expanded on Space Station – May 28, 2016

Research from ISS continues to grow in scientific prestige and impact.

- Annual results are now being compiled quarterly due to the amount of throughput
  - A highlights and results tabulation document to be published each year
  - 2015-2016 installment in final NASA editorial process.
  - 103 Journal publications
  - Huge surge in biological discovery in the past year
- Use of scientific valuation results across all-ISS to help explain its accomplishments
  - Portrayals of subsets of experiments by partner or module do not represent the full international accomplishments



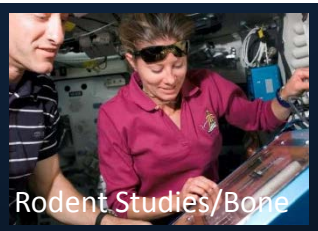
ISS Publications and the Map of Science



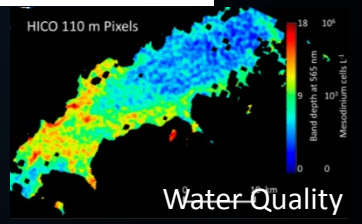
- As of January 31, 2017
- 1300+ journal articles (by DOI) through the UCSD program = 348 journals ("records").
- Online tools being released throughout the coming 12 months (Full Toolbox Upgrade)

Colors = disciplines.
Nodes = subdisciplines.
Node size = #articles published

7 Publications in the Top 5 Global Journals 2015-2016		
Journal (# of articles)	Impact Factor	Eigenfactor
PLOS One (4)	3.057	1.81924
PNAS (1)	9.423	1.32650
Physical Review Letters (2)	7.645	0.82028


Rodent Studies/Bone

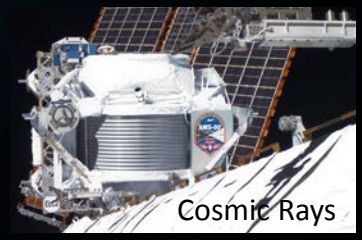
Fish Studies



Water Quality


Microbes

Hair Analysis


Cosmic Rays

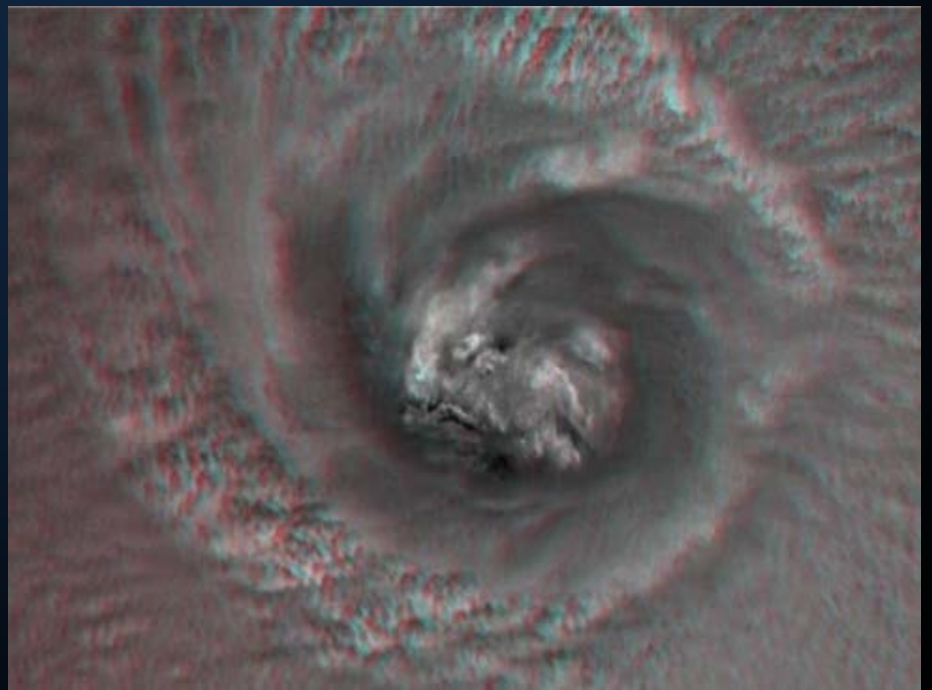
ISS Returns Economic and Societal Benefits for Humanity

- Economic Enhancement for the **Benefits for Humanity** 3rd Edition, 2018
  - Identify new Benefits stories since 2015
  - Estimate economic impact for all Benefits stories, update contributions from stories identified in the past
  - International Space Exploration Forum, March 2018
  - Discussions among ISS Partner leadership including Heads of Agencies, Spring 2018

Examples of new Benefits Stories:

CyMISS: Cyclone Intensity Measurements from the ISS

- Obtains measurements supporting the use of the “Carnot engine” model of tropical cyclones (TCs) to achieve remote measurements of the intensities of the strongest TCs more accurately than existing remote-sensing methods.
- Presented to the Director of NOAA and his team at the NOAA Atlantic Oceanographic Laboratory (AOML) to determine approaches to including it in modeling and predicting hurricane intensities and paths.



Examples of new Benefits Stories:

Human Emulation System
(Application from Capillary Flow Investigations)

- A living biological platform that can be used for predicting human response to diseases, medicines
  - Organ-Chips, which are micro-engineered environments lined with specific, living human cells and tissues.
  - Chip's tiny channels reproduce blood and air flow and recreate natural physiology and mechanical forces that cells experience within the human body.
  - "Emulate" is at the early stages of taking an individual patient's stem cells and differentiating them to create personalized Organ-Chips for precision medicine and personal health applications on Earth.

ISS Research Web Resources

ISS Research & Technology
http://www.nasa.gov/iss-science/

@ISS_Research

ISS Research Stories via e-mail
http://go.usa.gov/26ue

Space Station Research Explorer App

iPad Android